Re-Innovation Nation:

The Strategic and Political Logic of Technology Transfer Policy in Rising China

by

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Abstract

This project examines China's efforts to accelerate its economic rise using *technology extraction policies*, defined as measures that condition foreign access to China's market on technology transfers to domestic firms. Using original data, I address two puzzling and previously unexamined patterns in China's technology transfer behavior. First, China's use of tech extractors rose sharply in the years after it joined the World Trade Organization (WTO) in 2001, only to fall equally dramatically after 2015. Second, within this broad-based increase after 2001, there was surprising variation across industries in China's use of these tools. China issued tech extractors liberally in many high value-added industries, including high-speed rail, aircraft manufacturing, and renewable energy technology. At the same time, it used them sparingly in others, such as battery technology, precision measurement equipment, and semiconductor design and fabrication.

What explains variation in China's use of technology extraction policies? I argue that national power and regime security concerns lead China to pursue tech extraction in strategic industries, but that China is constrained in doing so, even in the most strategically vital sectors, by its bargaining power over foreign firms. China's leverage is weakest when policy enforcement capacity is low and when it sits in the middle of global value chains in an industry, such that most imports consist of foreign inputs to be processed locally for re-export elsewhere. In these industries, China relies more on foreign firms to drive export growth and employment than they rely on it as a final market. This limits China's bargaining power, constraining the use of tech extractors.

I evaluate these arguments using a combination of statistical analysis of an original industry-level dataset on technology extractors from 1995-2020 and detailed qualitative case studies of tech extraction in three strategic industries. My data, based on manual analysis of several hundred Chinese language regulations, reveal that strategic industries account for 85 percent of the increase in the use of tech extractors after 2001. However, I find that China is more than twice as likely to use these policies in strategic industries in which it is downstream of value chains as a final market than in those in which it is intermediate. Case studies of tech extraction efforts in wind turbine technology, semiconductors, and aviation illuminate the relationship between enforcement capacity and the rise of tech extractors, value chain position and the non-use of these tools in some strategic sectors, and the causes behind the decline of technology extraction policies after 2015.

Thesis Supervisor: M. Taylor Fravel
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Chapter 1

Introduction

China's entry into the World Trade Organization (WTO) in 2001 was a turning point for both the Chinese and world economies. More than any other single event, it ushered in the high tide of the process of globalization that began with the liberalization of international capital flows in the 1970s and 1980s and accelerated with the expansion of global production networks after the Cold War. In the two decades after its accession, China's share of world merchandise exports rose from 3 to 15 percent, a stunning increase given that in the same period total global exports rose four-fold in value and trade's share of world gross domestic product (GDP) increased nearly ten percentage points.[1] By 2021, China accounted for 31 percent of global manufacturing value-added output, more than the United States, Japan, Germany, and India combined.[2] On the eve of WTO entry, by comparison, its manufacturing output was roughly one-seventh that of the United States.

This sea change in China's place in the world economy coincided with and owed much of its force to a surge of foreign, and especially American, capital into the country after 2001. Although foreign multinational enterprises (MNEs) had long maintained a presence in China, throughout the 1990s uncertainty stemming from China's lack of Permanent Normal Trade status from the United States deterred many firms from investing heavily in factories there. With WTO entry, this uncertainty evaporated. Between 2001-2015, annual net foreign direct investment (FDI) inflows to

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[1] United Nations Conference on Trade and Development (UNCTAD, Available at: https://unctadstat.unctad.org), World Bank National Accounts Data (Available at: https://data.worldbank.org).

[2] UNCTAD, (Available at: https://unstats.un.org).

China and Hong Kong quintupled, from $78 to $423 billion, much of it originating in the United States. Along with this unprecedented influx of foreign capital came an equally significant influx of foreign technology, expertise, and managerial knowhow. These inputs would help cement China's rise, first as the world's workshop, and later as a technological superpower in its own right.

This project examines the Chinese state's efforts to harness that influx of foreign technology so as to turn China into a cradle of "indigenous innovation" (自主创新), and in doing so catapult the country to the commanding heights of the global division of labor. I do this by developing and testing a theoretical framework to explain China's use of what I call *technology extraction policies*, or technology extractors, for short. I define these as policy tools that condition foreign access to the Chinese market on foreign firms' willingness to share technology and expertise with domestic firms. Put simply, technology extractors enlist foreign firms, as owners of technology, in the project of national industrial upgrading. In that capacity, they have proved among the most consequential and controversial elements in China's foreign economic policy toolkit in recent decades, both helping make China a world leader in sectors like high-speed rail and artificial intelligence and hastening the U.S.-China trade war and the escalation of Sino-American strategic competition.

Using a new industry-level dataset on three measures which formed the backbone of China's push to "introduce, digest, absorb, and re-innovate" (引进消化吸收再创新) foreign technology from 1995-2020, I address two puzzling and previously unexamined patterns in China's technology transfer behavior. First, the use of tech extractors rose significantly in the years after WTO entry, only to collapse similarly dramatically after 2014. Despite China's pledge to stop conditioning market access on technology transfers as part of its WTO accession protocols, the total number of tech extractors in place – including ownership restrictions on inward FDI, local content requirements, and preferential public procurement policies – increased more than six-fold between 2012-2012, from around 50 to nearly 340. By 2016, however, that number had fallen back to 1990s levels, and by 2018 only a handful of formal tech extraction policies remained in place. This represented a stunning reversal from the peak in the early 2010s, when some form of overt, central-level technology extraction policy could be found in roughly one-quarter of all industries in China.

Second, within the substantial and broad-based increase in China's technology extraction efforts after WTO entry, there was puzzling variation across industries in China's propensity to impose these measures. China issued tech extractors energetically in most high value-added, high-technology sectors. For instance, from 1995-2020, it introduced 29 distinct JV mandates and other ownership restrictions on FDI in commercial aircraft manufacturing, 24 in automotive production, and 21 in power generation (including renewable energy). At the same time, however, it used tech extractors sparingly, and in some cases not at all, in a number of equally vital high-technology industries, including batteries and accumulators, various kinds of precision measurement and navigational equipment, and perhaps most surprisingly, semiconductor design and fabrication – arguably *the* strategic high-technology industry *par excellence*. After 2001, China never once issued JV mandates or explicit local content requirements in any part of the semiconductor supply chain, even as it ramped up the use of these tools in most other high value-added industries.

Summary of the Argument

What explains variation in China's use of technology transfer policies? To begin, what accounts for the conspicuous rise and fall over time in the number of tech extractors in place? Second, and more importantly, why does China enforce these measures energetically in many high-technology industries but not in others, including some where we might expect them to be most prevalent?

The core argument of this project is that top-down national power and regime security concerns lead China to pursue technology extraction in strategic industries, but that China is constrained in issuing tech extractors, even in the most strategically important sectors, by its bargaining power over the foreign firms that invest there. China's bargaining power rests on two key pillars. The first is what I call central state *enforcement capacity*, by which I mean the state's ability to effectively coordinate and implement national policy priorities on a nationwide basis over and against potential opposition from subnational or private actors. I expect increased enforcement capacity to lead to broad gains in the use of technology extractors across strategic industries.

The second pillar is China's position in global value chains – a term used to describe the fragmentation of production activities for a given good across different countries and continents – in an industry. Where China sits in these global value chains (GVCs) shapes the *balance of dependence* between China and foreign firms, or whether China depends more on foreign firms as suppliers and as drivers of export growth than they depend on it as a final market for their goods and services. The less this balance favors China, the weaker its leverage and the less likely it is to impose technology extractors. I expect the balance of dependence to most favor China when it sits primarily downstream of production networks as a final demand center, such that most of what is imported into China is ultimately consumed there. By contrast, this balance will favor foreign firms when China occupies an intermediate position in global production networks in an industry – that is, when most of what China imports is not actually consumed within China, but rather processed locally and re-exported, as more finished goods, to consumer markets elsewhere.

To explain when China uses technology extraction policies, we must begin by understanding the underlying purposes that drive this behavior. The first part of my argument holds that Chinese leaders' core interest in bolstering China's national security and the legitimacy of the Chinese Communist Party (CCP) regime provides the central motivation behind technology extraction. That motive, in the words of CCP General Secretary Xi Jinping, is for China to become a dominant global power by seizing "the commanding heights of technological competition" in the 21st century.[3]

In making this argument, I draw on realist approaches to political economy, which emphasize the intelligibility and analytical value of the notion of a "national interest" that is not reducible to the parochial concerns of individuals or societal interest groups. As Kirshner (2022) observes, this concept is rooted in the state's role as provider of public goods like national defense, but can be usefully understood to encompass not only territorial sovereignty and domestic political autonomy but a range of "broad, long-term goals" that derive from and advance these basic imperatives (Kirshner, 2022, 131). I argue that in the context of China today, ensuring national economic security by establishing the country's preeminence in high technology industries is one such goal.

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[3] Xi Jinping. 2018. "Strive to be the World's Leading Science Center and Innovation High Ground," Retrieved July 26, 2022 (Available at: *http://www.qstheory.cn*).

Realism is particularly well-suited to explaining China's technology transfer behavior given the country's status as simultaneously (1) a rising great power faced with an increasingly dangerous strategic environment due to heightened economic and security pressures from the U.S. and its allies and partners; (2) a late modernizer that has self-consciously modeled its industrial policy strategy on those of earlier East Asian developmental states; and (3) an authoritarian regime that has long staked its political legitimacy partly on economic performance. Indeed, for each of these classes of state there is a sizeable literature to support the notion that long-term, top-down power and security considerations influence economic policy. Contemporary China, uniquely, qualifies as all three. Moreover, the view that top-down security concerns drive China's industrial policy behavior is consistent with the large literature on economic performance as a pillar of regime legitimacy in post-Mao China (Nathan, 2003; Tan, 2021), and with evidence that Chinese leaders publicly and privately discuss technology transfer policy in explicitly strategic terms (Doshi, 2021).

I expect China to pursue technology extraction in sectors likely to provide the highest return in terms of national power and competitiveness. These are often called strategic industries (Hsueh, 2011, 2016). Following Ding and Dafoe (2021), I define strategic industries as sectors with great economic or military utility, which generate broad positive spillovers for the economy, and the spillovers of which do not easily diffuse across national borders. Because these industries have many features of public goods, achieving optimal results often requires state intervention, especially in less developed contexts. Examples of strategic sectors include defense industries, basic infrastructure, and other high value-added industries with steep barriers to entry.

Whereas strategic interests explain when China would like to use technology extractors, however, they do not fully specify when it actually uses these tools — and when it does not. Answering this question matters because strategic motives alone cannot account for important variation in Chinese behavior. To start, to the extent top-down strategic interests vary over time, they do so gradually. Variation in security imperatives thus cannot explain the sudden rise in the use of tech extractors in the post-WTO period (nor the subsequent fall). Likewise, although strategic interests account for much cross-industry variation in China's behavior, they do not explain all of it, including the sparing use of technology extractors in some strategic high tech industries where we might expect them to be most prevalent, such as semiconductor production.

The second part of my argument fills these gaps by examining China's bargaining power over the foreign firms that do business there. I use the term bargaining power to denote China's ability to induce foreign firm compliance with technology extraction policies. This rests fundamentally on whether China can credibly threaten to cut off access to its market if foreign firms refuse to share technology with local partners (Hirschman, 1945; Shambaugh, 1996). China's ability to do so depends foremost on a combination of central enforcement capacity, which shapes the state's ability to bargain with foreign firms as a reasonably cohesive and unified actor, and where China sits in GVCs in an industry, which influences its relative dependence on foreign firms.

I argue that gains in central state enforcement capacity following administrative restructuring in the late-1990s and early-2000s best explain increases in both the number of technology extractors in place in strategic industries and the vigor with which those policies were enforced in the years after China joined the WTO. In the leadup to WTO accession, China's leaders became increasingly concerned that the country's economic policy institutions (including state-owned enterprises) were ill-equipped to capitalize on the opportunities and manage the competitive pressures WTO entry would create (Pearson, 2005; Zheng, 2004; Chen and Naughton, 2016). This fear helped catalyze a series of reforms aimed at reducing the bureaucratic fragmentation exposed by China's protracted WTO accession process and, more generally, at building a more effective regulatory and administrative state (Liang, 2007; Pearson, 2001; Hsueh, 2011). One result of these reforms was the steady consolidation of control over industrial and technology transfer policy in the hands of a small number of "apex" macroeconomic planning bodies with greater autonomy and authority than their predecessor agencies (Heilmann and Shih, 2013). I argue that the rise of these agencies, above all the National Development and Reform Commission (NDRC), best explains the growing assertiveness of Chinese tech extraction efforts after WTO accession.

But if increased enforcement capacity explains the rising intensity of tech extraction efforts over time, it does not account for substantial industry-level variation in the use of these tools across strategic industries. To answer this question, we must look at where China sits in GVCs in an industry. I argue that China's position in global production networks shapes its use of tech extractors by altering the balance of dependence between China and foreign firms. When China is downstream of value chains as a final market, I expect this balance to favor China. In these industries, foreign firms' heavy reliance on Chinese final consumption leaves them highly vulnerable to disruptions to commercial flows with it. This gives Chinese authorities significant leverage to extract market access concessions, including compliance with technology transfer policies.

By contrast, when China sits in the middle of value chains as an intermediate production node, foreign firms depend less on China as a final market. Most of what firms import into China in these industries is not, in fact, consumed there. Rather, it is processed locally for assembly into more finished goods and re-exported to consumers in the United States, Europe, and other countries. At the same time, China in these industries relies heavily on foreign firms and the value chains they govern to guarantee its access to overseas consumer markets, and in turn to sustain export growth and associated employment in China. I argue that this combination of reduced foreign firm reliance on the Chinese market and increased Chinese reliance on foreign firms to fuel export growth shifts the balance of dependence in foreign firms' favor. This enables investors to more credibly threaten a costly exit from the Chinese market and more effectively resist technology extractors. As a result, I expect China to issue policies that condition market access on technology transfers less often in industries in which it occupies an intermediate position in global value chains.

Regarding the fall of technology extractors, I argue that a confluence of factors made it such that by the mid-2010s the anticipated costs associated with these policies began to outweigh their expected benefits for further industrial upgrading. By the 2010s Chinese firms were quickly gaining ground on foreign competitors, capturing domestic and foreign market share in many sectors in which China had pursued foreign technology transfers most energetically the previous decade. Increased Chinese competitiveness at once reduced the need for tech extractors and stoked foreign corporate and governmental pushback against them, most notably from the United States. Related to this, as Chinese firms became more competitive and began seeking opportunities for overseas expansion, both firms and state officials in China became more sensitive to the risk of reciprocal restrictions on Chinese FDI by foreign governments angry over market access limitations in China. The reduced utility of tech extractors, combined with a desire to avoid precisely the kind of negative reciprocity employed by the Trump administration, led China to substitute away from these policies in favor other avenues of technology transfer after 2014-2015. These included, most notably, technology-focused overseas investment by Chinese firms and various less direct, and therefore less easily monitored, inducements to share technology with local enterprises.

Importance and Contributions

In addition to helping fill an empirical gap in our knowledge of Chinese industrial and technology policy, the project makes several theoretical contributions to research in international relations and political economy. First, although much has been written about the causes and consequences of great power transitions – the process by which one state supplants another as the dominant power in the international system – we know comparatively little about *how* rising powers like China actually rise, and why some countries rise while other, similarly situated countries do not.

Attention to this "how" matters because standard variables like factor endowments, exogenous technological change, and the structure of state institutions only go so far in explaining the dramatic ascents of states like Bismarck's Germany, Meiji or postwar Japan, and post-Mao China (Gilpin, 1987; Kennedy, 1987; Drezner, 2001). For each of these countries – cases on which much of our theorizing about modern great power politics rests – concrete, contingent policy choices, many directly concerned with the absorption of foreign technology and know-how, played an enormous part in fomenting their rise. To explain how these countries rose, were must understand their choices. This, in turn, requires examining the motives behind and constraints on those choices.

In addition, examining these motives offers a chance to revisit influential arguments about the sources of economic policy decisions in the international political economy (IPE) literature. Mainstream accounts of trade and other commercial policies emphasize the bottom-up determinants of policy outcomes: policies are understood to originate in the preferences of individuals (as consumers, workers, or asset owners) or firms, with the state acting primarily as an aggregator of and arbiter between those often-conflicting interests (Grossman and Helpman, 1994; Scheve and Slaughter, 2001; Lake, 2009; Kim, 2017). Although these dynamics undoubtedly shape policy, however, they coexist and contend with other, top-down sources of economic decision-making which standard political economy models are ill-equipped to explain. I argue that making sense of Chinese technology transfer policy requires putting top-down motives like national and regime security at the center of analysis. By "bringing the state back in" to the study of one important form of trade-related policy in the world's largest trading nation, I also hope to demonstrate the enduring relevance of realist approaches to political economy (Gilpin, 1975; Krasner, 1976; Kirshner, 2022). Once a fixture of scholarly debates in IPE, in the post-Cold War period realism's emphasis on the independent role of state preferences not reducible to societal interest groups has been gradually relegated to the margins of mainstream (American) IPE. I expect this trend to reverse in the coming years as the rise of China and attendant revival of industrial policy in wealthy democracies leads to the "securitization" of an ever-increasing share of states' foreign economic policies.

Finally, closer scrutiny of China's use of technology extractors can help clarify how China's rise is similar to and how it differs from those of earlier rising powers. Like all late modernizers, China's defining challenge in the past four decades has been to escape the "poverty trap" (Ang, 2016). Indeed, despite years of rapid economic growth after Mao's death, China entered the post-Cold War and even post-WTO eras desperately poor and profoundly technologically backward in virtually every industrial sector. Against this backdrop, like its predecessors, and in particular the postwar developmental states of Japan, South Korea, and Taiwan, China had no choice but to look abroad in order to acquire the technological inputs needed to jumpstart its industrialization.

But although China has self-consciously followed the playbook of the canonical postwar developmental states – one which was itself modeled on the experiences of Meiji Japan and imperial Germany, which in turn took cues from Alexander Hamilton's America – it has also had to contend with several distinctive conditions. These conditions have implications that reach far beyond China because they are rooted in changes in the structure of the international system and in historically new developments in the organization of economic activity globally.

The first such change was the end of the Cold War. Whereas postwar Japan, South Korea and Taiwan were largely spared by their status as Cold War U.S. allies from having to "trade" access to their domestic markets in return for technology, China had no such luck (Samuels, 1991; Mason, 1992; Amsden, 1989). As the painful battles over China's WTO accession and the U.S. decision to grant China permanent normal trade status showed, Beijing's only path to acquiring foreign technology lay in opening its market to foreign competition. This was especially true in the first ten to fifteen years after China joined the WTO, when Chinese firms lacked the resources to simply buy foreign technology companies. For China's leaders, the central dilemma was how to relax controls on foreign inflows without letting more productive foreign firms wash out local ones. This dilemma was far more acute for China than its forebears, and managing it required institutional and policy innovations which earlier developmental states could largely do without. Tech extractors were one key mechanism by which China's leaders sought to resolve this dilemma after the Cold War.

A second no less significant but much less remarked change was the steady privatization of most industries in advanced industrial societies over the course of the second half of the 20th century.[4] This process meant that by the time China's technology extraction efforts got underway, ownership of most key technologies was concentrated in the hands not of states or state-linked entities, but of private firms. As a result, to a far greater extent than earlier developmental states but in ways that may foreshadow what developing economies like India, Indonesia, and Brazil will face if and as they seek to replicate China's successes, bargaining with foreign firms over the terms of technology transfer has defined China's modernization efforts.

The growing prominence of state-firm over state-state relations in determining international technology flows in the post-Cold War era has created clear opportunities for states like China.

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[4] With the partial exception of the United States, nationalization of heavy industry and manufacturing sectors was commonplace among OECD countries in the first three decades after World War II. The pace and level of privatization among OECD countries picked up in the 1980s, reached an all-time high in the 1990s, and has remained steadily high since then. For more, see OECD. 2009. "Privatisation in the 21st Century: Recent Experiences of OECD Countries," Retrieved April 21, 2023 (Available at: *https://www.oecd.org*).

Especially in the leadup to and aftermath of China's WTO accession, foreign MNEs seeking access to the Chinese market were often prepared to share technology in exchange for market access. Indeed, some even lobbied their home governments for relaxed enforcement of export controls in sectors like computer electronics and aircraft manufacturing to facilitate exports to and investment in China. Without the interest of Western businesses in the Chinese market, along with their efforts to clear China's path to integration into the liberal trade order, Chinese firms would have found it much harder to acquire the technology and training they sought. Certainly, China had no analogue to postwar Japan, which benefited from the direct U.S. government transfers of military technology and enormous U.S. government-supported transfers of commercial technology.

But if the concentration of technology ownership in the hands of firms operating at a distance from their (mostly Western and liberal democratic) home governments helped make large-scale technology acquisition feasible for China, this effort has also been shaped and constrained in new ways by a second attribute of the post-Cold War world: the globalization of production networks. The fragmentation of the stages of production for individual goods across countries and continents has important effects on the power balance between states that host foreign investment and the firms that invest in them (Johns and Wellhausen, 2016). Most importantly, I argue, it gives foreign firms that use host countries as bases for processing goods to be re-exported elsewhere new sources of leverage they can use to push back against coercive actions by even powerful host states with large internal markets. In doing so, it challenges the conventional equation of market size with coercive economic leverage (Drezner, 2007; Drezner, Farrell and Newman, 2021). More importantly, it qualifies, if not completely overturns, the "obsolescing bargain" model that has long defined the study of FDI politics, whereby firms enjoy leverage over host states prior to investing but lose it after they make the investment (Vernon, 1971). In a world of GVCs, host states reliant on integration into these networks to fuel exports have less to gain and more lose by expropriating foreign investments. For firms, this is a new and potentially durable source of power over host states.

Technology has always been indispensable to national power. But seldom if ever has the relationship between national power and mastery of cutting-edge technologies been tighter than it is today. Unfortunately for most countries, at the same time that this relationship has strengthened, the barriers to technological mastery have grown exponentially higher, driven by the extraordinary increase in the complexity and capital intensity of key technologies. In such a world, it is simply not possible for poorer countries to "catch up" without access to and the opportunity to "digest" and "absorb" foreign technology. The wager of this project is that to understand how late modernizers and rising powers like China rise requires putting the relationship between the states that want technology and the firms that control it at the center of analysis. And in a world of global production, understanding this relationship requires tracing how states' and firms' differential positioning in fragmented value chains shapes their incentives and relative bargaining power.

Overview of the Chapters

Chapter two systematically defines and operationalizes the concept of technology extractor, surveys the history of Chinese technology transfer efforts, and compares tech extractors with other forms of technology transfer policy used by China. It then situates China's use of these tools in relation to the longer history of mercantilist thought and practice and compares China's behavior to similar actions by earlier late modernizers and other contemporary developing economies. It elaborates the arguments above regarding how changes in the distribution of power and the nature of the global economy after the Cold War have altered the conditions under which rising powers like China rise.

Chapter three outlines my theory of variation in China's use of technology extractors and describes the empirical strategy used to test the theory. First, I develop my argument about the top-down motives behind technology transfer policy in China and contrast this perspective with approaches to trade policy that emphasize the role of bottom-up interest group pressures. I argue that in China's case, top-down security concerns rooted in a reasonably coherent appraisal of the national interest provide a better basis for understanding why China pursues tech extraction in something like "objectively" strategic industries, or those most countries would regard as such.

From there, I turn to the question of how China's bargaining power over foreign firms limits to the use of tech extraction policies even in highly strategic industries. I suggest China's bargaining power rests on a combination of central state enforcement powers and where China sits in global value chains in an industry. I situate enforcement capacity in relation to two other roughly simultaneous changes that influenced China's bargaining position in the early 2000s – WTO entry in 2001 and the 2003 CCP leadership change – and discuss why I focus on central enforcement capacity as the key variable in explaining the rise of tech extractors between 2001-2011. I then build out my argument about how variation in China's position in GVCs shapes the balance of dependence between China and foreign firms, leading China to use fewer technology extractors in strategic industries in which it is intermediate to value chains. The chapter ends with a detailed discussion of my empirical strategy, which combines statistical analysis of an original industry-level dataset on technology extractors with detailed qualitative case studies of tech extraction efforts in three strategic high-tech industries: wind turbine technology, semiconductor design and fabrication, and commercial aircraft manufacturing.

In chapter four, I introduce my dataset on technology extractors and use it to test my arguments about the rise of these policy tools and variation across industries in their use. The first part of the chapter provides a detailed overview of how I collected data for and coded each variable of interest. The second part of the chapter uses descriptive statistics to illustrate the broad contours of China's use of these policy tools in the post-Cold War and post-WTO periods. I then conduct a series of statistical tests to evaluate the relationship between China's position in global value chains, measured using the share of imports tied to export processing trade, and China's use of tech extractors in strategic industries. The chapter concludes with a discussion of additional tests I ran to evaluate the robustness of my findings to alternative explanations, model choices, and measurements of key variables.

Chapter five presents the first of three industry case studies I use to probe the mechanisms behind specific parts of the theory. This chapter uses the case of wind turbine technology to examine (1) the relationship between enforcement capacity and the use of technology extractors in strategic industries in which China is downstream of GVCs; and (2) how increased Chinese competitiveness in strategic high-tech sectors alters the costs and benefits of using technology extractors, leading China to abandon these policies. Although China has pursued technology transfers in wind turbine manufacturing since at least the early-1990s, bureaucratic fragmentation within its central state constrained these efforts throughout that decade. This changed abruptly with the creation of the NDRC as China's sole apex macroeconomic planning body in 2003. Almost immediately after its formation, the NDRC began to enforce local content and joint venture requirements in wind power far more actively than its predecessor agencies. Given China's position downstream of GVCs as a major final market – the vast majority of wind turbine-related imports into China were consumed within China – foreign wind turbine makers had few resources they could leverage to push back against these policies. As a result, virtually all major foreign wind firms partnered with and trained local suppliers in response to the NDRC mandates. This contributed to dramatic growth and improvements in China's local wind turbine manufacturing industry, with Chinese firms largely cornering the domestic market and starting to expand abroad by the turn of the decade. Increased Chinese competitiveness, in turn, provoked foreign backlash to technology extractors in the sector. As the risks of negative reciprocity rose, China swiftly removed most formal technology transfer policies in wind power after 2009.

Chapter six explores Chinese tech extraction efforts in semiconductor design and fabrication. Semiconductor fabrication is among the world's most strategically vital industries, and China's leaders have long recognized the importance of foreign technology transfers to their efforts to nurture indigenous innovation in the sector. Despite this, in the decades after China joined the WTO, it never once issued formal JV requirements or other FDI ownership restrictions in any part of the semiconductor supply chain. Likewise, I find no evidence of formal local content requirements in the sector, and although China has used some preferential government procurement policies, it does so to a much lesser extent than in other strategic high-technology sectors. What explains the dearth of technology extraction policies in semiconductors? This chapter draws on interviews with current and former industry executives, industry insiders, supply chain experts, and experts from academia and think tanks to argue that China's intermediate position in GVCs, and the dependencies this fostered on foreign electronics companies, best explains the absence of tech extractors in semiconductor design and fabrication. In the second part of the chapter, I explore how increased final demand for consumer electronics within China in the 2010s strengthened the Chinese state's bargaining power over foreign chipmakers, leading to more energetic pursuit of foreign technology transfers. However, due to increased foreign scrutiny of China's use of joint venture requirements and similar policies, after 2010 these efforts took the forms of outward FDI by Chinese companies and other less "traditional" means for eliciting technology transfer.

Chapter seven revisits my arguments about the rise and fall of tech extractors by examining China's use of these policy tools in commercial aircraft manufacturing. As in wind power, China has employed tech extractors liberally in aircraft manufacturing, especially after administrative reforms centralized decision-making and improved China's bargaining power in the early post-WTO years. But whereas increased domestic competitiveness led China to abandon these tools in wind power by the early 2010s, slower progress in aircraft manufacturing kept them in place in the sector for much longer. I provide evidence that foreign aircraft businesses were not particularly concerned about competition from their Chinese counterparts, and thus continued to view the benefits of compliance with tech extractors as outweighing the risks. Relaxed foreign pressure for their removal, combined with the continued utility of these policies for industrial upgrading in the sector, led China to maintain tech extractors for longer in aerospace than in industries like wind power.

In addition, I use the case of aircraft manufacturing to examine why, even in industries in which China enjoys significant leverage as a downstream consumer and in which it uses technology extractors energetically, there is often wide variation in the extent of genuine technology transfer entailed by foreign firm compliance with these policies. In the final part of the chapter, I trace the experiences of McDonnell Douglas, Airbus, Boeing and GE Aviation in China to make the case that global market structure and firms' position within that structure shape their willingness to share technology with Chinese counterparts. These industry- and firm-level dynamics explain why China has generally had more success in extracting technology from relative laggards or newcomers than from industry leaders. The chapter provides a detailed look at granular bargaining dynamics over technology between the Chinese state and foreign firms.

The concluding chapter summarizes my core arguments and findings regarding the rise and fall of technology extractors over time and variation across industries in their use. It then offers more general reflections on the implications of current tensions in U.S.-China relations for the future of technology transfer policy in China and generally. I argue that policies and pressures like those foreign firms face in China are responses to fundamental conflicts over the international distribution of technology and wealth. As such, efforts to extract technology will persist as long as control over core technologies remains as concentrated and uneven as it is today. I conclude that in pushing firms to shift production away from China, governments like the United States may leave them more, not less, vulnerable to technology transfer pressures by removing an important source of firm leverage over China – namely, control over value chains in which China is embedded.

Chapter 2

Chinese Technology Extraction in Context

Introduction

How do rising powers like China rise? Seminal works on power transitions – the process by which one state supplants another as the dominant world power – identify differential rates of economic growth across countries as the engine of international systemic change (Gilpin, 1981; Kennedy, 1987). However, international relations (IR) theory has surprisingly little to say about what causes differential growth rates or why, for example, two similarly endowed countries like China and India circa 1980 might follow different economic, and thus power, trajectories.

This gap matters for IR theory for at least two reasons. First, China's rise was not inevitable. Rather, China is one in a long line of states that grew national power through top-down efforts to "construct comparative advantage" in high value-added industries (Evans, 1995), including through what Chinese officials call the "introduction, digestion, absorption, and re-innovation" of advanced foreign technology. Like China, these earlier late modernizers – Bismarck's Germany, Witte's Russia, Meiji Japan, the postwar East Asian developmental states, and even the early United States, to name a few – pursued state-supported industrial transformation in large part to improve their positions in the global division of labor and, in turn, in the international balance of power (Samuels, 1991, 1994; Frieden and Rogowski, 2014). Despite this, existing theories of power transitions either elide the causes of rising powers' rise or credit exogenous factors like economic endowments, technological change, or the structure of inherited institutions. In doing so, they gloss over the reality that state choices driven partly by power and security concerns are essential to explaining why some states rise and others do not.

Second, failure to identify the concrete policy choices and tools by which rising powers rise limits our ability to compare across cases of such states. To be sure, the ascents of the countries listed above share important similarities, not least a common commitment to achieving rapid economic development through industrial policy. By they also differ in key respects, many of which owe to changes in the economic, political, and technological contexts in which they rose.

For example, the increased pace of innovation in information technology after World War II made "indigenizing foreign know-how" through technology transfers far more central to the "catch up" strategies of postwar Japan, South Korea, and Taiwan than it was for 19th century Germany or the United States under Alexander Hamilton, though these countries also relied on reverse engineering imported technologies (Amsden, 1989, 14). Likewise, although similarly dependent on foreign technology transfers, the postwar developmental states and contemporary China differ markedly in how they secured such transfers. Industrializing as Cold War allies of the United States at a time of relatively restricted international capital flows, the canonical developmental states licensed technology from the U.S. military and American firms (often with Washington's encouragement) without substantially opening their markets to foreign goods and capital in return (Mason, 1992; Samuels, 1991). By contrast, China's economic rise began in a world of liberalized capital flows and globally fragmented production, and one dominated by a United States unwilling to grant China the same forbearance it showed its Cold War allies. These conditions forced China to develop new policy tools to secure the foreign technological inputs necessary to jumpstart its economic and technological rise.

This chapter helps answer the question of how China rose by defining and operationalizing one such set of tools, which I call *technology extraction policies*, or tech extractors, for short. I characterize these as measures that condition foreign access to China's market on foreign firms' willingness to partner with, and through these partnerships transfer technology and know-how to, Chinese firms. In effect, tech extractors exchange market access – the ability to invest or sell goods and services in China – for technology and expertise. In doing so, they enlist foreign firms, as owners of technology, in the project of strengthening Chinese firms' own "indigenous innovation" capabilities. As I noted in the introductory chapter, I focus on three policy tools that best fit the concept of tech extractor in post-WTO China. These are joint venture (JV) requirements and other ownership restrictions on inward FDI into China, local content requirements, and preferential government procurement policies.

The remainder of the chapter elaborates the concept of tech extractor and puts China's use of these policies in context. The chapter accomplishes three main tasks. First, it shows that technology extraction is an integral component of the "indigenous innovation" paradigm that has defined Chinese industrial policy in the post-WTO period. Second, it argues that China's pursuit of tech extraction may be distinct in scope and scale, but it is not unique. State-directed foreign technology acquisition has been a recurrent feature of mercantilist practice since at least the early 19th century. To develop a fuller picture of the motives behind China's behavior, it helps to situate China in relation to this longer mercantilist legacy. Finally, I demonstrate that these parallels notwithstanding, Chinese technology extraction efforts in the post-WTO period differ in key respects from similar actions by earlier late modernizers and other contemporary developing economies.

The chapter proceeds as follows. Section two more systematically defines technology extractors and traces the evolving role of tech extraction in China's industrial policy strategy. Section three relates Chinese tech extraction behavior to earlier debates about mercantilism and "infant industry" protection in the 18th through 20th centuries. It argues that the mercantilist tradition to which China belongs rests on fundamentally different assumptions from those of classical economic theory about the nature of the state, the fungibility of comparative advantage, and the optimal relationship between the state and markets. Section four surveys the rising prominence of technology transfer policy as a mercantilist practice after World War II, and in particular to the "catch up" strategies of the postwar East Asian developmental states on whose experiences China has self-consciously modeled its own industrial policy strategy. Section five examines key differences between China's behavior and similar actions by earlier late modernizers and other contemporary developing economies. I then briefly conclude.

What are Technology Extraction Policies?

Technology extractors are policies whose aim or substantial effect is to promote "indigenous innovation" by means of what Chinese officials call the "introduction, digestion, absorption, and re-innovation" of foreign technology. They do this by conditioning access to or preferential treatment in the Chinese market on foreign firms' readiness to partner with domestic enterprises, and through these partnerships transfer technology and expertise. I define "technology" broadly to encompass not only hardware and software, but also technical expertise, process knowledge, managerial competence and other forms of intangible know-how. Against this backdrop, policies can contribute to technology extraction in several ways. This includes, most directly, compelling foreign firms to transfer physical machinery or license intellectual property to local partners. But it also includes incentivizing foreign enterprises to train or share technical expertise, process knowledge, or managerial and operational know-how with Chinese businesses.

Technology extractors belong to the broader umbrellas of industrial and technology transfer policy. Following Naughton (2021), I define industrial policy as "any type of selective, targeted government intervention that attempts to alter the sectoral structure of production towards sectors that are expected to offer better growth than would occur in the (non-interventionist) market equilibrium" (Naughton, 2021, 19). Foreign technology transfer policies, in turn, are measures that contribute to altering the "sectoral structure of production" in this way by facilitating the flow of technology from foreign organizations to domestic ones.

Understood this way, technology transfer policy is a "big tent" concept that encompasses a range of practices. Technology extraction, which leverages the ability to regulate inflows of foreign goods and capital to encourage technology transfer, is one such practice. Other notable forms of technology transfer policy in China include outward direct investment by Chinese firms, which uses overseas mergers and acquisitions to gain access to foreign know-how; talent acquisition programs like China's "Thousand Talents Plan," which recruits experts from abroad (primarily but not solely from overseas Chinese communities) to work in research institutions and state-owned enterprises in China; and industrial and cyber espionage, through which Chinese state entities and firms appropriate trade secrets and proprietary IP from foreign companies.

All of these forms of technology transfer policy have material implications for foreign firms and countries, contributing collectively to what FBI Director Christopher Wray decried as "the greatest long-term threat to [the United States'] information and intellectual property, and to [its] economic vitality."[1] In industry case studies, I explore China's use of a range of practices linked to technology transfer, including outward FDI by Chinese firms. This being said, there are good reasons to focus on technology extraction policies, in particular. First and foremost, tech extractors have been the most prominent and consistent form of technology transfer policy in China since the start of Reform and Opening in 1978. In no small part this is because until recently China had few alternatives. Prior to 2014-2015, it lacked the resources or capabilities to "go out" in search of foreign technology on a large scale. Meanwhile, before 2011, talent acquisition efforts were narrowly focused on recruiting small numbers of leading overseas ethnic Chinese technical advisors, not broad-based recruitment of foreign experts and younger educated Chinese returnees. In short, for most of the past forty years, China's only real path to securing foreign technology has been through inward foreign investment – hence the centrality of tech extractors, which harness foreign inflows as means to technology transfer.

Operationalizing Tech Extractors

Building on more than two dozen interviews with business executives, government officials, and experts across industry, policy, and academia, as well as a survey of academic, policy, and media

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[1] Christopher Wray, "The Threat Posed by the Chinese Government and the Chinese Communist Party to the Economic and National Security of the United States," Retrieved April 12, 2023 (Available at: *https://www.fbi.gov*).

writing on China's technology transfer activities, I identify three policy tools that best fit the concept of tech extractor in China.

The first and substantively most important is equity or cooperative joint venture (JV) requirements and other FDI ownership restrictions. In China as in other countries, JVs are limited liability companies which pool assets from two or more partners to form a separate legal business entity. For most of the Reform and Opening period, JVs have been the Chinese state's preferred route for FDI into China in high value-added industries, as well as the primary institutional vehicle through which China solicited foreign technology transfers (Pearson, 1992). Although JVs mandates are not strictly a "forced indigenization policy," nonetheless from the start "a primary goal of the joint venture policy was to provide China with foreign technology to which it might not otherwise have access" (Pearson, 1992, 145). Moreover, JVs aim to provide such access in a specific way: By maintaining "the foreign sector in a subordinate position, to make 'foreign things serve China"' (Pearson, 1992, 145). Echoing this, McGregor (2011) observes that in high-tech sectors like high-speed rail and aircraft manufacturing, "technology transfer has always been the key priority" for Chinese officials, and historically "two forms were used: licensing agreements and direct joint venture partnerships" (McGregor, 2011, 33). Notably, licensing agreements were often written into JV contracts: As Pearson observes, "technology was usually transferred as part of a foreign side's capital contribution, or through licensing agreements attached to the contract" (Pearson, 1992, 145).

The second policy instrument I examine is local content requirements. On their face, these policies, which mandate that products sold in the host market be made with a certain share of locally-produced components, appear to be straightforward non-tariff barriers. However, China has used them in industries like aircraft manufacturing in ways that do not simply limit foreign competition, but instead induce foreign firms to partner with, train, and share technology and expertise with local suppliers (Lewis, 2012; Blustein, 2019). A telling example, which I return to in detail in Chapter Five, comes from the wind power industry. In 2005, the NDRC, China's top macroeconomic planning body, decreed that domestic wind farms must purchase turbines containing at least 70 percent locally-produced parts. Far from deter foreign participation in China's wind turbine market – which would have been infeasible given China's limited wind turbine manufacturing capabilities at the time – the NDRC directive prompted foreign manufacturers like Spain's Gamesa and General Electric to form joint ventures with local suppliers, open new Chinese facilities, and dispatch "small armies" of engineers and managers to China to train local workers (Blustein, 2019). In the case of Gamesa, these engineers not only oversaw "the construction of [an] assembly plant, but fanned to local Chinese companies and began teaching them how to make a multitude of steel forgings and castings, and a range of complex electronic controls." By 2009, Gamesa estimated it had trained more than 500 Chinese companies in manufacturing various wind turbine components.

Finally, I examine policies that grant preferential treatment in government procurement to products made by Chinese-invested firms or which contain "Chinese intellectual property." Although many countries use public procurement policies to support domestic producers (Kono and Rickard, 2014), China is distinctive in leveraging "procurement rules...to require technology transfer" from foreign investors (Sutter, 2020, 65). China's enormous public procurement market has long been a source of frustration for foreign firms, who frequently complain of discrimination in procurement not only by state agencies covered by the country's two main procurement laws, the Government Procurement Law (GPL) and the Tendering and Bidding Law (TBL), but also by state-owned enterprises, which the laws do not cover. I focus on a specific form of procurement policy which has been most directly implicated in technology transfer efforts: product catalogues that link preferential treatment to whether products are made by Chinese-invested firms or contain Chinese IP, and as such contribute to promoting indigenous innovation. As Karen Sutter observes, China has used these catalogs to "require foreign technology transfer through inclusion and exclusion of targeted products and vendors," with preference conditional on whether "the underlying knowhow [is] transferred to a Chinese entity (Sutter, 2020, 65). As the U.S.-China Business Council notes, a common response to these policies, and more generally a strategy foreign firms adopt to ensure their access to China's public procurement markets, is to form "strategic partnerships" such as JVs with domestic firms in order to locally develop and trademark products for the Chinese market.[2]

From "Trading the Market" to "Introduce, Digest, Absorb, Re-Innovate"

In terms of policy formulation, the history of Chinese tech extraction efforts can be divided into two main phases. Phase one reached its peak during the first major wave of FDI into China from 1992-1998 and is associated with the concept of "trading the market for technology" (以市场换技术). This semi-official strategy, which appeared in ten central-level policies issued between 1986-2006, is most closely associated with JVs in automotive manufacturing in the 1990s (Feng, 2016). Although never officially disavowed, it largely disappeared from central policy discourse after WTO entry. In part, this reflected the need to bring China's policies into alignment with its WTO commitments, at least formally: an explicit policy of "trading the market for technology" was a clear violation of China's pledge, as part of its accession agreement, not to require technology transfers in exchange for market access. At the same time, however, the gradual scrubbing of "trading the market" from China's policy lexicon pointed to a deeper shift underway in its approach to industrial policy in general and technology transfer policy in particular after WTO.

Over the course of the 1990s, China's leaders grew increasingly frustrated with the evident failure of Sino-foreign JVs to produce globally-competitive Chinese brands in automotive manufacturing, electronics, and other high-tech sectors (Chen, 2018).[3] By the end of the decade, a rising chorus of officials began to call for China to reduce its reliance on simple imports of foreign technology and to put more emphasis on fostering Chinese industry's "indigenous innovation" capacity.

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[2] The U.S.-China Business Council, November 2012, "Navigating China's Public Procurement Market: Background, Challenges, and Best Practices," Retrieved May 19, 2023 (Available at: *https://www.uschina.org*).

[3] Consistent with this, several scholarly works from the 1990s and early 2000s found some evidence that Sino-foreign JVs in the 1990s provided relatively limited technological spillovers to the rest of Chinese industry (Lemoine and Ünal-Kesenci, 2004; Shi, 2001). Broadly speaking, this probably accurately characterizes the situation in the 1990s, though even here the evidence is more mixed than wholly negative. It is also not very systematic, based instead on anecdote, indirect evidence, or studies of individual industries. Unfortunately, this early work has led some observers to extrapolate from trends in the 1990s to the post-WTO period without attention to changes in China's approach to technology transfer policy and its relationship to the "indigenous innovation" paradigm. More recent empirical evidence suggests JVs generated technological spillovers in the 2000s. Moreover, these spillovers extended beyond Chinese JV partners both vertically, to other domestic firms located along particular supply chains, and horizontally, across the industry.

In line with this trend, just as “trading the market” was fading from the policy lexicon, the number of central-level policies with the term “indigenous innovation” began to rise, from five in 1995, to seven four years later, to twenty-six on the eve of WTO entry in 2001. The number of central regulations with this term would increase by an order of magnitude in later years as indigenous innovation became enshrined as the organizing principle of China’s industrial policy strategy.

The decline of “trading the market” and corresponding rise of indigenous innovation has led some observers to suggest that technology transfers became less integral to Chinese industrial policy after WTO. This view is mistaken. To begin, it is hard to reconcile with the numerical increase in JV mandates and other tech extractors after WTO, as well as vastly increased foreign attention to Chinese tech transfer activities. More importantly, it is inconsistent with Chinese policy on indigenous innovation itself. Far from disappear, the idea of “trading the market” was instead reformulated and reinvigorated in the 2000s under the new moniker “introduce, digest, absorb, re-innovate.” Crucially, from the start the notion of “absorbing” and “re-innovating” foreign technology has been closely tethered to indigenous innovation. Of the 342 central policy documents issued between 2005-2023 containing the phrase “introduce, digest...,” 242 (70 percent) also contain the term indigenous innovation, according to data from the Peking University Laws and Regulations Database. This relationship is even more pronounced in local-level policies, where 76 percent of policies mentioning this phrase concern indigenous innovation promotion. Meanwhile, roughly one in ten of the 4,172 central policies on indigenous innovation reference “introduce, digest...”. This is an extraordinarily high share considering the former’s ubiquity in official Chinese policy discourse. Given the centrality of “indigenous innovation” to the political economy of contemporary China writ large, it also reinforces that no account of the “rise of state capitalism” in China is complete without attention to technology transfer policy.

In reality, the decline of “trading the market” and rise of the indigenous innovation paradigm signaled not the end of technology extraction efforts but the start of a second, more ambitious phase. The roots of this phase date back to the middle of the 1990s, but it began in earnest in the first decade after WTO entry. The clearest inflection point in this process was the launch of the

Medium- and Long-Term Program for National Science and Technology Development 2006-2020, hereafter the Medium- and Long-Term Program or simply MLP. First announced in December 2005 and formally adopted in early 2006, the MLP is often credited with introducing indigenous innovation to China's policy lexicon. As we have seen, this is not quite accurate, but the MLP did decisively place indigenous innovation at the heart of China's macroeconomic policy program. Before 2005, the term had never been used more than 29 times in a year in central regulations. In 2005, mentions of indigenous innovation increased to 83, and in 2006 to 315. Between 2006-2022, the term would appear on average 226 times per year in central-level policy documents.

Critically, the MLP is also the first Chinese policy document to use the phrase "introduce, digest, absorb, re-innovate." In fact, the MLP introduces "introduce, digest..." as part of the very definition of indigenous innovation, listing it as one of three means by which to improve "national innovation capabilities." Later on, the MLP devotes an entire section to "strengthening the digestion, absorption, and re-innovation of imported technologies" (加强对引进技术的消化、吸收和再创新) as one of nine "Important Policies and Measures" by which to advance indigenous innovation. Although the section does not mention TMFT by name, it does admonish officials to formulate policies that restrict the "blind duplication of imported [technologies]" (限制盲目重复引进), a possible veiled reference. In place of "blind" replication, the section outlines several "active policy measures" through which to advance IDAR, including "establishing special funds" (设立专项资金), launching "major national construction projects" (国家重大建设工程), and the "joint implementation of the introduction, digestion, absorption and re-innovation of imported foreign technology by industry, academia, and research institutes, with enterprises as the main body" (支持以企业为主体、产学研联合开展引进技术的消化、吸收和再创新). Finally, it is worth noting that the section explicitly ties IDAR to the development of "major equipment and key products with indigenous intellectual property rights" (具有自主知识产权的重大装备和关键产品). This same phrase later forms the basis of efforts to link indigenous innovation to public procurement policies, which, incidentally, is the next of nine "important policies" listed in the MLP.

In the next chapter, I describe the process by which the MLP was translated into concrete tech extraction policies by the NDRC (which in April 2006 emerged as the Program's lead implementation agency), the Ministry of Finance (MOF), and after 2008 the Ministry of Industry and Information Technology (MIIT). Here it is sufficient to emphasize that from its inception, "introduce, digest..." was understood and overtly framed as central to the indigenous innovation paradigm. As both the language of the MLP and Chinese policy practice in its wake indicate, China's leaders not only did not consider technology transfer policy to be in tension with indigenous innovation, but in fact saw these dynamics as inseparable, with success in the latter dependent in part on success in the former. At the same time, as the MLP suggests, China's leaders were aware that in order for foreign technology transfers to contribute meaningfully to building "indigenous intellectual property," Chinese policy would have to go beyond blind duplication to help domestic firms truly "digest," "absorb" and "re-innovate" on top of imported foreign technologies.

Conceptual Scope Conditions

Before proceeding, it is worth briefly noting three scope conditions for the concept of technology extractor as used here. First, although in my industry case studies I explore informal pressures to share technology along with other forms of tech transfer policy, my argument focuses on formal, publicly documented policies. I do this for several reasons. At the simplest level, formal policies can be studied systematically and with reasonably high confidence in the precision and reliability of the resulting indicator. Informal inducements or pressures to share technology cannot.

More importantly, the available evidence suggests that most informal bargaining over technology transfer has historically taken place within formal arrangements such as equity JVs, for example over the terms and extent of technology licensing between partners. Indeed, one reason foreign firms operating in China generally prefer to do so as wholly foreign-owned enterprises (WFOEs) is the protection such ownership provides against "illegal technology transfer" when compared with joint ventures (Gallagher, 2005, 44). This suggests informal pressures to share technology will be positively correlated with the presence of formal policies, and thus the distribution of the latter provides a useful if imperfect guide to that of the former, at least through the mid-2010s.

Finally, apart from what they tell us about informal pressures, formal policies are worth studying because they provide important information about China's bargaining power over foreign firms. For foreign firms, complying with policies that require them to form new ventures is costly, not least due to heightened risks of "illegal" technology transfer. All else equal, most firms most of the time prefer not to enter such partnerships when they can avoid doing so. This explains why the gradual relaxation of ownership restrictions in most industries starting in the late-1980s led to a surge in the number of WFOEs in China (Wang, 2015, 42). Because compliance with formal restrictions is costly and foreign firms can be expected to resist it, the presence of these tools is a valuable indicator not only of Chinese authorities' priorities in terms of technology transfer, but also when they enjoy the leverage to compel foreign compliance with those priorities.

Second, because I am interested in the use of trade and foreign investment regulations to advance national industrial policy goals, my analysis centers on policies issued by central state agencies. This is sensible in the first instance because what is arguably the most substantively important form of technology extractor, JV requirements and other FDI ownership restrictions, is a strictly central-level policy. More fundamentally, although subnational levels of administration in China take their broad policy cues from the center – and thus local technology extraction behavior can be expected to covary with that of the central state – research on "fragmented authoritarianism" provides ample evidence of how central priorities get diluted during local implementation. Given often significant differences in priorities between the center and localities, to lump the two levels of policymaking together would likely bias our understanding of the center's motives.

Finally, I exclude from the analysis a number of policies which ostensibly serve goals unrelated to industrial policy, such as national and cyber security, or which function primarily as market barriers rather than inducements to partner with and share technology with domestic firms. This includes measures like data security evaluations and cybersecurity standards as well as most technical standards. Both sets of policies are linked indigenous innovation, but their connection to IDAR is murky at best. There is anecdotal evidence of data security evaluations and technical standards leading to transfer of technology or IP in some cases, but concrete examples are few and far between and, to my knowledge, have not been linked to clear central directives.

China in Relation to Mercantilist Thought and Practice

China's pursuit of industrial transformation through technology extraction is not entirely unique. Rather, China belongs to a long history of top-down efforts to "construct comparative advantage" in high value-added industries, including by means of foreign technology transfers (Evans, 1995). To fully appreciate China's actions – including what makes the China case distinct – it is important to situate Chinese technology extraction in the post-WTO period in relation to that history. This section and the next trace the line that runs from mercantilist writings in 16th through 18th century England all the way to post-WTO China. I do this in two steps. Below, I examine the theoretical foundations of mercantilism. As will become apparent, many of the same ideas behind, and even similar kinds of language to that used in, Chinese industrial and technology policies can be traced back directly to the earliest mercantilist writings. In the next section, I look at technology transfer's rise from a minor motif in early mercantilist discourse to a major theme as the pace of technological innovation accelerated in the 20th century.

Mercantilism emerged in response to two important changes in early modern European social and political life. The first was the rise of merchants as a major economic force due to technological advances that expanded global trade in the 16th and 17th centuries. The second was the gradual emergence of the territorial nation-state as the dominant mode of political organization in Europe. As a result of these changes, rulers both became more concerned with expanding national wealth and power and came to see merchants, a relatively marginal class in pre-modern Europe, as key allies in this endeavor (Irwin, 1996). Early mercantilist writings began from the premise that merchants' profit motive *could* converge with the state's interest in national power, but this did not mean it necessarily would. Mercantilism arose as a theory of how to reconcile the potential "divergence between the private interests of the merchant and the broader interests of the nation" through “state regulation of trade” (Irwin, 1996, 32).[4]

Today, mercantilism is associated with the argument that because the gains of trade derive primarily from exports and the inflows of foreign specie they generate (which can be used to purchase arms and soldiers), governments should pursue a favorable balance of trade by promoting exports and restricting imports. Early mercantilist thinkers certainly made this argument, and export promotion and import controls have long been core mercantilist policies. But as early as the late 17th century, accruing foreign specie for purposes of investing in military power had become a secondary goal in mercantilist writings. “Instead,” as Irwin (1996) observes, over the course of the 17th and 18th centuries “mercantilists increasingly considered trade as an effectual means of promoting the economic development of the country and creating greater employment opportunities by expanding the manufacturing sector” (Irwin, 1996, 37). In other words, mercantilist thinkers were concerned not only with whether a country exported more than it imported, but with what it exported and imported. Their goal became to encourage exports (and restrict imports) of goods whose production does the most to promote development, while encouraging imports (and restricting exports) of goods whose production adds the least value to the domestic economy.

Viewed this way, mercantilism offered the first theory of economic modernization. This theory rested on the assumption that private actors pursuing narrow economic interests without state “guidance, oversight, and intervention” would lead to sub-optimal developmental outcomes, namely by leaving poorer countries overly dependent on exports of low value-added raw materials and imports of high value-added manufactured goods (Irwin, 1996, 32). This, in turn, could undermine a country’s long-term ability to compete on the international stage by limiting its productive capacity and hampering the creation of a skilled labor force. Crucially, mercantilists began developing these ideas well before Adam Smith and the advent of classical economic theory. Indeed, Smith’s challenge to mercantilists’ concern with the disharmony between private interests and the general welfare provides the basis for classical economics.

It is worth elaborating the theoretical differences between mercantilism and the classical

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[4] Much of the discussion of mercantilist thought in this section draws from Chapter 2 of Irwin (1996).

economic turn inaugurated by Smith because these same differences animate debates about industrial policy today, including American policymakers' complaints about "unfair" Chinese trade and foreign investment policies. Mercantilism and classical economic theory differ on numerous fronts, but for our purposes four philosophical points of divergence stand out as critical. The first is that mercantilism and classical economic theory hold incompatible underlying conceptions of the state. Classical economics proceeds from what Katzenstein (1977) calls a "sociological perspective" on the state, in which societal interest groups are causally prior to and determine state preferences. By contrast, mercantilism builds from what we might call a "statist interpretation" of policymaking. This view treats the state as a relatively autonomous actor with interests which cannot be reduced to those of societal groups or particular classes (Katzenstein, 1977, 602).

The second point of divergence, which follows partly from the first, is their understanding of the relationship between domestic and international divisions of labor. Adam Smith's key insight was that specialization increases productivity and therefore profits at the level of firms and wealth at the level of the nation. Smith also understood that free trade between countries extrapolates the division of labor from firms in a country to countries in the international system, thereby raising aggregate wealth in the system. But Smith believed countries should export all goods in which they enjoyed an absolute cost advantage over competitors (Irwin, 1996) . To take David Ricardo's famous example, if Portugal produces both wine and cloth more cheaply than England, it should (in Smith's view) export both goods to England and import whatever goods England enjoys an absolute advantage in producing. Critically, this emphasis on absolute advantage implied a limit to the analogy between firms and countries: Firms in the nation (like workers in the firm) should specialize in one activity, but nations were justified in producing different kinds of goods provided they had an absolute cost advantage over other countries. In other words, firms in the national economy and nations in the world economy were not like units.

With the concept of *comparative* cost advantage, classical economists like David Ricardo and James and John Stuart Mill sought to obliterate this distinction. These writers' revolutionary insight was that even if a country produced many goods more cheaply than all other countries, it would be best off if it focused on exporting the one good it produced more cheaply than all other goods it could produce, importing the rest. Thus, continuing Ricardo's example, if Portugal makes both wine and cloth more cheaply than England but wine more cheaply than cloth, it should produce only wine and import its cloth from England. According to this view, in a world of free trade there was no logical difference between workers in firms, firms in the nation, or nations in the world. Specialization along comparative advantage lines at one level implied specialization at the next, and a world organized according to a global division of labor among specialized nations would maximize global welfare.

This is a welcome conclusion for anyone who views the state "sociologically," as a mechanism for aggregating and adjudicating among competing societal preferences. If the state is an extension of society whose interests derive from the latter, then the difference between national and international policy domains is one of scale but not kind. In such a world, international politics reflects the harmony or disharmony of interests among societal groups, which may be organized nationally or transnationally, or both to varying degrees (Moravcsik, 1997). It does not reflect competition for power between states as such. Indeed, in this worldview the term "state" is little more than a convenient shorthand for the complex process by which coalitions of societal interests come together to produce and enforce policy.

Mercantilists working in the wake of Ricardo, most prominently the German economist and historian Friedrich List, accepted that a division of labor among nations pursuing their comparative advantage would maximize global welfare. But they nonetheless rejected this vision as untenable.

Like realist IR theorists in the 20th century, 19th century mercantilists argued that the state is not simply a transmission belt for societal interests. Rather, it is an actor with independent interests rooted in (1) its status as the sole legitimate arbiter of societal disputes in a given territory, and (2) the lack of a comparable sovereign at the world level. As Waltz (1979) argued, the presence of the state orders domestic politics hierarchically, allowing functional differentiation among units in society. By the same token, the absence of a world government orders international politics anarchically, forcing states to confront each other as like units in a zero-sum contest for power and security. In such a world, following Ricardo's injunction to specialize would leave countries with a comparative advantage in low value-added goods less well off, and thus less able to secure themselves, than those with a comparative advantage in higher value-added goods. As long as states care about security and relative power – that is, as long as the international system is anarchic – they will inevitably reject this injunction, these writers held. To specialize would be foolish for all but the very strongest states, who dominate the "commanding heights" of the world economy.

The third point of divergence between mercantilism and classical economics is their treatment of comparative advantage itself. Is comparative advantage best understood as a given and fixed condition which states can either conform to or ignore? Or is it a malleable quality that states can manipulate through policy? As Evans (1995) observes, classical economic theory is "adamantly on the side of structure" over state agency. "If you are sitting on copper deposits," he summarizes, "you are stupid not to sell copper. If your climate allows you to grow superior coffee, you should take advantage of it. Whether these are privileged or disadvantaged sectors in the global economy is neither here nor there. Countries must do what they do best. To do otherwise is self-destructive. The international division of labor presents itself as a structural imperative" (Evans, 1989, 8).

Mercantilists would accept the given and relatively fixed nature of comparative advantage in things like natural resources: No amount effort will turn energy-scarce countries like Japan and South Korea into major oil exporters. But they reject the fixity of comparative advantage as applied to high value-added industries like manufacturing. As Friedrich List argued, the United Kingdom enjoyed a comparative advantage in manufacturing because it got a head start, not because of some deep-set genius or other quality of British workers. At best, mercantilists suggest, the classical concept of comparative advantage – and with it, the admonition to follow one's inherited advantage – is mistaken. At worst, it is a way for states at the top of the division of labor to rationalize their position and compel those below to accept their station. As List wrote, referring to Britain, "[a]ny nation which by means of protective duties. . . has raised her manufacturing power. . . to such a degree of development that no other nation can sustain free competition with her, can do nothing wiser than to throw away these ladders of her greatness, to preach to other nations the benefits of free trade, and to declare in penitent tones that she has hitherto wandered in the paths of error, and has now for the first time succeeded in discovering the truth" (List, 1841, 295).

This leads to the fourth fundamental difference between mercantilism and classical economics: Their prescriptions regarding the state's role in the economy. For classical economics, that role is limited. If the state is not a distinct actor but simply a filter for societal interests, then there is no conceptual difference between national and international levels of analysis. The latter is an extension of the former. If this is true, then the same principles of specialization at the national level should apply at the international level, too. If, in addition, the key variable that justifies specialization at both levels, comparative advantage, is understood as given and relatively fixed, then policies that interfere with the pursuit of this inherited advantage are bound to produce inefficiencies and leave the nation and world worse off. In short, according to this view, not only is the state not a meaningful actor in its own right, but even if it were, it would not be justified in intervening to reshape the sectoral structure of the economy. Hence, the optimal policy is laissez-faire.

By contrast, if the state is distinct from society as the conceptual and practical boundary between the (hierarchical) national sphere and the (anarchic) international sphere, then it is no longer clear that the principles which govern economic life at the national level of analysis apply at the international level. In fact, in a world where anarchy makes states into like units who compete for relative power, specialization at the national level is almost always suboptimal from a power perspective, whatever its benefits for global welfare. Indeed, specialization is an optimal strategy only for countries which already dominate the most productive and profitable industries. If, in addition, comparative advantage in such industries is not given or even particularly fixed but rather manipulable through policy, it follows that not only *can* states intervene to "create" comparative advantage in more productive industries, but any state not already at the top of the global division of labor *should* do so. Any other choice would be tantamount to accepting less power and less security for the nation, which no rational state with the wherewithal to fend for itself would do.

Mercantilists' most potent defense of state management of trade came from arguments for "infant industry" protection. Unlike early mercantilist balance of trade arguments, which placed no limits on how long governments could maintain trade protections, infant industry arguments framed protection as a temporary expedient. Advocates of infant industry protection accepted classical arguments about the inefficiency of protectionism and embraced the goal of free trade in the long run. But a short-term loss in efficiency was a reasonable price to pay, they argued, if it allowed poorer countries to "catch up" to their wealthier peers in industries more conducive to what Hirschman called a "multidimensional conspiracy" in favor of development (Hirschman, 1977, 96). Indeed, insofar as such protections helped nurture domestic industries with broad economic and technological spillovers, they may even be justified on the basis of long-term national and even global welfare – that is, without recourse to realist arguments about national power and security. This possibility led John Stuart Mill, the dominant figure in mid-19th century classical economic theory, to offer a qualified defense of infant industry protection, provided such protections were strictly temporary. Unfortunately, testing this hypothesis proved hard because establishing a valid counterfactual is exceedingly difficult. But the welfare argument's face plausibility, along with apparent evidence from cases like the United States under Alexander Hamilton and the postwar East Asian developmental states, has made it hard to dismiss on theoretical grounds, contributing to these arguments' longevity.

The Rise of Technology Transfer in the Twentieth Century

Technology transfer has been a recurrent feature of writing on economics since at least Adam Smith, who defended free trade partly on the basis that it facilitated the cross-border diffusion of new technologies (Irwin, 1996, 80). The first person to make the case for technology transfer as an instrument of mercantilist policy was John Rae (1813-1893), a Scottish explorer and émigré to Canada whom Irwin credits, along with Alexander Hamilton and Friedrich List, as one of the three most important post-Smith defenders of infant industry protection. As Irwin argues, Rae's main innovation was to frame the discussion of infant industry promotion less in terms of trade restrictions – the focus for both Hamilton and List – than of "the advisability of government assistance to the transfer of superior technologies from other countries" (Irwin, 1996, 122). Writing in 1834, Rae argued that imported technologies, by "their very existence in any society, gives a powerful stimulus to the ingenuity of its members," helping to "stimulate invention and diminish the propensity to servile imitation" (Irwin, 1996, 123). Given these benefits, Rae suggested support for introducing foreign know-how as a complement to temporary market barriers in state-led efforts to promote infant industries.

Despite their early start in mercantilist theory, technology transfer policies of the sort that proliferated in decades after the second world war remained a fairly marginal part of the mercantilist toolkit through the first half of the 20th century. The closest analogues during the late 19th and early 20th centuries were the practices of hiring foreign engineers to train local producers and sending teams of local engineers abroad for education and technical training. This strategy reached its apogee in Meiji-era Japan (Pyle, 2009), but governments across Europe and in Russia also organized educational exchange programs and recruited foreign engineers in addition to purchasing equipment from abroad (Frieden, 2007; Frieden and Rogowski, 2014).

Amsden (1989) explains the 20th century rise of technology transfer in terms of changes in the basic mode of industrialization. Whereas the "invention" of new fundamental technologies drove industrialization in 18th and early 19th century England and "innovation" based on these technologies fueled industrialization in late 19th century Germany and the United States, Amsden suggests industrialization "occurs now among 'backward' countries on the basis of learning," for example by reverse-engineering imported technologies (Amsden, 1989, 4). Amsden offers three reasons why advancements in science made foreign technology transfers the primary vehicle for such learning in the 20th century. First, the "higher scientific content" of modern technology "increased its codifiedness or explicitness, making it more of a commodity and hence more technically and commercially accessible and diffusible from country to country" (Amsden, 1989, 7). Second, the increased sophistication of transport and communication technologies allowed technical assistance, "not being dependent on the know-how of a specific person...[to] be dispatched over longer distances to larger numbers of people more quickly and anonymously." Finally, the "rise in the scientific content of technology" led to a "crowding out of art by science on the shop floor," dealing "a blow to the skilled worker." This made technical operations "far easier to transfer to a group of latter-day learners among whom all-around mechanical skills are scarce" (Amsden, 1989, 7).

These developments help explain the central role of technology transfer in the (re)industrialization strategies of postwar Japan, South Korea, and Taiwan, the canonical East Asian developmental states. As Samuels (1994) observes, postwar Japan "benefited from a staggering number of technology transfers with leading foreign (almost entirely U.S.) military and commercial producers" (Samuels, 1994, 271), which in turn laid the "technological basis for nearly all of Japan's modern industries" (Samuels, 1991, 51). Amsden similarly emphasizes the importance of technology transfers, especially from the United States, to industrialization in South Korea under Park Chung-hee, who "learned the importance of indigenizing foreign ideas" from studying postwar Japan and its Meiji precursor (Amsden, 1989, 14). Likewise, Wade (1990) describes how economic planners in Nationalist-controlled Taiwan, recognizing that developing domestic capabilities in "key industrial sectors" would require "massive foreign help, which only the United States was in a position to provide," initiated a "wholesale redirection of technology transfer efforts from Europe to the United States" after 1949 (Wade, 1990, 259).

Just as significant as the sheer importance of foreign technology transfers to the postwar East Asian developmental states' industrialization strategies was *how* these countries went about securing such transfers: by directly licensing technology from foreign (mostly U.S.) firms and governments. As Mason (1992) observes, postwar Japan used extensive tariff and non-tariff barriers and an elaborate system of investment controls to discourage "most inflows of FDI but encourage inflows of foreign technology" (Mason, 1992, 151). The result was that "modern Japan...received less foreign direct investment...than any other major industrialized country," with most foreign companies virtually barred from the Japanese market despite "extraordinarily intensive" efforts to gain access (Mason, 1992, 3). Mason continues that "these investment controls, together with stringent barriers to trade, left most U.S. firms with only one real 'option' if they sought to participate in the postwar economy: license technology to Japanese firms. And license they did" (Mason, 1992, 151). South Korea adopted an identical strategy, using both tariffs and import quotas as well as strict controls on foreign capital inflows "to protect domestic industry from direct foreign investment" even as it facilitated technology licensing on a large scale (Amsden, 1989, 74). As in Japan, economic planners in South Korea used restrictions on imports and investment to leave foreign companies seeking to participate in the country's rapid industrialization with no option but to sell their technology directly to local competitors.

Although Taiwan pursued a broadly similar strategy, as Wade notes, it was "less selective about foreign investment than Japan and South Korea" (Wade, 1990, 150). As such, Taiwan can be seen as an intermediary case between Japan and South Korea and China's later efforts to "trade the market for technology." By the 1970s, technology transfer became one of several criteria Taiwanese officials used to evaluate inward FDI proposals, alongside factors such as whether prospective investments would bolster local export industries or improve Taiwan's international support (Wade, 1990, 150). Like China after it, Taiwan introduced mandates that inward FDI take the form of joint ventures and comply with local content and technology transfer requirements in sectors like automotive manufacturing (Wade, 1990, 154). Nonetheless, as Wade concludes, inward FDI remained at best a secondary source of technology for Taiwan, one which though important to Taiwan's development, was "not as important as is often thought" (Wade, 1990, 149).

At least two factors combined to make direct licensing a viable means to secure technology transfers for the postwar East Asian developmental states. The first and by far most important was Washington's desire to rapidly re-industrialize these countries as an economic and military bulwark against the Soviet Union and the People's Republic of China in East Asia. As key Cold War allies of the United States, postwar Japan, South Korea and Taiwan enjoyed extraordinary American forbearance, with Washington providing all three virtually unrestricted access to the U.S. market without asking them to meaningfully open their markets to U.S. goods and capital in return. They also benefited from a combination of direct technology transfers from the U.S. military and strong encouragement from policymakers in Washington for commercial technology transfers. As Mason (1992) recounts, even leading U.S. chip makers like Texas Instruments and Fairchild Semiconductor received almost no support from Washington in their efforts to gain access to Japan's market. As Robert Noyce recounted, the "only thing important for the U.S. Embassy was maintaining U.S. bases in Japan," and policymakers in Washington were remiss to take any steps, including forcing Japan to open its market to American firms, that might risk that position (Mason, 1992, 195). Mason likewise quotes a lobbyist from Texas Instruments as complaining that American diplomats "were useless" in defending the interests of American businesses in Japan. The result was that "for most American companies...technology licensing offered the only viable method of participating in the Japanese market" (Mason, 1992, 194). Much the same could be said of South Korea, and to a lesser extent Taiwan, during the Cold War decades.

The second factor that facilitated technology licensing was that, with few exceptions, U.S. companies during this period were more than willing to sell their technology to local counterparts. As Samuels observes, American manufacturers derived "substantial income from these transfers of technology" (Samuels, 1994, 271). Moreover, in the early decades of the Cold War the U.S. advantage in information and other advanced technologies was so pronounced that American firms had little reason to fear Japanese or South Korea upstarts like NEC and Samsung would be able to compete with, let alone outcompete, them anytime soon. Against this backdrop, although some firms like Texas Instruments remained highly protective of their core intellectual property, most U.S. firms did not hesitate to license technology to their East Asian counterparts when it became clear this was their only option for participating in local markets.

What Makes China Different?

China can and should be understood as part of the heritage of mercantilist ideas described in the previous two sections. This connection is "philosophical" insofar as many of the same basic concerns that have animated mercantilist writing since the 17th century also underpin contemporary China's pursuit of economic transformation through industrial policy. It is also literal. Chinese leaders from Deng Xiaoping onwards actively studied and self-consciously modeled their approach to modernization on the experiences of the postwar East Asian developmental states, especially Japan (Vogel, 2011; Heilmann and Shih, 2013). These states, for their part, looked for guidance to the example of Meiji-era Japan, which itself was a devoted student of Bismarck's Germany and the ideas of Friedrich List. A long but direct line of emulation and adaptation binds these disparate cases together under the banner of mercantilism.

Although far from *sui generis*, the case of China nonetheless stands out in theoretically significant ways. What makes contemporary China different is best grasped by comparing the Chinese experience against those of two relevant reference groups. The first and most significant is China's late modernizer forebears, and in particular the postwar developmental states. The second is other contemporary large developing economies like India, Brazil, and Indonesia, which provide the closest approximation of a "counterfactual" for China in the post-WTO period.

The central and obvious difference between post-WTO China and these reference points is that none of them engaged in "trading the market" to promote the "digestion, absorption, and re-innovation" of imported foreign technologies on anywhere near the same scale. As discussed in the previous section, with the partial exception of Taiwan, the canonical East Asian developmental states remained almost entirely closed to foreign investment during the crucial years of their economic ascents. Although all three depended heavily on technology transfers, "trading the market" was not among the major avenues by which they did so. Instead, the vast majority of the foreign technology on the basis of which these countries "caught up" to the West came from licensing agreements not tied to market access concessions. Nor did 19th century late modernizers or import-substitution industrialization regimes in 20th century Latin America and elsewhere engage in anything reminiscent of "trading the market" on a scale even close to China. These countries instead relied on more traditional forms of "strategic trade policy" such as targeted market closures to protect domestic infant industries from foreign competition.

The second main comparison group is other large developing countries, such as India, Brazil, and Indonesia. Given their size, level of development, and relatively diverse economies, these countries provide the closest thing to a "counterfactual" for post-Reform and Opening and post-

WTO China. Moreover, they each use some or all of the policies I associate with technology extraction in China. The key question, however, is whether they use these policies to encourage foreign firms to partner with or otherwise support local competitors, and if so, whether they do so to a similar extent as China. Unfortunately, other countries' use of these policies is not well-documented at the level of industry-years, which limits more systematic comparison with China.

Given these data limitations, to assess the nature and extent of technology extraction in India, Brazil, and Indonesia and how it compares with China, I surveyed the United States Trade Representative's (USTR) National Trade Estimate (NTE) reports on each country from 2001-2015. Published annually, NTE reports provide country-by-country summaries of major trade-related policies and trade or investment barriers based on a combination of data compiled by the USTR and other government agencies as well as feedback solicited from American firms that export or invest abroad. As such, they provide the most comprehensive and detailed year-by-year portrait of a given country's policies on trade, FDI, intellectual property protections, and so forth.

For each country report in each year, I counted the number of times each of the following four terms is used: technology transfer, joint venture, local content requirement, and government procurement. I then read through each reference to the above terms to determine the significance of its use. If other countries use these policies to the same extent and for the same purposes as China, then we should see these terms appear similarly frequently in their NTE reports.

Overall, the results indicate that China is an extreme outlier for most of the study period for each of the four search terms. No NTE report between 2001-2015 mentions technology transfer in connection to Brazil. The term appears in reports for India and Indonesia a maximum of two times in a given year and appears 0 times in 8 reports on India and 10 reports on Indonesia. Moreover, "technology transfer" is never used in relation to a trade restriction or requirement in India reports, and only once in relation to Indonesia. By contrast, "technology transfer" is used in every NTE on China, appears and average of 4 and maximum of 9 times in a single report, and is almost always used in relation to terms like "requirement" or "forced." Likewise, the term "joint venture" appears an average of 25 times per China report, 3.6 times per India report, 3.5 times per Indonesia report, and 0.85 times per Brazil report. “Local content requirement” appears an average of 2.9 times per China report, 0.92 times per India report, 2.2 times per Indonesia report, and 3.6 times per Brazil report (but 0 or 1 times in most years before 2013). Finally, government procurement appears on average 15 times per China report, 4.6 times per India report, 4.6 times per Indonesia report, and 3.2 times per Brazil report. In sum, with the exception of local content requirements, which Brazil appears to have used aggressively in 2013-2015, NTE reports mention each policy between 1.3 and nearly seven times as often with respect to China as to the country with the next highest count. And in Brazil’s case, NTE reports provide no hint that local content policies are used to encourage foreign firms to train and source from local suppliers.

To be sure, a simple count of the frequency with which these terms appear in USTR reports offers at best a rough proxy of the true distribution of these policies across countries. The sheer importance of China as a U.S. trade partner and the intensity of FDI in China during this period may well bias the results somewhat in China’s favor. This being said, it is highly improbable that if any of these countries used technology transfer policies on a scale and in ways comparable to China, it would not be reflected in these reports. Meanwhile, there are few other countries that share the same basic conditions – technological underdevelopment and large internal markets – that both necessitate technology transfers and provide the leverage needed to extract them from foreign investors. Ultimately these policies matter because they have material effects on foreign firms. The NTE reports provide a good, if approximate, guide to where those effects are most pronounced, and therefore most merit scholarly attention.

The above discussion suggests China is meaningfully different in its use of technology extractors from its most relevant comparison groups, especially in the post-WTO period. But why is it so different? Many factors contribute to China’s distinctive experience, including many aspects of its international political and economic organization that are idiosyncratic to China and rooted in the country’s tumultuous modern history and peculiar Stalinist institutional inheritance. Here, I want to focus on features of the external strategic, economic, and technological environments in which China rose, as well as China’s unique place in them.

When comparing China with the postwar East Asian developmental states, the clear and decisive difference is that the key periods of industrial transformation in the former took place against the backdrop of the Cold War. First and foremost, this meant that Japan, South Korea, and Taiwan enjoyed historically unprecedented tailwinds in their (re)industrialization efforts in the form of broad and energetic support from a U.S. that not only controlled half of the world's wealth and much of its advanced technology, but which was committed to rapidly rebuilding the non-communist parts of East Asia as military-industrial bulwarks against Soviet influence. Another not entirely unrelated legacy of the Cold War era was the ubiquity and acceptance of market barriers and controls on capital inflows and outflows as legitimate tools of foreign commercial policy, including in most of the world's leading democratic capitalist countries. Combined with the positive force of U.S. support for industrialization, this normative climate created permissive conditions for governments in Tokyo, Seoul, and Taipei to pursue technology transfers without opening their markets to outside competition. By the time this permissive climate began to shift for Tokyo in the late 1970s, Japan's GDP per capita was nine-tenths that of the United States.

In sharp contrast to this, China began the crucial decades of its economic rise in the 1990s and 2000s not as a Cold War ally of Washington, but as an impoverished and isolated socialist state in a post-Cold War world dominated by a United States ideologically committed to liberalizing trade and international capital flows. Moreover, China had the misfortune of attempting to join the General Agreement on Tariffs and Trade and later the WTO just as anger in Washington over American MNEs' struggles to access the Japanese market was reaching a boiling point. Against this backdrop, it was virtually unthinkable that China could acquire the foreign technological inputs it needed without opening its market to foreign, especially U.S., goods and capital in return. The U.S. government's intense concern not to repeat what it saw as its mistakes in Japan hung like a shadow over China's WTO accession negotiations and helps explain why they were so fraught and protracted. Far from the forbearance it had shown Japan, South Korea, and Taiwan, the U.S. entered bilateral talks on China's WTO entry intent to extract maximum market access concessions and strong protections for American firms' intellectual property rights.

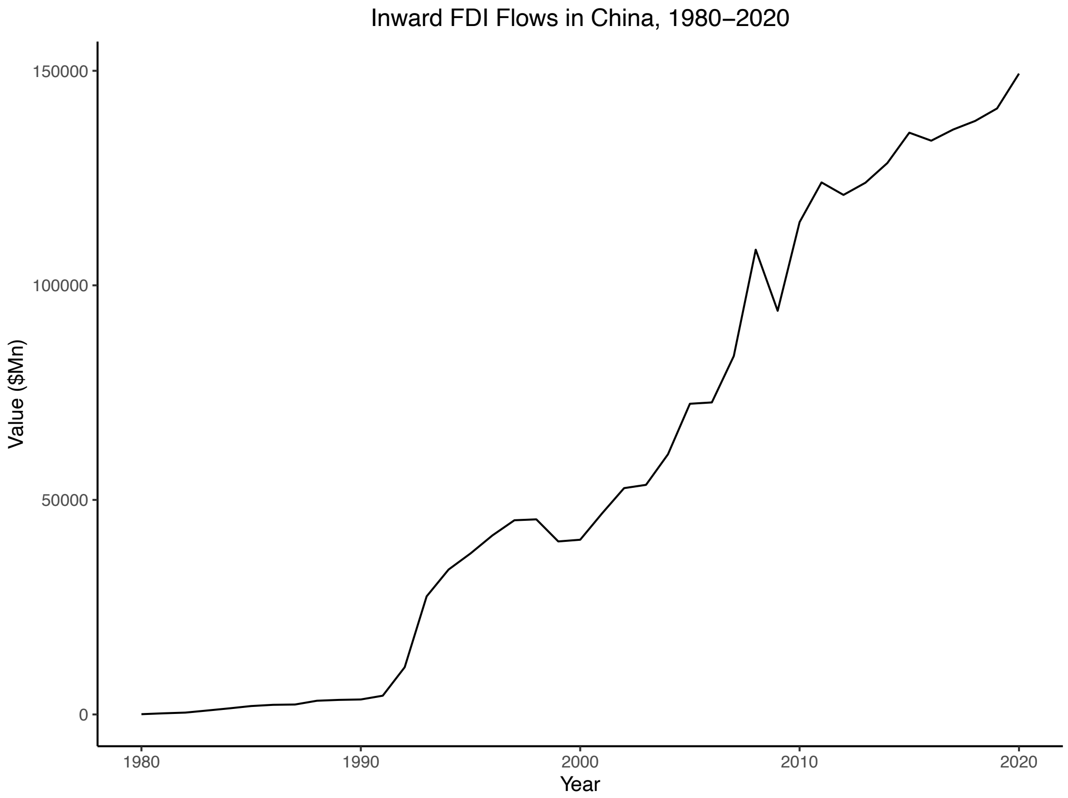

Figure 2.1: **Inward FDI Flows in China, 1980-2020**: The 1990s saw a first wave of inward FDI flows into China, followed by a much larger (and continuing) wave following China's accession to the WTO in 2001. Source: UNCTAD.

A second crucial difference that separates China from earlier East Asian developmental states, and to some extent from other developing economies today, is the nature of production networks and China's position therein. All previous late modernizers rose in a world where production was organized nationally, with almost all of the production process for a given good taking place not only within the borders of one country but often at one or a handful of sites managed directly by a single firm. China began its economic rise just as broad reductions in capital controls, combined with advances in transportation and information and communications technologies, were paving the way for the fragmentation of production across sometimes dozens of sites managed by as many horizontally-linked firms spanning multiple countries.

As suggested above, these developments created new pressures to liberalize FDI controls not faced by China's predecessors. But they also created new opportunities for technology transfer and spillovers as a growing number of foreign firms looking to lower costs established manufacturing operations in China. Although this process began in the 1990s, it accelerated dramatically after WTO entry. Indeed, for all intents and purposes, WTO entry marked the true beginning of China's economic rise: From 2001-2017, China's share of world manufactured goods exports rose from 3 to 15 percent (and over 17 percent including Hong Kong). The globalization of production also sets China apart from other developing economies because China itself has been a key driver of the growth of GVCs and concentration of world manufacturing in East Asia. Although Brazil, India, and Indonesia are all integrated into production networks, none is anywhere near as central as China is today. Brazil's primary role in global value chains is as a supplier of raw materials like iron ore and agricultural goods. India's is as a provider of information technology-related services.

Of the three, Indonesia today is the most similar to China in the early post-WTO period, but for much of the past three decades it too has primarily exported raw materials, along with textiles and other low value-added goods. China's singular combination of a large and rapidly growing internal market and a vast and cheap manufacturing base made it an irresistible destination for MNEs, especially after WTO entry and Permanent Normal Trade status from the United States reduced uncertainty in the investment environment. Against this backdrop, even if India, Indonesia, and Brazil had wanted to engage in technology extraction with China's fervor, they almost certainly could not have done so. After 2001, foreign investors of all sizes and in virtually all sectors were desperate to gain a foothold in China, and most were more than willing to share technology as the price of admission. Whether they would have been so willing elsewhere is far less certain.

Conclusion

Technology extraction has been integral to Chinese industrial policy since the start of economic Reform and Opening in 1978. In the decades before China joined the WTO, this manifested in a semi-official policy of "trading the market for technology." By the end of the 1990s, however, a combination of pressure to scrub measures that too obviously flouted the terms of China's WTO accession agreement and growing frustrations within Chinese officialdom at the apparent failure of "trading the market" to produce more than "blind duplication" of foreign technologies precipitated a move towards a new industrial policy strategy anchored in fostering "indigenous innovation." It might be tempting to read the rise of "indigenous innovation" and coincident decline of "trading the market" in Chinese official rhetoric as announcing a shift away from technology transfer as a pillar of industrial policy in the era of "state capitalism." In fact, even as they abandoned "trading the market" in name, Chinese planners were busy incorporating a more ambitious restatement of its core logic into the foundations of the indigenous innovation paradigm itself. With the 2006 Medium- and Long-Term Program's exhortation to promote indigenous innovation through the "introduction, digestion, absorption, and re-innovation" of foreign technology, the practice of tech extraction gained a new lease on life. In the fifteen after it joined the WTO, China would pursue technology extraction on a scale and with force without parallel in the pre-WTO period.

But while China's use of technology extractors is extreme both in its scope and its implications for world politics, it is not unique. Rather, China belongs to a long history of efforts to radically transform states' positions in the global division of labor and international balance of power by means of rapid, state-led industrialization. As such, China's use of industrial and technology transfer policies must be understood in relation to the legacy of mercantilist ideas, from early efforts to craft a theory of economic modernization based on state regulation of trade to the postwar East Asian developmental states' pursuit of industrial transformation through systematic foreign technology transfers. A clear, if winding, line of emulation, adaptation, and even policy innovation binds contemporary China to these earlier late modernizers under the broad banner of mercantilism.

At the same time, these important parallels notwithstanding, China's experience differs in important ways from those of its forebears, as well as of other contemporary developing economies. These differences reflect not only the peculiarities of China's history and internal conditions, but also, crucially, the strategic, political, and economic contexts in which it rose. That context powerfully energized Chinese technology extraction efforts in the post-WTO period, even as they shaped and constrained its ability to extract technology from foreign firms in historically new ways.

Chapter 3

Explaining Chinese Technology Extraction

Introduction

The previous chapter elaborated the concept of *technology extraction policies*, defined as measures that condition foreign access to the Chinese market on transfers of technology and expertise to local firms. It then operationalized this concept in terms of three policy tools which formed the backbone of China's efforts to promote "indigenous innovation" through the "introduction, digestion, absorption, and re-innovation" for foreign technology in the decades after it joined the World Trade Organization (WTO) in 2001. These tools – joint venture (JV) requirements and other ownership restrictions on inward foreign direct investment, local content requirements, and preferential government procurement policies – were the most visible means by which post-WTO China sought to extract the "technology component" of FDI and channel it towards upgrading China's own industrial base (Tan, 2021). They were also among the most controversial, figuring prominently in the U.S. case for a trade war with China.

When China joined the WTO in 2001, it pledged to not to condition market access on foreign technology transfers. Despite this promise, China pursued technology extraction more energetically and on a greater scale in the years after accession than it ever had in the first two decades of economic Reform and Opening. On the eve of WTO entry, approximately 50 tech extraction policies were in place across roughly two dozen industries in China. Ten years later, more than 300 such measures were in force, covering well over 100 distinct industries. Nor was this change simply numerical. Just as important, as case studies of technology extraction in the wind power and commercial aircraft manufacturing industries demonstrate, the quantitative shift in the prevalence of tech extractors went hand-in-hand with a qualitative improvement in the intensity and effectiveness of their enforcement.

The rise of Chinese technology extraction was remarkable in scope and scale. But encompassing as these efforts were, they were not without notable, and puzzling, gaps. For example, whereas Chinese authorities energetically deployed technology extractors in high value-added sectors like automotive manufacturing, high-speed rail, and renewable energy technology, they used them sparingly in others like semiconductor production, batteries, and precision measurement and navigational equipment. The near-absence of tech extractors in semiconductors is especially surprising given the CCP's keen interest in developing the sector and longstanding recognition that to do so required access to foreign technology. "Arranged marriage" JVs with foreign chipmakers had been the crux of integrated circuit (IC) industrial policy in the 1980s and 1990s. After 2001, China never issued JV mandates in any part of the semiconductor design and fabrication supply chain.[1]

What explains variation in Chinese technology extraction behavior in the post-Cold War and especially post-WTO periods? Why does China impose these policy tools in some high value-added industries but not in others? When do Chinese authorities pursue technology extraction most intensively? In this chapter, I develop a theoretical framework to account for two forms of empirical variation in China's use of technology extractors. The first is variation over time. The number of technology extractors in place rose to unprecedented levels in the decade after WTO entry, only to fall, in equally dramatic fashion, to the lowest levels in at least two decades after 2015. The second is variation across industries in the use of these policy tools, and in particular the decision not to introduce them in sectors which, based on Chinese authorities' stated goals and previous behavior, should have been among the *most likely* targets for technology extraction after 2001.

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[1] Consistent with previous works, I use the terms semiconductor, integrated circuit, and chip interchangeably.

Regarding the rise of technology extractors and variation across industries in their use, my core argument is that top-down national power and regime security concerns lead China to pursue tech extraction in strategic industries, but that China is constrained in imposing these policy tools, even if the most strategic sectors, by its bargaining power over foreign firms. Building on realist approaches to foreign economic policy and consistent with the literature on authoritarian regimes, I argue that the Chinese central party-state's desire to improve China's position in the international balance of power and to combat internal threats to regime security provide the core motive behind technology extraction (Kirshner, 2022; Svolik, 2012). That motive, according to CCP General Secretary Xi Jinping, is for China to "seize the commanding heights of technological competition" in the twenty-first century – and in doing so, to become a leading global power.[2]

But where top-down power and security interests explain why China overwhelmingly pursues technology extraction in strategic industries, bargaining power explains under what conditions it actually *uses* tech extractors in these industries – and when it does not. In short, I expect China to introduce technology extraction policies more often in strategic industries than in non-strategic ones, and in strategic industries in which it enjoys high bargaining power vis-à-vis foreign firms over those in which it does not. At very low levels of bargaining power, I expect China to largely avoid using these measures, even in the most strategically important industries.

I disaggregate China's bargaining power into two main components. The first is the *enforcement capacity* of China's central state, which shapes its ability to bargain with foreign investors as a unified actor. The second is China's position in global value chains (GVCs) in a given industry, which determines the *balance of dependence* between China and the foreign firms investing there.

My argument about central enforcement capacity builds directly on two important strands of recent research. The first is the "new interdependence" literature, which highlights how institutional reform and consolidation can strengthen states' market power, understood as the ability to shape commercial actors' behavior through conditional market access controls (Drezner, Farrell and Newman, 2021; Kalyanpur and Newman, 2019; Newman and Posner, 2010; Farrell, 2006).

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[2] Xi Jinping. 2018. "Strive to be the World's Leading Science Center and Innovation High Ground," Retrieved July 26, 2022 (Available at: *http://www.qstheory.cn*).

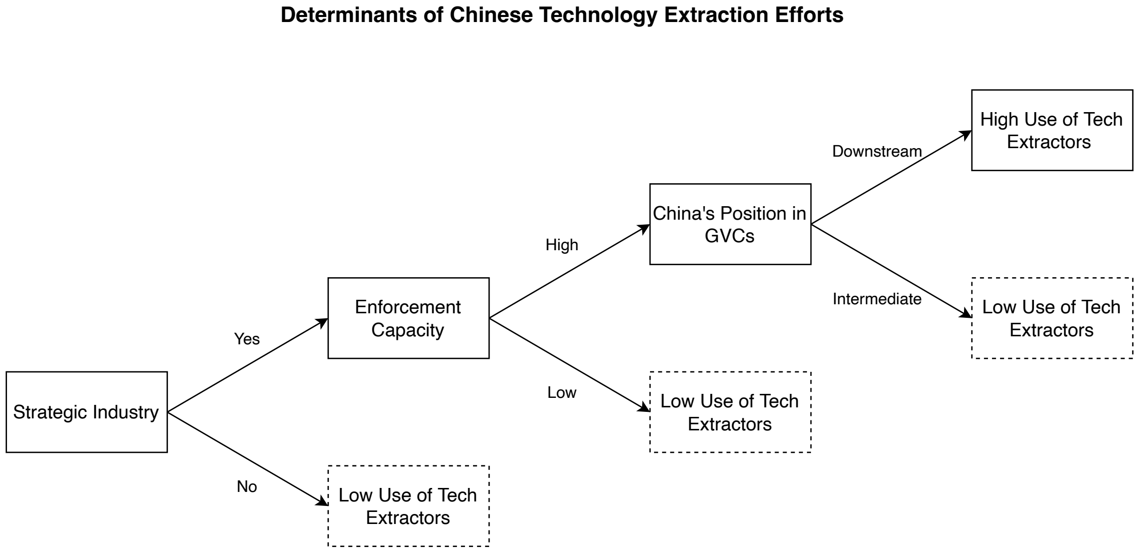

Figure 3.1: **Determinants of Chinese Technology Extraction Efforts**: China pursues technology extraction most actively in strategic industries when central state policy enforcement capacity is high and it sits downstream of global value chains as a final market.

The second is a growing body of work on the revival of Chinese industrial policy in the 2000s (Naughton, 2021, 2015; Tan, 2021; Chen and Naughton, 2016; Naughton and Tsai, 2015; Heilmann and Shih, 2013). Consistent with both literatures, I examine the process by which two rounds of administrative restructuring in 1998 and again in 2003-2005 yielded a more cohesive, potent, and autonomous macroeconomic policy apparatus than existed prior, and one far better equipped to enforce tech extractors in the face of opposition from subnational or private actors, including foreign firms. These changes, I argue, paved the way for broad-based growth in Chinese tech extraction efforts across strategic industries.

My argument about China's position in GVCs builds on but qualifies another core idea from the international relations literature on market power – namely, that market size determines a state's bargaining power over commercial actors (Drezner, 2004, 2007; Shambaugh, 1996). Although having a large internal market certainly improves a state's ability to extract concessions from foreign firms, market size alone does not adequately explain cross-industry variation in bargaining power, especially in the era of transnational production. Instead, I argue that granular variation in China's leverage over foreign investors depends critically on where it sits in GVCs.

When China sits downstream of global production networks as a final demand center, I expect foreign firms to depend more on China as an end market than China depends on them as suppliers of goods and services or employers. As a result, in industries in which most of what foreign firms import into China is ultimately consumed there, China's central state is able to extract market access concessions from foreign firms dependent on the Chinese market, including compliance with technology transfer mandates. High bargaining power over foreign firms explains the prevalence of tech extractors in sectors like high-speed rail, automotive production, and aircraft manufacturing.

The balance of dependence between China and foreign firms changes dramatically, however, in industries in which China occupies an intermediate position in GVCs – that is, when most of what it “consumes" consists of imports of foreign inputs to be processed locally, assembled into more finished goods, and exported back out to consumer markets elsewhere. In these sectors, not only do foreign firms depend less on China as a final market, but China depends heavily on foreign firms and the value chains they govern to guarantee its access to overseas consumer markets, and in turn to drive export growth and associated employment inside China. Reduced foreign firm reliance on China as an end market, combined with increased Chinese dependence on foreign firms to support exports and employment, gives foreign firms a powerful new source of leverage they can use to push back on technology transfer mandates.

I discuss the logic behind this argument at length later in the chapter, but to briefly illustrate why position in GVCs better explains China's bargaining power than market size, consider again the semiconductor industry. After subtracting imports related to the export-processing trade, China took in roughly 3.6 percent of global imports for semiconductors and related components such as diodes and transistors between 2001-2008. This sizeable share of final global demand for ICs was comparable to China's share of the world market for rail transport-related imports, 3.7 percent, and well above its 1-2 percent share of the global market for personal motor vehicles during that period. If market size explains bargaining power, then China should be at least as likely to impose tech extractors in ICs as in autos and rail. In fact, China introduced on average 5 and 9 tech extractions policies in autos and rail transport each year from 2001-2008, and none in semiconductors.

This puzzling pattern becomes less so when we consider that including export-processing trade-related imports, China accounted for an astounding 21 percent of the global market for ICs from 2001 to 2008. Thus, roughly 80 percent of semiconductor and related component imports into China during this period were simply processed in China before being exported back overseas. By contrast, China re-exported just 1.2 and 5.6 percent of imports related to autos and rail, respectively. In short, whereas China sat comfortably downstream of GVCs in autos and rail, it was positioned squarely in the middle of them in semiconductors, and electronics manufacturing more generally.

A key implication is that in semiconductors in the post-WTO period, China relied on foreign firms not only as suppliers of goods and services, but as drivers of export growth and related employment, both directly and indirectly through their role in supporting the country's wider electronics manufacturing sector.[3] From the perspective of foreign firms, this is a powerful source of leverage over China, especially in the post-WTO period, when exports as a share of China's gross domestic product rose from 20 to 35 percent. As I explore in Chapter 6, interviews with numerous industry executives, insiders, and experts suggests this leverage was a critical check on the use of technology extractors in semiconductor production in the first decade after China joined the WTO.

The above arguments help explain the rise of tech extractors after 2001 as well as variation across industries in their use. But why did these policy tools virtually disappear in the second decade after WTO accession? As I discuss below, the causes behind the decline in formal technology extractors, though closely related to their rise a decade earlier, are largely unrelated to the *causes* behind their rise. By 2014-2015, China had made impressive progress towards the world technological frontier in many of the industries in which it pursued technology extraction intensively after WTO entry. As a result, tech extractors lost much of their utility in these sectors. At the same time, as Chinese firms became globally competitive, foreign governmental pressure to remove tech extractors escalated – and with it, the risk of reciprocal restrictions on trade with or FDI from China. As the potential costs of formal technology extractors began to outweigh their benefits, Chinese

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[3] Foreign firms thoroughly dominated processing trade in China in the first decade after WTO accession. For example, in 2005 foreign firms and foreign-invested JVs accounted for 68 and 17 percent of all processing-trade related imports into China, respectively.

authorities opted to remove them. However, as I discuss, this did not necessarily mean the end of tech extraction, but rather the substitution of less direct for more formal, publicly-documented means of acquiring foreign technology.

The remainder of the chapter proceeds as follows. Section 2 lays out assumptions underlying my theory. Section 3 elaborates my argument about the strategic and political motives behind technology extraction. Section 4 explores how China's bargaining power over foreign firms constrains its use of these policy tools, even in the most strategically vital high value-added sectors. In Section 5, I examine the fall of technology extractors in the second decade after WTO entry. Section 6 outlines the multi-method research design I use in Chapters 4 through 7 to test my theory's main claims. I then briefly conclude.

Assumptions

This section lays out four assumptions that underpin my argument. The first two concern the nature and motives of China's central party-state. The second two concern China's bargaining power.

First, I assume that the members of China's central party-state – defined as top CCP officials, senior military officers, and the State Council, China's cabinet[4] – have a shared interest in the survival of the Chinese nation-state and of the governing CCP regime. As such, where these two fundamental issues are concerned, it is reasonable to describe China as a relatively cohesive actor. This is not to suggest that China's central party-state is only united in these two issue areas or that it always pursues these ends in the same ways. It simply means that China's leaders have a consistent common interest in securing the country and CCP regime from external as well as internal threats.

Second, I assume that the Chinese central party-state thinks strategically about how to bolster China's external and internal security. With respect to external security, this implies, at a minimum, that China works to enhance its position in the international balance of power by improving its military capabilities and the size and sophistication of its industrial base. With regard to internal

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[4] In practice, these groups closely overlap with one another.

security, it suggests that China's leaders seek to minimize both factional political and policy conflicts within the regime and state apparatuses and broader social unrest through a combination of repression, cooptation, and regime legitimation strategies. I draw these arguments directly from realist theories of international relations and from the literature on authoritarian regimes in general and Chinese politics in particular. Although realism encompasses diverse viewpoints, most realist IR theorists agree that states seek security, that the international system is anarchic, and that anarchy compels security-seeking states to augment their relative power, including by investing in greater military and industrial capabilities (Mearsheimer, 2001). The literature on authoritarian regimes is similarly diverse, but most scholars would agree that authoritarian leaders want to stay in power and that this entails neutralizing threats to the legitimacy and security of the regime (Svolik, 2012; Gandhi, 2008; Gandhi and Przeworski, 2006). Since the start of Reform and Opening, economic performance – the promise of consistent improvements in the size and sophistication of China's economy, and in turn in living standards – has been one of the two most important pillars (along with nationalism) of regime legitimacy in China (Nathan, 2003; Tan, 2021; Zhang, 2023).

The final two assumptions concern the bargaining relationship between China and foreign investors. To begin, I assume that compliance with technology extractors is costly for foreign firms. The costs of compliance can be direct, such as upfront expenses related to forming a JV with a Chinese firm. They can also be indirect, including the long-term cost of increased competition from Chinese businesses that benefit from foreign technology transfers. The key point is that foreign firms prefer not to internalize these costs. That is, all else equal, foreign firms prefer not to enter into contractual relationships with local firms that require them to transfer valuable technology and expertise. This does not mean foreign investors never seek a Chinese partner in the absence of formal ownership restrictions on inward FDI. Rather, it means that holding other factors constant, investors will prefer not to enter such partnerships, which at a minimum require them to share profits and, at a maximum, entail sharing valuable technology with potential future competitors. This assumption is consistent with evidence that the number of wholly foreign-owned enterprises (WFOEs) in China increased sharply following the relaxation of FDI ownership restrictions in the late-1980s (Wang, 2015, 42), and that one important reason foreign firms prefer WFOEs to JVs is the protection the former provides against "illegal technology transfer" (Gallagher, 2005, 44).

Finally, I assume foreign firms want access to China's market and will pay some price – including, potentially, compliance with technology extractors – to get it. Though intuitive, this assumption merits discussion because it departs somewhat from previous work on firms' FDI location choices. Building on the "obsolescing bargain" concept from Vernon (1971), existing research focuses on competition among host countries to attract foreign investors, which are assumed to enjoy leverage over host countries prior to the decision to invest (Jensen, 2003; Li and Resnick, 2003). This assumption is defensible if we assume host countries to be roughly homogeneous units. It breaks down, however, in a world where host countries vary wildly in size and resources, and in which economies of scale compel firms to exploit the biggest market possible.

In practice, it is not an exaggeration to say that there has never been a market in which more foreign firms across more industries were more desperate to gain a foothold than China's after it joined the WTO and secured Permanent Normal Trade Status from the United States. The enormous resources and energy U.S. businesses invested in securing Congressional support for China's WTO accession attests to the unprecedented global corporate interest in penetration China's rapidly growing market. To take just one example, in 2001 the *New York Times* described how Boeing leaned on its "10,000 suppliers...spread across 420 of the nation's 435 congressional districts" to lobby U.S. government officials on China's behalf.[5] Similar stories abound in mainstream media coverage of China's WTO accession process in the U.S. and other wealthy industrial democracies. For our purposes, the key point is that such expectations provided China's leaders with a fairly high baseline level of bargaining power with foreign investors *ex ante* – that is, prior to foreign firms' decision to invest. China could and did use that leverage to extract sometimes significant market access concessions, including compliance with technology transfer policies. Against this backdrop, the key question becomes not whether and when China enjoys bargaining power, but rather under what conditions China's bargaining power exceeds that of foreign firms. Put another way, we must

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[5] Bradsher, Keith. 2001. "Rallying Round the China Bill, Hungrily," in *The New York Times*, Retrieved June 7, 2022 (Available at: *https://www.nytimes.com*).

ask when and how foreign firms are able to “claw back” sufficient leverage to dissuade China from imposing formal conditional market access restrictions such as technology extractors.

The Strategic and Political Logic of Technology Extraction

This section unpacks my claim that top-down national power and regime security concerns lead Chinese authorities to pursue technology extraction in strategic industries. I make two main points. First, I argue that top-down security interests lead Chinese authorities to prioritize the development of strategic industries because these sectors promise the biggest return on China’s investment in terms of growing its relative power and promoting the CCP regime. Second, I suggest China’s status as a rising great power, authoritarian regime, and late modernizer predisposes the central party-state to view industrial policy, including the use of technology extractors, as a desirable means to improve Chinese competitiveness in strategic industries. I then address two alternative views of the motives behind technology extraction and explain why they are unpersuasive.

From Top-Down Interests to Strategic Industries

In Section 2, I assumed Chinese authorities think strategically about how to improve China’s position in the international balance of power and minimize internal threats to the CCP regime. In order to satisfy these dual imperatives, I expect China’s leaders to strive to increase the size and sophistication of the country’s industrial base. Doing so has direct benefits for both external and internal security. A large, diversified, and internationally competitive industrial base limits China’s vulnerability to sanctions, trade embargoes, and other forms of economic coercion while expanding the resources China can bring to bear in coercing other states (Lind and Press, 2018). At the same time, showcasing its success in fostering growth and technological upgrading helps promote the regime at home (Tan, 2021). This is especially important for the CCP, which has long staked its popular legitimacy in large part on economic performance (Nathan, 2003).

Increasing the size and sophistication of China’s industrial base also has important indirect security benefits. Perhaps most fundamentally, it expands the scale and improves the quality of resources China can invest in military capabilities, which most directly determine its position in the international balance of power (Waltz, 1979; Mearsheimer, 2021). In addition, it gives the CCP more and better resources to invest in repression, cooptation, and various forms of regime legitimation at home. Increasingly sophisticated surveillance technologies have dramatically improved the CCP's ability to police politically undesirable behavior and speech (Chin and Lin, 2022; King, Pan and Roberts, 2013). Likewise, China's economic growth, and the CCP's control over key avenues of wealth creation, helps the central party-state coopt politically important societal groups such as entrepreneurs and intellectuals as well as regime insiders through various forms of side payments (Truex, 2014). Finally, beyond its direct impact on popular support, the CCP's ability to deliver growth and development facilitates regime promotion in other ways, including financing more effective and ubiquitous propaganda.

Given the manifold security benefits of economic growth and industrial upgrading, the next question is how China deploys its limited resources to maximize these ends. Simply put, I expect China to prioritize the development of strategic industries because these industries promise the biggest political, military, and economic return on the state's investment. The term "strategic industry" often appears as a scope condition in research on Chinese political economy, indicating a broad (if generally implicit) recognition that in some domains economic policy emanates from the top down (Li, 2013; Tan, 2021, 2020). However, with rare exceptions (Hsueh, 2011, 2016), the category of strategic industry is seldom systematically defined and operationalized, nor is the logic that leads China to deem certain sectors strategic explained (Pearson, 2015; Norris, 2016). Unfortunately, international security research is also often somewhat vague as to why and how industries become "strategic" (Mastanduno, 1991; Wohlforth, 1999; Hanson, 1998; MacIntyre, 2001). In China's case, the task of identifying "objectively" strategic industries is complicated by the fact that central state policies readily declare sectors strategic. This creates inferential challenges for researchers, who should neither ignore these stated beliefs nor take them at face value.

To resolve this problem, I follow Ding and Dafoe (2021), who draw from strategic trade theory and related literatures to outline a general definition of strategic industries as sectors with great economic or military utility, which generate positive externalities such that markets alone will underinvest in them, and the positive spillovers from which do not easily diffuse across national borders. Building on their argument about the three "logics" by which a sector or asset may be regarded as strategic, I identify three classes of strategic industry: (1) Industries with high barriers to entry due to significant research and development (R&D) requirements, cumulative learning effects, or economies of scale in production, (2) basic infrastructure with significant economy-wide spillovers, and (3) industrial inputs for which supply is limited or concentrated in a few firms, countries, or regions, and thus vulnerable to disruption. As Ding and Dafoe argue, the characteristics of these sectors make it likely that commercial actors, left to their own devices, will underinvest in them. As a result, achieving optimal outcomes requires attention from the highest levels of the state. The combination of economic and military utility, spillover effects, and the need for state support is what qualifies these industries as "strategic."

Top-down security interests lead China to invest in strategic industries because these sectors promise to deliver the biggest bang for the central state's policy buck. High-valued added industries not only generate higher financial returns than low value-added sectors. They also spur technological innovation and human capital growth, leading to increased productivity and economic development. In addition, because many strategic industries contain dual-use or potentially dual-use goods – that is, products with both civilian and military uses – improved competitiveness in these sectors can directly and indirectly contribute to national military capabilities. This effect is particularly salient in sectors like commercial aircraft manufacturing, where most major structural components and internal systems are "inherently dual-use" and, as a result, there is "no question...that foreign involvement in China's aviation manufacturing industry is contributing to the development of China's military aerospace capabilities" (Cliff, Ohlandt and Yang, 2011, 37). But it also applies to a range of ostensibly purely or primarily commercial technologies, not least semiconductors and related equipment. A similar case could be made for basic infrastructure and various kinds of "general purpose technologies" such as rail transportation, improvements in which not only reduce economic transaction costs but lower barriers to social control and improve military effectiveness. Finally, state investment in securing supply lines for key industrial inputs, which similarly facilitates industrial development, has the enormous added benefit of insulating the economy from politically costly supply disruptions.

Importantly, not all industries with economic or military utility are strategic. Low value-added sectors like consumer retail have significant economic utility as sources of employment, while personal firearms can be very useful in war. But relatively low barriers to entry and limited economic spillovers mean that markets alone will tend to meet demand in these industries, limiting both the need and incentive for sustained state involvement. In Chapter 4, I provide a detailed discussion of how I code strategic industries, as well as a table listing all industries I code as such during the study period.

From Strategic Industries to Technology Extraction

The above discussion suggests top-down security concerns lead China to pursue increased competitiveness in strategic industries. It does not necessarily follow that China will do so by means of industrial policy, defined as targeted government interventions that attempt to "alter the sectoral structure of production towards sectors that are expected to offer better growth than the (non-interventionist) market equilibrium" (Naughton, 2021, 19). Classical economic theory cautions against this type of intervention as inefficient and distortionary. This view animates long-held skepticism in the economics profession and in policy communities in liberal market economies towards strategic trade theory, import-substitution industrialization, the developmental state, and related concepts. Although in practice liberal market economies like the United States also engage in industrial policy, at least until recently these countries seldom relied on state intervention to fundamentally reshape the sectoral structure of the economy. To establish that China's interest in nurturing robust domestic capabilities in strategic industries drives its use of industrial policy, I must therefore show why, in China's case, industrial policy is seen as a desirable means to this end.

I argue that China's status as at once a rising great power, an authoritarian regime, and a late modernizer conditions its leaders to view industrial policy in general and technology transfer policy in particular as integral to the country's ability to "catch up" to the world technological frontier in strategic industries. To begin, as hegemonic stability theory suggests, from the perspective of expanding a country's relative power, laissez-faire is an optimal economic strategy only for the dominant state(s) in the system, which in the industrial era almost by definition possess the largest and most sophisticated industrial bases (Kindleberger, 1973; Gilpin, 1975; Krasner, 1976). More specifically, there are good reasons to expect rising great powers, for which the "disposing and constraining" pressures of the international system are most acute, to be particularly prone to view economic liberalism as sub-optimal for increasing their share of world power (Waltz, 1979; Mearsheimer, 2001). Certainly, the empirical record indicates that most rising great powers in the modern era, including the United States for much of the 19th century, engaged in a fairly high degree of state-led industrialization.

A similar argument can be made for authoritarian regimes, which are less free than democracies to take the security of the governing regime from internal threats for granted (Svolik, 2012). This underlying regime insecurity leads many non-democracies to view economic performance as a way to boost not only aggregate welfare or the political prospects of individual leaders, but support for the regime itself. At the same time, the absence of clear constitutional limits on the exercise of political power means weaker exogenous constraints on the state's ability to intervene in the economy (Pepinsky, 2014). I expect the combination of high political stakes and relaxed constraints on state action to make autocracies more receptive to industrial policy than democracies, all else equal. In China's case, this receptivity to industrial policy is likely amplified by the country's Leninist institutions, which place extreme emphasis on top-down political and economic control, and the legacy of the Mao-era planned economy (Walder, 2015; Fewsmith, 2021).

Finally, I expect China's status as a late modernizer to incline it towards viewing industrial policy as a good strategy for "catching up" to its more advanced peers. This argument closely parallels hegemonic stability theory, but substitutes for the international balance of power the global division of labor. In short, the literature on late modernizers and related concepts like developmental states maintains that market forces will tend to entrench a global division of labor, the major benefits of which accrue to firms and countries that sit at its top, which in turn will tend to be those that modernized first (Evans, 1995; Amsden, 1989; Johnson, 1982; Wade, 1990). In such a world, the entrenchment of norms in favor of unrestricted market competition and against state intervention in the economy most benefits those countries already at the top of the economic pecking order. As Friedrich List, echoing this sentiment, famously wrote, it is a “common device that when anyone has attained the summit of greatness, he kicks away the ladder by which he has climbed up, in order to deprive others of the means of climbing up after him" (Helleiner, 2021, 3). Against this backdrop, states that fall behind or inhabit the bottom rungs of the division of labor cannot count on market forces to lift them up the value-added ladder. For these countries, industrial policy is the only feasible means to escape the lower reaches of the division of labor. In the cases of developmental states like postwar Japan, South Korea, and Taiwan this imperative was rooted in external and internal security concerns (Samuels, 1991; Doner, Ritchie and Slater, 2005).

That China belongs to all three of these categories makes it unusually likely among countries today to view industrial policy as an optimal strategy for improving internal and external security. Doing so entails, first and foremost, catching up to the world technological frontier in strategic industries. Given the technical complexity of most of these industries today and China’s exceedingly low starting point, it is no surprise that foreign technology transfer has been a central pillar of Chinese industrial policy throughout the period of Reform and Opening. Simply put, there was no way for Chinese authorities to achieve their developmental goals absent technology extraction on a significant scale. As I discuss in Section 4, China’s relatively weak bargaining power over foreign firms in the early years after Reform and Opening period constrained its ability to impose industry-wide technology transfer requirements. But as the Chinese state’s bargaining power increased in the post-WTO period, these constraints melted away in most strategic industries.

Alternative Views of China's Motives

That top-down security interests lead China to pursue technology extraction in strategic industries is arguably not surprising. Nonetheless, the argument merits elaboration because it cuts against the grain of Open Economy Politics (OEP) and fragmented authoritarianism, arguably the dominant heuristics in research on international political economy (IPE) and Chinese politics, respectively (Lake, 2009; Lieberthal and Oksenberg, 1988; Mertha, 2009). Though different in many ways, these approaches share a certain skepticism towards the idea of the national state as a meaningful, relatively cohesive actor with interests apart from those of the societal, bureaucratic, or factional interest groups which compose it.[6] Scholars working within these research programs might concede the intelligibility of the "national interest" when it comes to traditional "hard" security domains. But they would contend that in areas like trade and investment policy, in which the survival of the state is not typically at stake but that of societal interest groups is, the interests of the latter are more important than those of the former in shaping policy outcomes.

Bottom-up demands for protection and liberalization, the key explanatory variable in mainstream political economy models of trade politics, undoubtedly explain important variation in trade and FDI policy in China, where rent-seeking by state-owned enterprises (SOEs) is widespread. Likewise, there is no question that competition among elite political factions, bureaucratic agencies, and different levels of administration, the foci of fragmented authoritarianism, shapes policy outcomes in China. Nevertheless, neither approach offers a satisfying explanation of the motives behind Chinese technology extraction in general and in the post-WTO period, in particular.

To begin, the premise that Chinese central authorities view economic policy as less directly related to state and regime survival than military policy may be plausible on issues such as whether the tariff on a given product is six percent or two percent. It is less plausible in the domains of "macroeconomic control" (宏观调控) and long-term development planning. Though important

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[6] This skepticism is explicitly hardwired into the theoretical foundations of OEP. In the case of fragmented authoritarianism, it is less intrinsic and is seldom made explicit. However, I would argue that it nonetheless characterizes most research done under the broad banner of fragmented authoritarianism. As such, it helps explain the relative inattention to the central party-state as an actor in contemporary Chinese politics research as compared to subnational and bureaucratic actors.

for the bottom lines of firms, product-level tariff policies, taken individually, are politically trivial for the state as a whole. It would thus be no surprise to learn that lobbying by firms and industry groups shapes tariff rates in China at the margins.

The same cannot be said of macroeconomic planning. No other political regime alive today invests more time, energy, and resources in planning than the CCP. Policies like the Five Year Plans (FYPs), which form the cornerstone of China's policy planning cycle, are more than mere pageantry. They are authoritative statements of the CCP's development goals that directly affect the allocation of resources (Heilmann and Melton, 2013). And although numerous and diverse actors participate in the planning process, there is little evidence that the parochial interests of firms, industry associations, or individual provinces substantially determine policy*making* (as opposed to downstream implementation) for programs like the FYPs, especially in recent decades. The notion that such parochial interests provide the motive behind technology extraction is doubly implausible. As I discuss below, during the post-WTO period this domain was tightly controlled by a single agency, the National Development and Reform Commission (NDRC), which China's leaders went to great lengths to insulate from precisely these pressures (Heilmann and Shih, 2013).

Beyond this, the argument that bottom-up interest group pressures explain technology transfer policy is hard to square with the empirical record. Although China certainly imposes technology extractors in industries long-dominated by powerful SOEs, it also frequently uses them in industries that were previously virtually non-existent in China, and which lacked any meaningful domestic constituency. Moreover, as the case study on wind energy in Chapter 5 shows, Chinese authorities often pursue the development of "emerging industries" like renewable energy in the face of foot-dragging by major SOEs in related sectors, such as traditional power generation. If bottom-up interest group demands provide the motive behind technology extraction, we should consistently observe these policies being used after the emergence of a sizeable domestic industry or following entry into the sector by powerful SOEs. In many cases, we observe the opposite.

As for fragmented authoritarianism, two additional points bear emphasis. First, bureaucratic fragmentation within China's central state declined sharply in the post-WTO period, at least in the domains of industrial and technology policy. This trend, which I examine at length in my discussion of central enforcement capacity in Section 4.1, has been widely documented in the literature on the "rise" of Chinese industrial policy (Naughton, 2005, 2015, 2021; Naughton and Tsai, 2015; Chen and Naughton, 2016; Heilmann and Shih, 2013; Pearson, 2015; Tan, 2021). Although there is some debate over when precisely this process began and what caused it, there is broad agreement that by the mid-2000s a small coterie of like-minded agencies led by the NDRC dominated China's industrial policy agenda. Thus, to the extent political fragmentation explains technology extraction in post-WTO China, it is by virtue of its decline.

Second, fragmented authoritarianism is best understood as a heuristic for analyzing policy-making processes, not a theoretical framework complete with clear prescriptions about who counts as an actor, which actors matter, and what they want. Its core assertion, that "policy made at the center becomes increasingly malleable" to parochial influences as it moves down the ladder of implementation (Mertha, 2009, 996), leaves open the question of what motivates the center. Of course, central authorities may be more or less united in their motives in a given issue area and time. But this is very different from asserting the center is never united on any issue. The key point for this approach is that whatever the center's goals, the fragmented structure of the Chinese state acts as a constraint on its ability to realize those goals. As such, even high levels of fragmentation are compatible, at least in theory, with the notion that China's leaders share a consistent motive to make China and the CCP regime strong and secure. In practice, many works that identify with the fragmented authoritarianism framework assume as much. To take one recent example that this project builds on, Tan (2021) contrasts China's central state, whose interest in "regime promotion" leads it to prioritize the "technology component" of FDI as a means to national industrial upgrading, with local governments, which care more about FDI's short-term political benefits.

To summarize, this section elaborated how top-down national power and regime security concerns lead China to pursue technology extraction overwhelmingly in strategic industries. It then endeavored to show why this approach is more persuasive as an account of the motives behind tech extraction than interest group-based models or fragmented authoritarianism. Having established the strategic motives behind the use of technology extractors, in the next section I explore how variation in China's bargaining power constrains China from imposing these policy tools at certain times and in certain industries.

How Bargaining Power Constrains Technology Extraction

Although the previous section explained in which industries China *would like* to use technology extractors, it did not specify under what conditions China actually *will* use these policy tools. Doing so is important because the strategic and political logic outlined in Section 3 cannot account for critical variation over time and across industries in Chinese technology extraction efforts.

To begin, to the extent that the top-down security concerns which lead China to pursue tech extraction in strategic sectors vary over time, they do so gradually. Chinese authorities were not dramatically less concerned with national and regime security in 1997 than in 2007. And while China's economic rise accelerated after 2001, it was a rising power, an autocracy, and a late modernizer before it joined the WTO. Empirically, we know that China pursued technology transfer in strategic industries like auto manufacturing, semiconductors and oil and gas exploration starting in the early 1980s. Variation in underlying security imperatives is thus not sufficient to explain the marked escalation in the use of technology extractors in the decade after WTO entry.

Likewise, although top-down security concerns explain most cross-industry variation in China's use of tech extraction policies after 2001, they do not explain all of it. Specifically, strategic interests do not account for the puzzling absence or near-absence of these measures in sectors which, judging by their incontestable strategic importance as well as Chinese officials' stated goals and previous actions, should have been among the most likely targets for technology extraction in the post-WTO period. Far from random anomalies, I argue, these "dogs that did not bark" reveal systematic constraints on China's ability to condition foreign access to its market on transfers of technology and expertise to local firms. These constraints have important implications for our understanding of technology transfer in the era of transnational production networks, and in turn for firms' and governments' efforts to regulate this behavior.

This section fills the above gaps in our knowledge by examining variation over time and across industries in China's bargaining power with respect to foreign firms. Simply put, I expect China to pursue technology extraction most intensively when its bargaining power with foreign investors is strong. Major gains in China's bargaining power will lead to corresponding increases in the use of technology extractors. By the same token, when China's bargaining power is weak, so too will be its propensity to use these policy tools, even in the most strategically important industries. At very low levels of bargaining power, China will be no more likely to impose technology extractors in strategic industries than it is in non-strategic ones.

I use the term bargaining power to denote China's capacity to induce foreign firms' compliance with technology extractors. Fundamentally, this capacity rests on whether Chinese authorities can credibly threaten to cut off access to China's market if foreign firms do not agree to transfer technology to local Chinese partners (Hirschman, 1945; Wagner, 1988; Krasner, 1991; Shambaugh, 1996). China's ability to do so, I suggest, depends on two main factors. The first is the *enforcement capacity* of China's central party-state, understood as the ability to enforce national priorities consistently and effectively on a nationwide basis.

Building on recent work that highlights the impact of domestic regulatory institutions on states' ability to "mobilize market power" to shape private actors' behavior, I expect increases in central enforcement capacity to bolster China's bargaining power over foreign firms (Farrell, 2006; Newman and Posner, 2010; Kalyanpur and Newman, 2019). As a result, broad gains in enforcement capacity should lead to similarly broad gains in the use of tech extractors in strategic industries. Greater enforcement capacity boosts China's leverage primarily by enabling individual agencies to bargain with foreign investors as credible stand-ins for the central party-state as a whole.

The second factor is China's position in global value chains, which I argue determines the degree and direction of "asymmetrical interdependence" between China and foreign firms (Keohane and Nye, 1977). I use the term *balance of dependence* to capture this notion of asymmetries in relative reliance between the two parties. The more the balance of dependence favors China – that

Bargaining Power and Technology Extraction in Strategic Industries

Foreign Firm Relative Reliance on China / Enforcement Capacity	Low	High
High	Low Use	High Use
Low	Little to No Use	Low Use

Figure 3.2: **Bargaining Power and Technology Extraction in Strategic Industries**: China uses technology extractors most actively when central enforcement capacity is high and when foreign firms rely more on it than the reverse. When either enforcement capacity is weak or the balance of dependence favors foreign firms, China will use these policies less frequently and enforce them less energetically. When enforcement capacity is low *and* China depends more on foreign firms than the reverse, China should seldom introduce tech extraction policies.

is, when foreign firms depend more on access to China's market than China depends on foreign firms as suppliers of goods and services or sources of employment and growth – the greater its bargaining power, and thus the more likely it is to impose technology extractors. When the balance of dependence favors foreign firms, I expect Chinese authorities to refrain from using overt technology extraction policies, including in highly strategic sectors.

In Section 2, I assumed (1) compliance with technology extractors is costly for foreign firms and (2) intense investor interest in the Chinese market imbues China with a fairly high baseline level of bargaining power, especially in the post-WTO period. Given these assumptions, the critical question is under what conditions foreign firms can reclaim leverage over China, inducing Chinese authorities not to impose technology extractors. I expect foreign firms to be best positioned to do so when China depends more on them not only as suppliers of goods and services but as drivers of export growth and associated employment than they depend on it as a final market. This will be the case, I argue, when China primarily occupies an intermediate position in GVCs in an industry. In such industries, foreign firms' activities in China consist primarily of importing inputs from overseas, processing them locally, and re-exporting them as more finished goods to consumer markets abroad. As I explore below, while foreign firms in these industries still depend on China in various ways, for most of the post-WTO period (and still today in most industries) this dependence was more than offset by China's reciprocal reliance on them as employers and gatekeepers to overseas markets.

The remainder of the section develops the above arguments at greater length. I first examine how administrative restructuring in the late-1990s and early 2000s increased Chinese central state enforcement capacity, paving the way for a broad-based escalation in Chinese technology extraction efforts following the launch of the National Medium- and Long-Term Program for Science and Technology Development, 2006-2020, hereafter MLP, in late-2005 and early-2006. I then explore how variation across industries in China's position in global value chains affects what Hirschman (1945) calls relative costs of "adjustment" following trade or investment disruptions, and in turn shapes the balance of dependence between China and foreign investors.

Central Enforcement Capacity and the Rise of Technology Extraction

My argument that gains in Chinese central enforcement capacity explain the rise of technology extractors in the decade after WTO entry draws on two important bodies of literature in political science. The first, referenced above, is the "new interdependence" research program, which extends earlier efforts to theorize the concept of "market power" as a property not only of firms, as per the organizational economics literature, but of states, as well.

Whereas early work in this area defined market power primarily as a function of the size of a country's internal market (Shambaugh, 1996; Drezner, 2004, 2007), scholars associated with the new interdependence approach emphasize the role of domestic institutions in augmenting or limiting the bargaining power afforded by market size. Thus, for example, Kalyanpur and Newman (2019) examine how the harmonization of stock market governance in the European Union after 1999 bolstered European and undercut U.S. market power, leading many non-U.S. firms to delist from U.S. stock exchanges rather than comply with the 2002 Sarbanes-Oxley Act. A key implication of this work is that holding market size constant, changes in institutions, and in particular reforms that centralize decisions concerning market access, improve the state's ability to mobilize market power for political ends (Kalyanpur and Newman, 2019, 8).

The second body of literature, as noted in the introduction, concerns the revival of Chinese industrial policy, along with related concepts such as the rise of Chinese “state capitalism," and more recently “party-state capitalism," during the Hu Jintao-Wen Jiabao (2003-2013) and Xi Jinping (2013-Present) administrations (Naughton, 2005, 2015, 2021; Tan, 2021; Chen and Naughton, 2016; Naughton and Tsai, 2015; Pearson, 2015; Heilmann and Shih, 2013; Lardy, 2014; Pearson, Rithmire and Tsai, 2022). As this literature shows, institutions of central economic governance in China underwent profound changes in the decades after WTO accession. Though this process had many dimensions, at its core was the consolidation of economic policy authority in the hands of a reformed and restructured central party-state apparatus. Moreover, although the centralization of economic policy authority accelerated after the 2008-2009 Global Financial Crisis and again after Xi Jinping came to power in 2012-2013, more recent research locates its origins in the publication of the MLP in 2005-2006 (Naughton, 2021; Tan, 2021).

In line with these works, I identify the launch of the MLP between December 2005 and February 2006 as a watershed in the growth of both Chinese central enforcement capacity and China's use of technology extractors. But my argument goes further, situating the MLP and the years 2005-2006 as the bookend to a longer process of institutional reform and restructuring aimed at building a more cohesive, autonomous, and potent central policy apparatus. As I show, this reform process, which unfolded in two major waves of administrative restructuring in initiated 1998 and 2003, respectively, the was most important factor behind the expansion of central enforcement capacity in the post-WTO period. As such, it provides the "critical antecedent" to the rise of technology extraction in strategic industries after the launch of the Medium- and Long-Term Program (Slater and Simmons, 2010).

Administrative Restructuring and Central Enforcement Capacity

The case studies in Chapters 5 and 7 examine the implications of administrative restructuring for technology extraction in individual industries in greater depth. Here, I give an overview of the administrative reform process, its motives, and its consequences for central enforcement capacity. I then discuss two closely related potential alternative explanations for the rise of technology extraction after 2006 and explain why gains in enforcement capacity following administrative restructuring offers the best explanation for the rise over time in tech extraction efforts.

Before examining the 1998 and 2003 rounds of institutional reforms, it is important to understand the context in which China's leaders pursued these reforms. Chinese political life in the first two decades of Reform and Opening conformed closely to the portrait of "fragmented authority" offered in (Lieberthal and Oksenberg, 1988). This fragmentation extended across all levels of the political system. Factional conflicts were a recurrent motif among the upper echelons of the CCP elite throughout the 1980s and 1990s (Lieberthal and Oksenberg, 1988; Shih, 2008; Heilmann and Shih, 2013). Likewise, a profusion of sectoral ministries – a legacy of the Stalinist planned economy of the Mao era – made the economic policy process into a tangle of horse trading among vested interest groups (Heilmann and Shih, 2013; Liang, 2007). Meanwhile, fiscal and aministrative decentralization in the 1980s entrenched the divide between central and local interests and vitiated the center's ability to enforce policies consistently across regional jurisdictions (Shirk, 1993). Central control was arguably further vitiated by simultaneous effort, beginning in 1988, to partially decouple the party from the state and the state from enterprises (Ngok and Zhu, 2007).

Periodic bouts of administrative restructuring were one means by which China's leaders sought to address these problems. In the first major administrative reform of the post-Mao period, China in 1982 cut the number of ministries and other constituent bodies in the State Council from

100 to 61 and trimmed total State Council personnel from 51,000 to 30,000 (Ngok and Zhu, 2007; Christensen, Lisheng and Painter, 2008; Wang, 2010). In 1988, they again cut the number of State Council bodies, which had since grown from 61 to 72, down to 65, while taking steps to professionalize the bureaucracy (Ngok and Zhu, 2007). A wave of reforms in 1993 sought to create an administrative apparatus that could "satisfy the requirements of a developing market economy" by corporatizing a limited number of industrial ministries (Ngok and Zhu, 2007, 226). Keeping with tradition, the 1993 restructuring also cut the number of State Council bodies, which had grown back to 86, this time down to 59.

The 1998 and 2003 rounds of administrative restructuring thus belonged to a tradition of regular top-down reform efforts aimed at improving governance through a combination of streamlining and professionalization. The 1998 and 2003 rounds built on this tradition, but went much further in the direction of recentralizing policy authority and consolidating central enforcement capacity.[7] Restructuring in 1998 downsized the State Council once again, with the number of constituent departments falling from 50 to 29. More importantly, the 1998 round eliminated 15 (of 20 total) industrial line ministries, transferring their responsibilities to the newly-elevated State Economic and Trade Commission (SETC). Created in 1993 by then-Vice Premier Zhu Rongji, the SETC replaced the State Planning Commission (SPC), the Mao-era planning body, as China's lead macroeconomic policy coordination agency when Zhu succeeded Li Peng as Premier in 1998. Between 1998-2003, the SETC would serve as China's top economic policy organ and the main enforcer of Zhu's signature initiative, restructuring China's state-owned sector (Naughton, 2018).

The elimination of industrial line ministries was an important milestone in the growth of Chinese central enforcement capacity. Competition among these ministries had been a key cause of the fragmentation of policy authority within China's central state during the 1980s and early 1990s. It opened opportunities for regulatory capture by vested sectoral interests, bred policy incoherence,

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[7] After a decade of sweeping decentralization in the 1980s, the 1990s witnessed the start of a similarly broad-based recentralization process. Accounts differ as to when this recentralization began, with Huang (2008) locating its origins in the fallout from the Tiananmen Crisis and the transition to Jiang Zemin as CCP General Secretary in June 1989. Perhaps the clearest turning point, however, was fiscal reforms in 1994 that returned control over collection of most government revenues to the center (Naughton, 2018).

and made it difficult for China to present a unified front when negotiating with foreign partners. Nowhere was this more apparent than in China's WTO accession process. Fifteen years of bilateral negotiations with the United States over WTO entry crystallized the pathologies of two-level games, as Chinese negotiators struggled to reconcile stringent U.S. demands with aggressive opposition from a myriad of industrial ministries that bureaucratically outranked them (Pearson, 2001; Liang, 2007; Zeng, 2007). By abolishing these ministries and consolidating their responsibilities under the SETC, whose high rank and direct line to Premier Zhu imbued it with much greater authority individual industrial regulatory bodies, the 1998 reforms closed key channels through which sectoral interests had traditionally influenced central policy outcomes. This simultaneously helped insulate central decision-making from bottom-up pressures and enhanced the center's ability to impose its vision against opposition from those same pressures.

If the 1998 reform bolstered central enforcement capacity by streamlining the bottom of the central state pyramid, then the 2003 round did so by targeting fragmentation at the top. At first glance, the 2003 administrative reform appears much less ambitious than its predecessor, with the net number of constituent bodies of the State Council falling by just one, from 29 to 28. But this figure belied a shift in the structure of economic policymaking no less significant for central enforcement capacity than the elimination of sector-specific ministries.

Since the start of Reform and Opening, China had never had fewer than two top macroeconomic planning agencies at any one time.[8] Although these bodies had nominally distinct mandates, in practice their overlapping responsibilities and powers all but guaranteed they would compete for control over the policy agenda. These conflicts, in turn, fed into and were fed by parallel political struggles among the agencies' respective patrons in the CCP elite. Thus, during the 1980s the conservative SPC, the Mao-era planning body, vied for influence with the State Economic Commission (SEC), which favored a Japanese *keiretsu*-style approach to industrial policy and SOE management, as well as with the State Structural Reform Commission (SSRC), which advocated market-oriented reforms and the separation of the state from enterprises.

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[8] Much of the discussion in the next several paragraphs is drawn from Heilmann and Shih (2013).

When reformist leader Zhao Ziyang fell from power following the 1989 Tiananmen Square crisis, so too did the SSRC, of which he had been a key patron. With the SSRC's termination, China's tripolar planning structure gave way in the 1990s to a loosely bipolar system centered on competition between the SPC and SEC. This competition persisted throughout the decade, with the SPC somewhat more dominant from 1993-1998 (when Li Peng, its patron, served as Premier) and the SEC, reorganized as the SETC in 1993, clearly more powerful during Zhu's tenure as Premier. When he assumed office and elevated the SETC as China's top agency, Zhu successfully demoted the SPC, remolding it as a macroeconomic policy think tank called the State Development and Planning Commission (SPDC). Importantly, however, Zhu did not eliminate the SPDC. Though diminished, it remained a potent policy and political force throughout Zhu's time in office.

Like competition among industrial line ministries, competition at the top of China's central policy apparatus exacerbated policy incoherence as each apex agency pursued its separate agenda without much in the way of apparent coordination. Thus, to take one example, the SETC and SPC launched similar but unrelated wind power industrial policies in the space of a few months in 1997. In addition to its inefficiency, this redundancy left foreign investors (as well as domestic firms) confused and uncertain as to whom they should report to. More concerning for China's leaders, fragmented enforcement created loopholes commercial actors could exploit to evade compliance with central policy goals.

The 2003 administrative restructuring ended the pattern of competition among apex agencies by eliminating the SETC and re-elevating the SPDC, now renamed the National Development and Reform Commission, as China's sole top macroeconomic planning and policy coordination body. The formation of the NDRC was a watershed in the trajectory of Chinese central enforcement capacity. Within a few years of its creation, the NDRC would establish itself as by far the dominant macroeconomic policy bureaucracy of the Hu Jintao-Wen Jiabao administration and China's closest approximation of the ideal typical developmental "pilot agency" embodied in the Johnson (1982) account of MITI in postwar Japan. Just as important as the NDRC's rise and subsequent accumulation of power, however, was the Hu-Wen administration's simultaneous decision to abolish the SETC, which left the NDRC unrivaled in its core policy domains.[9]

The NDRC quickly capitalized on the lack of competition to broaden the scope of its authority. A key step in the expansion of the NDRC's enforcement capacity, and a crucial link between this capacity and the rise of technology extraction, was a June 16, 2004 State Council decision which vested the NDRC with final approval for all large-scale investment projects nationwide. Crucially, this included all inward foreign investments with a value of $100 million or more in sectors where FDI was formally "encouraged" and above $50 million in industries where FDI was allowed but restricted.[10] At the same time, the decision transferred to the NDRC primary authority over the Foreign-Invested Industry Guidance Catalogue, which would remain the authoritative regulation on inward FDI into China for the next fourteen years.[11] In effect, the 2004 decision gave the NDRC the nearly-exclusive power to decide in which sectors foreign firms could invest and under what conditions. This power included the right to determine which industries would be subject to formal JV requirements and other ownership restrictions on inward FDI. In August 2005, the State Council revised the guideline, further entrenching the NDRC's authority.

With control over investment approvals, the NDRC could veto any project that did not advance its developmental agenda. Not surprisingly, this control became a key lever of influence for the NDRC at a time when foreign and state-led investment were key pillars of China's fast-paced economic growth. As a 2012 American Chamber of Commerce report on China's FDI regulatory regime noted, the "project approval" stage of the FDI approval process, over which the NDRC enjoyed exclusive control, was a key bottleneck Chinese authorities used to extract concessions from foreign investors. Moreover, the report observed, "categorizations and conditions" such as mandates that foreign firms form JVs with local partners, were "largely based on China's industrial

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[9] No official reason was given for the decision to eliminate the SETC. Most likely, this decision reflected well-founded concerns that the SETC was too close to outgoing Premier Zhu Rongji and would not be a committed enforcer of the Hu-Wen administration's policy priorities.

[10] An English-language version of the June 2004 State Council decision is available at: *https://en.ndrc.gov.cn*

[11] Prior to 2003, the SPDC, SETC, and Ministry of Foreign Trade and Economic Cooperation jointly issued the FDI Guidance Catalogue. After 2003, the NDRC jointly published the Catalogue with the Ministry of Commerce (MOFCOM), the successor to MOFTEC. However, the NDRC retained sole power of approval. As I discuss below, NDRC outranked MOFCOM bureaucratically and is widely understood to have been far more powerful than MOFCOM in practice throughout this period.

policies," over which the NDRC exerted final and often total control.[12] The net effect of these moves was to turn the NDRC into China's "Super-Ministry, [positioned] one half-step above everyone else in the government, the general headquarters of the economy" (Naughton, 2015, 36). As Lardy (2014) notes, the NDRC's securing of project approval authority "allowed it to dominate economic policymaking from almost the beginning of the Hu-Wen era" (Lardy, 2014, 49).

This is not to say the NDRC enjoyed complete freedom of action, at least at first. Previous work has identified the Ministry of Commerce (MOFCOM) as an early competitor to the NDRC, while noting that MOFCOM both formally ranked below the NDRC in China's bureaucratic hierarchy and was far weaker in practice (Tan, 2021).[13] My own interviews with former U.S. trade officials suggest that although individual departments within MOFCOM tasked with managing China's WTO accession process endeavored as "keepers of the flame" of market reform, these voices were marginal in a ministry otherwise ready to "snuff the flame out" when demanded by the "more energetic" NDRC.[14] Likewise, the NDRC reportedly faced some pushback early on from the more market-oriented People's Bank of China. But by the end of 2003, the NDRC had "won the support of Premier Wen Jiabao and became the dominant voice in macroeconomic policy" (Naughton, 2015, 29). As Naughton notes, having won this "policy mandate from the leadership, [the] NDRC began enforcing a more rigorous investment approval regime" (Naughton, 2015, 30).

The consolidation of economic policy authority under the NDRC, and in particular its control over project approval, enhanced the center's ability to extract compliance with national policy initiatives. The result was that by 2005 China's central state was much better positioned to bargain with foreign investors as a single, unified actor than at any point in the decades prior. China's bargaining position was further strengthened by the character of the NDRC itself. The Hu-Wen administration had gone to great lengths to bolster the NDRC's autonomy and organizational

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[12] U.S. Chamber of Commerce. 2012. "China's Approval Process for Inboun Foreign Investment: Impact on Market Access, National Treatment, and Transparency," Retrieved April 25, 2023 (Available at: *https://www.uschamber.com*)

[13] This difference in bureaucratic rank meant the NDRC could issue binding orders to MOFCOM, but not the reverse (Mertha, 2018). The only partial exception to this rule was the Ministry of Finance, which by virtue of its status as as a "macroeconomic control" body (along with the NDRC and People's Bank of China) held a rank more akin to a Commission, despite its name.

[14] Interview, Washington, D.C., April 2021.

integrity. This included staffing its leadership with officials who lacked strong ties to industry and would be driven, Hu and Wen hoped, by "patriotic commitments to make China...a strong and competitive industrial power" (Heilmann and Shih, 2013, 17). It also included steps to insulate the NDRC from foreign pressure. As one former U.S. trade official told me, foreign officials and business leaders during this period had very limited access to the NDRC compared with other ministries such as MOFCOM and the Ministry of Finance (MOF).[15] This lack of access freed the NDRC to take "neither WTO rules nor the need to comply with international obligations into account when setting policies," instead leaving the much weaker MOFCOM, as foreigners' main point of contact, "to deal with any problems that might later emerge" (Tan, 2021, 110).

From Enforcement Capacity to Technology Extraction

A core contention of this project is that the growth in central enforcement capacity following the elimination of industrial line ministries after 1998, and in particular with the rise of the NDRC, was the most important factor behind the increase in Chinese tech extraction efforts after 2006. To understand why, it is helpful first to situate my argument in relation to existing research on the "resumption" of industrial policy in China during this period (Naughton, 2021).

Western scholarly interest in Chinese industrial policy has grown substantially in recent years. In part, this interest reflects the psychological impact of China's rapid advance towards the world technological frontier in high value-added sectors long dominated by firms from the United States and other advanced industrial economies (Wang, 2021). In part, it is a response to a tangible shift in the tenor of Chinese economic policy over the past fifteen years or so, and especially in the decade since Xi Jinping became General Secretary in late 2012 (Pearson, Rithmire and Tsai, 2022). The coincidence of these trends has prompted researchers to ask whether and in what ways they may be related. This, in turn, has spurred efforts to identify turning points in the evolution of Chinese economic and industrial policymaking.

A first wave of works on Chinese "state capitalism" and the related concept of *guojin mintui*

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[15] Interview, Washington, D.C. October 2021.

(国进民退), or “the state advances, the private sector retreats,” highlighted China’s response to the Global Financial Crisis in 2008-2009 and Xi Jinping’s rise in 2012-2013 as watershed moments after which China turned away from the liberalizing course set by WTO entry (Naughton, 2015; Lardy, 2014; Tan, 2021). But as several recent and important contributions show, though China’s embrace of top-down industrial policy accelerated after the financial crisis and again under Xi Jinping, this trend predates both developments (Naughton, 2021; Tan, 2021; Chen and Naughton, 2016). These works instead point to the years 2005-2006, and in particular the launch of the MLP, as inaugurating China’s post-WTO industrial policy drive.

Consistent with this view, I identify the year 2006 as an inflection point in Chinese technology extraction efforts. Although the prevalence of tech extractors rose somewhat – and more importantly, as I explore in the wind power case study in Chapter 5, the NDRC began enforcing tech extractors more assertively – before 2006, there is little question that China used more technology extractors after the launch of the MLP than before. Likewise, in line with Naughton (2021) and Tan (2021), I argue that the MLP is important for understanding why the use of technology extractors increased when it did. However, to say the MLP *caused* the surge in Chinese tech extraction after 2006 is somewhat misleading; as I noted in the previous chapter, the concept of “indigenous innovation" with which the MLP is most closely associated in fact predates the Program by a decade.

Instead, I argue that the MLP’s significance rests primarily in its impact on the central state’s capacity to coordinate and implement pre-existing policy priorities. Concretely, the MLP bolstered this capacity in two ways. First, by providing a clear and authoritative statement of the leadership’s priorities, the Program helped align incentives and mobilize coordinated action between the NDRC and other agencies, most notably the MOF, tasked with implementing its key initiatives. Second, by positioning the NDRC as the Program’s lead enforcement agency after April 2006, the Party leadership signaled its confidence in the agency, giving it *carte blanche* to extend technology extraction efforts already underway in core NDRC policy domains such as energy to a wider array of strategic industries. Crucially, however, it was the enforcement capacity accumulated through earlier administrative reforms that enabled the translation of the MLP’s ambitious yet open-ended exhortations into concrete tech extraction policies.

To substantiate this argument, it is important to say something about what kind of policy the MLP was, and what it was not. First published in December 2005 and formally launched in February 2006, the National Medium- and Long-Term Program for Science and Technology Development 2006-2020 "was not in itself an industrial policy," but rather a statement of "principles. . . intended to guide subsequent action" (Naughton, 2021, 51). In this way, the MLP was "typical of the top-level, programmatic documents that form the keystone of the structured policy process in the Chinese system" but which in themselves are "not," nor are intended to be, "really operational" (Naughton, 2021, 51). Rather, in keeping with a long CCP tradition of top-down mobilizational campaigns aimed at overcoming political fragmentation and coordinating state action, the main contribution of the MLP was discursive (Ye, 2019). Most importantly, it elevated "indigenous innovation" to center of the Chinese policy lexicon and laid out a theory of how nurturing this capability would transform China into a globally competitive "economic great power" (经济强国).

The policy process surrounding the MLP's formulation and implementation clearly reflects its non-operational character. To begin, the NDRC and other top economic policy organs such as the MOF were only peripherally involved in developing the MLP.[16] Responsibility for drafting the program fell instead to the Ministry of Science and Technology (MOST), which lacked significant enforcement powers. The result was that, in sharp contrast to later industrial policies like the 2010 Strategic Emerging Industries (SEI) initiative, for which "the lead agency...was always the NDRC," the MLP "started as a science policy, and only subsequently spilled over into industrial policy" (Naughton 2021, 59). As one interviewee, a former MOST official who worked on the MLP, told me, the NDRC and MOF were important "in the budget allocation for the implementation of the MLP" after its launch.[17] But when it came to coordinating the drafting of the program document – a "remarkably open" three-year process involving thousands of scientists, engineers, and even foreign experts (Cao, Suttmeier and Simon, 2006, 38) – MOST was always "the key player."

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[16] Ma Kai, chairman of the NDRC, served on the 26-person leading small group convened by Premier Wen Jiabao in June 2003 to coordinate work on the program. But so did the heads of virtually every State Council constituent body.

[17] Interview, Zoom, November 2021.

It was only after the launch of the MLP, as China's leaders sought to translate the program into operational industrial policies, that the NDRC took center stage. In April 2006, the State Council published a list of 99 measures meant to steer the MLP's implementation (Serger and Breidne, 2007). Of these, the NDRC was named lead agency on 29, the most of any one ministry (the MOF came second, with 21 policies). More important than the number was the kind of tasks given to the NDRC. These included management of key technology "megaprojects" described in the program, supervision of state investment in high-tech industries, the lead role in nurturing a local venture capital ecosystem, and a broad mandate to "promote the industrialization of indigenous innovation advances" (促进自主创新成果产业化).[18] Most critically for our purposes, four of the NDRC's implementation tasks directly concerned the regulation of inward FDI.

Against this backdrop, it is neither surprising nor a coincidence, I suggest, that the number of foreign investment ownership restrictions doubled, from 52 to 103, in the 2007 revision of the FDI Guidance Catalogue, the first published after the launch of the MLP (the growth in explicit JV mandates was even greater, from 28 to 65). The line between the 99 implementing policies issued in April 2006 and the expansion of technology extraction efforts in the 2007 Catalogue could scarcely be more direct. While the implementing policies are clearly inextricable from the MLP itself, however, to conflate them is to ignore important differences in the "data generating process" for each policy. It was not obvious that the MLP would successfully make the transition from "programmatic document" to operational industrial policy. That it did owes as much to the NDRC's energetic enforcement as to the program itself.

To summarize, the launch of the MLP in 2006 is integral to explaining why the sharp increase in Chinese technology extraction efforts began in 2007 rather than 2005 or 2009. This being said, I argue that the critical variable which explains why the MLP ultimately led to a surge in China's use of these policy tools is not the program itself, but the growth of central enforcement capacity in the years immediately prior. Specifically, I point to (1) the elimination of most industrial line

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[18] See 实施《国家中长期科学和技术发展规划纲要》的若干配套政策. A Chinese-language version of the NDRC's first implementing policy, 关于促进自主创新成果的若干政策, which discusses technology transfer, is available at: *http://www.most.gov.cn*). A Chinese-language version of the full list of implementing policies is available at: *http://www.gov.cn*)

ministries after 1998, which substantially insulated the central policy process from sectoral interest group pressures, and (2) the NDRC's formation in 2003 and its consolidation of control over project approvals in 2004-2005 as necessary conditions for effective translation of the MLP's exhortations into a coherent and concrete technology transfer policy program.

Alternative Explanations for the Rise of Tech Extractors

The above discussion made the case that gains in central enforcement capacity best explain the rise of technology extractors in the post-WTO period. Specifically, I argued that enforcement capacity accounts for how Chinese central state agencies, above all the NDRC, successfully operationalized the MLP's lofty but vague exhortations to promote "indigenous innovation" by means of the "introduction, digestion, absorption, and re-innovation" of foreign technology into concrete, actionable technology transfer policies. Put another way, central enforcement capacity is the key factor without which the observed rise in the number of tech extractors (and just as important, the increase in the assertiveness with which they were enforced) in the post-WTO era would not have occurred or would have been weaker. As such, it best explains the timing as well as the scope and scale of Chinese technology extraction efforts in this period.

Although for inferential purposes it helps to think about the causes of effects in terms of central tendencies, reality, of course, is multidimensional and overdetermined. This is true for tech extraction in post-WTO China as for any non-trivial aspect of political life in any context. When it comes to the rise of technology extractors, two other potential "alternative explanations" merit attention. I put the term in scare quotes because these explanations are best thought of not as substitutes for my own, but rather complements that "fill in the picture," so to speak. They do so by highlighting different aspects of what was in many ways a revolutionary period for China – the years leading up to and following its accession to the WTO – in terms of both the country's internal organization and its position in the world economy.

The first concerns two aspects of WTO accession itself. According to this approach, it could be that the rise in tech extraction efforts resulted from a combination of (1) the increase in China's bargaining power due to rising foreign interest in the Chinese market, and (2) the weakening of WTO accountability mechanisms after China fulfilled its final accession commitments in 2005.

As I have already discussed, WTO entry was a pivotal moment for China's rise, as or possibly even more significant than Deng Xiaoping's 1992 "Southern Tour." Moreover, by reducing uncertainty over the country's regulatory environment, it turbocharged foreign interest in investing there. This was particularly true of Western MNEs, which had contributed far less than firms from Hong Kong, Taiwan, and Japan to the first major wave of FDI into China in the 1990s. Dramatically increased interest in the Chinese market naturally raised China's "baseline" bargaining power, making possible more energetic use of technology extractors. But if this rising baseline alone explained China's behavior, we should see either a clear inflection in the number of tech extractors just before or after WTO entry or a steady increase in the ensuing years. Instead, as I show in the next chapter, we see a sharp numerical jump in 2007-2008, followed by a second jump in 2009.

Tan (2021) helps fill this gap, noting that although China formally joined the WTO in 2001 its accession protocols called for a phased implementation of key market access commitments. She argues that as China formally fulfilled its last commitments in 2004-2005, the WTO's ability to hold China accountable declined, clearing the way for the reassertion of state control and revival of industrial policy thereafter. From this we might infer that the combination of rising baseline bargaining power and reduced WTO oversight explains the scale as well as the timing of the increase in Chinese tech extraction. This is unlikely for several reasons. To begin, the steepest reductions in tariffs and other market access restrictions came in 2002; average tariff and non-tariff barriers had largely leveled off by 2004, some three years before the increase in tech extractors. Moreover, as Tan acknowledges, WTO accountability never extended far into China's core economic policy institutions, especially the NDRC. There is no particular reason to think the NDRC's already limited responsiveness to China's WTO obligations suddenly declined further in 2005, let alone 2006-2007 as it revised and expanded the FDI Guidance Catalogue. Finally, and perhaps most important, the notion that the conclusion of China's WTO accession timeline led to the revival of industrial policy in China is hard to reconcile with the fact that drafting of the MLP began not in 2005 but in

May 2003, months after the Hu Jintao-Wen Jiabao administration took office (Cao, Suttmeier and Simon, 2006; Chen and Naughton, 2016).

But if WTO accession and accountability do not sufficiently explain the rise technology extractors, nonetheless the decision to join the WTO does constitute the closest thing to a true "independent" variable in the sense of an exogenous shock on China's institutional development, and hence on the growth in enforcement capacity. It is the enormous competitive pressures and opportunities opened by WTO entry that simultaneously necessitate and make politically possible the Chinese leadership's huge investments in building a modern regulatory and administrative state under the Jiang-Zhu and Hu-Wen administrations. In this sense, the gains in enforcement capacity which enable increased tech extraction are themselves at least partly "endogenous" to WTO entry. Critically, however, I find no evidence in official policy documents that these gains were causally downstream of industrial policy or tech extraction. That is, institutional reforms and gains in enforcement capacity were for all intents and purposes "exogenous" to our outcome of interest, technology extraction. At most, it is possible to view both institutional reforms and rising Chinese interest in tech extraction as reactions to WTO accession. But in the sequence of events, the former precedes and clears a path for – in other words, is causally prior to – the latter.

The second alternative explanation focuses on the leadership transition from the Jiang-Zhu to the Hu-Wen administration in 2003. According to this view, whereas Jiang Zemin and especially Zhu Rongji were committed to deepening market reforms, Hu and Wen preferred a stronger central state role in managing the economy. This shift in preferences between administrations, in turn, led to the revival of industrial and technology transfer policy later in the decade. There is some support for this argument. The Hu-Wen leadership did clearly favor more state intervention in the economy, for example to help mitigate rapidly worsening economic imbalances between coastal and inland regions or cities and the countryside (Fewsmith, 2021). Likewise, it is notable that Wen launched the drafting process for the MLP two months after assuming the role of Premier in March 2003 (Chen and Naughton, 2016). This would make the MLP one of the first significant acts of his tenure. In sum, the leadership change and attendant shift in top-level policy priorities undeniably mattered for the subsequent course of events.

But this argument also suffers from several shortcomings that limit its explanatory power. First, it overstates the differences and underplays the continuity between the two leaderships. Wen Jiabao served as Vice Premier under Zhu Rongji from 1998-2002, and there is little in his earlier career to suggest a particular affinity for industrial policy. In fact, Wen first rose to prominence in the 1980s in connection with two pro-market reform leaders, Hu Yaobang and Zhao Ziyang. Nor was the Jiang-Zhu administration as liberal-minded as it is sometimes portrayed, as Huang (2008) makes clear. Indeed, although oriented around a different vision of industrial policy from that which emerged in the post-WTO period, the SETC's approach to macroeconomic policy was nonetheless rooted in *a* vision of industrial policy, one descended from postwar Japan (Heilmann and Shih, 2013). Finally, as noted in the previous chapter, the term "indigenous innovation" was in common use in central-level policies well before Wen assumed office and launched the MLP.

An explanation grounded in leadership and preference changes is unpersuasive for at least two more reasons. First, as Tan observes, it infers "the cause of an outcome from the effect itself, implying whatever type of change the leadership desires can and will happen" (Tan, 2021, 91). In effect, it says that if technology extraction increased under Hu and Wen, it must be because Hu and Wen wanted it to increase. This explanation is unsatisfying for the same reason that arguing the MLP caused the revival of industrial policy is – namely, it says nothing of the factors that enable the move from interest to action. To this, one could respond that the leadership transition represented not a change in preferences but in resolve: Hu and Wen succeeded where Jiang and Zhu did not because they were more committed. This, too, is unlikely. By most accounts, Jiang and Zhu were stronger leaders than Hu and Wen, and specifically were better able to discipline the state apparatus (Tan, 2021). Hu and Wen are widely seen as somewhat weaker. As Tan (2021) argues, they struggled in particular to discipline China's most powerful state organ, the NDRC.

Global Value Chains and the Balance of Dependence

Though China overwhelmingly introduces technology extractors in strategic industries, it does not do so evenly. Instead, Chinese authorities largely avoid using these policy tools in a number of sectors which, judging by their clear strategic value and by Chinese leaders' stated beliefs and prior policies, should have been among the most likely targets for tech extraction after WTO entry. Taken alone, enforcement capacity cannot explain this cross-industry variation: The NDRC's approval authority varies over time, but not at the level of individual sectors. What, then, accounts for variation in the prevalence of tech extractors across otherwise similar strategic industries?

I argue that although gains in central enforcement capacity raise China's overall bargaining power with foreign firms, even after controlling for this effect there remain important differences in its bargaining power in particular industries, and by extension its propensity to impose technology extraction policies. These differences derive from what I call the balance of dependence between China and foreign firms. When foreign investors rely more on China as a final market than China relies on them as supplier or employers, I expect this balance to favor China, leading to more intensive use of tech extractors. Alternatively, when China depends more on foreign firms to sustain economic growth than those firms rely on it as a final demand center, I expect the balance to favor investors. In such industries, China will largely refrain from using tech extractors.

In Section 2, I assumed compliance with technology transfer mandates is costly for foreign investors, but that investors are willing to pay some price (including, potentially, compliance with tech extractors) in exchange for access to China's market. Likewise, I assumed that investor expectations about China's future market growth gives Chinese authorities a fairly high baseline level of bargaining power with foreign firms. Against this backdrop, the critical question is under what conditions foreign investors are able to reclaim some bargaining power over China, and in doing so, induce Chinese authorities to limit their use of technology extractors.

My core argument is that industry-level differences in the balance of dependence between China and foreign firms rest fundamentally on China's position in global value chains in a given sector. I expect this balance to favor China in industries in which it primarily sits downstream of GVCs as a final market. In these industries, most of what foreign firms import into China is actually consumed there. This leaves foreign firms dependent – in many cases, heavily so – on Chinese demand. At the same time, because foreign firms in these sectors are primarily engaged in selling *to* rather than exporting *from* China, the latter may rely on them to supply goods and services, but it does not depend on them to drive export growth and associated employment. The result is that foreign firms simultaneously depend on China *and* have relatively few resources they can leverage to "claw back" bargaining power over it. All else equal, this leaves Chinese authorities less constrained in the use of technology transfer mandates.

To illustrate this argument, consider an anecdote from the high-speed rail industry. According to one former employee I spoke with from the American Chamber of Commerce in Shanghai, when China's leaders decided to build out the country's high-speed rail network in the early 2000s, they invited the heads of each of the "Big Four" high-speed rail firms – Siemens, Alstom, Bombardier, and Kawasaki – to China and put them up in adjacent rooms in the state-owned Beijing Hotel. As this person recounted, over the course of a week Chinese officials rotated between the executives' rooms, playing each off the others until they had secured deals involving "maximum technology transfer at a minimum price."[19] China could achieve such commitments precisely because the high-speed rail firms were desperate to capture a piece of what they rightly predicted would be one of the largest infrastructure construction projects in human history. In an industry characterized by large economies of scale and high levels of international concentration, to lose out on the Chinese market would have been a significant blow to each firm's long-term viability.

This anecdote may be partly apocryphal and is likely at least somewhat exaggerated in its details. Nonetheless, it illustrates a dynamic that surfaces frequently in writing about the experiences of foreign firms in China in industries in which the latter is downstream of GVCs as a final demand center. In short, in the years after China's WTO entry, foreign MNEs had powerful incentives to gain a foothold in the Chinese market. Lacking meaningful sources of countervailing leverage over Chinese officials, they typically had little option but to comply with technology transfer mandates

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[19] Interview, Zoom, December 8, 2021

as a condition of market access. As I explore in the case study on aircraft manufacturing in Chapter 7, even within these arrangements foreign firms often worked to limit transfers of the most sensitive technologies to Chinese partners. But that is secondary to the fact that foreign firms in these industries, in compliance with policy requirements, took the costly and risky step of partnering with, training, and licensing some level of technology to local firms.

This dynamic changes significantly, however, when China occupies an intermediate position in GVCs – that is, when most of what it imports in an industry is not finally consumed there, but consists of foreign inputs that are processed locally, assembled into more finished goods, and re-exported back out to consumers in other countries. In these industries, two conditions hold. First, foreign firms depend less on Chinese demand; this follows from the fact that most of what they import into China is not, in fact, consumed there. Second, China in these industries relies heavily on foreign firms and the value chains they govern to guarantee its access to overseas consumer markets, and in turn to sustain export growth and associated employment in China. I argue that this combination of reduced foreign firm reliance on the Chinese market and increased Chinese reliance on foreign firms to fuel export growth shifts the balance of dependence in foreign firms' favor, enabling them to more credibly threaten a costly exit from the Chinese market and more effectively resist technology extractors. The greater China's relative reliance on foreign firms to drive exports and employment, I argue, the less prone Chinese authorities will be to impose tech extractors.

The concept of balance of dependence builds directly on the notion that asymmetries in interdependence variously enhance and constrain actors' ability to secure favorable terms in bargaining situations (Keohane and Nye, 1977). But to develop this claim in the context of tech extraction in China, I look to an earlier work which itself helped inspire Keohane and Nye's discussion of asymmetric interdependence. In his 1945 book *National Power and the Structure of Foreign Trade*, Albert O. Hirschman examines the conditions under which states can exploit trade relations as a source of power and influence over other states. His core argument is that the "relative ease of adjustment after an interruption to trade" determines the credibility of threats to disrupt existing flows, and in turn structures the bargaining relationship between trade partners (Hirschman 1945, 28). When adjustment is equally costly for all parties, it is difficult for any one country to credibly threaten to curtail trade relations with the others. But in the (more realistic) scenario in which adjustment is less painful for one country than for another, the first country can more credibly threaten to interrupt trade in order to extract concessions from the second. The longer and more painful the adjustment process for the second country, Hirschman adds, the more willing it will be to "do *anything* in order to retain their foreign trade," and therefore the greater the bargaining power of the first country (Hirschman, 1945, 17).

Hirschman advances a number of hypotheses regarding what shapes the relative ease or difficulty of adjustment. Most relevant for understanding the relationship between China and foreign firms is his discussion of factors that raise the "length and painfulness of the adjustment process" for exporters relative to importers (Hirschman, 1945, 18). Hirschman admits that in some situations exporters will have lower adjustment costs than importers, for example when one country monopolizes the supply of a good used by many. But in general, he suggests, the reverse will be true. Put simply, this is because the main short-term cost of losing a supplier is higher consumer prices as more expensive alternatives are located, either at home or abroad. By contrast, the key short-term cost of losing a market for exports is increased unemployment until alternative markets arise. The former cost is uncomfortable but generally politically bearable, not least because consumers face steep collective action costs. The latter cost can be catastrophic, both economically and politically. This is especially true, he notes, when factor mobility is low and when export industries, and thus the economic and political fallout from lost export markets, are geographically concentrated in a few politically important regions (Hirschman, 1945, 28).

This same intuition explains why China faces higher adjustment costs, and enjoys correspondingly lower bargaining power, in industries in which it is intermediate to GVCs. Because most of what China imports in these industries is simply processed locally for re-export overseas, not finally consumed in-country, China faces incentives analogous to those of Hirschman's exporter countries. For China's leaders, disruptions to trade and FDI flows in these sectors first and foremost imply lost employment, and only secondarily higher consumer prices. For a regime long ridigly

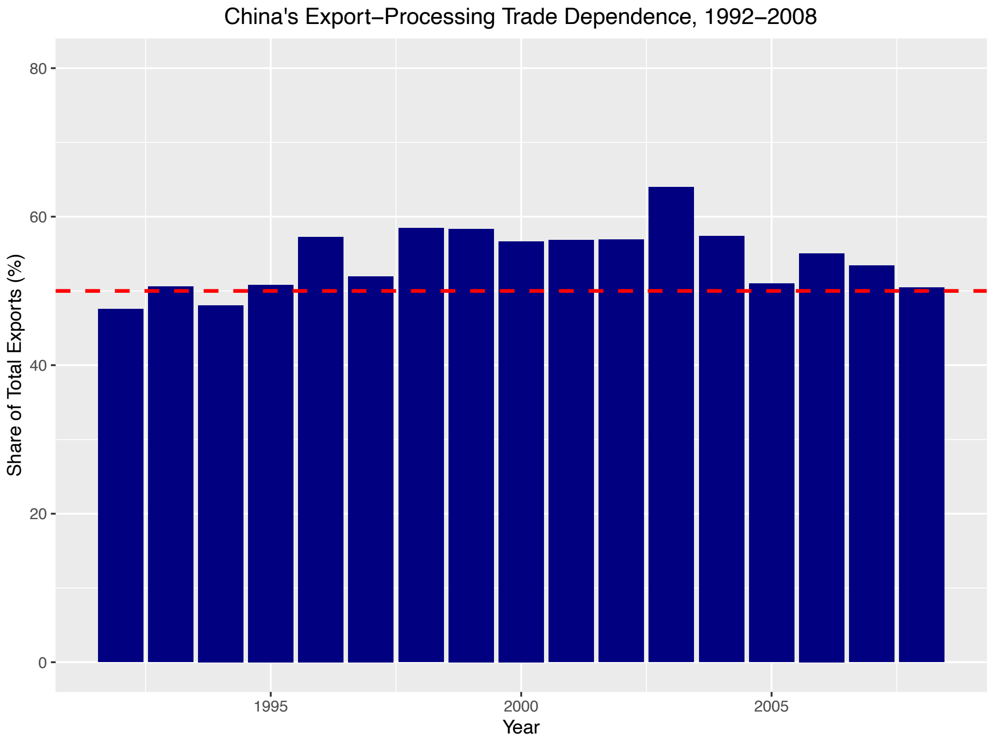

Figure 3.3: **China's Export-Processing Trade Dependence, 1992-2008**: Export-processing trade consistently accounted for more than half of all Chinese exports from 1992-2008, a period during which exports as a share of China's GDP equivalent rose from 13.6 percent to 36 percent. Notably, over this same period China's GDP rose more than ten-fold, from $426 billion to $4.594 trillion, and its share of world goods exports increased from 2.3 percent to 8.9 percent. Sources: UNCTAD, Word Bank, NBS.

committed to a policy of full employment, and which has quite explicitly staked its legitimacy on economic performance, such losses are intolerable (Nathan, 2003). This situation is made worse by the fact that China's export processing trade, and thus employment tied to GVCs, is heavily concentrated in a few wealthy and political sensitive coastal cities and their surrounding regions.

To underscore the scale of China's reliance on, and in turn its vulnerability to exit by, foreign firms in these industries, consider that in the post-WTO period exports as a share of China's gross domestic product (GDP) reached 36 percent, making China's one of the most export-dependent major economies in the world. As Figure 3 shows, during this period, processing trade accounted for over 50 percent of Chinese exports, according to data from the National Bureau of Statistics (NBS). Finally, according to data from China's General Administration of Customs, foreign firms and their local affiliates accounted for over 80 percent of processing trade in China. In short, in the decade after China's WTO accession roughly 14 percent of Chinese GDP depended on foreign firm-controlled value chains servicing overseas customers.

It is hard to estimate the precise number of jobs tied to these activities in China. However, employment data published by the NBS gives some sense of the scale of the problem China would face in the event of major disruptions to export-processing trade. Between 2000-2014, the total number of people employed directly by foreign firms in China rose from 6.4 million (2.4 percent of total urban employment) to 29.5 million (7.5 percent of total urban employment). In 2007, the year after the MLP's launch, foreign firms accounted for 8.8 percent of employment in Beijing, 13.4 percent in Tianjin, and 14.1 percent in Shanghai. In that same year, the micro-electronics industry accounted for 14.3 percent of urban employment in China. Importantly, these figures only capture direct employment tied to foreign firms and electronics manufacturing. This same period saw China's internal migrant labor force swell to well over 200 million, much if not most of which was engaged in jobs either directly or indirectly tied to export-oriented manufacturing. Against this backdrop, there can be little doubt that a disruption to trade and foreign investment in industries closely tied the processing and re-export of foreign inputs would have significant implications for social stability, especially in major coastal cities.

To be sure, even in industries in which China is intermediate to GVCs, its greater relative dependence on foreign firms is just that. Foreign firms in these industries also depend on China for inexpensive labor and high-quality transportation and other export-manufacturing-related infrastructure. Disruptions to trade thus also impose potentially severe costs on these firms, for example forcing them to invest in factories and associated infrastructure in other countries. The key, however, is that firms' reliance on China in these sectors is offset by China's reciprocal reliance on them as employers and as conduits to global consumer markets. In many of these industries, China's final market is – or certainly was during the first decade after WTO entry – fairly small after factoring out consumption related to processing trade, further reducing foreign firms' dependence on China. But even where China's final market is large globally in absolute terms, as in semiconductors, as long as that market is smaller than the market for export-processing trade, then foreign investors will enjoy considerable leverage over China. The crucial point is that although the relationship between China and foreign firms remains interdependent, the more intermediate China is to GVCs, the more likely it is that asymmetries in interdependence favor firms.

To summarize, I expect foreign firms' reduced reliance on China as a final market and China's increased dependence on foreign firms to drive export growth and associated employment to tilt the balance of dependence in favor of foreign firms when China is intermediate to GVCs. Foreign firms in these sectors are better positioned to credibly threaten a costly exit from the Chinese market than are their counterparts in industries in which China is downstream of GVCs. As a result, I expect China to seldom condition market access on technology transfers in these sectors. By comparison, when China is more downstream of GVCs, and thus when most of what it imports is consumed within China, I expect the balance of dependence to favor China. Tech extractors will be most prevalent in strategic sectors that meet this criterion

Alternative Explanations and Scope Conditions

This section addresses four potential alternative explanations for the low incidence of technology extractors in some strategic industries, as well as two scope conditions for the argument. The first alternative explanation suggests the sparing use of technology extractors in industries like semiconductors reflects characteristics of the industries themselves, such as extreme technical complexity and rapid innovation or a high degree of international concentration. Under the first scenario, Chinese officials may conclude that the requirements for "catching up" to the world frontier in highly complex industries characterized by rapid innovation are simply too great for policies like joint venture requirements to be of much use in nurturing domestic capabilities. In the face of foreign investor opposition to these measures, Chinese officials may decide the costs of tech extractors outweigh their benefits in such industries and opt against them.

Technical complexity and the pace of innovation surely help explain variation in the effectiveness of technology transfer policies, but they do not account for the absence of tech extractors to begin with. China uses technology extractors extensively in many industries characterized by significant technical barriers to entry and high rates of investment in R&D, including commercial aircraft manufacturing, satellite and space technologies, advanced telecommunications equipment, and more. Like semiconductor design and fabrication, producing goods like large civil aircraft depends not only on mastering a wide array of discrete and highly complex technical processes, but on building and refining the process knowledge needed to seamlessly integrate these steps into a unified production program. It is by no means clear that making semiconductors is fundamentally more difficult than building large aircraft. And while the rate of innovation in ICs is unusually fast, it is not obvious that innovation is faster in other areas in which China seldom uses technology extractors, such as batteries and precision measurement equipment, than in the above industries.

Second, China's relative bargaining power may depend less on where it sits in GVCs than on the number and size of foreign firms in an industry. According to this view, the fewer and larger the firms in an industry, the lower the barriers to collective action and the greater the resources firms can mobilize to oppose technology transfer requirements. This argument has some merit. Certainly, the largest MNEs can bring enormous resources to bear in lobbying officials at every level of administration in China for favorable policies or treatment. Moreover, as I explore in the commercial aircraft manufacturing case in Chapter 7, there does appear to be a relationship between foreign firms' industry position and the extent to which they engage in meaningful technology transfer *within* their partnerships with Chinese firms, if not the use or non-use of technology extractors in the first place. But this argument faces both empirical and theoretical shortcomings that limit its explanatory power overall. Empirically, it is hard to reconcile with the assertive use of tech extraction policies in a number of globally concentrated industries, including wind turbine manufacturing, high-speed rail, and especially commercial aircraft manufacturing.

Theoretically, although plausible that firms in highly oligopolistic industries will cooperate to mutually forego the Chinese market in a bid to force Beijing to abstain from imposing tech extractors, in practice this is highly unlikely. To the contrary, as soon as the number of producers in an industry exceeds one, foreign firms will quickly find themselves caught in a prisoner's dilemma vis-à-vis China, with each firm facing powerful incentives to defect from cooperation (i.e. agree to share technology) in exchange for an asymmetric advantage in the Chinese market. These incentives will be especially strong in industries characterized by large economies of scale, which characterizes virtually all oligopolistic industries (Milner and Yoffie, 1989; Krugman, 1986).

This is not to suggest variables like technical complexity, IP protectiveness (reflected in measures like patent concentration), and market structure have no impact on foreign firms' willingness to comply with technology transfer requirements. Several of my interviewees cited these factors, along with value chain position, as inputs into bargaining dynamics between China and foreign investors. Crucially, however, these variables struggle to explain wide observed variation in China's use of formal technology transfer policies across otherwise similarly situated industries.

Third, it could be that export controls on dual-use technologies like those agreed to under the Wassenar Arrangement deter China from issuing formal technology transfer mandates in some strategic industries. This is almost certainly not the case. Although China does not use tech extractors often in some technologies covered by Wassenar, such as computers and electronics or navigational equipment, it uses them liberally in others, including aerospace and propulsion technologies, marine systems, sensors and lasers, and telecommunications equipment. Moreover, in the 1990s and early 2000s, American firms lobbied the U.S. government strongly (and to a large extent successfully) for the relaxation of enforcement of export controls in industries like electronics and aerospace.[20] As the aircraft manufacturing case in Chapter 7 shows, the presence of export controls had little impact on the use of tech transfer policies in the post-WTO period.

The fourth potential alternative explanation is that pushback from local governments, not China's position in GVCs, explains why China seldom introduces technology extractors in some strategic industries. Tan (2021) suggests divergent policy priorities between central and local governments explain the persistence of liberal FDI policies in semiconductors during the post-WTO period. Specifically, she argues that the liberalization of FDI policy in semiconductors under Document 18 in 2000 led to increased IC-related foreign investment in cities like Shanghai,

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[20] Steven Greenhouse, May 25, 1991, "U.S. and Allies Move to Ease Cold War Limits on Exports," *The New York Times*, Retrieved May 4, 2023 (Available at: *https://www.nytimes.com*).

which in turn lobbied against the imposition of investment controls that might stem future foreign investment. This local opposition “meant that the central government found its ability to advance its priorities on technological upgrading to be substantially weakened” in ICs (Tan, 2021, 135).

In fact, this argument is broadly consistent with my own, which emphasizes the export growth and employment dependencies fostered by China’s position in GVCs but is agnostic regarding the precise mechanism(s) by which those dependencies induce central authorities to refrain from issuing tech extractors. As Tan suggests, local officials’ opposition to FDI restrictions in semiconductors stemmed from their “rank promotion imperative,” which led them to prioritize “short-term output and employment maximization” over technological upgrading (Tan, 2021, 121). Whether opposition from local officials is the sole pathway by which growth and employment concerns reach central policymakers or is one of many pathways (including, for example, direct lobbying of central authorities by foreign MNEs), all that matters for my theory is that the decision not to issue tech extractors be rooted in *growth and employment* concerns, and not some other motive. My argument linking such concerns to GVC position has the added benefit of helping explain the *persistence* of tech extractors in other industries in which foreign firms also provide significant concentrated urban employment, such as aircraft manufacturing and automotive production. The difference, I argue, is that in these industries almost everything foreign MNEs import into in China is ultimately consumed within China, bolstering its leverage over foreign investors.

Finally, it is worth briefly discussing two potential conditions on the scope of the argument about GVC position and the balance of dependence. In theory, this balance could favor China in industries in which it is both intermediate to production networks *and* for all intents and purposes non-substitutable as a production base. In these cases, although China would still depend on foreign firms to drive export growth and employment, foreign firms’ reciprocal reliance on China as an export-processing hub could plausibly outweigh this dependence, giving China relatively more leverage. This dynamic arguably characterizes the relationship between Apple and China in recent years, and has led some observers to question whether Apple could feasibly extricate itself from

China.[21] In response to this, I would highlight two points. First, the Apple case, while fascinating and important, is extreme. No other major foreign electronics firm is anywhere near as dependent on Chinese manufacturing and assembly. Second, although Apple (via Foxconn) has assembled devices in China since 2001, its acute reliance on the Chinese manufacturing and supply ecosystem is very much a function of the 2010s. (The first iPhones and iPads were released in 2007 and 2010, respectively). Generalizing from Apple, the implication is that my argument about GVC position and bargaining power may not apply in some industries after approximately 2015. But if China's comparative advantages are now so great as to make it effectively irreplaceable as an export-processing hub in some sectors, this was almost certainly not yet the case during the peak years for China's use of tech extractors.

The second scope condition is the mirror image of the first. Regardless of its position in GVCs, China may lack leverage to impose tech extractors on highly-differentiated (i.e. non-substitutable) goods over which one foreign firm enjoys a complete and durable monopoly – that is, for which barriers to entry are sufficiently high to make it effectively impossible to find short-term substitutes. However, goods of this sort that are also strategic assets in which a state like China's would pursue technology extraction are exceptionally rare. Even in semiconductors, only one segment of the industry – extreme ultraviolet lithography (EUV) – is a true monopoly at present. Other segments of semiconductor supply chains, while quite concentrated, are no more so than aircraft manufacturing, in which China has imposed more tech extractors than any other single industry.

The Fall of Technology Extractors

No less dramatic than the rise in the number of technology extractors in place after 2006 was their collapse after 2014-2015. In that year, China imposed a total of 291 distinct tech extraction policies, down somewhat from the peak of 339 in 2012 but still significant. By 2018, the total had fallen to 11. Two years later, only 4 formal tech extractors remained in place. What explains this decline?

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[21] McGee, Patrick. 2022. "How Apple Tied Its Fortunes to China," *Financial Times*. Retrieved January 21, 2023 (Available at: *https://www.ft.com*).

Why was the rise of tech extraction policies in the wake of China's WTO accession so short-lived?

I argue that although the decline of technology extractors after 2015 is closely related to their rise after 2006, the reasons for this decline are unrelated to those behind the rise. That is, gains in central enforcement capacity caused the surge in technology extraction efforts in the post-WTO period, but it was not corresponding losses in enforcement capacity that drove their collapse after 2015. As such, the fall of tech extractors, understood as formal policies that openly condition access to China's market on foreign firms' willingness to partner and share technology with Chinese businesses, lies outside the scope of my theory about the rise of these policy tools.

Nonetheless, this phenomenon merits attention for several reasons. To begin, to the best of my knowledge the decline in China's use of formal technology transfer policies after 2015 has yet to be documented in the scholarly or policy literatures. Moreover, given that concerns over "forced" technology transfer were central to the Trump administration's official rationale for its trade war with China, it is surprising and even puzzling that Chinese authorities had largely ceased to use formal technology extractors well before the trade war began. Finally, examining the causes behind the decline in technology extractors draws attention to, and helps explain, China's simultaneous efforts to substitute away from formal technology extractors in favor of alternative, and less easily policed, means to secure foreign technology and expertise.

Simply put, I argue that China abandoned technology extractors after 2015 because the costs of these policy tools, in the form of credible threats of reciprocal restrictions on trade with and investment from Chinese firms by key trade partners, had begun to outweigh their utility for industrial upgrading. Three developments led China's leaders to this conclusion. First, by 2014-2015, China had made impressive progress towards the world technological frontier in many of the sectors in which it had pursued tech extraction most intensively following WTO entry. As a result of this progress, technology extractors lost much of their original utility in these sectors.

Second, as Chinese firms became more competitive in high value-added sectors like high-speed rail and wind and solar energy, they sought to expand into overseas markets, including establishing operations in major trade partners like the United States and Western European countries.

Though partly or even largely driven by firm-level commercial interests, this overseas expansion received a significant boost from the "Go Out" campaign, a semi-official Chinese state initiative to encourage outward FDI by Chinese firms, which took off around 2013-2014. It also coincided with an increase in state support for outward investment in ICs and other high-tech industries as a means to acquire cutting-edge foreign technology and expertise, most notably with the creation of a National IC Fund in 2014. The net effect of these actions was a remarkable increase in the scale of outbound Chinese FDI between 2013-2017, as well as a shift in the composition of Chinese investment from a strong focus on mineral fuels and towards the sorts of high value-added industries where technology extractors predominated in China.

Finally, starting in 2008-2009 and accelerating after 2012-2014, the combination of persistent restrictions on foreign access to the Chinese market and explosive growth in Chinese outward FDI provoked increasingly vocal opposition to technology extractors from foreign governments, in particular the United States. As foreign governmental pressure to remove tech extractors mounted, so too did the risk of reciprocal restrictions on trade with or investment from Chinese businesses. Precisely because of its explosive growth, after 2014 the prospect of restrictions on Chinese outward FDI into markets like the United States became far more costly and threatening than it would have been a few years earlier. Heightened U.S. scrutiny of investment from China after 2014 made this threat not only costly, but credible. Given the declining utility of formal technology extractors for domestic industrial upgrading and the large and growing importance of maintaining access to foreign markets for Chinese FDI, China's leaders rationally concluded that these policy tools had served their purpose in most industries. As a result, after 2015 China eliminated them *en masse*.

Importantly, the decline of technology extractors did not always herald the end of Chinese technology acquisition efforts, just as the absence of these tools in sectors like ICs in the wake of WTO entry did not mean China stopped pursuing technology transfers in them. Though there is reason to believe Chinese efforts to "trade the market for technology" did decelerate in some industries with the fall of technology extractors, it is also clear that in other industries foreign firms continued to face enormous pressure to partner and share technology and expertise with Chinese firms in exchange for market access. The main difference is that in the era of technology extractors, such pressures were often (though not always) conveyed openly in the form of overt mandates that foreign investors enter into JVs with or source from Chinese firms. With the fall of technology extractors, these inducements were increasingly conveyed informally.

Research Design

To evaluate my theory's main claims, I adopt a multi-method research design that combines statistical analysis of an original dataset on technology extractors with detailed qualitative case studies of Chinese tech extraction behavior in three strategic industries: wind energy, semiconductors, and commercial aircraft design and manufacturing. I use a multi-method research design because this approach helps to maximize both the internal and external validity of my findings. Given that China employs hundreds of tech extractors across over one hundred distinct industries during the post-WTO period, it is hard to be confident in the generalizability of inferences based on a few cases, no matter how well chosen. At the same time, statistical analysis allows me to estimate relationships between variables of interest across a large number of observations, but it is less well-suited to evaluating mechanisms. The appeal of a multi-method research design is that it lets me take advantage of the strengths of each method while compensating for its shortcomings.

Chapter 4 describes the quantitative empirical portion of my research design at length, so I do not elaborate it in detail here. To preview, the chapter leverages statistical tools to examine my arguments about the rise of technology extractors after 2006 and the relationship between bargaining power and China's propensity to impose these measures in strategic industries. I do this using an original dataset on the three policy instruments that conform to the definition of technology extractor developed in Chapter 2: (1) Formal joint venture requirements and other ownership restrictions on inward FDI, (2) explicit local content requirements, and (3) preferential government procurement policies. The first part of Chapter 4 describes the steps I took to create this dataset. I first describe how and from what sources I collected data for and constructed my measure of the outcome variable, industry-year variation in China's use of technology extractors. I then detail the procedure I used to measure and code my main explanatory variables of interest: the strategic status of an industry, temporal variation in central enforcement capacity, and industry-level variation in China's position in global value chains. The final dataset covers the universe of technology extractors in China from 1995-2020.

In the second part of Chapter 4, I use this dataset to test three hypotheses derived from my theory. The first is that China uses technology extractors in strategic industries more often than in non-strategic ones. The second is that China's use of technology extractors in strategic industries (relative to non-strategic ones) increases after 2006. The third hypothesis is that as the share of Chinese imports associated with processing trade rises, China's propensity to impose tech extractors in strategic industries will decline. Using both descriptive and statistical analysis, the chapter provides strong evidence that top-down strategic interests drive China's pursuit of technology extraction, and that this relationship is robust to various measures of bottom-up interest group pressures. Likewise, I demonstrate that China is substantially less likely to employ technology extractors in strategic industries as the share of imports associated with processing trade rises. I further show that this relationship is robust to controlling for market size, various measures of product type, and to the use alternative measures of the outcome and explanatory variables.

The rest of this section describes how I structure the qualitative empirical portion of the dissertation, which consists of case studies of Chinese technology transfer policy in the wind energy, semiconductor, and commercial aircraft sectors in Chapters 5 through 7, respectively. The case studies have two main objectives. The first objective is to evakuate my arguments about variation over time in decisions to introduce and remove technology extractors. Specifically, I want to examine my claims that (1) increased central enforcement capacity leads to more intensive technology extraction efforts in strategic industries, but only when China sits downstream of GVCs, and (2) the risk of reciprocal controls by major trade partners on Chinese trade and FDI leads China to remove technology extractors in most industries after 2015.

To evaluate these arguments, I adopt a "before and after" controlled comparison research design, in which the researcher leverages variation over time within a single case to assess relationships between variables of interest. The great advantage of a "before and after" design, relative to comparison across cases, is that it allows researchers to hold constant many observed and unobserved confounders by focusing on a single industry. In doing so, it allows for more precise evaluation of causal claims (George and Bennett, 2005). The "before and after" approach is especially well-suited to my research objectives because my study period is fairly cleanly divided by the "shock" of administrative restructuring and the rise of the NDRC.

The second main objective of the case studies is to test my argument about variation across industries in Chinese decisions to introduce technology extractors. Specifically, I want to examine the argument that China's position in GVCs is the key factor behind decisions not to use technology extractors in otherwise strategic industries. To do this, I combine within-case analysis of technology extraction in individual industries with cross-case comparisons, treating each case as one observation in a three-case comparative analysis. To maximize inferential leverage from the cross-case comparison, I must be careful to select cases that adequately capture variation in my key variables of interest. Below, I describe my case selection strategy in greater detail. I then briefly discuss the methods of inference I use in the case studies.

Case Selection

Three main criteria guided my case selection. First and foremost, I wanted to ensure the cases capture the full range of variation on my outcomes of interest. The first and most important outcome of interest for my theory is the introduction of tech extractors. To guard against the risk of biased inferences due to selecting on the dependent variable, it was important to examine at least one industry in which China pursued technology extraction intensively and at least one industry in which it used these policy tools sparingly, if at all. In addition to my theory's core predictions about the introduction of technology extractors, I also wanted to test the argument linking increased Chinese competitiveness to the decline of technology extractors. This required selecting at least one case in which China introduced and later removed tech extractors, and one in which it introduced technology extractors but did not remove them, or did so later.

Second, it was important that the cases exhibit sufficient variation on China's bargaining power, which is the key variable in my theory for explaining cross-industry variation in the use of technology extractors in strategic industries. This meant selecting at least one case in which China processed and re-exported almost everything it imported during the study period, and therefore occupied an intermediate position in GVCs, and at least one in which it ultimately consumed the vast majority of imports at home. For the case studies, I chose to examine only industries that qualify as strategic by the definition developed in Section 4. Not only are these industries more substantively important for understanding contemporary Chinese political economy, but holding this variable constant allows me to more precisely estimate the impact of variation in bargaining power. In the quantitative empirical analysis in Chapter 4, I briefly discuss a few of the rare non-strategic industry-years in which China introduces these measures.

Finally, to maximize the generalizability of the findings, it was important to select cases which, taken together, provided a broad portrait of the Chinese economy. For example, if I only examined technology extraction in microelectronics industries, this might raise concerns that any inferences made would not apply in other similarly strategic but substantively different industries such as transportation and energy. I was thus careful to select industries from different sectors.

Guided by these criteria, I chose to study the wind energy, semiconductor design and fabrication, and civil aircraft design and manufacturing industries. The wind power industry, which I examine in Chapter 5, provides an important test of the theory because it has positive values my independent variables of interest. It is a strategically important industry in which China sits downstream of GVCs and in which the domestic Chinese industry matures greatly over the course of the study period. As such, tech extraction behavior in wind energy should conform closely with my theory's predictions. The wind industry also offers ideal conditions to "horse race" my argument about the strategic motives behind Chinese tech extraction against the alternative explanation that bottom-up interest group demands for state support drive this behavior. If interest group pressures explain when China pursues technology extraction, then the wind industry would be among the *least likely* targets for these policy tools. This is because prior to the imposition of technology extractors, China's domestic wind energy industry was virtually non-existent. As such, it lacked any clear constituency to lobby the central state for conditional market access restrictions.

In Chapter 6, I investigate the near absence of technology extractors in semiconductors during the post-WTO period. The IC industry provides a powerful test of the theory's predictions because, based on the sector's incontestable strategic importance as well as the previous actions and stated goals of China's top leaders, semiconductors should have been among the *most likely* targets of technology extraction efforts. Joint ventures between foreign chip makers and domestic firms handpicked by China's top leaders were integral to semiconductor industrial policy starting in the early 1980s, and Chinese authorities did not hide that the core aim of such "arranged marriages" was to facilitate technology transfer. Moreover, from the vantage of interest group models, semiconductors should have been among the *most likely* targets for technology extraction. As of the late-1990s, China's IC industry consisted a small number of large, politically well-connected, import-competing state-owned enterprises (Fuller, 2016). This is precisely the kind of actor interest group approaches expect to push hardest and most successfully for protection. Yet, China never once issued JV mandates or other ownership restrictions on inward FDI in ICs, nor did it introduce explicit local content requirements in the industry. Indeed, China used these policy tools in almost every industry named in the MLP as a target for "indigenous innovation" support *except* semiconductors. And although Chinese authorities did issue preferential government procurement policies in ICs after 2009, they did so to a much lesser extent than other high-tech and high value-added sectors. Against this backdrop, the IC industry offers a crucial test of the argument that strategic importance alone does not guarantee China's use of technology extractors. As I explore in the chapter, the semiconductor case provides strong support for my hypothesis that weak bargaining power due to GVC position constrains the pursuit of technology extraction in otherwise strategic industries.

Finally, Chapter 7 explores Chinese technology extraction efforts in the aircraft manufacturing. Like wind energy, commercial aircraft production is a strategic industry in which China sits comfortably downstream of GVCs. As such, it should conform to my theory's prediction that China will pursue technology extraction intensively in strategic industries in which it enjoys substantial bargaining power over foreign investors. Unlike wind energy, where in the span of less than a decade China's domestic industry went from virtually non-existent to a leading source of manufacturing innovation globally (Nahm, 2021), China has struggled to "catch up" to the world frontier in commercial aircraft design and manufacturing China. As such, the industry provides a useful test of my argument about the causes behind the decline in technology extractors. If foreign opposition to tech extractors is fiercest in sectors where China is increasingly competitive, then we might expect pressure to remove these tools to be lightest in industries like aircraft manufacturing, where China has made less progress.

In addition, I use the aircraft manufacturing case to extend the project beyond its core focus on the decision to use or not use tech extractors to instead examine variation in the "effectiveness" of these policies – that is, whether they lead to meaningful technology transfer – within industries in which China uses these policies liberally. Through close analysis of the varied experiences of four foreign aircraft manufacturers in China, I show that market structure and firms' position therein shapes their willingness to transfer technology to Chinese partners. The analysis sheds light on more granular dynamics of bargaining over technology between China and foreign firms. In doing so, it sheds new light on the question of when and why technology transfer policies work.

Methods of Inference

I use two methods, congruence testing and process tracing, to evaluate the conditions under which China introduces and removes technology extractors in my three case studies. I use congruence tests to determine whether the observed values of the explanatory and outcome variables support my theory about the motives behind and constraints facing China's pursuit of technology extraction, as compared to several candidate alternative explanations. Congruence testing provides a "first cut" assessment of my theory's performance, but it does not allow me to test the mechanisms that link variation in the explanatory variables to the observed outcomes. Process tracing helps to fill this gap. My theory, interest group models, and the "fragmented authority" heuristic make different predictions about the motives and decision-making procedure behind the use of technology extractors. Likewise, my theory's expectations about the timing of the increase in technology extraction differ somewhat from those of other recent accounts of the revival of Chinese industrial policy during the Hu-Wen administration. By tracing the decision processes behind technology extraction in individual industries, I can more precisely evaluate the persuasiveness of my theory's causal mechanisms relative to other approaches.

Conclusion

This chapter outlined a theory of the motives behind and constraints facing Chinese technology extraction efforts. The aim of the theory is to explain two important and previously unexamined forms of empirical variation in China's use of technology extractors. First, the prevalence of these policy tools rose to unprecedented heights in the decade after WTO entry, and in particular following the launch of the MLP in 2006, only to collapse in equally dramatic fashion after 2015. Second, within the broad-based surge in technology extraction efforts after 2006, there is puzzling cross-industry variation in China's propensity to issue tech extractors. Specifically, although China overwhelmingly introduces these tools in high value-added and high-tech industries, it largely refrains from using them in several industries which, based on these industry characteristics as well as Chinese authorities' prior actions and stated goals, should have been among the most likely targets for technology extraction after WTO entry.

My core argument is that top-down national and regime security concerns lead China to pursue technology extraction in "objectively" strategic industries, but that China is constrained in using these measures by its bargaining power with foreign investors. I expect China's bargaining power to be highest when central enforcement capacity is high and when China is downstream of global value chains as a final consumer. When both conditions are met, I expect China to pursue technology extraction intensively in strategic industries. By contrast, when China is intermediate to GVCs, and therefore dependent on foreign firms as sources of employment and as gatekeepers to overseas markets, I expect the balance of dependence between China and foreign investors to tilt in favor of the latter. In such industries, China will be reluctant to use technology extractors, even when central enforcement capacity is high and the industry is of great strategic value.

In the following four chapters I test this theory. In Chapter 4, I use descriptive and statistical analysis of an original dataset to examine the relationship between a sector's strategic status, gains in central enforcement capacity, and position in GVCs, on the one hand, and the rise and cross-industry variation in the use of technology extractors, on the other. Chapters 5 through 7 use within-case analysis and cross-case comparisons to provide an additional test of the theory's predictions, to examine the causal mechanisms behind it, and to assess the theory's performance relative to prominent candidate alternative explanations.

Chapter 4

Analyzing Chinese Technology Extraction

Introduction

The previous chapter developed a theoretical framework to explain variation over time and across industries in China's use of *technology extractors*, defined as policies that condition foreign access to the Chinese market on transfers of technology and expertise to local firms. I proposed that top-down national power and regime security concerns lead China to pursue technology extraction in strategic industries, but that China is constrained in using these tools by its bargaining power over foreign firms. The greater China's bargaining power in a given strategic industry, the more likely it will be to impose technology extractors. The weaker its bargaining power, the less likely it is to issue these policies, even in the most strategically vital high-technology industries.

Chapter 3 further disaggregated China's bargaining power into two main variables. The first is the enforcement capacity of China's central party-state. The second is China's position in global value chains (GVCs) in a given industry. I argued that increases in central enforcement capacity bolstered China's bargaining power in general, leading to increased Chinese technology extraction efforts across strategic industries. However, I predicted China would impose fewer tech extractors in strategic industries in which it occupies an intermediate position in GVCs. When China is primarily a hub for processing imported foreign inputs and re-exporting them (as more finished goods) overseas, it relies more on foreign firms and overseas markets to drive economic growth and employment within China than foreign firms depend on it as a final demand center. As a consequence of this dependence, China will generally refraing from using policies that risk provoking exit by foreign firms and backlash from trade partners in these sectors. By contrast, China will pursue tech extraction intensively in strategic sectors in which it sits downstream of GVCs, and is thus less dependent on foreign firms and overseas markets to drive growth and employment.

This chapter evaluates these arguments through statistical analysis of an original industry-level dataset on technology extractors in China from 1995-2020. It demonstrates three core findings. First, China uses these policy tools much more often in strategic industries than in non-strategic ones. Second, China's use of tech extractors in strategic industries increased meaningfully in the wake of administrative reforms that enhanced Chinese central enforcement capacity after 2006. Third, when most Chinese imports in an industry consist of foreign inputs to be processed locally and re-exported overseas, the marginal effect of an industry's strategic importance on China's propensity to use tech extractors declines significantly. Put another way, the relationship between strategic importance and Chinese use of technology extractors is largely conditional on where China sits in global production networks. When China is downstream of GVCs as a final market, there is a strong positive association between the strategic status of an industry and the use of tech extractors. But as China becomes more intermediate to GVCs, that relationship largely vanishes.

The chapter proceeds as follows. Section 2 describes the steps I took to collect data for and construct measures of my variables of interest. Section 3 provides a first look at the final dataset itself. Section 4 outlines several testable hypotheses based on my arguments and summarizes how I test them. In section 5, I summarize key results from the statistical analysis and discuss a range of tests I conducted to evaluate the robustness of the findings. Section 6 briefly concludes.

Data Collection and Measurement

Political scientists and policymakers alike should want to understand when and how China uses the policy tools I label technology extractors for at least two reasons. To begin, these policy tools, far more than tariffs and other conventional market barriers, are what foreign firms that invest and operate in China actually care about. This much is readily apparent in the documents that outlined the U.S. government's underlying rationale for imposing trade sanctions on China in 2018. For example, the March 2018 United States Trade Representative (USTR) Section 301 Investigation Report, which was widely credited with launching the U.S.-China trade war and is largely based on public and private consultations between the USTR and American businesses and industry associations, discusses technology transfer and joint ventures no fewer than 229 and 81 times, respectively. By comparison, it refers to "tariffs" four times, never discusses import quotas or other standard non-tariff barriers, and makes virtually no mention of the U.S.-China trade balance. Given this, any account of the trade war's origins that does not examine the distributional consequences of technology transfer policies, and in turn their impact on foreign firms' political behavior vis-à-vis both China and their home states, will be incomplete (Davis and Wei, 2020).

The stakes of knowing how China has used these policy tools arguably extend well beyond China and the U.S.-China relationship, however. Technology extractors in many ways exemplify the kind of barriers to "deep economic integration" the reduction of which has replaced the battle against tariffs as the organizing principle of international trade policy in recent decades (Rodrik, 2018). Importantly, tech extractors share characteristics that distinguish them even from other so-called "deep" or "disguised" barriers, which, though by design harder to monitor than "at the border" barriers like tariffs, nonetheless have much the same effect: To deter foreign competition. By contrast, tech extractors are not only compatible with foreign market entry, but in many cases actively incentivize it. Indeed, China explicitly encourages inward FDI in 60 percent of industries in which it issues JV mandates. Like other deep barriers, technology extractors help create an uneven playing field between foreign and domestic firms. But they do so in a peculiar and theoretically significant way: by exploiting foreign firms' short-term interest in China's market for their help in fostering domestic capabilities in the longer run. As such, these measures stand at the threshold between trade and industrial policy and illustrate how the former can be made to serve the latter. As governments in wealthy and poorer countries alike re-embrace industrial policy (in no small part in response to China's actions), understanding these dynamics will be more important than ever.

Despite this, to-date there has been no systematic effort to document and quantitatively analyze variation across industries and over time in China's use of technology extractors. A number of earlier works in the Chinese politics literature examine one or more of the policy tools I label technology extractors, but they do so qualitatively and with a focus on specific industries or time periods. Pearson (1992) offers a lucid account of the origins and evolution of joint venture policies in early post-Reform and Opening China. Likewise, the essays in Zhou, Lazonick and Sun (2016) explore Chinese efforts to "trade the market for technology" in automotive manufacturing, high-speed rail, telecommunications, and more. Meanwhile, other scholars have studied the use of JVs, local content requirements, and government procurement in wind energy (Lewis, 2012; Nahm, 2021), semiconductors (Tan, 2021; Fuller, 2016; Mays, 2013), and at the local level (Mertha, 2005*a*). This is to say nothing of the sizable policy literature on Chinese technology transfer efforts (Hannas, Mulvenon and Puglisi, 2013; Hannas and Tatlow, 2020; McGregor, 2011). But none of these works attempt to systematically measure or evaluate China's use of these policy tools.

In part, this gap reflects the daunting empirical challenges to doing so. Off-the-shelf data sets on tariff and non-tariff market barriers either do not include tech extractors or measure them at far too high a level of aggregation to be useful. Nor do Chinese authorities record them in any organized way. Constructing a measure of technology extractors therefore requires locating, collecting, and manually analyzing hundreds of pages of Chinese-language laws and regulations. Not only is this process time- and labor-intensive, but because almost all of these documents only exist in Chinese, it requires Chinese language facility. Against this backdrop, it is not surprising that previous work has eschewed systematic measurement of these policy tools and instead focuses on technology transfer efforts in one or a handful of sectors.

The remainder of this section outlines the steps I took to construct my industry-level dataset on technology extractors, as well as my measures of other key variables of interest. I use this dataset in sections 3 through 5 to examine the relationship between strategic importance, China's position in GVCs, and variation in Chinese technology extraction behavior.

Measuring Technology Extractors

Fundamentally, I am interested in explaining when, why, and how China's central party-state has sought to secure transfers of technology and expertise from foreign investors to Chinese enterprises in the post-Cold War and post-WTO periods. This implies at least two conditions on the scope of policies and behaviors I study. First and foremost, it suggests a focus on policies issued by central state agencies. As has been widely documented, the interests of sub-central authorities often do not align with those of China's central state (Shirk, 1993; Montinola, Qian and Weingast, 1995; Mertha, 2005*b*). As such, sub-central policies do not reliably reflect the industrial policy goals of the central party-state.

Second, it suggests an emphasis on policies that are codified in publicly issued laws and regulations, as opposed to purely informal behaviors such as verbal inducements or threats. Beyond being difficult to measure in a systematic fashion, such behaviors provide little information about China's bargaining power over foreign firms because, unlike formal policies, there is no clear "cost" associated with them. At any rate, as I discussed in Chapter 2, the available evidence suggests that most informal bargaining over technology transfer takes place within formal arrangements, so the latter provide a reasonable, if necessarily imperfect, guide to the distribution of the former.

Based on these conditions, I focus my analysis of Chinese technology extraction on three policy tools which formed the backbone of the Chinese central state's efforts to "introduce, digest, absorb, and re-innovate" foreign technology in the post-WTO period: (1) Joint venture requirements and other formal ownership restrictions on inward foreign direct investment (FDI); (2) explicit local content requirements; and (3) policies that link preferential treatment in government procurement to whether or not products are made by Chinese-invested firms or contain Chinese intellectual property. I created my measure of industry-year variation in China's use of these tools based on formal laws and regulations issued by Chinese central-level agencies. I draw these documents from two main sources: (1) Official websites of Chinese central state agencies, and (2) The Peking University Center for Legal Information's Laws and Regulations Database (LRD). LRD is a comprehensive and widely-used repository of laws and regulations published by Chinese state entities since 1949 (Tan, 2021, 2020; Jaros and Tan, 2020).

Foreign Investment Ownership Restrictions

I draw data on ownership restrictions for inbound FDI from the Foreign-Invested Industry Guidance Catalogue (外商投资指导目录) and the Special Administrative Measures on Foreign Investment Access (外商投资准入特别管理措施), commonly known as the 'Negative List' (负面清单). The Catalogue was the authoritative regulation on inward FDI into China from 1995-2017, after which it was replaced by the more streamlined Negative List. The Catalogue is divided into three sections listing industries in which FDI is 'encouraged' (鼓励), 'restricted' (限制), and 'forbidden' (禁止), respectively. In addition to sorting industries into these three categories, the Catalogue also included industry-specific ownership restrictions. The precise language of these restrictions changes over time. For example, prior to 2002, the Catalogues do not explicitly reference equity or cooperative JVs, instead using phrases like "wholly foreign-owned operations not allowed" (不允许外商独资经营) or "the Chinese party must hold a controlling position" (中方控股或占主导地位). Given the limited number of alternative ownership structures at the time, however, these conditions for all intents and purposes required the formation of equity or cooperative joint ventures.[1] After 2002, the two most common restrictions are explicit JV requirements (限于合资，合作) and variations on the mandate that Chinese companies retain a "controlling stake" in foreign-invested projects. Using FDI Catalogues from 1995-2017 and Negative Lists from 2018-2020, for each ownership restriction I recorded the type of restriction, the year issued, and Chinese-language industry description.

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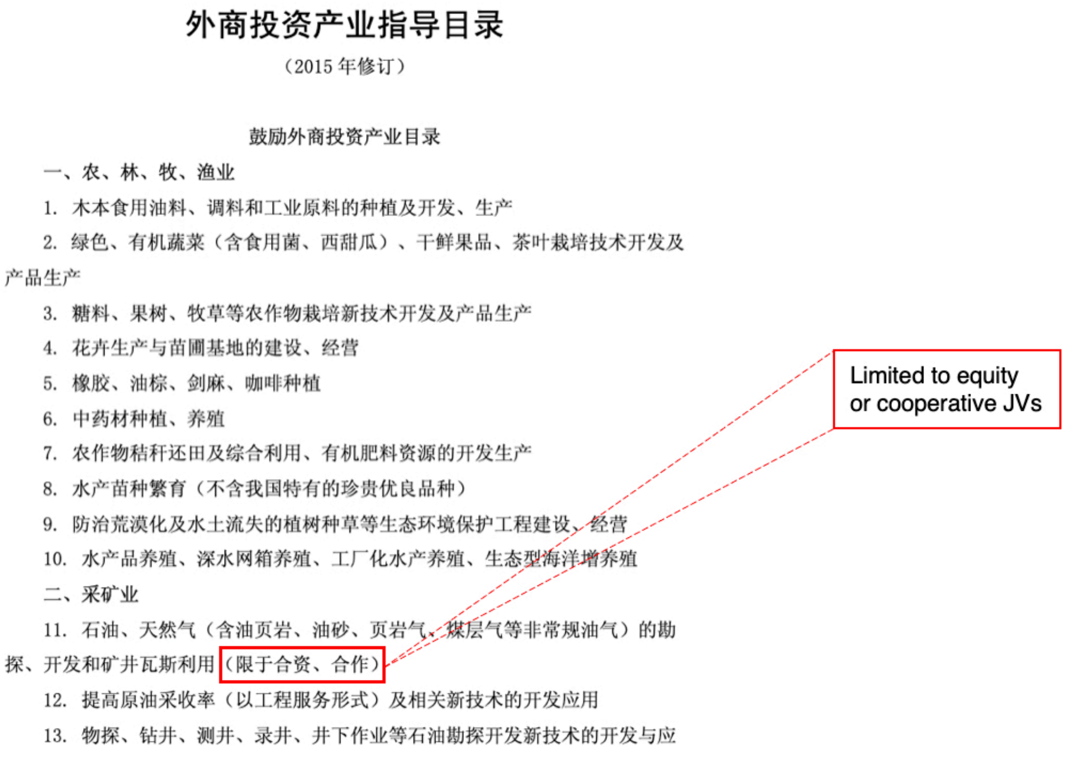
[1] In 1995, China authorized a third ownership structure for foreign-invested firms, called Foreign Investment Companies Limited by Shares, or FICLIBS, but as of 1999 only 18 such companies had been formed.



外商投资产业指导目录

（2015 年修订）

鼓励外商投资产业目录

一、农、林、牧、渔业

1. 木本食用油料、调料和工业原料的种植及开发、生产

2. 绿色、有机蔬菜（含食用菌、西甜瓜）、干鲜果品、茶叶栽培技术开发及产品生产

3. 糖料、果树、牧草等农作物栽培新技术开发及产品生产

4. 花卉生产与苗圃基地的建设、经营

5. 橡胶、油棕、剑麻、咖啡种植

6. 中药材种植、养殖

7. 农作物秸秆还田及综合利用、有机肥料资源的开发生产

8. 水产苗种繁育（不含我国特有的珍贵优良品种）

9. 防治荒漠化及水土流失的植树种草等生态环境保护工程建设、经营

10. 水产品养殖、深水网箱养殖、工厂化水产养殖、生态型海洋增养殖

二、采矿业

11. 石油、天然气（含油页岩、油砂、页岩气、煤层气等非常规油气）的勘探、开发和矿井瓦斯利用（限于合资、合作）

12. 提高原油采收率（以工程服务形式）及相关新技术的开发应用

13. 物探、钻井、测井、录井、井下作业等石油勘探开发新技术的开发与应

Limited to equity or cooperative JVs

Figure 4.1: **Foreign Investment Catalogue (2015 Revision)**: An image of the first page of the 2015 revision of the Foreign Investment Catalogue. A requirement that foreign investors in oil and gas industries form equity or cooperative joint ventures with Chinese firms is highlighted in red.

I coded industries by manually matching industry descriptions in the Catalogues to descriptions in the Chinese Standard Industrial Classification (CSIC) system. In many cases, industry descriptions in CSIC and the Catalogues and other laws and regulations use identical Chinese-language terms. This facilitates reliable matching by reducing coder discretion and uncertainty. Moreover, the 2017 revision of CSIC has been harmonized with the International Standard Industrial Classification (ISIC, Revision 4), and thus can be easily merged with other economic data. All industries are coded at the CSIC/ISIC 4-digit, or most granular, level. Altogether, I identified 237 unique ownership restrictions spanning 92 (of 420) ISIC 4-digit industries across 8 Catalogues and 2 Negative Lists from 1995-2020 (1997, 2002, 2004, 2007, 2009, 2011, 2015, 2017, 2018, 2020), for a total of 1,234 industry-years.[2]

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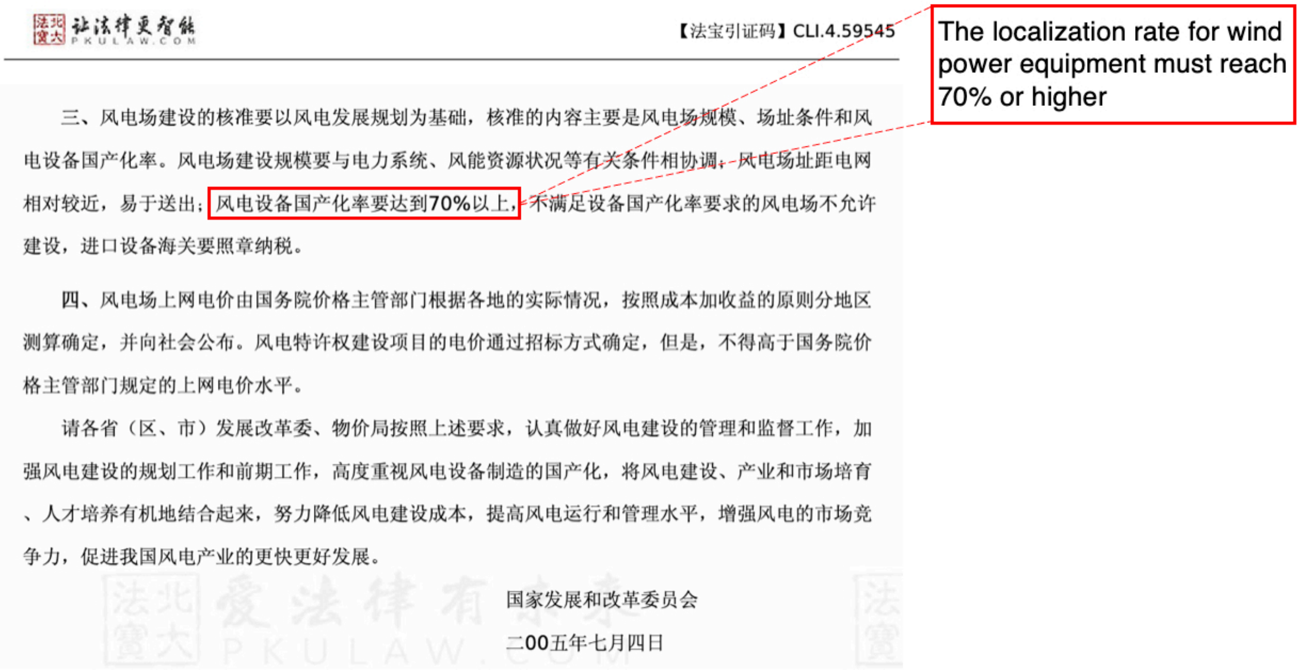
[2] For a more detailed discussion of my coding procedure, with examples, see Appendix A.

Local Content Requirements



【法宝引证码】CLI.4.59545

三、风电场建设的核准要以风电发展规划为基础，核准的内容主要是风电场规模、场址条件和风电设备国产化率。风电场建设规模要与电力系统、风能资源状况等有关条件相协调，风电场址距电网相对较近，易于送出；风电设备国产化率要达到70%以上，不满足设备国产化率要求的风电场不允许建设，进口设备海关要照章纳税。

四、风电场上网电价由国务院价格主管部门根据各地的实际情况，按照成本加收益的原则分地区测算确定，并向社会公布。风电特许权建设项目的电价通过招标方式确定，但是，不得高于国务院价格主管部门规定的上网电价水平。

请各省（区、市）发展改革委、物价局按照上述要求，认真做好风电建设的管理和监督工作，加强风电建设的规划工作和前期工作，高度重视风电设备制造的国产化，将风电建设、产业和市场培育、人才培养有机地结合起来，努力降低风电建设成本，提高风电运行和管理水平，增强风电的市场竞争力，促进我国风电产业的更快更好发展。

国家发展和改革委员会

二00五年七月四日

The localization rate for wind power equipment must reach 70% or higher

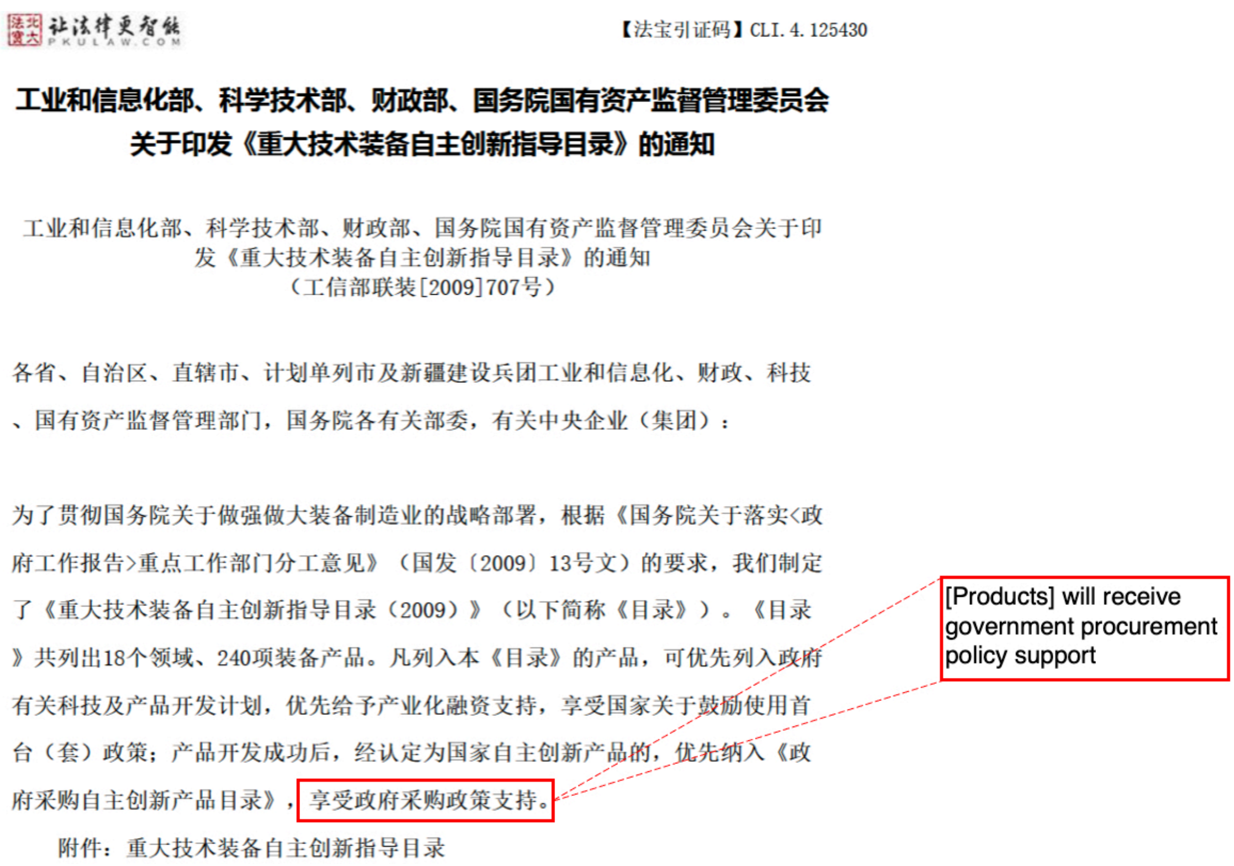
Figure 4.2: **2005 NDRC Local Content Requirement**: A selection from a 2005 NDRC Notice requiring wind farms built in China to utilize 70 percent local content. As I explore in Chapter 5, this Notice prompted foreign wind turbine makers to dramatically expand operations in China. The numerical content target is highlighted in red. Source: LRD.

To collect data on local content requirements, I first read through a sample of well-known content requirements published by central agencies in the post-WTO period. Perhaps the most famous of these was a 2005 notice issued by the NDRC that mandated wind farms built in China to utilize at least 70 percent domestically manufactured content. From this sample, I compiled a short list of key terms associated with these policies, mostly slight variations on the phrases “national production rate" (国产化率) and “local production rate" (本地化率). I then searched the LRD for all central-level regulations containing at least one of these phrases. These searches yielded 148 policies – including administrative regulations, departmental rules, party regulations, draft regulations, and work reports – each of which I read closely to determine the context and significance of its use of the relevant phrase. From this sample, I identified 29 unique policies containing explicit numerical targets for specific industries. Based on exact matching as well as manual analysis, I identified 54 CSIC 4-digit and 29 ISIC 4-digit industries corresponding to these 29 policies. In some cases, requirements specify a cancellation date. Where no date is given, I code the content requirement as having been in effect for five years to account for routine policy decay over time. Altogether, I identified 216 ISIC 4-digit industry-years subject to formal, explicit local content requirements.

Preferential Government Procurement

Preferential government procurement is more challenging to code than ownership restrictions and local content requirements. Although China has published a number of government procurement product catalogues, there is often no way, based on the catalogues themselves, to identify industries in which Chinese-owned or -invested enterprises or products made with intellectual property (IP) registered in China receive preferential treatment. Nor in most cases is there clear external evidence – for example, from reports and surveys conducted by foreign industry groups like the U.S.-China Business Council or negotiations between China and foreign governments – pointing to a link between these catalogues and preferential treatment for domestically-produced goods. Against this backdrop, rather than simply code every industry or product included in government procurement catalogues as being subject to preferential treatment, I opt for the more conservative approach of relying on policies that explicitly link preferential treatment to whether a product is made with Chinese involvement or for which there is strong external evidence for such a link.

To the best of my knowledge, the only policy that meets this criterion is the Guiding Catalogue for Major Technical Equipment Indigenous Innovation (重大技术装备自主创新指导目录), hereafter Indigenous Innovation Catalogue. First published in 2009 and revised once in 2012 before being canceled in 2015, the Indigenous Innovation Catalogue was a direct descendant of the MLP, which called for the “establishment of a coordination mechanism for government procurement of indigenous innovation products" (建立政府采购自主创新产品协调机制) to “promote the digestion, absorption, and re-innovation of imported technologies." This link was made concrete in the list of 99 implementing policies for the MLP published in April 2006; of the 21 measures



【法宝引证码】CLI. 4. 125430

工业和信息化部、科学技术部、财政部、国务院国有资产监督管理委员会关于印发《重大技术装备自主创新指导目录》的通知

工业和信息化部、科学技术部、财政部、国务院国有资产监督管理委员会关于印发《重大技术装备自主创新指导目录》的通知
（工信部联装[2009]707号）

各省、自治区、直辖市、计划单列市及新疆建设兵团工业和信息化、财政、科技、国有资产监督管理部门，国务院各有关部委，有关中央企业（集团）：

为了贯彻国务院关于做强做大装备制造业的战略部署，根据《国务院关于落实<政府工作报告>重点工作部门分工意见》（国发〔2009〕13号文）的要求，我们制定了《重大技术装备自主创新指导目录（2009）》（以下简称《目录》）。《目录》共列出18个领域、240项装备产品。凡列入本《目录》的产品，可优先列入政府有关科技及产品开发计划，优先给予产业化融资支持，享受国家关于鼓励使用首台（套）政策；产品开发成功后，经认定为国家自主创新产品的，优先纳入《政府采购自主创新产品目录》，享受政府采购政策支持。

附件：重大技术装备自主创新指导目录

[Products] will receive government procurement policy support

Figure 4.3: **Preferential Government Procurement**: An image of the preamble to the 2009 Indigenous Innovation Catalogue. An explicit pledge to give “indigenous innovation products" government procurement support is highlighted in red. Source: LRD.

assigned to the Ministry of Finance, 6 concerned government procurement, and of these 3 focused specifically on the Indigenous Innovation Catalogue. In December 2006, the MOF, in conjunction with the NDRC and Ministry of Science and Technology (MOST), followed up with a series of “Administrative Measures on the Accreditation of National Indigenous Innovation Products," (国家自主创新产品认定管理办法) which formally outlined plans for creating the Indigenous Innovation Catalogue. Although it took another three years for the MOF, NDRC, and MIIT to complete the Catalogue, these earlier measures make clear that 2006 marked in the key inflection point in China’s efforts to link public procurement to IDAR and indigenous innovation. Consistent with this, the preamble to the 2009 Indigenous Innovation Catalogue pledged that “indigenous innovation products" (自主创新产品) listed therein would henceforth “enjoy government procurement support" (享受政府采购支持).

According to the U.S.-China Business Council (USCBC), the category “indigenous innovation product" encompasses goods that “have been produced by an enterprise that has full ownership of IP in China either via its own technological innovation activities or because a Chinese enterprise, work unit, or citizen has, by legal means, obtained the China IP rights" and which have a “trademark that is owned by a Chinese company and registered in China."[3] Although there has been some uncertainty over the precise meaning of these requirements and key terms like “indigenous intellectual property rights" (自主知识产权), Chinese central state policies issued between 2006-2010 make clear that products from foreign-invested firms were eligible for “indigenous innovation" status, though at least initially accreditation appears to have been conditional on transferring core IP to local partners.[4] According to the USCBC, by 2010 several products made by foreign-invested firms had received “indigenous innovation" accreditation. Meanwhile, that same year China reportedly began considering draft rules that would define products as “domestic" if they met a certain threshold (unspecified, though likely 50 percent) of locally-manufactured content.[5] Although it is unclear whether or when this regulation went into effect, there is no question that categories like “indigenous" and “domestic" were not intended to exclude foreign participation altogether. Rather, as Sutter (2020) and others observe, procurement rules like those tied to the Indigenous Innovation Catalogue were used “to require technology transfer" from foreign firms seeking access to China’s vast government procurement market (Sutter, 2020, 65).

In late 2011, following pushback from foreign firms and governments, China took steps

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[3] USCBC, May 1, 2010, *China Business Review*, “Domestic Innovation and Procurement." Available at: *https://www.chinabusinessreview.com*. This is a direct translation from the December 2006 “Administrative Measures for the Identification of Indigenous Innovation Products.”

[4] In testimony delivered to the U.S.-China Economic and Security Review Commission on May 4, 2011, Alan Wm. Wolff, a lawyer who served as Deputy Director-General of the World Trade Organization, cited an MOF Notice which called on government procurement agencies to “give priority to award contracts to those foreign companies transferring core technologies." I have not been able to locate an original Chinese-language document that contains this precise language. However, the 2007 Notice on “Indigenous Innovation Government Procurement Evaluation Method" (自主创新产品政府采购评审办法), which Wolff cites, does note that “when a consortium [of firms] participates [in public procurement bids], if one party to the consortium is a supplier of indigenous innovation products, then the consortium will be seen as a supplier of indigenous innovation products" (联合体参与投标时，联合体中一方为提供自主创新产品的投标供应商的，联合体视同自主创新产品供应商). Wolff’s testimony is available at: *https://www.uscc.gov*.

[5] USCBC, “Domestic Innovation and Procurement"

to formally de-link the Indigenous Innovation Catalogue from government procurement policy. Despite this move, however, there is substantial evidence that a *de facto* link between the Catalogue, which was revised and expanded in 2012, remained in place until the Catalogue's final cancellation in 2015. In May 2013, the U.S.-China Business Council reported that 85 percent of companies they surveyed had experienced no change in China's behavior since the 2011 decisions.[6] Meanwhile, the EU SME Centre reported that in May 2012 the MOF issued regulations barring central agencies from importing wholly foreign-made products if "indigenous" equivalents were available.[7] As Chow (2013) observes, the very fact that the Indigenous Innovation Catalogue was re-issued, this time spearheaded by the strongly industrial policy-oriented MIIT (in conjunction with the MOF and MOST), was itself an ominous sign that left foreign businesses uncertain whether "Chinese central level authorities will respect the 2011 revocation" (Chow, 2013, 89). These concerns appear to have been well-founded. As late as 2016, in response to U.S. official requests, China's State Council issued a call for both central agencies and sub-central governments to "further clean up related measures linking indigenous innovation policy to the provision of government procurement preference," a pledge the USTR said had still not be wholly fulfilled as of March 2021.[8] This conclusion is widely supported in research by the Information Technology and Innovation Foundation (ITIF), a U.S.-based think tank,[9] as well as my own interviews with former U.S. trade officials, current and former industry executives, and industry group representatives.

Based on this evidence, to construct my main measure of preferential government procurement policies I use both the 2009 Indigenous Innovation Catalogue and the 2012 revision. However, as guard against the risk that using both versions biases my results, I re-run the analysis excluding procurement data from 2012-2015. I find that this has no appreciable impact on the results, which are presented in Appendix D at the end of the chapter. Overall, I identified 379 products in 32 ISIC

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[6] USCBC, May 1, 2013, "Status Report: China's Innovation and Government Procurement Policies." Retrieved April 24, 2023 (Available at: *https://www.uschina.org*.)

[7] EU SME Centre, "Understanding China's Government Procurement Processes," Retrieved April 24, 2023 (Available at: *http://www.iberchina.org*.)

[8] USTR, 2021 National Trade Estimate Report, Retrieved April 24, 2023 (Available at: *https://ustr.gov*.)

[9] Ezell, Stephen. 2021. "False Promises II: The Continuing Gap Between China's WTO Commitments and Its Practices," Retrieved May 1, 2023 (Available at: *https://www2.itif.org*.)

4-digit industries across both the 2009 and 2012 Catalogues, for a total of 205 industry-years.

Measuring Strategic Industries

Because I am interested in China's treatment of “objectively" strategic industries, or industries considered strategic generally rather than specific to China, I need a measure of this concept that is exogenous to Chinese policy. To this end, I construct a measure of strategic industry adapted from the typology in Ding and Dafoe (2021). Building on their argument about the three “logics" by which a sector or asset may be regarded as strategic, I identify three types of strategic industry: (1) industries with high barriers to entry due to high research and development (R&D) requirements, cumulative learning effects, or economies of scale in production, (2) basic infrastructure with significant economy-wide spillover effects, and (3) industrial inputs for which supply is limited or concentrated in a few firms, countries, or regions, and thus vulnerable to disruption. As Ding and Dafoe (2021) argue, the characteristics of these sectors make it likely that markets, left to their own devices, will underinvest in them. As a result, achieving optimal outcomes often requires attention from the highest levels of the state. This need for state support – which, I would add, is especially acute for late modernizers like China – is what qualifies these industries as “strategic."

To measure the first type of strategic sector, I leverage the “Global Innovation 1,000" dataset published by the consultancy `Strategy&`. This dataset contains detailed information on R&D expenditures by firm and industry for the top 1,000 corporate R&D spenders globally between 2012-2017. Although individual governments and international organizations like the Organization for Economic Cooperation and Development (OECD) sometimes publish data on public R&D expenditures, this data tends to be measured at the national level, and where more detailed information is available it is aggregated far above industry (e.g. ISIC 4-digit) or even sector (ISIC 2-digit) levels. The “Global Innovation 1,000" index thus provides by far the most granular picture of R&D spending available. Based on this data, I code 115 ISIC 4-digit industries as strategic, about one-quarter of all ISIC 4-digit industries. To ensure this list captures a “global," rather than China-specific, conception of strategic, I exclude expenditures by Chinese firms, though doing so has no effect on the final list of ISIC 4-digit industries.

For the second type of strategic sector, basic infrastructure, I hand coded a short list of 13 ISIC 4-digit industries covering traditional basic infrastructure assets like roads and railways, ports, power generation and supply, and other basic utilities. Finally, I code the the third type of strategic industry using the United States Defense Logistics Agency's Strategic Materials list, which includes 66 raw material inputs considered “critical to national security" by the Department of Defense. All of these materials fall under two ISIC 4-digit industry codes: “0721 – Mining of uranium and thorium ores," and “0729 – Mining of other non-ferrous metal ores."

In total, I identify 129 unique strategic industries at the ISIC 4-digit level. These industries span 12 ISIC 2-digit sectors, with the bulk concentrated in Manufacturing (66 ISIC 4-digit industries, or 52 percent of the total), followed by Transportation (15 ISIC 4-digit industries) and Publishing (12 ISIC 4-digit industries), a sector which in the ISIC typology encompasses telecommunications and data processing and storage services. Although what counts as strategic may vary over time, it does so gradually, especially at the level of aggregation at which I measure strategic industries. I therefore code industries as strategic across the entire study period. After carefully reading the list of industries, I did not identify any that were clearly not strategic from 1997-2020. Substantial overlap between the list and sectors named in major Chinese industrial policies further reinforces my measure's validity. A more detailed discussion of my coding procedure and full list of strategic industries is available in Appendix B.

Measuring Bargaining Power

According to my theory, China's willingness to impose technology extractors depends on how much bargaining power it wields. This in turn depends on two factors, both of which must obtain in order for China to pursue intensive technology extraction in a given industry-year. The first is the central state's enforcement capacity, which shapes its ability to bargain with foreign investors as a unified actor. In Chapter 3, I discussed in detail the process by which two rounds of administrative restructuring between 1998 and 2003 yielded a more coherent, effective, and interventionist economic policy apparatus than had existed in decades prior. In particular, I highlighted the creation of the National Development and Reform Commission (NDRC) in March 2003 as a “super-Ministry" for macroeconomic planning and policy coordination. I then traced the steps the NDRC took in 2004-2005 to cement its status as “the general headquarters of the economy" (Naughton, 2015, 36), including gaining power of approvals for all large-scale inward FDI. I suggested that this process paved the way for aggressive enforcement of technology extractors across a broad swath of strategic industries after the launch, in 2006, of the MLP.

In line with the discussion in Chapter 3, I use the launch of the MLP to proxy for the start of a period of enhanced central state enforcement capacity. As the case studies in Chapters 5 and 7 show, the initial increase in Chinese tech extraction efforts is firmly rooted in the 2003 administrative reforms and precedes the MLP by at least two years. Nonetheless, the MLP provided political cover for a dramatic escalation in China’s, and in particular the NDRC’s, enforcement of technology extractors. Importantly, the NDRC was not heavily involved in drafting the MLP, which was spearheaded by the Ministry of Science and Technology (MOST) and overseen by Premier Wen Jiabao. The NDRC only became directly involved in April 2006, when it was named lead agency on 29 (of 99 total) “supporting policies" for the implementation of the MLP. As such, the MLP can be understood as something approaching an “exogenous shock," if not to the NDRC’s interest in technology extraction, then to its capacity to enforce technology extractors. My choice of 2006 is consistent with two important recent works which identify 2005-2006 as a watershed in the history of Chinese industrial policy (Naughton, 2021; Tan, 2021).

The second factor underpinning China’s bargaining power is its position in global value chains (GVCs) in a given industry. Specifically, I expect China to enjoy greater bargaining power in industries in which it primarily sits downstream of GVCs as an end consumer. In these industries, China is less dependent on foreign firms and markets as sources of economic growth and employment and better able to shape consumption patterns through targeted policy interventions such as infrastructure investment initiatives. By contrast, China’s bargaining power will be weaker in industries in which it occupies an intermediate position in global value chains – that is, industries in which foreign firms use China primarily as a base for processing imported foreign inputs and re-exporting them (as more finished goods) to consumer markets overseas. When most of what China “consumes" in an industry consists of temporary imports of foreign inputs to be processed locally and shipped back out, China will depend more on foreign firms and the overseas markets they serve to drive growth and employment than these firms will depend on China as a final consumer. This is especially true for the period between WTO accession and the 2008-2009 global financial crisis, during which exports as a share of China’s GDP increased from 20 to 35 percent.

Consistent with the above, I measure China’s position in GVCs in terms of the share of Chinese imports that are associated with processing of foreign inputs for re-export to consumers overseas. To calculate this quantity at the industry level, I leverage the Chinese Customs Data (CCD) dataset.[10] Published by China’s General Administration of Customs, the CCD contains detailed information on the universe of import and export transactions across China’s borders at the Harmonized System (HS) 8-digit product-level, totaling over 160 million observations from 1997-2013. In addition to information on the value of imports and exports by transaction, the CCD also discriminates between types of import transaction. Specifically, the CCD distinguishes between “general trade" (一般贸易), which in the case of imports refers to goods imported into and consumed within China, and several categories of “processing trade" (加工贸易), in which firms import foreign inputs and re-export processed outputs to consumers overseas. I focus on two such categories, “imported processing and assembly trade" (来料加工装配贸易) and “outsourced processing trade" (进料加工贸易), which are the most substantively relevant forms of processing trade for my purposes and which together account for over 98 percent of all import transactions that could feasibly fall under the category of processing trade.[11] I use these variables to construct a measure of the share of Chinese imports by ISIC 4-digit industry that are associated with processing trade. I calculate this by creating a variable for the HS 4-digit heading associated with each 8-digit product in the CCD, merging this with the comparable ISIC 4-digit industry code, and summing

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[10] My sincere thanks to Hao Zhang for providing and Jiwan Jeong for helping process this data.

[11] Including other types of imports related to processing trade, such as “imported processing and assembly equipment" (来料加工装配进口的设备) does not meaningfully impact on my results, but I exclude these because it is less clear (or even unlikely) that they refer to goods imported into and subsequently re-exported from China.

the value of imports by industry, conditioning on a dummy for processing trade.

Given my argument that China's position in GVCs influences its bargaining power vis-a-vis foreign firms, it is worth emphasizing that foreign firms have historically dominated processing trade in China. For example, according to the CCD, in 2005 44 percent of all Chinese imports were for processing trade, of which foreign firms and foreign-invested equity JVs accounted for 68 and 17 percent, respectively. Chinese state-owned enterprises (SOEs) had the next largest share, 9.3 percent, followed by foreign-invested cooperative JVs at 2.3 percent. For comparison, foreign firms and Sino-foreign JVs accounted for 19 and 18 percent of non-processing trade-related imports in 2005, respectively, compared with 42 percent for SOEs.

Covariates

In addition to my outcome and explanatory variables of interest, I collected data on two pre-treatment covariates which could confound my theory's prediction that top-down strategic interests and the bargaining power of China's central state vis-a-vis foreign investors explain variation across industries and over time in China's use of technology extractors. Each variable represents a different approach to measuring the underlying concept that bottom-up pressures from vested economic interest groups, not top-down strategic concerns, drive Chinese tech extraction efforts.

The first potential confounder I control for is the geographic concentration of industrial output. This widely used measure of the strength of interest group pressures captures the intuition that as actors become more spatially concentrated the barriers to collective action decline (Pincus, 1975; Busch and Reinhardt, 1999; Olson, 1971). More recently, scholars have used geographic concentration of industry across provinces and administrative regions in China to proxy the salience of local-level economic interests (Li, 2013; Tan, 2017). Against this backdrop, it could be that the observed relationship between the strategic status of an industry and the use of technology extractors is merely a byproduct of the fact that “strategic" industries tend to be more concentrated geographically and thus better able to secure preferential treatment from the central state, including through the use of technology extraction policies. Following Li (2013), I measure this concept using a Herfindahl-Hirschman Index (HHI) of the geographic distribution of industry by province and year. Formally, I calculate the index for a given industry i in a given year as:

$$H_i = \sum_{j=1}^{n} \big(\frac{X_j}{\Sigma X_j} \cdot 100\big)^2$$

Where X_j is the value of industrial output from industry i in province or administrative region j. To construct this measure, I hired a research assistant (RA) to scrape provincial-level industrial output data from the China Data Online portal maintained by the All China Marketing Company's All China Data Center. All data originally comes from China's National Bureau of Statistics (NBS). China Data Online publishes yearly industrial output data at the CSIC 4-digit level from 1999-2015, which I use to calculate the original industry-year HHI. However, due to data sparsity and quality issues (especially for years after 2011), for my main model specifications I use the mean and median HHI by industry, measured at the CSIC/ISIC 2-digit level. I find that using different versions of the HHI does not appreciably affect my results, but using the mean and median HHIs at the 2-digit level substantially alleviates data missingness problems.

The second potential confounder I control for is state-owned enterprises' (SOEs) share of industrial output. SOEs tend to be better politically connected than their private counterparts in China. It is also is well-known that SOEs regularly use their connections to local and central political leaders to secure various forms of preferential treatment (Leutert, 2018; **?**; Brødsgaard, 2012). As with geographic concentration, it could be that so-called "strategic" industries tend to be dominated by SOEs, and that lobbying for beneficial policies by these SOEs, not top-down security concerns, explains when China uses technology extractors. To control for this possibility, I construct a measure of SOE share of output by industry and year using data collected from the NBS. Unfortunately, the NBS only publishes this data at the CSIC 2-digit level and data sparsity across years remains a problem. For my main model specifications, I therefore use the mean and median of SOE share by CSIC/ISIC 2-digit level.

Descriptive Analysis

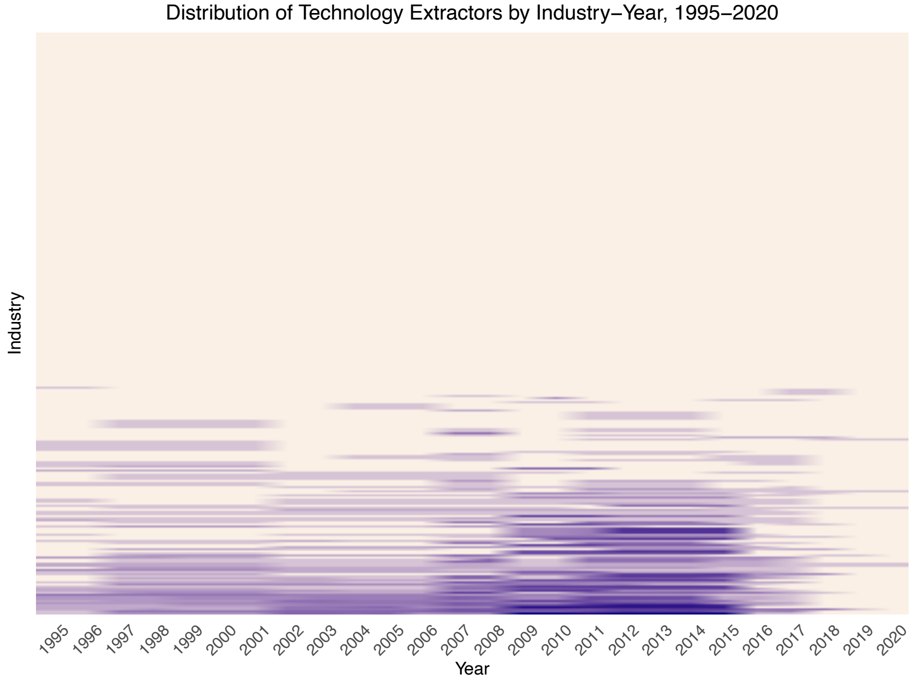


Figure 4.4: **Distribution of Technology Extractors by Industry-Year, 1995-2020**: A heatmap of the distribution of technology extractors by industry (y-axis) and year (x-axis). Industries are grouped based on the density of technology extractors, with darker regions indicating more intensive use of these policy tools. China's use of these policy tools is heavily concentrated in a relatively small number of industries. Likewise, China uses these policy tools much more intensively between 2007-2015 than in earlier or later years. Source: LRD, Author's calculations.

The final dataset spans 420 ISIC 4-digit industries over 26 years (1995-2020) for a total of 10,920 observations. Overall, I identify 3,096 strategic industry-years and 1,287 industry-years in which China imposes at least one technology extractor. Note that after controlling for re-export share and the controls, the effective number of observations falls to 3,480, covering 51 percent of all industry-years with at least one tech extractor but 75 percent of all tech extractors. This is unavoidable because processing trade data is only available for the 207 ISIC 4-digit industries for which there is trade data, and control data only covers secondary industries. To reduce the risk of bias due to missing data, Section 5 presents regression results with and without these variables.

Figure 4 displays the density of technology extractors across industries and over time. Lighter

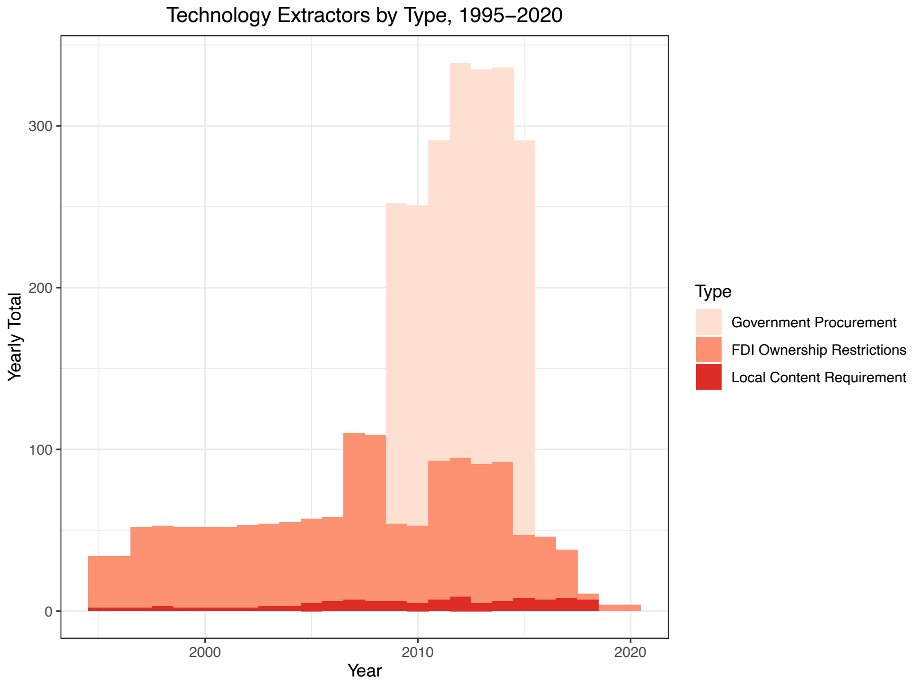
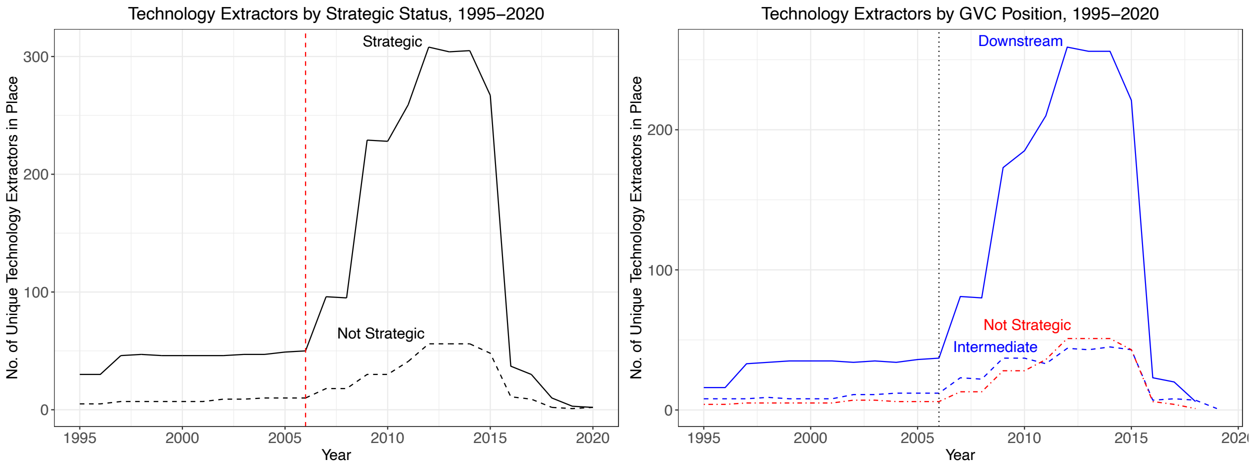


Figure 4.5: **Technology Extractors by Type, 1995-2020**: The total number of unique technology extractors in place by year and type of technology extractor. As the figure shows, the total number of technology extractors increases sharply after 2006. Preferential government procurement tied to the Indigenous Innovation Catalogue account for much of this increase, but the period saw sharp gains in the number of each type of tech extractor. Source: LRD, Author's calculations.

regions correspond to fewer tech extractors, with the light beige regions (which account for the bulk of industry-year combinations) indicating zero use of these policy tools. Darker regions reflect more intensive use of technology extractors. Strategic industries account for 78.7 percent of all industry-years with technology extractors, with the number of these tools used in any given strategic industry-year ranging from 0 to 48. The number of tech extractors in non-strategic industries ranges from 0 to 21, though China imposes more than 13 of these policies in any given year in just two industries that I code as non-strategic: "`ISIC 3821` – Treatment and Disposal of Non-Hazardous Waste," and "`ISIC 3822` – Treatment and Disposal of Hazardous Waste." Though I do not code them as such, both industries could feasibly qualify as strategic basic infrastructure.

Figure 5 shows variation over time in the total number of technology extractors in place, broken down by the type of policy tool. The number of tech extractors in use increased substantially after



(a) Strategic vs. Non-Strategic Industries

(b) High vs. Low Processing Share

Figure 4.6: **Technology Extractors by Strategic Status and Re-Export Share, 1997-2020**: The figures in panels (a) and (b) show a similar trend to Figure 5, but broken down by strategic versus non-strategic industries (panel a) and by the interaction between strategic status and position in GVCs (panel b). The vertical dotted line indicates the launch of the National Medium- and Long-Term Program for Science and Technology Development 2006-2020 (MLP) in 2006. These figures demonstrate that the surge in Chinese technology extraction efforts after 2006 was heavily concentrated in strategic industries. Specifically, it was centered in strategic industries where most of what China imported it consumed at home, and thus where the share of imports associated with processing trade was low. Sources: LRD, CCD, Author's calculations.

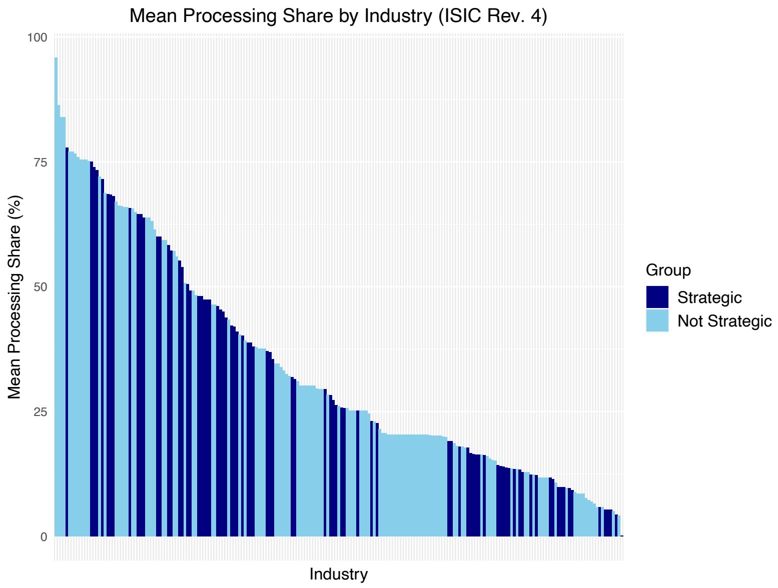
2006, though this change was somewhat unstable as Chinese agencies fine-tuned their policies in response to foreign pushback. After 2015, foreign opposition triggered a more permanent decline in the use of these tools. The Indigenous Innovation Catalogue accounted for much of the temporal variation in China's use of these tools. However, the period also witnessed a substantial increase in the number of foreign investment ownership restrictions, buoyed by sharp gains in the number of ownership restrictions in place, which rose from 50 in 2002 to 103 in 2007. Though much smaller in absolute terms, the number of local content requirements also increased dramatically after WTO entry, with the total number in place rising from 2 in 2002 to 7 in 2007, before peaking at 9 in 2012.

Figure 6 presents the same time trend as Figure 5, this time broken down by (1) strategic vs. non-strategic groups (panel a) and (2) strategic industries in which most of what China imports it consumes internally ("Downstream"), strategic industries in which most Chinese imports are processed for re-export to consumer markets overseas ("Intermediate"), and non-strategic industries (panel b). After dividing industries into five equally-sized quantiles based on re-export share, I assigned those in the 4th and 5th quantiles to “high" and those in the 1st-3rd quantiles to “low" processing trade share. The figure is based on median processing trade share from 1997-2013. The pattern is consistent across different measures such as the mean processing trade share and processing trade share in individual years.

As Figures 5 and 6 demonstrate, China’s use to technology extractors surged to unprecedented levels after 2006. Moreover, panel (a) in Figure 6 indicates that strategic industries account for the vast majority of this increase. This is consistent with my argument about the relationship between changes in central enforcement capacity and variation over time in China’s propensity to use technology extractors in strategic industries. Increased central enforcement capacity is indeed associated with broad gains in tech extraction efforts in strategic industries.

Strikingly, however, this prediction does not hold across all strategic sectors. Instead, as panel (b) indicates, China appears much less inclined to use tech extractors in strategic industries in which imports consist largely of foreign inputs that are processed in China and subsequently re-exported overseas. In fact, China appears to be no more likely to use technology extractors in this type of strategic industry than in non-strategic industries. This supports my argument that when China primarily occupies an intermediate stage in GVCs, as reflected in the share of total Chinese imports tied to processing trade, increased central enforcement capacity will not lead to greater use of technology extractors even in strategically vital industries. This suggests that both China’s position in GVCs *and* the enforcement capacity of its central state shape China’s ability to effectively wield bargaining power. No extent of central enforcement capacity can compensate for high dependence on processing trade. By the same token, when central enforcement capacity is low, China’s propensity to impose technology extraction policies is relatively low across the board, including in strategic industries in which China sits downstream of GVCs.

To guard against the risk that these findings are driven by one type of technology extractor, I re-produced both panels in Figure 6 individually for each policy tool. The results, presented in Appendix D, show a consistent trend across each type of policy tool. China is much more likely to



(a) Mean Share by Industry

Mean Processing Share (%), Select Industries

Rank	Industry	Share (%)	Strategic?
1	Beauty Products	95.8	No
2	Articles of Fur	86.2	No
3	Textile Fibers	83.9	No
4	Woven Textiles	83	No
5	Batteries	77.8	Yes
⋮	⋮	⋮	⋮
13	Music Instruments	75.1	No
14	Semiconductors	74.9	Yes
⋮	⋮	⋮	⋮
187	Dairy Products	6.5	No
188	Agri. Machinery	2.1	Yes

(b) Mean Share, Select Industries

Figure 4.7: **Mean Processing Share (%) by Industry**: Panel (a) orders all 207 ISIC 4-digit industries for which trade data is available according to the mean share of imports that are dedicated to processing of foreign inputs for re-export overseas. Although there is some clustering in the data, strategic sectors are well-represented at most levels of import processing share. Panel (b) lists select industries by the mean processing share. The strategic industry with the highest processing and re-export share is battery manufacturing (77.8%), followed by semiconductors and other electronic components (74.9%). The ranking of industries by processing share is broadly consistent with the conventional wisdom about China's role in global value chains. Sources: Author's data, CCD.

pursue each type of technology extraction in strategic industries than in non-strategic industries and in strategic industries with low re-export share than in those with high re-export share. As a further robustness check, I re-run my main model specifications with each type of tool individually set as the outcome variable. Those results, also presented in Appendix D, confirm that my findings do not depend on any one type of tech extractor. Notably, there is a reasonably high degree of overlap across industries in the use of each type of tech extractor. China uses at least two different types of technology extractor in 53 percent of all industries in which it uses these tools at least once, but these sectors account for 74 percent of all industry-years with tech extractors.

Figure 7 illustrates the distribution of industries in terms of the mean share of imports associated with processing trade. Panel (a) shows there is wide variation across industries in the importance of processing trade, with the mean processing share ranging from 0.2 to 95.8 percent.

Panel (a) also indicates that although there is some clustering in the data, strategic industries (dark blue) are well-represented at most levels of processing trade share; it could prove problematic for my argument if strategic industries were heavily clustered at one end of the spectrum or the other. Panel (b) provides a more detailed look at industries with high and low shares of processing trade imports. The list of industries is consistent with the conventional wisdom about China's role in global value chains. Given China's longtime status as "worskshop of the world" for low-end exports like clothing and apparel, it is not surprising that textile products have a high processing share. Nor is it surprising China consumes most agricultural machinery imports at home.

Finally, strategic industries appear to be comparable to non-strategic industries in terms of geographic concentration, with average median HHIs of 1,943 and 1,793 for strategic and non-strategic industries, respectively.[12] However, SOEs account for 26 percent of industrial output in strategic industries on average, compared with 11 percent for non-strategic industries. This is hardly surprising given the state's interest in developing strategic sectors, but it reinforces the importance of controlling for this potential confounder. I examine the alternative explanation that SOE lobbying drives tech extraction more closely in the wind power case study in Chapter 5.

To avoid confusion, before proceeding I should note that I do not examine the sharp decline in the incidence of technology extractors after 2015 in this chapter. As discussed in Chapter 3, the causes of the fall of technology extractors are largely orthogonal to the arguments tested in this chapter about the rise of these policy tools between 1995-2015. I examine these causes in much greater detail in the case studies in Chapters 5 through 7.

Empirical Strategy

The descriptive analysis in the previous section provides strong initial support for my theory's three main claims. These are: (1) Top-down national security and power concerns lead China to use technology extractors primarily in strategic industries; (2) Increased central enforcement capacity

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[12] The HHI ranges from 0 to 5,000. Industries with values between 1,500 and 2,500 are considered "moderately concentrated."

underpinned the surge in Chinese tech extraction efforts in strategic industries after 2006; and (3) Low (high) levels of final consumption (processing trade) will constrain China's bargaining power vis-à-vis foreign investors, reducing its use of these policy tools in otherwise strategic industries.

However, the above analysis does not tell us how variation in the strategic status of an industry, the share of imports dedicated to processing trade, or the interaction between these variables affect China's propensity to use tech extractors in a given industry-year. Nor does it indicate whether this relationship is robust to controlling for potential confounders, such as the risk that bottom-up interest group pressures, not top-down strategic concerns, drive Chinese technology transfer policy. Below, I outline my strategy for answering these questions. Specifically, I describe how I test the following three hypotheses derived from my theory:

> **Hypothesis 1:** All else equal, China will introduce technology extractors more often in strategic industries than in non-strategic industries.
>
> **Hypothesis 2:** China's use of technology extractors in strategic industries relative to non-strategic industries should increase following the launch of the MLP in 2006.
>
> **Hypothesis 3:** China will impose fewer technology extractors in strategic industries with higher import shares tied to processing trade than in strategic industries with lower shares.

To more formally test these hypotheses, I model the conditional expectation of the outcome variable, the number of technology extractors in place in industry i in year t, as a function of the interaction between the strategic status of an industry and the share of imports in that industry that are dedicated to processing trade. Because my outcome variable is a non-negative count variable with a relatively small number of a discrete integer values, I estimate this model using Poisson regression, with standard errors clustered by industry and year to account for overdispersion in the outcome (Cameron and Trivedi, 2005). As a robustness check, I also present results from Zero-inflated Poisson regression, which controls for the risk that overdispersion in the outcome variable is caused by a large number of zeros. This is an appropriate control in my case given the large number of industries in which China never uses technology extractors.

I model the conditional expectation of the number of tech extractors in industry i in year t as:

$$\mathbb{E}[Y_{it}|D_i, X_{it}, Z_i] = \exp(\alpha + \lambda_t + \beta D_i + \gamma X_{it} + \eta \cdot (D_i \cdot X_{it}) + \delta^T Z_i)$$

Where D_i is a binary indicator for industry strategic status, $\mathbf{X}_{it}$ is a vector with the share of imports tied to processing trade by industry-year, λ_t denotes year fixed effects, and $\mathbf{Z}_i$ includes controls for the median levels of geographic concentration and SOE share of industrial output by industry, as well as an indicator for the 2-digit sector level corresponding to each 4-digit industry. Note that in my main specifications I examine two measures of processing share. First, consistent with the above equation, I use a time-varying measure of processing share in industry i in year t (model 7 of Table 1). Second, I use a measure of median processing share by industry (models 3, 5-6, 8-9 in Table 1). This measure has the advantage of reducing year-to-year volatility in the share of imports tied to processing trade and thus gives a more reliable picture of the overall effect of processing trade dependence on Chinese behavior.

Results

This section presents results from my statistical analysis. The main results from Poisson regression are presented in models 4-7 of Table 1. Models 4-6 present results from regression using median processing share by industry as the moderator. Model 7 presents results using processing share by industry-year as the moderator and includes year fixed effects. As noted above, in addition to Poission regression with cluster-robust standard errors, I also ran my main model specification (model 6 in Table 1) using Zero-inflated Poisson regression. The results are presented in model 8 in Table 1. As a further check on the robustness of my findings, model 9 presents results from regression of an alternative measure of the outcome variable, the total number of tech extractors by industry throughout the study period. For this, I also used Zero-inflated Poisson to account for overdispersion in the outcome caused by a large number of zeroes. I also ran my main specifications using Negative Binomial regression and find that this does not affect the results. Finally, I ran three OLS models with the square root of the number of tech extractors by industry-year as my outcome.

Table 4.1: Results from Regression with OLS, Poisson, Zero-inflated Poisson

	Dependent variable:								
	TE by Industry-Year, Sq. Rt. (1-3)			TE by Industry-Year					Total TE
		OLS			*Poisson*		*FE Poisson test*	*Zero-inflated count data*	*Zero-inflated count data*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Strategic	**0.346*****	**0.252*****	**0.849*****	**2.779*****	**2.648*****	**2.846*****	**3.082*****	**0.568*****	**1.546*****
	(0.072)	(0.072)	(0.185)	(0.125)	(0.216)	(0.344)	(0.442)	(0.096)	(0.191)
Strategic x Med. Processing Share			**−0.009*****		**−0.014****	**−0.021*****		**−0.015*****	**−0.031*****
			(0.003)		(0.006)	(0.007)		(0.002)	(0.004)
Strategic x Processing Share							**−0.020****		
							(0.009)		
Strategic x Post-2006		**0.163*****							
		(0.054)							
Post-2006		0.026**							
		(0.012)							
Median Processing Share			−0.001		−0.0001	0.002		0.012***	0.022***
			(0.001)		(0.006)	(0.007)		(0.002)	(0.004)
Processing Share							0.009		
							(0.008)		
Constant				−2.478***	−1.791***	−1.870***	−2.097	1.589***	1.661***
				(0.114)	(0.200)	(0.333)	(6.642)	(0.096)	(0.193)
Year FE	Yes	No	Yes				Yes		
Controls	No	No	Yes	No	No	Yes	Yes	Yes	Yes
Observations	10,920	10,920	3,770					3,770	145
Adjusted R^2	0.270	0.249	0.198						

Note: Full Results in Appendix C. *p<0.1; **p<0.05; ***p<0.01

Models 1 and 3 replicate models 4 and 6 using OLS, while model 2 regresses the outcome on an interaction between strategic status and a dummy for the post-2006 period to test whether the pace of tech extraction increases in strategic industries following the launch of the MLP in 2006.

The results presented in Table 1 provide strong support for the hypotheses discussed in section 4. The coefficient on strategic status is positive and significant across all model specifications, indicating that strategic importance is indeed associated with increased use of technology extractors. Likewise, the coefficients on the interaction terms for strategic and processing share are negative and significant in all models. This suggests that higher levels of imports associated with processing trade exert downward pressure on the positive association between strategic status and the number of technology extractors in place. These results are robust to a range of modeling strategies, alternative measures of the outcome and moderator variables, and to the inclusion of controls for geographic concentration and SOE share of industrial output. Notably, in addition to the main count model results, Zero-inflated Poisson regression also estimates, for each variable, the likelihood of

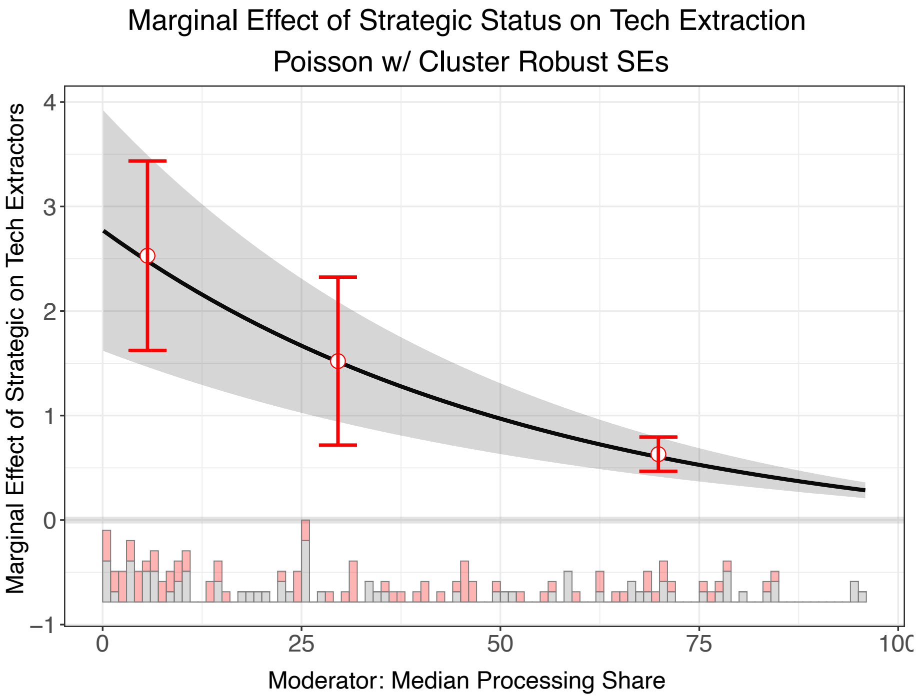

Figure 4.8: **Marginal Effect of Strategic Status on Tech Extraction**: The marginal effect of being a strategic industry on China's use of technology extractors declines as the share of imports associated with processing trade increases. Estimates are calculated using the flexible binning estimator provided in Hainmueller, Mummolo and Xu (2019), in which effects are separately estimated (using a Poisson link and standard errors clustered by industry and year) in low, medium, and high bins defined by the number of observations at each level of the moderator. Vertical bars along the x-axis indicate the number of strategic (red) and non-strategic (grey) industries at each level of the moderator.

"excess zeroes" associated with that variable. The results (not pictured) indicate that excess zeroes – industries that never receive tech extractors – are much less likely in strategic than in non-strategic industries. Finally, the positive and significant coefficient on the interaction term in model 2 indicates that the post-2006 period is associated with increased tech extraction efforts in strategic industries relative to non-strategic ones. This is consistent with the findings in Figure 7 and supports my argument that enhanced central enforcement capacity will lead to broad gains in China's use of technology extractors across strategic industries.

Figure 8 visualizes the relationship between an industry's strategic status and China's use of technology extractors at different levels of the moderator, the median share of imports linked to processing trade. As the figure indicates, China is much more likely to issue technology extractors

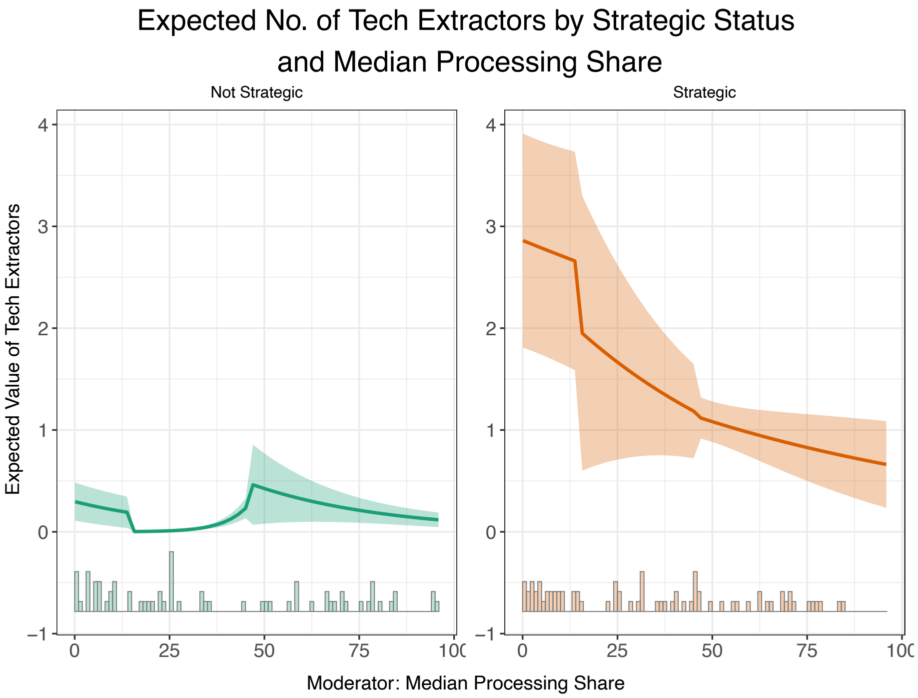

Figure 4.9: **Expected No. of Tech Extractors by Strategic Status and Median Processing Share**: This figure contrasts the expected number of technology extractors in place at different levels of the moderator in non-strategic industries (Group: 0, left) and strategic industries (Group: 1, right). Estimates are based on Poisson regression with cluster-robust standard errors. The relationship between tech extraction and strategic status is essentially flat at all levels of processing trade share in non-strategic industries. By contrast, it declines sharply as processing trade share increases in strategic industries. Figure produced using the `interflex` package in Hainmueller, Mummolo and Xu (2019).

in strategic industries when median processing share is low – that is, when most of what China imports in that industry is consumed at home, rather than processed for re-export overseas. In turn, China's propensity to use tech extractors declines sharply as median processing share rises. This supports my argument that China will be less likely to introduce these measures in industries where Chinese “consumption" (and the jobs and growth it supports) depends on overseas consumer markets. I replicated Figure 8 using linear and Negative Binomial link functions. The results, presented in Appendix D, depict a similar relationship between variables of interest.

Beyond its statistical significance, the impact of dependence on processing trade on the relationship between strategic status and technology extraction is also substantively large. As Figure 9 indicates, as the share of imports accounted for by processing trade approaches 100 percent, the expected number of technology extractors in place in strategic industries declines from over 4 to almost zero. Concretely, China uses on average about 2.4 fewer tech extractors in strategic industry-years in the 90th percentile of median processing share than those in the 10th percentile, equivalent to roughly one standard deviation. The near-complete absence of these tools in non-strategic sectors supports the prediction in Hypothesis 1. A raw plot of the relationship between processing trade and technology extraction in strategic versus non-strategic sectors, presented in Appendix C, reinforces this conclusion.

Overall, the results provide strong support for all three hypotheses outlined in the previous section. China pursues technology extraction much more intensively in strategic industries than in non-strategic ones (Hypothesis 1). Likewise, it's use of technology extractors in strategic industries increases, relative to non-strategic industries, after 2006 (Hypothesis 2). At the same time, when most of what China imports in a strategic industry it simply processes and re-exports overseas, Chinese authorities are much less likely to introduce these policy tools (Hypothesis 2). The results are robust to controlling for two measures of bottom-up interest group pressures and are consistent across a variety of modeling strategies.

Robustness Tests

I conduct several additional tests to probe the robustness of my findings. To begin, as noted earlier, to ensure that my results are not driven by any one type of technology extractor, I re-run my core model specifications setting each type individually as the outcome variable. Those results are presented in Appendix D. Likewise, as discussed above, I re-run my models excluding government procurement data from 2012-2015 and find that this too has no discernible impact on the results. In addition, it may be objected that the inclusion of basic infrastructure in my measure of strategic industries biases the results in favor of my argument that China uses tech extractors more often when it is downstream of GVCs. To guard against this risk, I re-run my full model specification using only R&D-intensive industries in my measure of strategic industry. As the results in Appendix D show, this yields an even stronger association between my variables of interest, indicating that the hypothesized relationship is stronger in high-technology industries than other strategic sectors.

To ensure my findings capture Chinese leaders' beliefs about strategic importance, I created an alternative measure of strategic based on industry lists provided in three authoritative central-level industrial policies. In addition to the MLP, these include the 2010 Strategic Emerging Industries (战略新兴产业) initiative and Made in China 2025 (中国制造2025), which was issued in 2015. Appendix B includes a list of these industries and my coding of them and presents results from re-running my main model specification using this alternative measure. The results show that alternating measures of strategic industry does not substantially affect my findings.

It could also be objected be that technology extraction depends less on GVC position than on product-level characteristics. For example, China may not pursue tech transfer in sectors characterized primarily by intermediate goods. In fact, China uses technology extractors heavily in many intermediate goods, including parts and accessories tied to downstream products like industrial machinery, civilian aircraft, and ships. However, to guard against the risk that product-level characteristics confound my findings, I re-run my main model specification with various measures of product type. The results, in Appendix E, show this has no impact on my findings.

Because my data covers a 26-year period, policy inertia may explain the persistence of these tools. To account for this, I run my main specification with 2- and 3-year lagged outcome variables, which reflects the intervals between revisions of relevant policies. The results, in Appendix F, show that controlling for temporal dependence does not significantly affect my findings.

Finally, previous work on market power in international relations measures this concept in terms of the size of a country's internal market (Drezner, 2007). I argue market size is insufficient to explain the balance of dependence between China and foreign firms. For example, after subtracting imports tied to processing trade, China took in roughly 3.6 percent of global integrated circuit (IC) imports from 2001-2008.[13] This was comparable to China's share of the world market for rail transport goods, 3.7 percent, and much greater than its 1 percent share of the global auto market during that period. If market size explains bargaining power, then China should be at least as likely

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[13] I use the terms integrated circuit, semiconductor, and chip interchangeably.

to impose tech extractors in ICs as in autos and rail. In fact, China introduced on average 5 and 9 tech extractors in autos and rail transport each year from 2001-2008, and none in ICs.

To more formally evaluate my argument, I examine the impact of market size on tech extraction using an approximate measure of China's share of global imports by industry after subtracting processing trade imports. Appendix G explains how I created this measure and presents results from running my main model specification with it. The results show that controlling for market size does not affect my findings.

Conclusion

This chapter outlined the steps I took to collect data for and construct a measure of variation across industries and over time in China's use of technology extractors. It then tested several hypotheses derived from my theory about the determinants of Chinese tech extraction. I found strong support my arguments that (1) China primarily introduces these policy tools in strategic industries, (2) China's use of technology extractors surged to unprecedented levels following administrative reforms that increased central coordination capacity after 2006, and (3) China's propensity to engage in tech extraction declines in proportion to share of imports in a given industry that are associated with processing foreign inputs for re-export as finished goods. These findings are robust to alternative model specifications and strategies, as well as the inclusion of a battery of controls.

Chapters 5 through 7 build on the evidence presented in this chapter to more closely examine the mechanisms linking strategic importance, position in GVCs, and China's use of tech extractors. They do so through qualitative case studies of Chinese tech extraction in three strategic industries: wind turbine technology, civilian aircraft manufacturing, and ICs. In addition, the case studies explore the reasons behind the fall of tech extractors after 2015 and the implications of this collapse for the future of Chinese tech transfer policy, two important issues not covered in this chapter.

Chapter 5

Technology Extraction in Wind Power

Wind power offers one of the more dramatic illustrations of China's rapid industrial transformation and rise up the global division of labor in the post-WTO era. When China joined the WTO in 2001, its domestic wind power industry was virtually non-existent. As late as 2004, foreign firms supplied nearly 80 percent of installed wind power capacity in China, which at 765 megawatts (MW) was equivalent to just over 1 percent of the global market. By 2012, Chinese installed capacity had grown 100-fold to over 75,000 MW, making it by far the world's largest wind power market. What is more, Chinese-controlled firms built and operated nearly 90 percent of that 75,000 MW. Today, China accounts for 39 and 28 percent of global onshore and offshore installed wind power capacity, respectively, and boasts five of the world's ten largest wind turbine manufacturers.[1] The extraordinary development of China's wind power industry after 2004 took place against the backdrop of an equally remarkable, but less remarked, escalation in Chinese efforts to "introduce, digest, absorb, and re-innovate" (引进消化吸收再创新) advanced foreign technologies in the sector. In late 2003, the newly-formed National Development and Reform Commission (NDRC), China's top planning and policy coordination body, launched a Wind Power Concession Program

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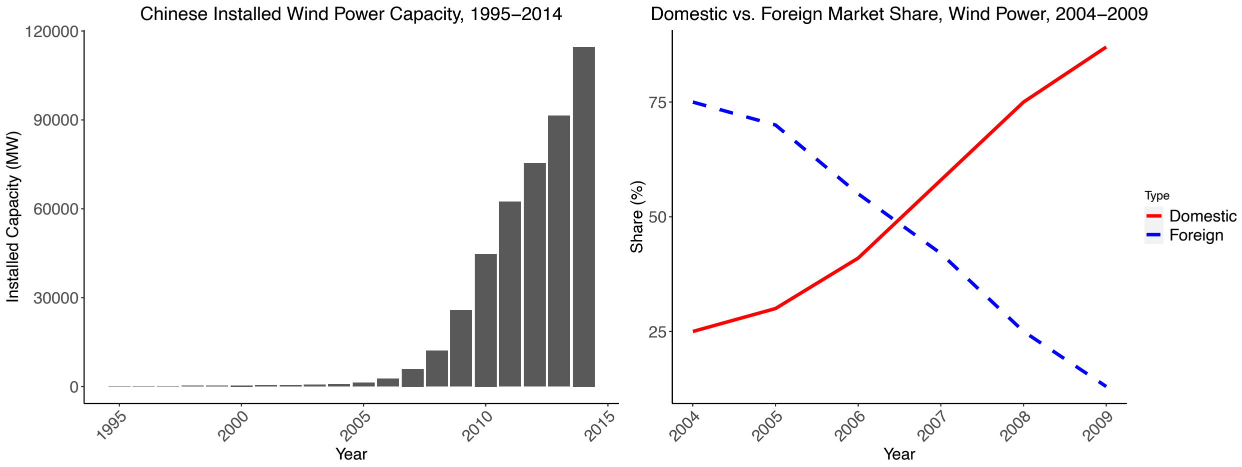
[1] Global Wind Energy Council, "Global Wind Report 2021," Retrieved May 21, 2022 (Available at: *https://gwec.net*.)



(a) Installed Wind Power Capacity (MW)

(b) Domestic vs. Foreign Share (%)

Figure 5.1: **Chinese Installed Wind Power Capacity, 1995-2014** and **Domestic vs. Foreign Market Share, Wind Power, 2004-2009**: Chinese installed wind power capacity increased 150-fold from 2004-2014, during which time Chinese firms' share of the domestic market rose from under 25 percent to over 90 percent. Sources: Global Wind Energy Council, Statista.

(风电特许权项目) to fuel the rapid expansion of large-scale wind power generation. By directing state-owned utilities to sign long-term purchasing contracts with wind farm developers covering the lifespan of the farm, the Program essentially eliminated any risk for developers – almost all of which at this stage were foreign or foreign-invested joint ventures. In exchange, the NDRC required all concession projects to use wind turbines made with at least 50 percent locally-manufactured parts. In September 2004, the NDRC increased the local content requirement for wind farms in the Program to 70 percent.

The Wind Concession Program was just the beginning. The real policy breakthrough came in June 2005, when the NDRC extended the 70 percent local content requirement to all wind farms built in China. By most accounts, that decision was the key factor that drove major multinational producers like Denmark's Vestas Wind Systems, Spain's Gamesa (now Siemens-Gamesa), and General Electric to dramatically expand operations in China. As Keith Bradsher observed in the *New York Times*, the "Chinese government bet correctly" that rather than fight the measure, "Gamesa and the other leading multinational wind turbine makers [would opt] to open factories in

China and train local suppliers to meet the 70 percent threshold."[2] The *Financial Times* decried the 2005 local content policy and a 2007 NDRC requirement that foreign investors in wind power form joint ventures with local firms as emblematic of a "pattern of forcing foreign companies to foster domestic competition through local content and technology transfer demands."[3] Technology extraction policies like local content and joint venture requirements were not the only variables behind the transformation of China's domestic wind power industry. Generous state support for research and development (R&D) and other direct and indirect subsidies were important factors, too, as were innovative manufacturing strategies pursued by entrepreneurs like Wu Gang, the founder and chairman of Xinjiang Goldwind Science and Technology Co., China's leading wind power developer (Lewis, 2012; Nahm, 2021). But as contemporaneous media reports, English- and Chinese-language secondary sources, interviews with Chinese and foreign business executives, and a careful examination of the industry's timeline all attest, the transformation of China's wind energy sector would very likely have been less sudden, and its impact on the global wind power sector less dramatic, absent technology extraction policies. Certainly, insofar as the introduction, absorption, and re-innovation of cutting-edge foreign technologies contributed to the Chinese industry's rise, the story of that rise cannot be told without these policy tools.

As striking as the escalation of technology extraction efforts after 2003 was the swift removal of the most salient and controversial such policies between 2009 and 2011. In October and November 2009, the NDRC eliminated the joint venture requirement and abolished the 70 percent local content requirement. In December 2010, China eliminated two other subsidy programs at the request of the United States Trade Representative (USTR). A few months later, China recommitted to eliminating discriminatory local content requirements and to remove a demand that foreign firms bidding for wind power projects have existing operations in China. Finally, in June 2011 China formally resolved a WTO dispute brought by the USTR on behalf of the United Steelworkers union by agreeing to eliminate a Ministry of Finance fund for promoting domestic

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[2] Keith Bradsher, "To Conquer Wind Power, China Writes the Rules," *The New York Times*, December 14, 2010, Retrieved May 22, 2022 (Available at: *https://www.nytimes.com*.)

[3] Kathrin Hillie and Josh Chaffin, "Protectionist fears over China stimulus," *Financial Times*, May 28. 2009, Retrieved May 20, 2022 (Available at: *https://www.ft.com*.)

wind manufacturing. Although China continued to pursue technology extraction (including through preferential government procurement) in the development of offshore wind turbines, by 2012 most if not all formal central state tech extraction policies for onshore wind power had been abolished.

The timing and motives behind the rise and fall of tech extraction efforts in China's wind power industry form the central "puzzle" that motivates this chapter. Regarding the rise, the evidence I present clearly indicates that growing central enforcement capacity, especially following the NDRC's elevation and consolidation of investment approval authority, was the primary factor behind China's heightened pursuit of technology extraction in wind energy after WTO entry.

Regarding the fall of technology extraction, I show that as Chinese firms cornered the domestic market for wind turbines and began to expand operations overseas, including in the United States and Western Europe, foreign corporate and governmental opposition to China's use of technology extractors at home escalated. With Chinese wind turbine makers now globally competitive, tech extractors had lost much of their original utility, and with the risk of reciprocal restrictions on Chinese outbound FDI in wind energy rising, these policy tools risked becoming liabilities for China. As a result, China responded to foreign governmental pressure by swiftly removing the most controversial conditional market access restrictions between 2009-2011.

As discussed in Chapter 3, I examine these arguments using congruence tests and process tracing in a "before and after" controlled comparison research design. For evidence, I draw on a combination of primary sources such as Chinese state policy documents, secondary sources in both Chinese and English, and interviews with industry insiders and academic experts.

The chapter proceeds as follows. In section 2, I discuss why wind power is a valuable case for testing my theory's mechanisms. Section 3 traces the evolution of technology extraction efforts in the wind industry before and after administrative restructuring, and in particular following the NDRC's rise from 2003-2005. In Section 4, I examine the motives behind the removal of technology extractors after 2009. Section 5 explores alternative explanations for China's policy behavior and demonstrates that they do not explain the timing of the rise or fall of technology extraction in the wind sector. I then briefly conclude.

Why Study the Wind Power Industry?

The development of China's domestic wind energy industry provides a valuable test of my arguments about the introduction and removal of technology extraction policies for three main reasons. First, not only is the wind power sector “strategic" according to the definition developed in Chapter 3, but it is also of substantive interest for understanding important aspects of contemporary Chinese political economy. Most notably, the trajectory of Chinese technology extraction in wind energy helps illuminate China's efforts to mitigate the social and political consequences of environmental degradation caused by decades of unchecked industrial development.

Second, wind power is, if not strictly a “least likely" case, then a *less likely* case from the perspective of interest group models of trade and FDI policy, which I regard as offering one of the most powerful potential alternative explanations for Chinese technology extraction efforts. If bottom-up protectionist demands explain the use of tech extractors, then we would expect to see China impose them after the emergence of a domestic wind industry of some size, or after powerful state-owned enterprises (SOEs) in related sectors expressed interest in wind. In fact, we observe nearly the opposite: Foot-dragging by major state-owned power generators and central policies that predate the very interest groups whose demands they supposedly reflect.

Finally, wind power exhibits positive values on my independent variables of interest: It is a strategic industry in which China sits comfortably downstream of global value chains (GVCs) and in which China becomes increasingly competitive during the study period. As such, it provides a valuable test of my main hypotheses regarding the use and removal of tech extraction policies. In the remainder of this section, I develop each of these arguments in greater detail.

Wind Power is a Substantively Important Industry

Quite apart from what it reveals about my theory, technology transfer policy in the wind energy industry is of substantive interest in context of the profound energy and environmental challenges China faces today. Globally and in China, wind power is the second largest source of renewable energy after hydropower, as well as one of the fastest growing. Wind features centrally in the carbon neutrality strategies of individual governments like China and the United States, the number one and number two producers of wind energy and greenhouse gas emissions, respectively, and in international agreements like the Paris Climate Accords. It is also a sizeable industry in pure dollar terms. In 2019, global wind turbine sales were valued at $81 billion, equivalent to about one-fifth of semiconductor sales worldwide and one-half the combined annual revenues of Boeing and Airbus.[4] Given its already significant scale and prospects for future growth as well as its important role in reducing global carbon emissions, the wind power industry, and China's position within it, merit greater attention by scholars of international relations and international political economy.

Understanding the policy dynamics behind the development of China's domestic wind industry is especially important given the sector's critical role in mitigating the environmental, as well as social and political, fallout from decades of fossil fuels-driven industrial expansion in China. The environmental consequences of China's development model are well-documented and need not be rehearsed in detail here. Perhaps most concerning for China's leaders is the potential for climate-related social unrest to undermine public support for the ruling Chinese Communist Party (CCP) regime. As awareness of environmental degradation has grown and protests over pollution have proliferated in recent years, the Chinese state has cracked down on potential sources of environment-related unrest through a combination of direct suppression of demonstrations, online censorship, and expelling environmental non-governmental organizations. At the same time, the CCP has sought to use state-led investment in making China a world leader in renewable energy technology to promote the regime at home (Tan, 2021). Wind power represents a high-point in this campaign not only because of the industry's scale and rate of growth, but also because compared with solar power, technological barriers to entry in wind power are high.

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[4] Estimate based on data from UNCTAD.

Wind Power is a “Less Likely" Case

In addition to its substantive interest, wind power provides a valuable test of my theory because it allows me to “horse race” my argument about the motives behind technology extraction against the alternative hypothesis that lobbying for central state protection by politically-connected economic interest groups, most notably powerful SOEs, drives China’s use of tech extractors. Lobbying by economic interest groups is far and away the dominant explanatory variable in mainstream political economy research on trade and FDI policy. Indeed, the view that parochially-minded bottom-up interest groups are the key actors in shaping international commercial policy is so pervasive as to be taken for granted in contemporary scholarship, with debates instead centering on which interest groups (classes, industries, firms) matter most and from where each derives its preferences.

Although interest group models have not been applied to Chinese industrial policy specifically, they have been advanced to explain trade policy in China – of which technology extractors are one form (Mertha, 2009; Kennedy, 2009; Deng and Kennedy, 2010; Li, 2013). More broadly, these models constitute an increasingly prominent and arguably dominant heuristic for analysts of Chinese political economy in the eras of Reform and Opening and the WTO. The possibility that bottom-up pressure for protection by politically-connected commercial actors drives China’s use of technology extractors therefore merits close scrutiny.

A key implication of interest group models is that commercial actors and their interests are causally upstream and constituted independently of state policy actions. That is, interest groups precede the policies which result from their demands for protection. If they did not, then there would be no sense in using interest group demands to explain trade and FDI policy outcomes.

Wind power provides fertile ground for testing this hypothesis because before the early 2000s China’s domestic wind energy industry was virtually nonexistent. Moreover, the available evidence suggests that the “Big Five” state-owned power generators not only did not push for supportive policies for domestic wind power, but resisted entering the industry. Guodian, the only Big Five member to have a major industry presence, did not enter wind power until 2007. Meanwhile, the fact that the NDRC had to mandate in 2007 that state-owned power generators increase the share of wind in their energy mix to 3 percent by 2010 suggests foot dragging by the latter.

Gerring (2007) defines a "least likely" case as "one that, on all dimensions except the dimension of theoretical interest, is predicted not to achieve a certain outcome and yet does so. It is confirmatory" (Gerring, 2007, 232). Based on this definition, I argue that wind power, if not a least likely case, is certainly a less likely case for my theory. This is because, based on a key dimension identified in the literature, the wind power industry should not have been subject to supportive state policies when it was – that is, before the emergence of a substantial domestic wind industry with the resources and wherewithal to lobby for this outcome.

Wind Power has Positive Values on Variables of Interest

The bulk of the chapter consists of a controlled comparison of variation in Chinese technology extraction efforts *within* the wind power industry "before and after" administrative restructuring in 2003. But the analysis in this chapter is also the first of three observations in a comparison *across cases* in Chinese decisions to use tech extraction policies, along with studies of the commercial aircraft and semiconductor manufacturing industries in Chapters 6 and 7, respectively.

In this context, wind power is an important case for my theory because of the three industries I examine, it is the only one to exhibit positive values on all three explanatory variables of interest. That is, it is a strategic industry in which China sits downstream of GVCs and in which Chinese competitiveness improves dramatically over the study period. It should therefore conform closely to two key predictions: (1) Gains in central enforcement capacity lead to more intensive use of technology extractors in strategic industries, but only when the balance of dependence between China and foreign firms favors the former; and (2) As Chinese firms become more globally competitive, the potential costs of negative reciprocity by major trade partners will begin to outweigh the benefits of tech extractors for further industrial upgrading, leading China to abandon these policy tools. I discuss the wind industry's values on the theory's explanatory variables below.

First, wind power belongs to at least one and arguably two categories of strategic industry as defined in Ding and Dafoe (2021) and operationalized and measured in Chapters 3 and 4. Most importantly, wind turbine design and manufacturing exhibits steep barriers to entry due to high R&D expenditure requirements, cumulative learning effects, and economies of scale in production. Barriers to entry in wind power were already deeply entrenched in the mid-2000s, by which point industry leaders such as Vestas and Gamesa had several decades of experience in wind turbine technology R&D and commercialization, and boasted highly skilled workforces with up to thirty years of accumulated process knowledge. These barriers have only grown since as the size, cost, and technological complexity of wind turbines have increased, and as successive waves of mergers and acquisitions have intensified oligopolistic rivalry among a handful of multinational enterprises (MNEs). Today, the four leading wind turbine manufacturers, which together control nearly 60 percent of the global market, all rank among the top 1,000 companies globally for corporate R&D expenditures; three are in the top 50, and two are in the top 25.

Given the technological barriers to building a commercially viable wind power sector, it is no surprise that from the industry's inception, government support has been instrumental to the development of national wind power industries. For example, between 1974-2009, the government of Denmark invested the equivalent of nearly 1 percent of the country's cumulative gross domestic product (GDP) into wind power-related R&D (Lewis, 2012). Governments in the United States, Germany, and the Netherlands have all likewise invested heavily in domestic wind energy industries through a combination of direct funding for R&D and tax breaks and other incentives. Against this backdrop, it is all but inconceivable that a latecomer like China could have built a competitive wind power sector absent significant support from the highest levels of the state. Not only was China starting from a very low base in terms of indigenous capabilities and firms, but it was entering a market dominated by a few large and well-resourced firms in command of relatively mature technologies and investing heavily in advancing the technological frontier in the industry.

In addition to conforming closely to what Ding and Dafoe (2021) call the "cumulative-strategic logic," wind power also arguably qualifies as a form of strategic basic infrastructure. Like other forms of basic infrastructure, wind power generates positive economic spillovers in various ways. These range from, at the most basic level, wind power's role as an increasingly important form of electricity generation, to more sophisticated forms of spillover from advances in large-scale turbine technology with applications in aerospace and shipbuilding, to, perhaps most importantly, the wind industry's role in developing new battery technologies (Lewis, 2019).

Second, China occupied a firmly downstream position in wind power GVCs throughout the post-WTO era. The mean and median share of wind turbine-related imports tied to processing trade between 1997-2013 were 12.8 and 8.6 percent, respectively. Between 2001-2007, when the NDRC imposed its most stringent conditional market access barriers in the sector, those shares were 7 and 5 percent. Interestingly, the share of Chinese wind power-related imports associated with processing trade begins to rise starting in 2007 as increasingly adept Chinese producers became more integrated into wind turbine GVCs. Nonetheless, this share never exceeds 35 percent, indicating that during the period for which data is available, China remained first and foremost a final demand center for wind energy products. I therefore expect Chinese authorities to enjoy substantial bargaining power over foreign firms in wind energy. In turn, gains in central enforcement capacity should lead to corresponding gains in tech extraction efforts in the sector.

Finally, wind power is an industry in which Chinese competitiveness improved dramatically over the study period. As noted above, throughout the 1990s and into the early 2000s, China lacked meaningful indigenous commercial wind turbine design and manufacturing capabilities. As late as 2003, China imported virtually all large-scale wind power generator sets from foreign suppliers like Vestas and Gamesa. The few turbine models that were produced domestically tended to be small and unsuited to commercial wind farming. Goldwind, China's leading wind energy producer, did not open its first major production facility for large-scale wind turbines – in this case, turbines ranging in size from 600 kilowatts (kW) to 1 MW – until 2002 (Lewis, 2012, 129). Other major Chinese wind producers like Dongfang Electric and Sinovel only began large-scale production in 2005 and 2006, respectively (Lewis, 2012, 104). Within a decade of Goldwind opening its first factory, however, Chinese firms cornered the domestic market (Gamesa, once the leading wind turbine supplier to China, saw its market share there drop from over 30 to under 3 percent during this period) and began expanding to markets overseas. Although Goldwind and other top Chinese firms continued to lag industry leaders like Vestas in producing the largest and most sophisticated turbines throughout the 2010s, they made swift progress in more mature onshore turbine technology and became pioneers in offshore wind energy. Today, the technological gap between Vestas and Goldwind, the number one and two wind turbine producers worldwide, is small.

The Rise of Technology Extraction Efforts in Wind Power

This section examines the evolution of central state-level technology transfer policy in the wind power industry from the sector's inception in the 1980s to the present. Specifically, it traces the process by which administrative restructuring and consolidation, which proceeded in two rounds between 1998 and 2003-2005, led to an intensification of technology extraction efforts in the industry. In doing so, the chapter illuminates the causal mechanisms behind my argument about the rise of technology extractors in strategic industries in the post-WTO period. In particular, it demonstrates that although China's central party-state has long viewed wind power as a strategic industry to be developed through the absorption of foreign technology, this vision only became a reality after institutional reforms increased central enforcement capacity.

The section proceeds in two parts. The first part provides an overview of technology extraction efforts before the culmination of administrative restructuring in 2003-2005. In the second part, I trace the process behind the surge in technology extraction efforts in wind power after 2003.

Technology Extraction Before Administrative Restructuring

Four observations summarize Chinese central state policy in the wind power industry prior to the conclusion of administrative restructuring in 2003-2005. First, beginning as early as 1994, Chinese central authorities clearly viewed wind power as a strategically important emerging industry in which domestic manufacturing capabilities should be cultivated through the extraction and re-innovation of foreign technology. Second, central-level policy during this period was bureaucratically fragmented, characterized by overlapping initiatives by independent agencies without apparent coordination. Third, technology extraction efforts before 2003 relied almost exclusively on soft inducements to encourage foreign technology transfers, not formal requirements. Finally, efforts to develop the domestic wind power industry in the 1980s and 1990s largely failed. China remained almost wholly dependent on foreign-made wind turbines throughout the pre-2003 period.

Efforts to develop utility-scale wind power in China began in 1986, when the Danish wind turbine maker Vestas installed three 95kW units in the Dabancheng district of Xinjiang. That same year, a $3.2 million grant from the Danish government established Xinjiang Wind Energy, China's first commercial wind power company and the predecessor to Goldwind, which was founded in 1998 (Clifford, 2015; Lewis, 2012). Three years later, Xinjiang Wind Energy imported and installed another thirteen 150kW wind turbines from the Danish firm Bonus at Dabancheng, marking the start of China's first wind farm (Lewis, 2012). In 1996, Xinjiang Wind Energy, which remained virtually China's only commercial wind power producer until 1998, obtained its first license to manufacture wind turbines from Jacobs Energie, a small German wind turbine designer. However, as late as 1998, turbines produced under this licensing agreement continued to rely largely on imported components (Lewis, 2012).

The earliest central state-level measure supporting Chinese wind power development appears to be a 1987 program to provide subsidized loans for rural energy development, "mainly for the promotion and application of wind power and other renewable technologies" (主要用于风力发电等可再生能源技术的推广应用).[5] But the first major central policies in wind power were two documents issued by the Ministry of Electrical Power Industry (MEPI) in July and September 1994. The first of these, titled "Provisions for On-Grid Wind Farm Management," required power generators to purchase electricity from wind farms and ordered grid operators to cover the difference in price between electricity from wind and from conventional sources.[6] The second, a

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[5] Zhang Zhengmin and Li Junfeng, "Evaluation of Policies Designed to Promote the Commercialization of Wind Power in China" 中国风电技术商业化促进政策评价与设计, May 15, 2002. This report, issued under the auspices of the Ministry of Science and Technology (MOST), the State Planning and Development Commission (SPDC), and the State Economic and Trade Commission (SETC), refers to the subsidy program: "我国政府从1987年起设立了农村能源专项贴息贷款，主要用于风力发电等可再生能源技术的推广应用." Zhang Zhengmin and Li Junfeng were research staff at the SPDC's Energy Research Institute (国家发展计划委员会能源研究所)

[6] Zhang Zhengmin and Li Junfeng, "Evaluation of Policies Designed to Promote the Commercialization of Wind Power in China."

"Notice on Policy for Electric Power Industry Technology," encouraged the "digestion, absorption, introduction" (消化吸收引进) and "gradual localization" (逐步国产化) of foreign 300kW units, and the introduction of 450-600kW units during the Ninth Five-Year Plan (1996-2000).

Under the Ninth Five-Year Plan, China's leaders approved the continuation of the 1986 National High Technology Research and Development Program, known colloquially as the 863 Program. Under the extension of 863, China earmarked some RMB 60 million for wind power-related R&D, to be administered jointly by the State Science and Technology Commission (SSTC, renamed the Ministry of Science and Technology, or MOST, in 1998) and the State Planning Commission (SPC, reorganized as the State Planning and Development Commission, or SPDC, in 1998), predecessor to the NDRC (Lewis, 2012). One program to develop 600kW turbines included a 40 percent local content requirement for all new projects, though given low levels of localization through the end of the decade it is unclear how strictly this measure was enforced.

Beginning in 1997, the SPC and State Economic and Trade Commission (SETC) each sought to assert their authority over the wind power sector. This was a significant development for two main reasons. First, as China's top economic planning and policy coordination agencies during the 1990s, the SPC and SETC were much more powerful and authoritative than MEPI (which was eliminated in the 1998) and the SSTC-MOST, which lacked enforcement powers. For the SPC and SETC to take on wind power policy thus signaled that China's leaders viewed it as an important industry to develop, despite the country's near-total lack of domestic wind turbine manufacturing capabilities at the time. Second, the SPC and SETC were longstanding rivals whose competition reflected not only parochial organizational imperatives but ideological struggles at the highest levels of the CCP leadership over the direction of Reform and Opening in its first two decades.

This competition manifested clearly in the wind power industry, where between 1997-2001 the SPC and SETC issued several overlapping policies to increase wind power capacity and promote the localization of foreign technology. Most notable among these were Double Increase (双加) and Ride the Wind (乘风计划), both launched in 1997. Double Increase, the SETC's signature initiative, sought to double China's 79MW of installed wind power capacity and encouraged, but did not mandate, technology transfer.[7] Ride the Wind, the SPC's answer to Double Increase, established two joint ventures in which the foreign partners agreed to transfer technology necessary to produce 20 percent of finished turbines locally, with a soft goal of increasing the local share to 80 percent as the Chinese side became more capable (Lewis, 2016, 290).[8]

In addition to these signature initiatives, both the SETC and SPC-SPDC continued to issue regulations to encourage technology transfer and the development of wind power capabilities in subsequent years. What is perhaps most striking about these policies is the extent to which they overlap, to the point of using virtually the same language. For example, in May 1997 the SPC published "Interim Measures for the Management of New Energy Capital Projects," in which it advocated "a combination of independent development and the introduction, digestion, and absorption of innovation" (采用自主开发与引进消化吸收创新) from abroad to nurture domestic wind power capabilities. In 2000, the SETC issued a "Notice of Guidance for Accelerating the Localization of Wind Power Technology Equipment" in which it similarly called for China, "on the basis of the introduction, digestion, absorption of advanced international technology" (在引进、消化、吸收国际先进技术的基础上), to "develop wind power equipment with indigenous intellectual property rights" (开发具有自主知识产权的风力发电设备).[9]

Finally, in December 2001 the SETC issued the last major central-level wind power industrial policy of the pre-2003 period. This "National Debt Wind Power" program committed to providing

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[7] This summary is based primarily on Lewis (2012). I was unable to locate the original policy document. Based on searches in Peking University's Laws and Regulations Database (LRD), the only two policies issued by the SETC that included the term 双加 were a 1994 "Notice on Increasing Investment and Accelerating the Pace of Transformation to Promote Economic Restructuring and the Level of Key Industries," (关于加大投资力度、加快改造步伐促进经济结构调整和重点行业上水平的意见的通知) and "Notice on the Implementation of the 1995 Deepening of Enterprise Reform to Improve Large- and Medium-Sized State-Owned Enterprises" (关于1995年深化企业改革搞好国有大中型企业的实施意见的通知). Neither policy mentions the wind power industry. Zhang Zhengmin and Li Junfeng (2002) briefly discuss the initiative and their description matches that in Lewis (2012), though they list a start date of 1995 for the initiative.

[8] The only official discussion of Ride the Wind I could find occurs in a 2001 document titled "The Tenth Five Year Plan for National Economic and Social Development: Key Special Plans for Energy Development" (国民经济和社会发展第十个五年计划能源发展重点专项规划) issued by the State Planning and Development Commission (国家发展计划委员会), which succeeded the SPC in 1998. The document calls for China to "continue to implement the 'Ride the Wind Plan,' to accelerate the pace of localization of power equipment" (继续实施"乘风计划"，加速风电设备国产化步伐).

[9] The Chinese-language name of the 1997 SPC policy is 新能源基本建设项目管理的暂行规定. The original 2000 SETC policy is 关于加快风力发电技术装备国产化的指导意见的通知.

subsidized loans to wind farm developers who purchased “qualified, locally made wind power components for new-generation projects.”[10]

These efforts by the SETC and SPC had mixed results. Between 1995-2000, total installed capacity increased nine-fold, from 38MW to 346MW, though this was far below China’s goal of 1,000MW by 2000 (Lewis, 2012, 52). However, almost all of this new capacity was built and operated by foreign firms. Precise market share figures from this period are not available, but as late as 2004, foreign firms accounted for over 75 percent of total installed wind power capacity in China. Of roughly 40 Chinese wind turbine companies in 1999, most made 100 watt units for household use.[11] As noted earlier, Goldwind, the first Chinese company to manufacture wind turbines at commercial scale, only opened its first major production facility in 2002. For its part, Ride the Wind met with limited success, which foreign participants in the initiative blamed on the fact that the Chinese government selected as their local partners firms with “little experience or interest in manufacturing wind turbines” (Lewis, 2016, 290).

Based on the above discussion, we can draw three main inferences about wind power industrial policy before 2003. First, although the industry remained in its nascent stages through the turn of the century, the central state took significant steps to encourage the development of domestic manufacturing capabilities as early as 1994. These efforts escalated substantially in 1997 when the SPC and SETC, China’s top economic policy bodies, launched initiatives to promote the industry. Second, from 1994 on China’s leaders saw the extraction and re-innovation of foreign technology as key means to develop domestic capabilities. In short, both the view of wind power as an industry whose development required intervention by the state and the commitment to technology extraction as a means to domestic industrial upgrading were present before 2003. Finally, central-level policy in the wind industry during this period was characterized by overlapping, even redundant initiatives launched by individual agencies without apparent coordination.

Many factors contributed to the slow start of China’s wind power industry. But the pattern

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[10] Dewey and LeBoeuf LLP. 2010. “China’s Promotion of the Renewable Electric Power Equipment Industry: Hydro, Wind, Solar, Biomass,” report for the National Foreign Trade Council. Pg. 50. Available at: *https://www.nftc.org*.

[11] Dewey and LeBoeuf, pg. 48.

described above suggests a fundamental issue: the fragmentation of policy authority across multiple agencies. Certainly, the ambiguous division of labor between the SPC-SPDC and SETC throughout the 1990s conforms to the concept of "fragmented authority" in (Lieberthal and Oksenberg, 1988). Likewise, policy behavior and outcomes during this period are consistent with fragmented authoritarianism's prediction that bureaucratic splintering breeds interagency competition and policy incoherence. The impact of bureaucratic fragmentation on technology extraction in the wind power industry becomes clearer when we consider the 2003 round of administrative restructuring and subsequent increase in Chinese technology extraction.

Technology Extraction After Administrative Restructuring

In March 2003, the incoming Hu Jintao-Wen Jiabao administration abolished the SETC and elevated the NDRC as China's top macroeconomic planning body. The NDRC's official mandate was to "improve the macroeconomic control system" (完善宏观调控体系) in order to "coordinate all aspects of reform, so that reform can better serve development" (综合协调各方面改革、使改革更好地为促进发展服务).

Chapter 3 provided an overview of the motives behind and overarching consequences of the 1998 and 2003 rounds of administrative restructuring in China. As I argued there, the two rounds can be usefully thought of as aiming to augment "macroeconomic control" by minimizing bureaucratic fragmentation at the bottom and top of China's policy apparatus, respectively. Rather than reproduce that discussion here, I refer interested readers to section 4 of Chapter 3.

Before proceeding with our discussion of wind power policy, however, two issues surrounding administrative restructuring and the rise of the NDRC merit further discussion because they bear on my argument that gains in central enforcement capacity, not changes in policy preferences, explain the rise of technology extraction. First, although national industrial and technological upgrading were among the many motives behind the NDRC's formation, this goal was not a primary stated reason for the 2003 reform. Put another way, the NDRC's creation was not in any meaningful sense "endogenous" to the goal of technology extraction. As such, administrative restructuring, and the NDRC's creation specifically, can be reasonably thought of as "independent" of, and thus preconditions for, the rise of technology extraction in the post-WTO period. As Ngok and Zhu (2007) summarize, "the main tasks of the 2003 Reform were to deepen the management system of state assets, to improve the macro-economic control regime, to strengthen the financial regulatory system, to integrate the domestic trade and foreign trade, and to enforce the food safety and production safety regulatory regimes" (Ngok and Zhu, 2007, 230). The official address announcing the NDRC's formation does twice mention "technology transformation investment" (技术改造投资), but this is one of at least two dozen distinct functions ascribed to the NDRC. Others include "promote small- and medium-sized enterprises" (促进中小企业发展), "actively promote reform of the investment and financing system" (积极推进投融资体制改革), "vigorously reduce administrative approval and micro-management services" (大力减少行政审批和微观管理事务), and "better give free reign to the market mechanism for regulating economic activities" (更好地发挥市场机制对经济活动的调节作用). In short, the NDRC's mandate involved many responsibilities beyond the vague goal of managing "technology transformation investment."[12]

Second, to the extent technological upgrading was a motive behind the NDRC's formation, this was by no means a new goal. As the discussion of technology extraction efforts in the pre-2003 period shows, Chinese authorities actively pursued "technology transformation," including through foreign technology transfers, during the 1990s. Indeed, the goal of upgrading China's science and technology capabilities is deeply embedded in the Communist Party leadership's post-1978 development strategy. Arguably the key implication of Deng Xiaoping's "Four Modernizations" campaign was to install science and technology as key means of production, and therefore scientific and technological experts as integral to the building of a modern, socialist market economy in China. Creating policy conditions for China to "catch up" technologically with advanced industrial societies was one of the earliest and most consistent goals of Reform and Opening. From this perspective, it would have been highly unusual for the NDRC's portfolio *not* to include technological upgrading.

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[12] "Notes on the Institutional Reform Program of the State Council," (关于国务院机构改革方案的说明) Wang Zhongyu, March 6, 2003. Chinese version available at: *http://www.npc.gov.cn*.

Timeline of Major Central State Policies in the Wind Power Industry

Year	Agency	Policy	Impact
1994	MEPI	"Provisions for On-Grid Wind Farm Management," 《风力发电场并网运行管理规定(试行)》	Required power companies to purchase wind farm electricity
1994	MEPI	"Notice on Policy for Electric Power Industry Technology" 《电力工业技术政策》的通知	Called for gradual localization of 300KW wind power units
1997	SETC	"Double Increase" (双加) program launched	Called for doubled output, encouraged localization
1997	SPC	"Interim Measures for the Management of New Energy Capital Projects" 《新能源基本建设项目管理的暂行规定》	Support "introduction, digestion, absorption" of foreign wind tech
2000	SETC	"Notice of Guidance for Accelerating the Localization of Wind Power Technology Equipment," 《关于加快风力发电技术装备国产化的指导意见》的通知	Encouraged JVs, reiterated need for "introduction, digestion, absorption" of foreign technology
2001	SETC	"'National Debt Wind Power' Project Implementation Plan," 《`国债风电'项目实施方案》	Established fund to subsidize domestic wind power
2001	SDPC	"The Tenth Five Year Plan for National Economic and Social Development: Key Special Plans for Energy Development," 《国民经济和社会发展第十个五年计划能源发展重点专项规划》	Formalized "Ride the Wind" policy begun in 9th Five Year Plan, encouraged increased localization
2003	NDRC	"Notice on the Issuance of Wind Power Concession Project Preliminary Work Management Methods and Related Technical Provisions," 《关于印发风电特许权项目前期工作管理办法及有关技术规定》的通知 "Technical Regulations for Wind Farm Site Selection," 《风电场场址选择技术规定》 "National Large-Scale Wind Farm Construction Pre-Construction Work Outline," 《全国大型风电场建设前期工作大纲》	Imposed 70 percent local content requirement for wind power concession projects managed by the NDRC
2005	NDRC	"Notice of Requirements for the Administration of Wind Power Construction," 《国家发展和改革委员会关于风电建设管理有关要求的通知》	Extended 70 percent local content requirement to all wind farms nationwide
2007	NDRC	"Medium- and Long-Term Program for the Development of Renewable Energy," 《国家发展改革委关于印发可再生能源中长期发展规划的通知》	Listed "large-scale wind power equipment" as focus area
2009	NDRC	"Notice on Abolishing The Localization Rate Requirement for Equipment Procurement in Wind Power Projects," 《国家发展改革委关于取消风电工程项目 采购设备国产化率要求的通知》	Rescinded 70 percent local content requirement for domestic wind farms

Figure 5.2: **Timeline of Major Central State Policies in the Wind Power Industry**: Before 2003, wind power policy was fragmented across multiple agencies. After 2003, the NDRC took virtually complete control of regulating the sector.

In fact, given the attention paid to industrial development through the absorption and re-innovation of foreign technology throughout the 1990s, it is striking these concepts did not feature more centrally in the NDRC's mission statement. At any rate, there is little evidence that the NDRC was created for the purpose of advancing technology extraction efforts. Significantly, it did not gain a key institutional lever for inducing technology transfers, foreign investment approval authority, until more than a year after its formation.

The Impact of Administrative Restructuring on Technology Extraction in Wind Power

Administrative restructuring had two main, and related, implications for technology extraction efforts in the wind power sector. First, it consolidated policy authority in the hands of a single agency. Before 2003 major central-level wind policy decision-making was spread across three agencies, two of which, the SETC and SPC, competed for status and policy influence. Second, it consolidated authority in the hands of a powerful and highly proactive agency.

The latter point is reflected in the speed with which the NDRC took the reins of wind power policy. Within months of its formation, the NDRC issued a string of measures establishing a new Wind Power Concession Project (风电特许权项目), including the "Notice on the Issuance of Wind Power Concession Project Preliminary Work Management Methods and Related Technical Provisions" and "Technical Regulations for Wind Farm Site Selection," both published on September 30, 2003, and the "National Large-Scale Wind Farm Construction Pre-Construction Work Outline," issued November 29, 2003. Notably, all three policies bear the full imprimatur of the NDRC itself, though presumably they were formulated by the National Energy Administration (能源局), which was housed within the NDRC.

The first two policies outlined the basic parameters of the Concession Project, under which the NDRC directed state-owned utilities companies to sign long-term purchasing agreements covering the lifetime of large-scale wind farms, developers of which would be selected through a tender-based system. When introduced in late-2003, the Concession Project included a 50 percent local content requirement for all turbines manufactured for concession wind farms. In 2004, the NDRC increased the requirement to 70 percent. Importantly, with the exception of Goldwind, which established a commercial-scale manufacturing facility in 2002, at this time virtually all wind farm developers in China were foreign. In effect, then, the Concession Project guaranteed sales and profits for foreign wind farm developers in exchange for their support in training local partners to manufacture and assemble wind turbines. Between 2003 and 2007, China added 3,550 MW of wind turbine through the Concession Project, equivalent to 65 percent of all installed wind power capacity added during the period and more than seven times the total capacity added in the previous fifteen years.

The real watershed in wind power technology extraction efforts came in July 2005, when the NDRC issued a Notice extending the 70 percent local content requirement to all wind farms developed in China.[13] Although many foreign firms were already working to meet this requirement in their Concession Project wind farms, other had opted to work outside the Concession Project, at least partly out of technology transfer concerns.

This changed with the 2005 Notice. Leading foreign multinationals responded immediately to the Notice by announcing plans to build or expand Chinese factories and sending small armies of engineers and managers to train local workers (Blustein, 2019). In the case of Gamesa, these engineers not only oversaw "the construction of [an] assembly plant, but fanned to local Chinese companies and began teaching them how to make a multitude of steel forgings and castings, and a range of complex electronic controls."[14] By 2009, Gamesa estimated it had trained more than 500 Chinese machinery companies in manufacturing various wind power components.

As domestic manufacturing capabilities improved and Chinese firms' gained market share, the NDRC issued new measures to facilitate further technological upgrading. In 2007, it imposed a JV requirement for foreign firms manufacturing turbines with a capacity over 1.5MW. These turbines were not only larger but also much more complex than the smaller 500-600kW units Chinese firms had begun to specialize in, and thus required further investment in building out local expertise. Two years later, China added 2.5MW onshore and 3-5MW offshore wind turbines and

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[13] NDRC, July 04, 2005, "Notice of Requirements for the Administration of Wind Power Construction," 国家发展和改革委员会关于风电建设管理有关要求的通知.

[14] Bradsher, Keith. *The New York Times*. December 14, 2010.

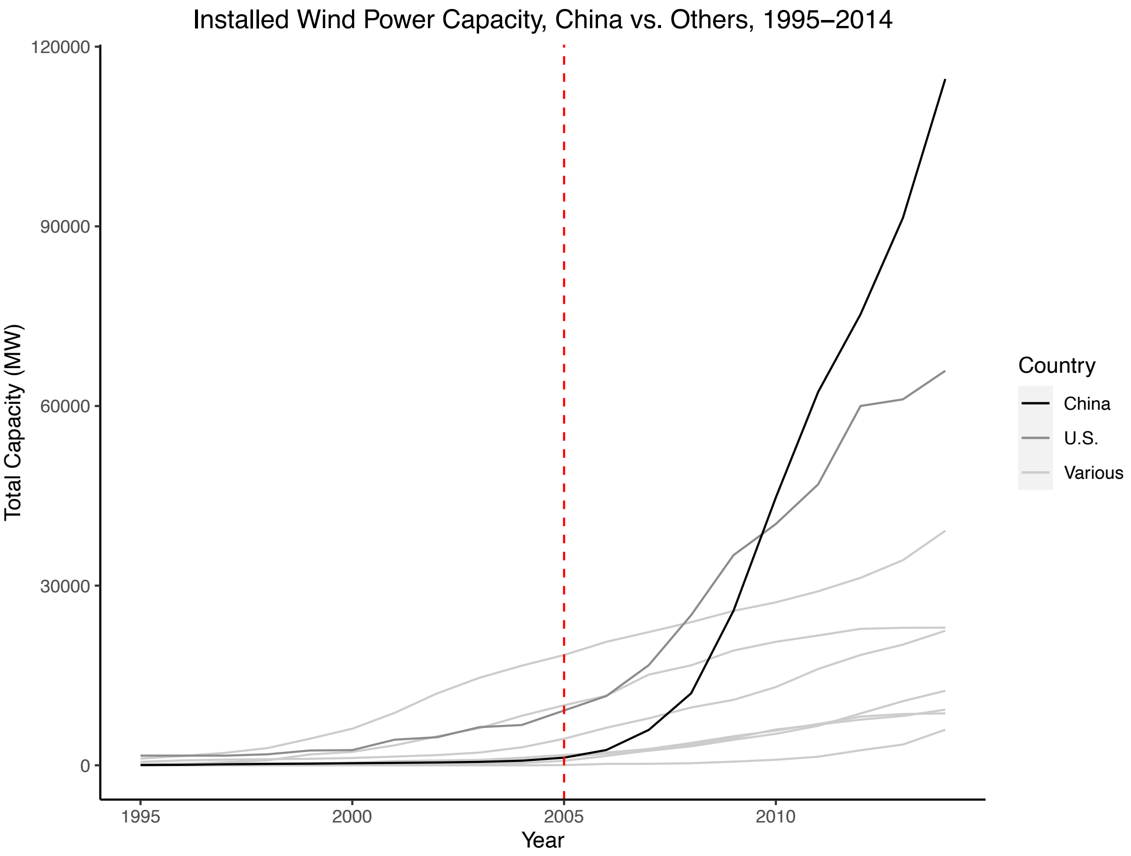

Figure 5.3: **Installed Wind Power Capacity, China vs. Others, 1995-2014**: China's installed wind power capacity grew sharply after 2005, the year the NDRC imposed a 70 percent local content requirement for wind turbines sold domestically. China overtook the United States as the world's largest wind power market in 2010. Source: Global Wind Energy Council.

associated parts to its Indigenous Innovation Catalogue. By 2009, however, Chinese firms had cornered the domestic market for most turbine models and had begun to expand sales overseas.

What impact did these policies have on the development of China's wind turbine industry? The bulk of the evidence, including contemporaneous news media coverage, subsequent secondary scholarship in both English and Chinese, and interviews with Chinese and foreign wind power executives, suggests the NDRC's actions, especially the 2005 Notice, were integral to the rapid expansion Chinese wind turbine manufacturing and Chinese producers' remarkable ascent up global value chains. Certainly, as Figure 3 shows, the timing of the increase in Chinese installed wind power capacity is consistent with my argument about the central role played by the NDRC.

Nonetheless, it is important not to overstate the significance of central level policies or underestimate other variables. For example, although the 2005 Notice almost certainly accelerated the pace of foreign investment in upgrading Chinese capabilities, foreign producers also had economic incentives to expand operations in China, not least because shipping finished wind turbines from Europe to China was expensive and logistically complex.[15] As Jorge Calvet of Gamesa observed, "Gamesa would have opened factories in China at some stage, regardless of the [2005] content policy," though likely not as quickly as it in fact did.[16] Vestas chief executive Ditlev Engel similarly "strongly believed that for us to be competitive in China, it was very important for us to develop an Asia supplier base."[17] Local government support was also crucial in translating central-level "indigenous innovation" goals into advances on the ground.

Whatever the significance of technology extraction policies for the development of China's industry, however, it is clear these policies became more frequent, more ambitious in scope, and more forcefully enforced after 2003, which is my outcome of interest. Likewise, the evidence indicates that the NDRC's unrivaled position and proactive posture after 2003 was a crucial factor behind the increased intensity of technology extraction efforts after 2003. It is noteworthy that the NDRC's actions follow almost immediately after its formation in March 2003, long predating the launch of the Medium- and Long-Term Program, or MLP . This lends support to my argument in Chapter 3 that administrative restructuring and the rise of the NDRC was the "critical juncture" that made possible a new wave of industrial policy activity of which the MLP was the first major statement. Although the MLP was the proximate cause of the surge in technology extraction efforts across industries after 2006, that program itself is best understood as dramatically amplifying policy trends that date at least to 2003 and the formation of the NDRC. It is worth reiterating, too, that although MOST was responsible for coordinating the drafting of the MLP, responsibility for implementing the most important parts of the program fell largely to the NDRC (Serger and Breidne, 2007).[18]

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[15] Expert Interview, Washington DC. November 2021.

[16] Bradsher, Keith. *The New York Times*. December 14, 2010.

[17] Ibid.

[18] In April 2006, the State Council issued a document titled "Some Supporting Policies for the Implementation of

The Fall of Technology Extraction in Wind Power

Almost as striking as the rise of tech extractors in wind power was their decline after 2009. On October 13 of that year, the NDRC removed JV mandates for inward FDI in wind turbines and related components. On November 25, the NDRC formally ended the 70 percent local content requirement for domestic wind farms. Over the course of the next year and half, Chinese authorities removed a number of other subsidy programs for domestic wind power development, including a Ministry of Finance-run fund to promote domestic manufacturing. By the end of 2011, the only formal central-level technology extraction policy in place in wind power was the 2009 Indigenous Innovation Catalogue, which included 2.5MW onshore and 3-5MW offshore wind turbines.

This section examines the process behind the removal of technology extractors in wind power. In line with the argument developed in Chapter 3, I suggest that three developments led China's leaders to conclude after 2009 that the costs of technology extractors, in the form of credible threats of reciprocal restrictions on trade with and investment from Chinese firms by key trade partners, had begun to outweigh their utility in the wind energy industry. First, as the discussion in the previous section demonstrates, by 2009 Chinese firms had made impressive progress towards closing the technological gap with industry leaders like Vestas and Siemens-Gamesa. As a result of this progress, tech extractors lost much of their original utility in the sector.

Second, as Chinese wind turbine makers became more competitive in the late-2000s, they began to expand sales and investments overseas, including establishing significant operations in the United States and Western European countries. In 2008, China became a wind turbine net exporter, and over the coming years its share of global wind turbine sales rose sharply, from essentially zero as late as 2005 to 14 percent in 2020. In another testament to Chinese firms' growing capabilities, during this time China also emerged as an important overseas investor in greenfield wind power projects. Unlike the overseas mergers and acquisitions which predominated in other technology sectors where China remained behind the technological curve, greenfield investments were not

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the "National Medium- and Long-Term Program for Science and Technology Development," ("国家中长期科学和技术发展规划纲要"的若干配套政策). Of the 99 implementing policies outlined in the document, 29 fell to the NDRC, the most of any agency, followed by the MOF at 21 and MOST at 17.

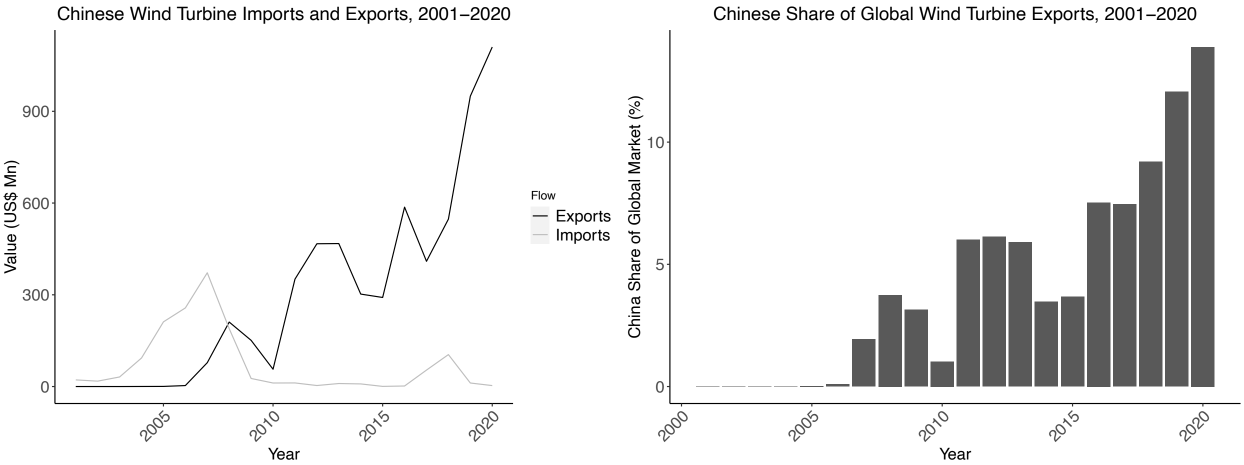
driven by tech acquisition interests. Instead, they signaled that Chinese firms could compete for and win contracts abroad. Xinjiang Goldwind led the way in such investments with several major projects in the United States between 2009-2011, and later in Chile and Australia.

Third, as Chinese companies solidified their hold over the home market and grew their international footprint, foreign firms and governments began to cry foul. Most egregious, in their view, was that China maintained tight controls on foreign penetration of its own market even as it exploited relatively open investment environments abroad. In an industry as internationally concentrated and with as large economies of scale as wind energy, and thus in which corporate profitability depends on exploiting the largest market possible, such asymmetric restrictions had potentially significant distributional consequences for foreign wind multinationals. Responding to firms' concerns, starting in 2009 the U.S. and various European governments and business associations put direct pressure on China's leaders to remove technology extractors in wind energy.

With Chinese firms now commanding upwards of a 90 percent market share at home and looking to expand their presence abroad further, public remonstrances by foreign governments made tangible the risks of keeping tech extractors in place by raising the specter of reciprocal controls on Chinese exports and outward FDI in the sector. Against this backdrop, Chinese authorities concluded that technology extractors had served their purpose and now risked becoming liabilities. They quickly moved to remove the most controversial and overt tech extractors in wind power.

The remainder of the section is divided into two parts. In the first part, I examine the rapid development of China's domestic wind power industry after 2004-2005. I then develop the link between increased Chinese competitiveness and foreign governmental pressure for the removal of technology extractors by showing that China's gains generated real distributional consequences for foreign wind companies. In the second part, I illustrate how foreign corporate and government pressure led Chinese authorities to remove technology extractors after 2009.

Distributional Consequences of Increased Chinese Competitiveness



(a) China Wind Turbine Exports

(b) China Export Market Share

Figure 5.4: **Chinese Wind Turbine Imports and Exports, 2001-2020** and **Chinese Share of Global Wind Turbine Exports, 2001-2020**: Chinese wind turbine exports grew sharply, both in absolute terms and as a share of the global market, between 2001-2020. Source: UNCTAD.

In 2001, China exported $20,000 worth of wind power generator sets, equivalent to .0018 percent of the global market. By 2008, Chinese wind turbine exports reached $210 million, about 4 percent of the global total, and included $107 million worth of exports to the United States.[19] Today, China accounts for 14 percent of wind turbine exports worldwide, supplies one-quarter of U.S. wind generator imports, and provides 12.3 percent of all German wind imports. Although foreign MNEs operating in China account for a portion of those exports, their share has declined steadily over time. Even those turbines exported under brands likes General Electric or Siemens-Gamesa now incorporate a multitude of Chinese-designed and -manufactured components.

As previous work shows, the rise of China's wind power industry is not simply a story of low costs (Lewis, 2012, 2016, 2019; Nahm, 2017, 2021). Instead, as Chinese firms expanded their market share at home and abroad, they invested heavily in improving in-house design and manufacturing capabilities. The result is that Chinese firms have steadily approached the world technological frontier in wind turbine manufacturing, as reflected in outcomes like maximum turbine unit size. In 2007, the largest turbine Chinese firms were capable of producing was 1.5MW, compared with a global maximum of 6MW. By 2014, China's leading wind turbine makers were

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[19] Data from UNCTAD.

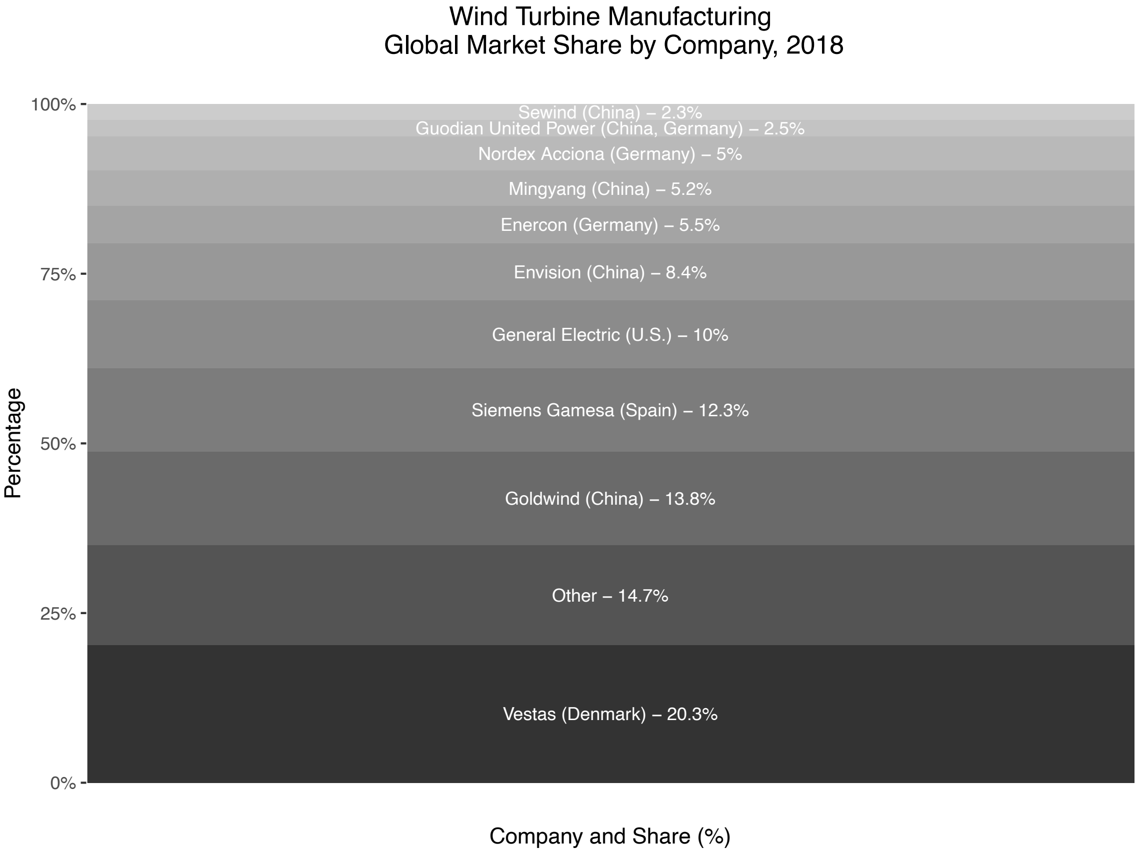

Figure 5.5: **Wind Turbine Manufacturing Global Market Share by Company, 2018**: Four firms - Vestas, Goldwind, Siemens Gamesa, and General Electric - account for nearly 60 percent of the global wind turbine market. Source: Statista.

manufacturing 6MW turbines, versus the global maximum of 8MW (Lewis, 2016). Today, top Chinese wind developers have all but closed the technological gap (Lewis, 2019).

This transformation had important implications for the commercial interests and political behavior of foreign MNEs. In the decade after the NDRC's 2005 local content requirement, foreign wind producers saw their share of China's market fall from nearly 80 percent to under 10 percent. To be sure, the market's phenomenal growth over the same period – from 2004 to 2014, installed wind power capacity in China increased 150-fold – ensured that even as their share of the Chinese market dwindled, foreign firms reaped substantial profits. Gamesa's 3 percent share of the Chinese market in 2009 was three times larger, in real terms, than its 35 percent share of the market in 2004.

Nonetheless, for foreign MNEs the loss of the Chinese market and the prospect of increased

Chinese competition overseas represented a significant threat. Globally, the wind market is highly concentrated. In 2018, four companies accounted for nearly 60 percent of wind turbine sales worldwide. When this level of industry concentration is combined with large economies of scale, the result is what economists call "oligopolistic rivalry," in which firms confront each other in the market much as states under anarchy: as adversaries in a zero-sum struggle for relative market share. This is because as economies of scale in production increase, for example due to high R&D expenditure requirements, so does the need to exploit the largest market possible. In this context, measures like local content and joint venture requirements that gave domestic firms a one-sided advantage in the Chinese market could "shift profits" away from foreign rivals, setting in motion a "circular causation from output to marginal cost to output" whereby domestic companies become larger and more profitable as foreign rivals shrink (Stegemann, 1989; Krugman, 1986).

It is thus not surprising that foreign MNEs in wind power were alarmed by the rapid improvement in Chinese capabilities. These concerns were powerfully magnified by the 2008-2009 global financial crisis, which dampened demand for wind turbines in the U.S. and Europe, forcing foreign firms to reduce output. The financial crisis triggered a wave of consolidation and downsizing in the sector, with even industry leader Vestas closing four factories and laying off one-eighth of its 24,000 employees. Concerns over Chinese competition in wind power reached a fever pitch in the United States in 2009 when a Chinese-American joint venture announced plans for a $1.5 billion wind farm in Texas that would utilize turbines manufactured in China. Although the firm later brokered a deal with the United Steelworkers to produce key components in the United States, the episode exacerbated fears in the U.S. that as domestic wind developers retreated, their Chinese competitors overwhelm the market – aided by government policies that artificially reduced costs, boosted margins, and facilitated further expansion.

Foreign Pressure and the Removal of Technology Extractors

The first indications of foreign governmental pressure to remove technology extractors in wind power came in the summer of 2009. On June 25, Premier Wen Jiabao promised German Chancellor

Angela Merkel that China would not discriminate against foreign firms in the industry. The next month, U.S. Secretary Steven Chu and Commerce Secretary Gary Locke flew to Beijing to discuss China's clean energy development policies. Finally, during the October 2009 session of the U.S.-China Joint Commission on Commerce and Trade (JCCT), Locke and U.S. Trade Representative Ron Kirk called on China to rescind the 2005 local content requirement.

American officials were pushing on an open door. Less than a month after the JCCT meeting, the NDRC rescinded its 2005 content requirement.[20] On October 13th, the NDRC repealed joint venture requirements in wind power. By the time the Obama administration formally opened an investigation under the WTO into Chinese protectionist policies in wind power in October 2010, the NDRC and MOF had removed at least two other subsidy programs. In a bid to resolve the WTO case, China in 2011 agreed to remove another, smaller subsidy program. But for all intents and purposes, China had substantially dialed down technology extraction policies and other supportive efforts well before the WTO petition was even filed.

Foreign government pressure clearly provided the immediate trigger for the removal of technology extraction policies in wind power. But the ease and swiftness with which such pressure, once applied, yielded policy change suggests that by 2009 Chinese leaders no longer saw tech extractors as critical to supporting domestic industrial upgrading. Moreover, quotes from Chinese officials and industry leaders indicate both groups were well aware tech extractors risked becoming liabilities as Chinese firms sought market share abroad. As Wu Gang, President and CEO of Goldwind put it in early 2010, "the cancellation of the 70 percent localization policy can benefit competition domestically but also encourage domestic enterprises to go international."[21] Wu added that because China canceled its policy proactively, it reduced "the possibility of encountering protectionist policies" in other countries when "China's companies develop their markets overseas."[22] This sentiment was widely echoed by other Chinese wind power executives, including Chen Danghui, a technical director at Sinovel, who observed, "[n]ow that we have grown up, the cancellation

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[20] NDRC, November 25, 2009, "Notice on Abolishing The Localization Rate Requirement for Equipment Procurement in Wind Power Projects," 国家发展改革委关于取消风电工程项目采购设备国产化率要求的通知.

[21] Dewey and LeBoeuf, pg. 59.

[22] Ibid.

of the [local content] requirement will not have any impact on us." Chinese government officials likewise publicly welcomed the policy change. In 2010, Shi Lishan, Deputy Director of the National Energy Administration, noted that "This regulation was formulated at the initial stage of China's wind power equipment development to protect domestic enterprises. Through development in the past years, domestic enterprises have increased their manufacturing capability and are able to join international enterprise to participate in fair competition in the market."[23]

The above statements provide clear and direct speech evidence that China's increased competitiveness in wind power, and in turn the prospect of expanding further overseas, had sensitized Chinese wind power executives and officials alike to the norm of reciprocity in international trade. These concerns, combined with the fact that they no longer need fear foreign domination of the home market, primed Chinese authorities to be highly responsive to foreign demands for the removal of tech extractors. By 2009, China had obtained the technological hardware and software it needed to build a world class wind energy industry. It had little more to absorb. With the cost-benefit calculus now favoring openness at home, China abolished technology extractors in wind energy even in the absence of actually punitive measures by foreign governments.

Alternative Explanations

The previous sections provided evidence on behalf of my arguments that administrative restructuring between 1998-2003 paved the way for a surge in technology extraction efforts in wind power by increasing central enforcement capacity, and that increased Chinese competitiveness combined with pressure from foreign governments led China to remove tech extractors after 2009. In this section, I address alternative explanations for the rise and fall of technology extraction policies in the wind power industry.

The first, and in my view most compelling, alternative explanation comes from interest group models of trade policy, which view policymaking as the result of a bottom-up process whereby

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[23] Dewey and LeBoeuf, pg. 58.

societal interest groups compete to bend policy outcomes in ways that benefit them materially. A core assumption of this framework is that political institutions influence trade policy outcomes primarily through their role as aggregators of interest group preferences which are defined in terms of economic characteristics exogenous to politics, such as factor endowments, industry advantage, and firm size. To the extent national governments have preferences over trade policy, they amount to a vague commitment to balancing the particularistic demands of societal interest groups against a general concern for national welfare (Grossman and Helpman, 1994). For the most part, however, interest group approaches either implicitly or explicitly treat national governments as little more than ciphers for the policy interests of the firms, industries, classes, or voters on whose political support they depend (Lake, 2009; Milner and Kubota, 2005; Kim, 2017).

The notion that politics is defined by competition for status and influence among parochially-minded actors – whether Communist Party elites, central state agencies, local governments, or state-owned enterprises – has been a mainstay of research on Chinese politics since the 1960s.[24] More recently, China scholars have extended this framework to examine the conditions under which actors positioned outside the political apparatus can shape national policy outcomes, including in trade policy (Mertha, 2009; Kennedy, 2009; Deng and Kennedy, 2010; Li, 2013). Although this research is seldom self-consciously framed as an application of interest group models to the Chinese case, the parallels are unmistakable. Most importantly, this research shares with interest group models an underlying assumption that the central state is not a meaningful, coherent actor endowed with distinctive preferences, but an arena in which competing interest groups vie for policy influence. To date, this framework has not been systematically applied to the case of Chinese industrial policy in the post-WTO era. But it is sufficiently well established to constitute the "null hypothesis" against which theories of Chinese political economy must be tested.

Lobbying for protection by economic interest groups cannot explain the rise of technology extraction efforts in wind power because, as one interviewee put it, the industry "did not exist"

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[24] See Lieberthal and Oksenberg (1988), Chapter 1, for a detailed review of early scholarly literatures on interest group-based approaches in research on Chinese politics.

before central-level policies created it.[25] As I demonstrated above, Chinese central state initiatives to develop domestic wind turbine manufacturing capabilities date at least to 1994, well before the development of utility-scale wind turbines in China and at least eight years prior to the first major production facility owned and operated by a Chinese firm was opened. Moreover, early efforts like the 1997 Ride the Wind program failed, in large part, because they relied on state-selected Chinese firms with no background or interest in developing wind turbines (Lewis, 2016).

Perhaps most telling is the role, or lack thereof, of China's "Big Five" power generators in the early development of the domestic wind energy industry. As "core" centrally-administered SOEs, the Big Five rank among the most influential and politically well-connected enterprises in China. Given their political stature and historical near-monopoly on electricity generation, the Big Five represent a natural constituency for central-level policies to promote wind power. As such, if lobbying by economic interest groups explains technology extraction efforts in the wind industry, such pressure would most likely emanate from these firms.

In practice, however, there is scant evidence that the Big Five power generators sought central state support for developing wind power. Indeed, prior to 2007, major state-owned power producers appear to have had little involvement in the industry. The first example of a Big Five firm developing wind power is the Huaneng Nan'Ao wind farm, which began operations in 2000. But as late as 2009, this project relied exclusively on wind turbines imported from Denmark and manufactured by Vestas. Today, the only Big Five power generator with a significant presence in the wind turbine manufacturing industry is Guodian, which created Guodian United Power, a wind power subsidiary, in 2007. Meanwhile, there is indirect evidence of foot-dragging by state-owned power generators when it comes to renewable energy. For example, in its 2007 "Medium- and Long-Term Program for the Development of Renewable Energy," the NDRC mandated that power generation companies with installed capacity greater than 5,000MW must increase the share of electricity they derive from non-hydro renewables from 1 to 3 percent by 2010 and 8 percent by 2020.[26] That such a

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[25] Expert Interview, Washington, D.C. November 2021.

[26] NDRC, August 31, 2007, "Medium- and Long-Term Program for the Development of Renewable Energy," 国家发展改革委关于印发可再生能源中长期发展规划的通知. The relevant section of the law: "对非水电可再生能源发电规定强制性市场份额目标：到2010年和2020年，大电网覆盖地区非水电可再生能源发电在电网总发电

mandate was deemed necessary suggests Chinese authorities feared that left to their own devices, power generators would not increase renewables' share in their electricity mix.

Although bottom-up interest groups likely did not cause the rise of tech extraction efforts in wind power, they did probably factor into decisions to remove these tools after 2009. At the very least, the NDRC and other central agencies undoubtedly consulted with domestic wind power producers when considering how to respond to U.S. and European demands for the elimination of the 2005 Notice and JV requirements. But given the central state's broader and explicit goal of encouraging outward investment by Chinese firms, especially after the start of the 2008-2009 global financial crisis, it seems unlikely that firm-level demands for liberalization were the only or even primary motive behind the decision to remove technology extractors in the wind industry.

A second possible alternative explanation focuses on the "shock" of WTO entry, which confronted Chinese firms with intense new competitive pressures but also provided a unique opportunity to channel surging inward FDI towards strengthening Chinese companies. It could be that after WTO entry in 2001, Chinese leaders recognized the urgent need to expand technology extraction efforts, and this new understanding drove a surge in the use of technology extraction policies. This is, of course, broadly consistent with my argument, which emphasizes the relationship between WTO entry and administrative restructuring in 1998 and 2003. But WTO entry alone does not explain the timing of Chinese technology extraction behavior. China joined the WTO in November 2001, but we do not see changes in technology extraction efforts in wind power until nearly two years later. On the other hand, Tan (2021) points to declining accountability to the WTO as China fulfilled the commitments outlined in its accession protocols as the main factor behind the rise of "state capitalism" after 2004-2005. But China's main commitment in wind turbines, to reduce tariffs on imported generator sets from 10 to 8 percent by 2002, hardly seems sufficient to have prompted the NDRC's response. Meanwhile, Chinese technology extraction efforts begin well before China had fulfilled many other WTO commitments, and thus before the decline in WTO accountability Tan emphasizes.

量中的比例分别达到1%和3%以上；权益发电装机总容量超过500万千瓦的投资者，所拥有的非水电可再生能源发电权益装机总容量应分别达到其权益发电装机总容量的3%和8%以上."

Conclusion

The wind power industry powerfully illustrates my argument that administrative restructuring was the crucial factor that facilitated the rise of technology extraction efforts in the post-WTO period. As I showed, China had sought to develop wind power through introducing, absorbing, and re-innovating foreign technology since at least the mid-1990s. However, these efforts bore little fruit before 2003. With the NDRC's formation – and, just as important, the elimination of bureaucratic rivals at the bottom and top of China's policy apparatus – China finally forged an institutional hammer capable of enforcing strict technology transfer policies in wind power emerged. I also demonstrated that although technology extractors generated significant income effects for foreign firms, and in turn foreign governmental pressure for their removal, this pressure was secondary in the eventual removal of these policies. Far more important was Chinese firms growing competitiveness and appetite to export and invest overseas, which sensitized firms and officials alike to the norm of reciprocity in international trade. The recognition of the need for reciprocity, and attendant risks of *negative* reciprocity by major trade partners, was the most important reason China eliminated major central-level technology extraction policies in wind power after 2009. Finally, I showed that prominent candidate alternative explanations do not adequately explain the timing or dynamics of technology extraction efforts in the wind energy industry.

Chapter 6

Technology Extraction in Semiconductors

Semiconductor design and fabrication is without question among the world's most strategically vital high-technology industries. Also known as integrated circuits (ICs) or simply chips, semiconductors are integral to all electronic devices, from computers to smart phones to modern vehicles and beyond. Advanced semiconductors are also among the most complex and capital- and knowledge-intensive goods in existence. The leading edge integrated circuits being manufactured today are the product of decades and tens of billions of dollars in research and development (R&D) and are made possible by the seamless integration of thousands of pieces of sophisticated machinery and at least as many highly-trained technicians in an intricate web of globe-spanning supply chains.

China's leaders have long viewed building a strong domestic semiconductor industry as critical to national security and long-term economic competitiveness. And although its approach to nurturing the sector has evolved over time, the post-Mao CCP leadership has never harbored illusions it could develop indigenous chipmaking capabilities absent access to foreign technology and know-how. Efforts to secure this technology are no less integral to Chinese IC industrial policy today, as the Xi administration embarks on a long march towards semiconductor self-reliance, than they were at the dawn of "Reform and Opening" in 1978 (Fuller, 2021; Segal, 2021).

Against this backdrop, it is puzzling that China largely refrained from introducing IC-related technology extractors – defined as publicly documented central state policies that condition access to or preferential treeatment in the Chinese market on foreign firms' willingness to partner with and transfer technology to local firms – in the post-WTO period. Since China began issuing industry-specific ownership restrictions on inward FDI in 1995, it has never once imposed controls such as joint venture requirements in the sector. Indeed, by 2007 China had enacted some form of FDI ownership restriction in nearly every industry targeted for "indigenous innovation" support in the MLP *except* semiconductors. Nor is there evidence in ICs of the sort of explicit local content requirements pervasive in sectors like wind power, high-speed rail, civilian aircraft manufacturing, and new energy vehicles. Finally, although China used preferential public procurement policies in the industry after 2009, it did so to a much lesser extent than in other strategic industries.

What explains the near absence of technology extractors in semiconductors after 2001? Why, in particular, did China refrain from imposing JV requirements and other ownership restrictions on inward FDI, historically the primary institutional vehicles through which it has sought foreign technology transfers? And if not through technology extractors, then by what other means did China pursue technology transfer in semiconductors in the post-WTO era?

These questions form the central puzzle that motivates this chapter. To answer them, I trace the trajectory of Chinese central-level policies in semiconductors from 1978 to the present. This trajectory differs markedly from those of most other strategic industries, in which administrative restructuring and consolidation in 1998 and 2003-2005 fueled a surge in tech extraction efforts. By contrast, semiconductor industrial policy in the immediate post-WTO period was characterized by liberalization of FDI controls and weak overt efforts to induce foreign technology transfer. Only after 2009, and especially with the launch of a National IC Investment Fund in 2014, did central state-led technology transfer efforts once again take center stage in Chinese semiconductor policy.

This unusual policy path has important implications for our understanding of variation across industries and over time in China's use of technology extractors. If bureaucratic consolidation within the central state is sufficient to explain when China introduces these policy tools in strategic industries, then we should observe Chinese authorities employ them in semiconductors – a strategic industry *par excellence*, as I argue below – at least as intensively as they do in other high value-added sectors targeted for industrial upgrading in major development programs like the MLP. That we do not suggests the strategic value of an industry and central enforcement capacity alone do not account for all of the relevant observed variation in Chinese tech extraction efforts.

I fill this gap by focusing attention on the other element of bargaining power discussed in Chapter 3: The balance of dependence between China and foreign investors. Previously, I argued China will be reluctant to impose technology extractors in industries in which it depends more on foreign firms as suppliers of goods and services and as sources of economic growth and employment than foreign firms depend on it as a final consumer market. I further anticipated that China's relative dependence would exceed that of foreign firms when it occupies an intermediate position in global value chains. When China is intermediate to GVCs, most of what it "consumes" consists of imports of foreign inputs to be processed locally and re-exported as more finished goods to consumer markets overseas. This has several implications for China's behavior. First, the greater the share of Chinese demand that is associated with processing trade, the smaller China's "true" final consumption, and in turn the weaker China's ability to leverage access to its internal market to require foreign investor compliance with technology extractors. Second, the greater China's reliance on processing trade, the deeper its dependence on the foreign firms which dominate GVCs not only as sources of direct employment in China, but also as gatekeepers to overseas consumers and drivers of export growth. I expect the combination of reduced leverage over and greater reliance on foreign firms to deter China from imposing tech extractors in these industries.

Building on this argument, I suggest that China's integration into semiconductor GVCs as an export-processing hub best explains the near-absence of technology extractors in ICs in the post-WTO period. Specifically, China's position in GVCs explains why the IC industry was largely excluded from the surge in technology extractors that followed the MLP's launch in 2006.

Prior to 2001, Chinese technology transfer efforts in ICs followed a similar trajectory to those in other strategic industries. Although China's leaders actively pursued foreign technology in a wide range of sectors during the 1980s and 1990s, weak central enforcement capacity and the small size of China's internal market undermined its bargaining power with foreign investors. This made potentially controversial policies like sector-wide JV mandates and local content requirements impractical in most industries. Instead, in ICs as in other strategic industries, throughout the 1990s China primarily pursued technology transfers through "arranged marriages" between foreign firms and hand-picked Chinese state-owned enterprises (SOEs). The direct involvement of top Chinese officials strengthened China's hand in negotiations over these JVs. Even so, as I discuss below, the small size of China's internal market was a powerful constraint on Chinese leaders' ability to find foreign partners willing to transfer technology to Chinese firms.

It was only after WTO entry that the trajectory of Chinese technology transfer policy in semiconductors began to diverge from that in other strategic industries. Accession to the WTO lifted China's "baseline" bargaining power by turbocharging investor expectations regarding the country's future market growth. Meanwhile, administrative restructuring in 1998 and 2003-2005 increased the enforcement capacity of China's central state. The result of these developments was a broad increase in technology extraction efforts in most strategic industries after 2006. Not, however, in semiconductors. In sectors like wind power, high-speed rail, and aircraft manufacturing China sat primarily downstream of GVCs as a final consumer market. That is, most of what China produced and imported in these sectors was ultimately consumed within China. This simultaneously gave China leverage over foreign firms' seeking access to the Chinese market and left China relatively free from any reciprocal reliance on those firms, for example to drive export growth. As a result, China faced few constraints on the use of tech extractors in these industries. By contrast, China's deep and deepening integration into semiconductor supply chains as an intermediate processing hub – by 2007, nearly 90 percent of Chinese IC imports would be tied to processing trade – left it heavily dependent on foreign chip makers and the markets they served to fuel its export-led growth model. This dependence ensured the "adjustment process" following a disruption to semiconductor trade and investment would be at least as painful for China as for the chip makers, if not more (Hirschman, 1945). This, in turn, undercut the credibility of Chinese threats to cut off access to its markets if chip makers refused to comply with technology extractors.

To be sure, China did not abandon technology acquisition efforts in ICs after WTO entry. Informal inducements on foreign investors to share technology and expertise remained commonplace, even in the early post-accession years when China's processing trade dependence was greatest and its bargaining power weakest. My argument is simply that dependence on processing trade deterred China from imposing formal technology extractors in ICs, especially in the first decade following accession. Because overt conditional market access barriers like tech extractors are both costly for foreign firms and relatively easy to police from the outside, imposing them required a willingness and ability on Chinese authorities' part to face down foreign opposition. It also required confidence that foreign firms would comply regardless of their protestations. As long as the balance of dependence favored foreign firms, China's leaders could not be confident in this outcome.

As with the other case studies, this chapter employs a "before and after" research design to examine my argument about the relationship between bargaining power and technology extraction in semiconductors. But whereas the other cases focus on administrative restructuring in 1998 and 2003-2005, this chapter directs attention to the growth in Chinese final demand for consumer electronics, and the corresponding decline in the share of Chinese imports tied to processing trade, in the decade after the 2008-2009 global financial crisis. I argue that as China moved from a firmly intermediate position in GVCs to a more downstream position, its bargaining power over foreign MNEs increased. The growth in Chinese bargaining power in ICs spurred more energetic tech acquisition efforts in the industry, though for reasons I explore later in the chapter, these efforts have by and large not taken the form of overt technology extractors. Instead, China's pursuit of foreign IC technology since 2014 has consisted primarily in outward FDI, commercial espionage, and more assertive but still informal inducements to share technology.

The evidence presented in this chapter draws on a variety of sources. This includes over a dozen interviews with current and former semiconductor industry executives and other industry insiders, former U.S. trade officials, lawyers, and analysts at think tanks and universities in the United States and China. The case study also draws on analysis of Chinese central state laws and regulations, Chinese trade and industry data, and a range of secondary sources.

The remainder of the chapter is organized as follows. Section two establishes why semiconductors provide a valuable test for my theory. Section three traces the evolution of Chinese IC industry policy from 1982-2008. Section four assesses the revival of tech transfer efforts in ICs after 2009. I conclude with reflections on what recent semiconductor industry policies portend for the future of technology transfer in China.

Why Study the Semiconductor Industry?

The semiconductor industry provides a valuable test of my arguments about variation across industries and over time in Chinese technology extraction efforts for three main reasons. First, semiconductors are substantively important. Indeed, the design and fabrication of advanced ICs is arguably the most strategically vital high-technology industry in the world today. As such, apart from its usefulness as a test of my theory, a case study on Chinese technology transfer policy in the IC sector represents a potentially valuable empirical contribution to the literature in its own right.

Second, the semiconductor industry exhibits negative values on my outcome variable for most of the study period. As such, a case study on ICs helps guard against the risk of selecting on the dependent variable, which can lead to biased inferences about relationships between variables of interest. For example, if I were to only examine the wind power and civil aircraft manufacturing industries, both of which were subject to intense technology extraction efforts after 2003-2005, I might conclude that increased central enforcement capacity invariably leads to greater use of technology extractors in strategic industries. As the statistical analysis in chapter four demonstrates, this conclusion would be mistaken. Although that analysis established a clear association between high processing trade-dependence and weaker Chinese tech extraction efforts in strategic industries, it shed less light on the mechanisms linking these variables. A qualitative case study can help to fill this gap by allowing me to trace the process by which variation in China's relative dependence on foreign firms influences Chinese tech transfer policy. Because of ICs' acute strategic importance, the industry's status as a "dog that did not bark" provides additional leverage for my clain that when China is intermediate to GVCs, large gains in central enforcement capacity are unlikely to lead to increased technology extraction efforts in even the most strategic of industries.

Finally, a case study on the IC sector provides valuable insight into when and why China uses tools of technology transfer other than formal technology extractors. In particular, semiconductor design and fabrication illustrates the rising importance of outward FDI by Chinese firms as a source of technology transfer after 2014 – the same process which led to the broad removal of formal technology extractors in other industries. More generally, semiconductors provide a glimpse of how Chinese technology transfer efforts have evolved under Xi Jinping, including China's growing tendency to substitute informal for formal measures for securing foreign technology.

The Strategic Importance of Semiconductors

There can be little doubt as to the economic importance of semiconductors. They are the world's third most imported good, the companies that make them are among the largest and most innovative in the world, and without them life as most of us know it would be unthinkable. Given the centrality of ICs to the global economy, a case study on China's efforts to acquire foreign technology and expertise in semiconductors constitutes a potentially valuable contribution to the literature regardless of what the industry says about my theory. International relations scholars, in particular, should care about China's position in the IC industry because of the sector's unparalleled strategic value, impact on current United States-China relations, and potential implications for East Asian regional security. To a very great extent, China's continued economic rise and the United States' ability to sustain its position at the top of the world political economy will depend on how the distribution of semiconductor design and fabrication capabilities evolves in the years ahead.

Although the importance of semiconductors is clear, it is worth reflecting on what, precisely, makes the sector *strategic*, defined as industries of great economic or military utility in which private markets alone are likely to underinvest, and which therefore require attention from the highest levels of the state (Ding and Dafoe, 2021). After all, many economically vital sectors, such as textiles and commercial real estate, would not qualify as strategic under this definition.

Semiconductors are strategic, even uniquely so, because they entail industrial processes and inputs that span each of the three classes of strategic sector Ding and Dafoe (2021) identify. To begin, semiconductor production is characterized by extraordinarily high financial and technical barriers to entry due to huge economies of scale and steep cumulative learning effects. IC design is the most R&D intensive industry in the world, with top design firms like Nvidia and AMD regularly investing up to a quarter of their annual revenues in research. Meanwhile, pureplay foundries that manufacture but do not design semiconductors spend up to 35 percent of their income on equipment: TSMC alone plans to invest up to $100 billion in new production capacity between 2021-2024 (Varas et al., 2021, 26). Compounding these financial barriers are the advantages incumbents gain through accumulated and deeply institutionalized process knowledge. Indeed, the cumulative learning effects that come with long experience competing at the leading edges of IC design and fabrication may well pose an even greater barrier to entry than money. As China has learned the hard way, even limitless resources -– including sufficient funds to buy entire teams of engineers from competitors – do not guarantee a world-class IC sector, at least in the near term.

In addition to high barriers to entry and steep cumulative learning effects, ICs also arguably belong to the two other classes of strategic industry identified by Ding and Dafoe: (1) basic infrastructure that generates large positive economic spillovers, and (2) critical inputs for which supply is limited or geographically concentrated, and therefore vulnerable to disruption. Semiconductors are the basic infrastructure of most forms of basic infrastructure, including transportation, power generation and transmission, telecommunications, and urban gas and sewage systems. As such, advances in semiconductors have huge spillover effects across society, effects that will become more salient as artificial intelligence (AI) applications proliferate and fifth-generation (5G) technology becomes an everyday reality. The relatively slow rollout of 5G base stations in the U.S. and Europe attests to how a lack of state involvement leads to sub-optimal outcomes in IC-related infrastructure.

Finally, production of the most advanced semiconductors, IC design software, and semiconductor manufacturing equipment (SME) is extremely concentrated and highly vulnerable to supply disruptions. For example, three firms, all headquartered in the United States, supply almost all of the most advanced electronic design automation (EDA) tools necessary to design cutting-edge chips (Triolo, 2021). Two firms, TSMC and Samsung, are capable of manufacturing the leading edge chips on which new smartphones and laptops run. And just one firm, the Netherlands' ASML, produces the extreme ultraviolet (EUV) lithography machines without which it is impossible for foundries like TSMC to print designs from firms like Apple using software from American EDA giants like Cadence onto silicon wafers. This concentration creates potentially crippling chokepoints for downstream electronics firms. China learned this the hard way, first after the U.S. Department of Commerce added the telecommunications giant Huawei to its "Entity List" in 2019, and more recently after Washington imposed export controls on advanced semiconductors and the tools used to make them (Fuller, 2021).[1]

High barriers to entry, huge technological spillovers, and vulnerable supply together make semiconductors a quintessentially strategic industry. High barriers to entry make it infeasible for latecomer firms like those in China to compete absent support from the state. Spillovers exacerbate incentives to free-ride for individual commercial actors who do not internalize all of the benefits of their investments, thus necessitating intervention by states as providers of public goods like R&D funding. The concentration of supply both geographically and within individual firms creates chokepoints that markets alone may be unable to resolve in a timely manner. For all of these reasons, it is infeasible that China could develop a competitive semiconductor industry absent close attention from the highest levels of the central party-state.

Semiconductors as a "Dog That Did Not Bark"

In addition to its intrinsic strategic importance, semiconductor production constitutes a valuable test of my theory because it exhibits negative values on my dependent variable, China's use of technology extractors, for most of the study period. Whereas bureaucratic consolidation led to a surge in technology extraction efforts in many strategic industries, Chinese policy in semiconductors followed a different path in the post-WTO period. Examining this divergence reduces the risk of

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[1] Jake Sullivan, October 12, 2022, "Remarks by National Security Advisor Jake Sullivan on the Biden-Harris Administration's National Security Strategy," Retrieved May 1, 2023, *https://www.whitehouse.gov*.

selecting on the dependent variable by looking at only "positive" or only "negative" cases.

Semiconductor design and fabrication is not the only strategic industry in which China introduces relatively few technology extractors during the study period. However, it provides unusual inferential leverage for my theory because from the vantage of strategic value alone and of interest group models of trade policy, semiconductors should have been among the *most likely* targets for technology extraction efforts in the post-WTO period. Given ICs incontestable strategic nature, strategic value alone cannot be sufficient to explain cross-industry variation in the use of tech extractors. Likewise, as of the late-1990s, China's IC industry consisted a small number of large, politically well-connected, import-competing state-owned enterprises (Fuller, 2016). This is precisely the kind of actor interest group approaches expect to push hardest and most successfully for protection. If bottom-up demands for protection or support explain China's policy behavior, then we would expect to see far more intensive use of technology extractors in semiconductors than in, for example, wind turbine technology. In addition, a case study on semiconductors is valuable because by "holding constant" strategic importance and administrative restructuring, IC design and fabriaction allows me to better assess the independent effect of location in GVCs on Chinese tech extraction activities. In this way, it provides insight into potential mechanisms behind the association between high levels of processing trade dependence in China and the reduced use of technology extractors in strategic industries.

Semiconductors and the Future of Technology Extraction in China

Finally, the semiconductor industry offers a valuable window into how Chinese technology transfer policy changed after the decline of formal technology extractors discussed in earlier chapters and illustrated most vividly by the wind energy case study. To recapitulate, after rising to unprecedented levels between 2006-2014, the total number of technology extractors in place declined dramatically after 2015. By 2018, China imposed just eleven of these policy tools across all industries, down from well over three hundred at the peak in 2013. As I argued in chapter three, rapid gains in Chinese competitiveness across a range of high-valued added sectors meant that by 2014 technology extractors had lost much of their utility for further industrial upgrading. Moreover, as newly capital-rich Chinese firms began to expand their overseas investments and operations after 2014, tech extractors risked becoming liabilities to the extent they provoked backlash by major trade partners. As the cost-benefit calculus of maintaining these policy tools shifted, China opted to remove them from most strategic industries.

The wind power industry exemplifies how increased Chinese competitiveness lowered the benefits and raised the potential costs of maintaining technology extractors. As Chinese wind turbine manufacturers consolidated their control over the local market and began expanding overseas by 2008-2009, China quickly moved to eliminate controversial local content and joint venture requirements in the sector. Meanwhile, aircraft manufacturing shows how technology extractors persisted in industries in which China struggled to catch up to the world technological frontier. As late as 2017, China maintained formal JV requirements in the commercial aircraft sector.

The semiconductor industry illustrates a third path taken by Chinese technology transfer policy in the decade after the 2008-2009 global financial crisis. In ICs, Chinese efforts to acquire foreign technology not only persisted but increased substantially in the 2010s. But unlike in most other strategic industries, these efforts centered not on publicly-documented that conditioned access to China's market on technology transfers. Instead, they consisted of a combination of informal inducements to transfer technology and overseas mergers and acquisitions by Chinese firms.

As I discuss below, between 2012-2016 Chinese technology-related outward direct investment increased ten-fold, with the lion's share of this investment going to semiconductors and associated industries in the United States and Europe. Behind this surge in outward FDI lay the National IC Investment Fund, a 2014 initiative launched by the State Council, China's cabinet, to jump start a new phase in the growth of the Chinese semiconductor industry. In addition to fueling a surge in overseas technology acquisitions, the "Big Fund," as it was known colloquially, also signaled the state's growing commitment to use its own buying power to bolster China's internal semiconductor market. Partly as a result of the Big Fund and partly due to secular growth in the domestic Chinese consumer electronics market, after 2013-2014 a much greater share of Chinese IC imports and production was consumed in China. The resulting increase in China's bargaining power paved the way for stronger efforts to extract foreign technology from both outward and inward FDI.

However, in order to avoid heightened foreign scrutiny and mitigate rising foreign backlash, especially from the United States after 2014, China largely eschewed formal restrictions on market access in semiconductor-related industries, instead relying on informal inducements to share technology with local partners. In this respect, Chinese policy in the semiconductor industry reflects a broader movement away from controversial and more easily monitored formal technology extractors and towards alternative means of technology acquisition in the Xi Jinping era. If recent developments in IC policy are any indication, this trend is unlikely to abate as long as Chinese firms continue to lag behind the world technological frontier in key high value-added industries.

Technology Transfer in Semiconductors, 1982-2008

This section examines Chinese technology transfer efforts in semiconductors in the first three decades of Reform and Opening. The section serves four main purposes. First, it establishes that China's leaders have consistently viewed ICs as a strategic sector throughout the period of Reform and Opening, and indeed did so long before Mao's death. Second, it demonstrates the centrality of foreign technology transfers to semiconductor development efforts in the 1980s and 1990s. Third, it illustrates Chinese leaders' awareness in the late-1990s that weak final demand in ICs hindered their ability to secure tech transfers from international partners. Fourth, it examines China's non-use of formal technology extractors in ICs between 2000-2008. It further provides evidence that China's greater relative dependence on foreign chip makers explains why China refrained from introducing technology extractors in ICs during the 2000s, even as increased central enforcement capacity drove explosive growth in their use in other strategic industries.

Semiconductor Industry Policy, 1982-1989

Chinese efforts to develop a domestic semiconductor industry date back to 1956, when the State Council, China's highest state body, issued the "Outline of the Long-Term Plan for Science and Technology Development, 1956-1967" (1956-1967年科学技术发展远景计划纲要), often referred to colloquially as the Twelve-Year Plan. Though best known for launching China's successful campaign to develop "two bombs, one satellite,"[2] the Twelve-Year Plan also identified semiconductors as a priority "new technology" for domestic development (Cao, Suttmeier and Simon, 2006). The following year, leading Chinese universities began offering courses in semiconductor design, and by 1965 China had produced its first integrated circuit (Mays, 2013, 56). This was a major accomplishment that placed China not far from the technological frontier in electronics. Unfortunately, the Cultural Revolution (1967-1976) brought further advances in semiconductor technology in China to a halt, and China rapidly fell behind overseas competitors during the 1970s.

Chinese IC development efforts recommenced shortly after Mao's death. In the late 1970s, semiconductors were identified as a priority industry under Deng Xiaoping's "Four Modernizations" campaign, which paved the way for a political rehabilitation of scientists by reframing science and technology as part of the economic base structure of society. This shift drove a flurry of central state activity in ICs, starting with the formation in 1982 of a Leading Small Group for Electronics, Computers, and Large-Scale Integrated Circuits (电子计算机和大规模集成电路领导小组), hereafter LSG. Between 1983-1989, the LSG spearheaded four overlapping initiatives in the sector, starting with the 1983 "Build Two Bases and One Point" (建立南北两个基地和一个点) program, which sought to turn Beijing, Shanghai, and Xian into incubators for IC-related training and R&D. Two years later, the LSG, now renamed the Leading Small Group for Electronics, Computers, and Large-Scale Integrated Circuits (电子计算机和大规模集成电路领导小组), outlined several "Strategies for the Development of China's Electronics and Information Industries," such as the use of "foreign technology to advance China's technology, including engaging in joint ventures

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[2] "Two bombs, one satellite" refers to the atomic bomb, intercontinental ballistic missiles, and China's first satellite, the Dong Fang Hong 1.

with foreign firms" (Simon and Rehn, 1988, 62). At a conference in 1986, the LSG launched the "5-3-1 Strategy," according to which most Chinese semiconductor firms should begin using 5 micron technology, a few leading SOEs should use 3 micron technology, and a "technical attack" should be launched to pursue 1 micron technology (Mays, 2013; Tan, 2021).[3]

Finally, in 1989 the LSG held a second conference that resulted in pledged investment of $600 million in the IC bases of Beijing and Shanghai and into five new "backbone" enterprises (五个主干企业), with a goal of meeting 60 percent of Chinese IC demand domestically by 1995 (Tan, 2021; Mays, 2013, 99). Notably, three of the five backbone enterprises were set up as Sino-foreign joint ventures for the express purpose of transferring foreign technology. A fourth, Huajing, formed a JV with Hong Kong-based China Semiconductor Manufacturing Corporation (CSMC) in 1997-1998. The only backbone firm without a JV was Huayue, which sought but failed to secure a foreign partner due to lack of interest from foreign chipmakers (Mays, 2013). Apart from these joint ventures, foreign semiconductor companies had relatively little presence in China in the 1980s, and U.S. chipmakers virtually none. Intel and IBM, the first major American entrants to the Chinese market, made early forays into China in the mid-1980s; Intel's Robert Noyce met with Premier Zhao Ziyang in 1984 and IBM opened an office in Beijing later that year.[4] But neither company had substantial operations in China before the early 1990s.

The frenetic pace of IC policy in the 1980s arguably betrays a degree of organizational incoherence. What it does not suggest is a lack of interest in the sector. The formation of an industry-specific LSG testifies to the central state's keen interest in developing ICs. That the LSG was chaired by Li Peng, China's then-Vice Premier who would go on to serve as Premier from 1993-1998, further indicates the high priority afforded ICs. It is also notable that Jiang Zemin, Party General Secretary from 1992-2002, served as Minister of Electronics Industry from 1982-1985, during which time he produced several high-profile speeches in ICs. Indeed, Jiang retained a deep

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[3] A micron is a unit of measurement equal to one one-thousandth of a millimeter. Transistors in leading edge chips today are measured in nanometers (nm), which are a thousand times smaller than a micron.

[4] Xinhua General News Service, May 25, 1984, "Zhao Ziyang Meets U.S. and Hong Kong Entrepreneurs," Retrieved May 4, 2023 from LexisNexis Academic. Financial Times, November 12, 1984, "IBM Launches China Subsidiary," Retrieved May 4, 2023 from LexisNexis Academic.

interest in ICs, penning no fewer than 27 speeches, articles, and reports on the sector between 1983-2008. In his 2009 collection *On the Development of China's Information Technology Industry*, Jiang highlights IT as one of two "strategic industries," along with energy, of greatest personal concern to him. Figure 1 presents a timeline of IC-related central state policies from 1982-2015.

To summarize, China's leaders have consistently viewed semiconductor production as a strategic industry whose development would require attention from the highest levels of the state. Likewise, they have long understood access to foreign technology would be integral to the development of a competitive domestic industry. Not only was this view explicitly endorsed in central-level policies from the period, but it guided policy practice in setting up the five "backbone" enterprises.

Semiconductor Industry Policy, 1990-1999

IC industrial policy in the 1990s was defined by two major state initiatives, Projects 908 and 909. Launched in 1990 and 1995, respectively, the Projects each aimed to build a semiconductor "national champion" capable of competing with leading semiconductor MNEs. Both failed, and in doing so prompted a shift in Chinese semiconductor industry policy after 2000. For our purposes, the Projects are informative for two main reasons. First, they reinforce the view that Chinese leaders have consistently seen ICs as a strategic industry in which China must extract foreign technology in order to become competitive. Second, China's struggle to secure a foreign partner for Project 909, and the means by which it eventually secured one, provide direct evidence not only that the balance of dependence favored foreign chip makers, but that Chinese leaders were aware that China's greater relative reliance undermined their bargaining power with foreign investors.

Begun in tandem with the effort to create five backbone semiconductor enterprises, Project 908 sought to transform one of those five firms, Huajing, into an IC national champion that would compete internationally at every stage of the semiconductor supply chain. To do this, the Project provided RMB 2 billion (about $500 million) in funds for Huajing to secure software and equipment from the American firm Lucent Technologies for a complete IC production line (Mays, 2013; VerWey, 2019). However, Project 908 struggled to gain traction, hampered by funding

Timeline of Major Central State Policies in the
Semiconductor Industry

Year	Agency	Policy	Impact
1982	State Council	Leading Small Group for Electronics, Computers, and Large-Scale Integrated Circuits Formed (电子计算机和大规模集成电路领导小组)	Established IC policy authority. Led by Li Peng
1983	LSG	“Build Two Bases and One Point” 《建立南北两个基地和一个点》	Identified Xian, Beijing, Shanghai as IC hubs
1986	LSG	“5-3-1 Strategy”	Set production targets
1989	LSG	Five “Backbone” Enterprises (五个主干企业)	Identified lead firms
1990	State Council, MEI, SPC	Project 908	Created Huajing
1995	State Council	Project 909	Created Huahong
2000	State Council	“Notice on the Issuance of Several Policies to Encourage the Development of the Software Industry and Integrated Circuit Industry” 《国务院关于印发鼓励软件产业和集成电路产业发展若干政策的通知》国法 18 号	Encouraged investment in semiconductors by firms of all ownership types
2006	State Council	“National Medium- and Long-Term Program for Science and Technology Development 2006-2020” 《国家中长期科学和技术发展规划纲要 (2006-2020)》	Launched “indigenous innovation” drive. Listed semiconductors
2009	MIIT, MOF, MOST, SASAC	“Guidance Catalogue for Indigenous Innovation Major Technical Equipment (2009 Edition)” 《重大技术装备自主创新指导目录(2009 年版)》	Explicit preferential government procurement policy
2010	State Council	“Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries” 《国务院关于加快培育和发展战略性新兴产业的决定》	Extension of MLP, Listed semiconductors
2011	State Council	“Notice on the Issuance of Several Policies to Further Encourage the Development of the Software Industry and Integrated Circuit Industry” 《国务院关于印发进一步鼓励软件产业和集成电路产业发展若干政策的通知》国法 4 号	Update to Document 18, replaced language encouraging FDI with call for overseas human capital
2014	State Council	“Guidelines for the Promotion of the National Integrated Circuit Industry” 《国家集成电路产业发展推进纲要》	Outlined policies to support domestic industry
2014	State Council	“National IC Investment Fund Official Established” 《国家集成电路产业投资基金正式设立》	Launched National IC Fund
2015	State Council	“Notice on the Issuance of *Made in China 2025*” 国务院关于印发《中国制造 2025》的通知 国发 28 号	Accelerated central state support for ICs

Figure 6.1: **Timeline of Major Central State Policies in the Semiconductor Industry**: In a signal of the IC industry’s exceptional strategic value, the State Council, China’s highest state body, has taken direct control over most major semiconductor-related industrial policies in the post-Reform and Opening period.

constraints, bureaucratic delays, and insufficient human capital. Lucent, which saw involvement in Project 908 as an opportunity to curry favor with Chinese authorities, eagerly supplied Huajing with equipment, process training, and even a design library to enable Huajing engineers to design their own chips (Fuller, 2005, 253). But Huajing was unable to put the pieces together into a working production line. The one bright spot was its partnership with CSMC, which formed a JV with Huajing in 1998 and subsequently absorbed its fabrication facilities (Fuller, 2005; Mays, 2013). Though Huajing-CSMC continued to manufacture low-end chips in the 2000s, it never regained its position at the center of Chinese IC industrial policy.

By 1995, China's leaders saw that Project 908 would fail. That November, the State Council and Ministry of Electronics Industry organized a series of meetings to plan its successor. Like Project 908, what became Project 909 sought to build an IC national champion, but with two key differences. First, Project 908 envisioned creating an integrated device manufacturer (IDM), or a single firm capable of designing, manufacturing, and assembling, testing, and packaging semiconductors in-house. Chinese authorities had failed to recognize that this model, though still viable for the largest and most sophisticated firms such as Intel, had come under intense pressure due to the rising cost and complexity of producing chips and the attendant rise of firms that specialized in one segment of the chipmaking process. By demonstrating the efficiency gains afforded by specialization, pureplay foundries like TSMC and "fabless" design firms like U.S.-based Nvidia were revolutionizing the semiconductor industry by early-1990s. Against this backdrop, China's goal of creating a world-class IDM from scratch appeared hopelessly outdated. Taking this lesson to heart, China's leaders decided to use Project 909 to build a foundry comparable to TSMC.

The second key change was to establish Project 909 as a JV from the start. A core lesson of Project 908 was that licensing software and equipment was not enough to build a competitive IC firm. As Hu Qili, who led Project 909 as Minister of Electronics Industry from 1993-1998, observed in his memoir *Ultra Large-Scale Integrated Circuit: Project Records* (超大规模集成电路工程纪实), the failure of Project 908 convinced China's leaders the sector "must depend on collaboration, not self-development" (Mays, 2013, 204). In Hu's view, the "harsh reality [is]...we must bring in international management and technical partners" (Mays, 2013, 205). To this end, Project 909 was set up as a JV between Shanghai Huahong, a state-owned foundry formed in 1996 and chaired by Hu, and the Japanese firm NEC.

Project 909 was also distinguished by strong support from China's top leadership. Hu Qili quotes Premier Li Peng declaring China must "spare no cost!" to support Huahong and the country's broader semiconductor industry. Likewise, he recounts Jiang Zemin reflecting, after a visit to Samsung's facilities in South Korea, that China must be ready to "smash the pot, sell the iron" to "make the semiconductor industry rise up" (Mays, 2013, 199). More concretely, Project 909 was the first industrial project to be co-sponsored by the State Council and the Central Committee, the highest formal Chinese Communist Party (CCP) organ (Mays, 2013, 208). Given the Party's political supremacy, this unusual designation would have made the Project perhaps the most authoritative industrial policy undertaken in China before the launch of the MLP in 2006.

Despite this backing, Project 909 struggled to secure a foreign partner. The key problem, as Hu recounts, was that the Project lacked a clear market. At the time, China's domestic consumer electronics market was too small to attract much interest from semiconductor MNEs. However, it would be years before any Project 909 joint venture began producing internationally competitive chips, especially given Huahong's non-existent capabilities. With no clear source of demand, foreign firms had little incentive to form a JV that would entail significant technology transfers. In short, China had no meaningful internal market for ICs, and therefore lacked bargaining power with potential foreign investors. No extent of senior political sponsorship could fill this gap.

To solve the problem, China's leaders manufactured a market for Project 909 in the form of a monopoly over the Chinese market for IC cards, or cards with chips used for transportation, telecommunications, banking, health care, social security, and more. In IC cards, Hu Qili spied a potentially powerful bargaining chip with foreign investors. The Chinese market for these cards had grown rapidly in the 1990s, bolstered by a 1993 initiative to expand China's information infrastructure (Fuller, 2005; Mays, 2013, 213). And because SOEs controlled the end uses of IC cards, authorities could easily manipulate demand for the ICs used in them by mandating that transportation and ID cards use a particular chip. In fact, in March 1997 the State Council announced that all Chinese state agencies would use Huahong's future chips (Mays, 2013, 213).

The foreign response to this news was swift. Almost immediately after the State Council announcement, Huahong entered into JV negotiations with Siemens, IBM, Rockwell, Toshiba, and NEC (Mays, 2013). China selected NEC, which had demonstrated a commitment to the country through its earlier JV with Beijing Shougang, one of the five backbone enterprises noted above. In the end, the JV proved modestly successful. Huahong-NEC began producing chips in 1999 and was mass producing a second generation IC card by 2004, but it did not become the chipmaking national champion China's leaders had envisioned.

Of course, China's leaders did not embark on Projects 908 and 909 in a vacuum. Rather, the Projects were launched against a backdrop of steadily rising investment in China by foreign, including American, chipmakers throughout the 1990s. As noted earlier, Intel and IBM had each had a presence in China since the mid-1980s, but neither manufactured there on a meaningful scale before the early 1990s. Importantly, both companies' major investments in China in the 1990s took the form of wholly foreign-owned enterprises (WFOEs), with IMB setting up its first major production facility as a WFOE in 1992 and Intel following suit in 1994.[5]

It is unclear based on news reports from the time whether these and other early investments by foreign chipmakers served the Chinese market or international markets. However, the fact that semiconductor-related FDI during this period was almost entirely concentrated in cities like Shenzhen, Tianjin, and Shanghai, which were home to China's earliest and largest export-processing zones, suggests the latter. Certainly, by the mid-1990s, the clear focus of U.S. chipmakers' investment in China was the export-processing trade. In 1996, Intel announced plans to invest $99 million to open a wholly-owned flash memory production facility in Shanghai's Pudong free trade zone, describing the facility as a "critical part of Intel's long-term strategy to meet international demand for flash memory chips."[6] As Xinhua reported in 2000, by 1998 Intel was producing three

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[5] On IMB, see Xinhua General News Service, March 25, 1992, "IBM to Build Beijing Plant," Retrieved May 4, 2023 from LexisNexis Academic. On Intel, see Xinhua General News Service, "Intel Steps Up Efforts to Expand Chinese Market Share," Retrieved May 4, 2023 from LexisNexis Academic.

[6] Xinhua General News Agency, November 14, 1996, "Micro Chips to be Made in Shanghai," Retrieved May 4,

million chips per week at its Pudong facility, 90 percent of which were sold outside of China.[7]

Semiconductor Industry Policy, 2000-2008

Chinese technology transfer efforts in semiconductors were not fundamentally different from those in other high value-added sectors in the pre-WTO period. Although China did not introduce ownership restrictions in semiconductors in the 1995 or 1997 FDI Guidance Catalogues, throughout the 1990s Chinese authorities pursued technology transfer through "arranged marriages" between individual foreign MNEs and hand-picked Chinese SOEs. This approach gave China greater control over the resulting JVs and, to the extent negotiations directly involved senior leaders, likely bolstered its otherwise weak bargaining position vis-à-vis prospective foreign investors.

After 2000, semiconductor industrial policy began to follow a different path from other strategic industries. In June of that year, the State Council released Document 18, which, among other things, encouraged IC-related investment from firms of all ownership types, including wholly foreign-owned enterprises (WFOEs).[8] At the time, this policy was neither unusual nor out-of-step with broader trends in Chinese economic reform. The Jiang Zemin-Zhu Rongji administration generally favored fairly relaxed controls on inward FDI. Moreover, with China's WTO accession looming, it is not surprising the CCP leadership opted to liberalize FDI regulations in what had been one of the most heavily scrutinized sectors during negotiations.

More surprising is the fact that China did not revise Document 18 in subsequent years, even as administrative reform and consolidation, the NDRC's reclamation of project approval authority in 2004-2005, and the publication of the MLP in 2006 drove a surge in the number technology extractors in other high value-added sectors. Instead, Chinese authorities refrained from imposing any sort of overt technology transfer requirement in ICs between 2000-2008. Whether the NDRC

2023 from LexisNexis Academic.

[7] Xinhua Economic News Service, April 3, 2000, Multinationals Keen on Shanghai's Pu," Retrieved May 4, 2023 from LexisNexis Academic.

[8] The full name of this policy is "State Council Notice on the Issuance of Several Policies to Encourage the Development of the Software Industry and Integrated Circuit Industry" (国务院关于印发鼓励软件产业和集成电路产业发展若干政策的通知).

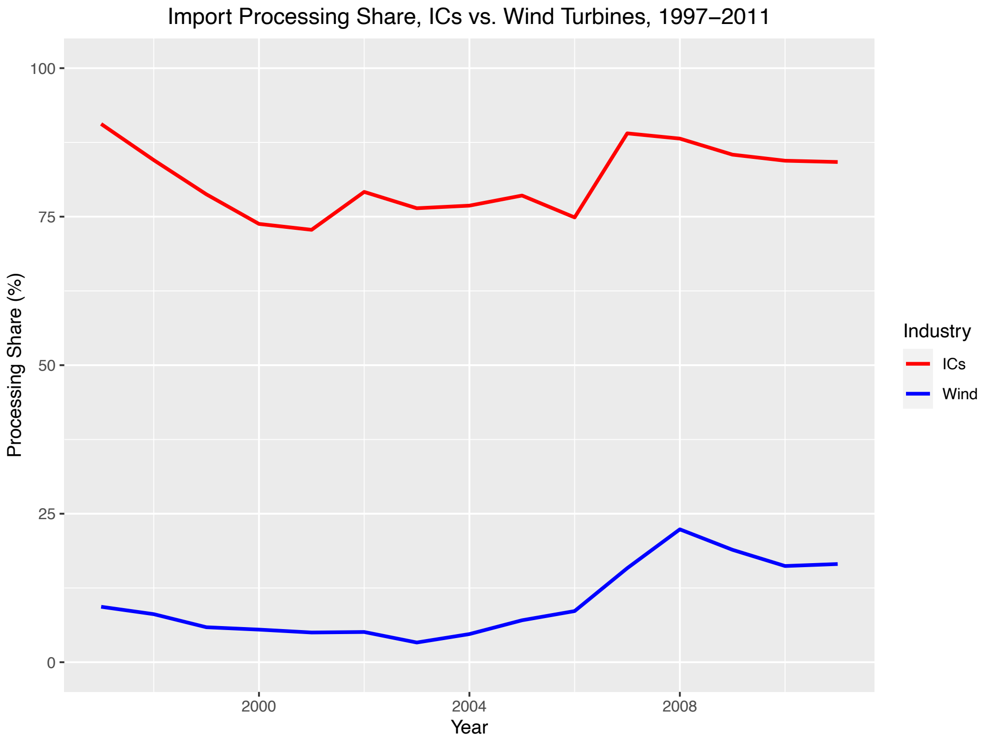

Figure 6.2: **Import Processing Share, ICs vs Wind Turbines, 1997-2011**: Between 1997-2011, the share of Chinese semiconductor-related imports tied to the export-processing trade, by value, consistently exceeded 75 percent. By comparison, for most of the period, no more than 10 percent of wind power-related imports were tied to processing trade. Put simply, whereas China was comfortably downstream of GVCs in wind power, it was firmly intermediate to them in semiconductor design and fabrication. Source: CCD.

chose not to introduce FDI ownership restrictions in ICs or was prevented from doing so by Document 18 or some other factor is unclear. Regardless, it is striking that by 2007 semiconductors were one of the few major strategic sectors not subject to some form of formal technology extractor.

Why did Chinese authorities refrain from imposing tech extractors in semiconductors during this period? Interviews with numerous IC industry insiders – including current and former industry executives, former United States trade officials, bank analysts, lawyers, and representatives from industry groups – indicate that the Chinese state's weak bargaining power due to relatively low levels of final demand within China and China's reciprocal dependence on export-processing trade was central to the absence of FDI controls during this period. As a senior industry association official told me, whereas industries such as high-speed rail and commercial aircraft manufacturing were “closed loops” in which China’s status as primarily a downstream market gave it “incredible leverage” over foreign investors, semiconductors were an “open loop,” meaning that most of what was imported into China was destined for re-export elsewhere. This gave China virtually “no influence over chip procurement” through the first decade after WTO accession.[9] Chinese export data from the time clearly reflect this “open loop” quality to China’s semiconductor industry. As Figure 2 shows, from 1997-2011 the share of Chinese semiconductor-related imports tied to export-processing consistently exceeded 75 percent. In the late-1990s and again after 2006, that figure reached or exceeded 90 percent. By comparison, for most of this period, 90 percent or more of China’s wind turbine-related imports were destined for consumption within China. In short, whereas China was comfortably downstream of GVCs in wind power, it was positioned firmly intermediate to production networks in semiconductors.

China’s heavy reliance on export-processing trade in semiconductors left Chinese policymakers reluctant to take any steps that might provoke foreign exit. As a former Qualcomm executive in China put it, semiconductors were “such an important input into the export engine” and because “all China has is the export engine, they don’t want to mess with it too much,” including by imposing policies that might deter foreign investment.[10] Another interview subject, a Taiwan-based bank analyst, agreed, noting that foreign chipmakers “were unwilling to do the investment if it required a JV structure,” so for China, the “only way to attract [FDI] was offering carrots rather than forceful requirements on companies to force” partnerships with local companies and technology transfers.[11] Echoing this, a Beijing-based lawyer for a U.S. multinational law firm suggested that China was so behind in ICs that “this was the only rational way to catch up quickly.”[12]

These comments underscore the fundamental weakness in China’s bargaining power over foreign investors, a weakness that persisted through the middle of the 2010s, when the growth in the Chinese domestic consumer electronics market bolstered China’s bargaining position. Moreover, they indicate the inextricable link between this weakness and the Chinese semiconductor industry’s

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[9] Interview, Zoom, December 8, 2021.

[10] Interview, Zoom, January 2023.

[11] Interview, Zoom, December 15, 2021.

[12] Interview, Zoom, December 2, 2021.

status as an “open loop” in which most of what entered the country was ultimately re-exported elsewhere as more finished goods. As another source, a leading industry expert, observed, during this time “much of the market was for re-export processing...so not strong leverage to impose JVs...[Instead,] China had to offer sweetheart deals to lure investment”[13]

To be sure, this did not mean China gave up on foreign technology transfers altogether in the years after WTO entry. Almost every person connected with the industry whom I spoke with emphasized that informal inducements to share technology were commonplace for foreign investors during this time. And even without a JV requirement, foreign firms sometimes found it in their interest to partner with local firms, not least because it made navigating China’s investment approval process easier. The key point, therefore, is not that Chinese authorities abandoned foreign technology acquisition as a goal in semiconductors after WTO entry, but that they refrained from issuing formal technology extraction policies. As the above quotes indicates, issuing policies like JV requirements required “leverage” on China’s part. Implicit in this claim is the notion that compliance with technology extractors is costly for foreign investors, and therefore that investors can be expected to resist such compliance through exit, voice, or both when Chinese bargaining power – that is, China’s ability to credibly threaten market access restrictions – is weak. As long as China’s semiconductor industry remained an “open loop,” this would be continue to be the case.

Media reporting from the time helps illustrate both foreign chipmakers’ surging interest in investing in China in the years surrounding WTO accession and the centrality of export-processing trade to that FDI. As Xinhua reported in December 2000, “nearly 400 out of the top 500 companies in the world have invested in China,” viewing it as “an ideal place for their export bases in the Asia-Pacific region.”[14] The article goes on to describe Intel’s expanding operations in Shanghai and Motorola’s plans to spend $1.9 billion on a new export-focused semiconductor production center in Beijing. In 2002, Intel announced plans to spend another $100 million to expand assembly, testing and packaging facilities in Shanghai.[15] This was followed by investments of $375 million in

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[13] Correspondence, January 17, 2022.

[14] Xinhua General News Service, December 6, 2000, “Multinationals Shift Export Bases to China,” Retrieved May 4, 2023 from LexisNexis Academic.

[15] Xinhua General News Service, May 21, 2002, “Intel Prepares for Pentium4 Production in Shanghai,” Retrieved

Figure 6.3: **Semiconductor Exports as a Share of Total Exports, 1992-2021**: Between 1992-2021, semiconductor-related exports' share of China's total exports, by value, rose from under 1 percent to 15.9 percent. During this same period, China's exports rose more than ten-fold by value and exports share of China's GDP increased from 13 to 36 percent. Source: UNCTAD.

Chengdu in August 2003 and $2.5 billion in Dalian in 2007, both for export-focused production facilities.[16] Nor was Intel alone in expanding its export-processing facilities in China. During this period, AMD, Texas Instruments, Toshiba, Mitsubishi, IBM, Micron technology, Applied Materials, and many others all opened or expanded chip production and assembly and testing operations in China, almost all aimed at servicing overseas export markets.[17]

To summarize, we can draw two main conclusions from the trajectory of Chinese technology transfer efforts in semiconductor production through the first decade after WTO entry. First,

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May 4, 2023 from LexisNexis Academic.

[16] Xinhua Economic News Service, January 23, 2007, "Intel Said to Launch Big Chip Factory in Dalian," Retrieved May 4, 2023 from LexisNexis Academic.

[17] On AMD, see Xinhua Economic News Service, April 21, 2004, "AMD to Build Packaging Plant in East China," Retrieved May 4, 2023, LexisNexis Academic. On Toshiba and Mitsubishi, see Xinhua Economic News Service, August 16, 2002, "Foreign Chip Packaging Plants Swarming Into China," Retrieved May 4, 2023, LexisNexis Academic. On Micron and Applied Materials, see Xinhua General News Service, May 24, 2007, "Applied Materials Joins New High-Tech Movement in Xi'an," Retrieved May 4, 2023 from LexisNexis Academic.

since at least 1982, China's leaders have seen ICs as a strategic industry in which building robust domestic capabilities would require extracting foreign technology and expertise. Although Chinese authorities' approach to developing the sector has evolved over time, its views on the strategic nature of ICs and the importance of foreign technology transfers have remained broadly consistent.

Second, Chinese technology transfer efforts in semiconductors during this period were constrained by China's reliance on foreign chipmakers to drive export-oriented electronics manufacturing. As Figure 3 shows, between 1992-2008, exports of semiconductor products as a share of total Chinese exports rose from under 1 percent to nearly 13.7 percent. According to data from the World Bank, in 2008 exports were equivalent to 32.6 percent of Chinese GDP. This suggests that semiconductor exports alone accounted for approximately 4.5 percent of GDP in that year, and likely a much larger share of industrial output in economically-dynamic and politically-sensitive coastal regions like the Yangtze and Pearl River Deltas.[18] Moreover, given China's meager chipmaking capabilities at the time, foreign firms accounted for the vast majority of these increases.[19] China's reliance on foreign chipmakers to drive export growth, combined with foreign firms' relatively lower reliance on China as a final market during this period, undercut China's leverage over prospective investors. This deterred China from introducing tech extractors in semiconductors even rising enforcement powers prompted an increase in the use of these measures in other strategic industries. The fundamental weakness of China's bargaining position in semiconductors stood out less through the end of the 1990s, when low enforcement capacity and uncertainty about China's investment environment suppressed China's overall bargaining position. But this weakness became glaring after 2003 as increased central enforcement capacity drove a wave of technology extraction efforts in other strategic sectors where the balance of dependence favored China.

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[18] This figure excludes general electronics manufacturing exports, which were much larger still.

[19] The Semiconductor Manufacturing International Corp. (SMIC), by far China's leading domestic chipmaker, was formed in 2000 but only emerged as a significant producer several years later. See *The Economist*, July 9, 2020,"Why SMIC is Surging," *https://www.economist.com*.

Technology Transfer in Semiconductors, 2009-Present

My core argument in this chapter is that China's intermediate position in semiconductor GVCs constrained Chinese authorities from introducing technology extractors in the sector in the post-WTO period. When China occupies an intermediate position in global production networks, it depends heavily on the foreign MNEs which dominate those networks and control the flow of goods to overseas markets as sources of direct employment and drivers of broader export and economic growth. This reliance shifts the balance of dependence between China and foreign investors in the latter's favor. The more intermediate China is to GVCs, and thus the more dependent it is on export-processing trade, the more this balance will favor foreign firms. Under these circumstances, China is unable to credibly threaten to cut off foreign firms' access to its market, undermining its bargaining power and forcing its leaders to avoid overt market access restrictions.

If this argument is correct, then changes in China's processing trade dependence should lead to corresponding changes in its bargaining power, and in turn the assertiveness with which it pursues foreign technology transfers in strategic industries. In this section, I show that this is indeed the case. In the decade following the 2008-2009 Global Financial Crisis, the growth of China's domestic consumer electronics and data server markets (the primary end-uses for semiconductors) meant that more of what China imported in semiconductors actually stayed in China, rather than being re-exported overseas. As China shifted from an intermediate to a more downstream position in electronics GVCs, its declining reliance on processing trade limited foreign firms' bargaining power. This, in turn, loosened constraints on Chinese authorities' technology acquisition efforts. The end result was that in the decade after the financial crisis China pursued technology transfers in semiconductors far more energetically than it had in the fifteen years prior. These efforts gained added momentum with the launch in 2014 of the National IC Fund, which inflated Chinese demand for semiconductors over and above what market forces alone would have produced.

Increased Chinese bargaining power led to more active pursuit of foreign technology transfers in ICs. However, these efforts primarily took forms other than technology extractors. China did include a number of semiconductor-related products in the 2009 and 2012 Indigenous Innovation

Catalogues. However, the most important vehicles for foreign technology acquisition in the post-financial crisis years were outward direct investment by Chinese firms and more more forceful but nonetheless indirect or informal – that is, not legally codified – inducements to share technology. This choice of policy tools was consistent with the broader shift away from technology extractors after 2014-2015. As I discussed in chapter three and revisited in the wind energy case study, that shift reflected a combination of factors, including the expansion of Chinese outward FDI and the simultaneous increase in foreign government pressure to remove market access restrictions.

Below, I show that the growth in China's internal electronics market reduced its reliance on processing trade in ICs. I then examine how this shaped Chinese tech extraction efforts after 2008.

China's Shifting Position in Semiconductor Value Chains

The first decade after WTO entry saw China's reliance on processing trade in ICs grow from bad to worse. On the eve of accession in 2001, 72 percent of all Chinese IC-related imports, by value, were tied to export-processing trade, according to official data from China's General Administration of Customs. By 2007, the year in which Chinese semiconductor processing trade dependence peaked, fully 89 percent of chips imported into China were destined for re-export elsewhere.

After 2008, however, this trend reversed. By 2013, a mere 27 percent of Chinese semiconductor imports were tied to processing trade. Though striking, this shift is unsurprising when viewed in context of the extraordinary growth in China's internal market for consumer electronics and other semiconductor-related products, such as servers and networking equipment, in recent years. As Figure 4 (next page) shows, between 2005-2017, Chinese demand for consumer electronics goods rose nearly six-fold, from RMB151 billion to RMB876 billion, outpacing overall GDP growth by nearly one-fifth and the growth of the global semiconductor market by a factor of two. Notably, over the same period China's share of global semiconductor imports by value (including export-processing trade) increased by less than three percentage points, from 21.7 to 24.2 percent. This suggests that between 2005-2017, imports tied to final consumption largely displaced imports tied to export processing trade in China's overall semiconductor and overall electronics import

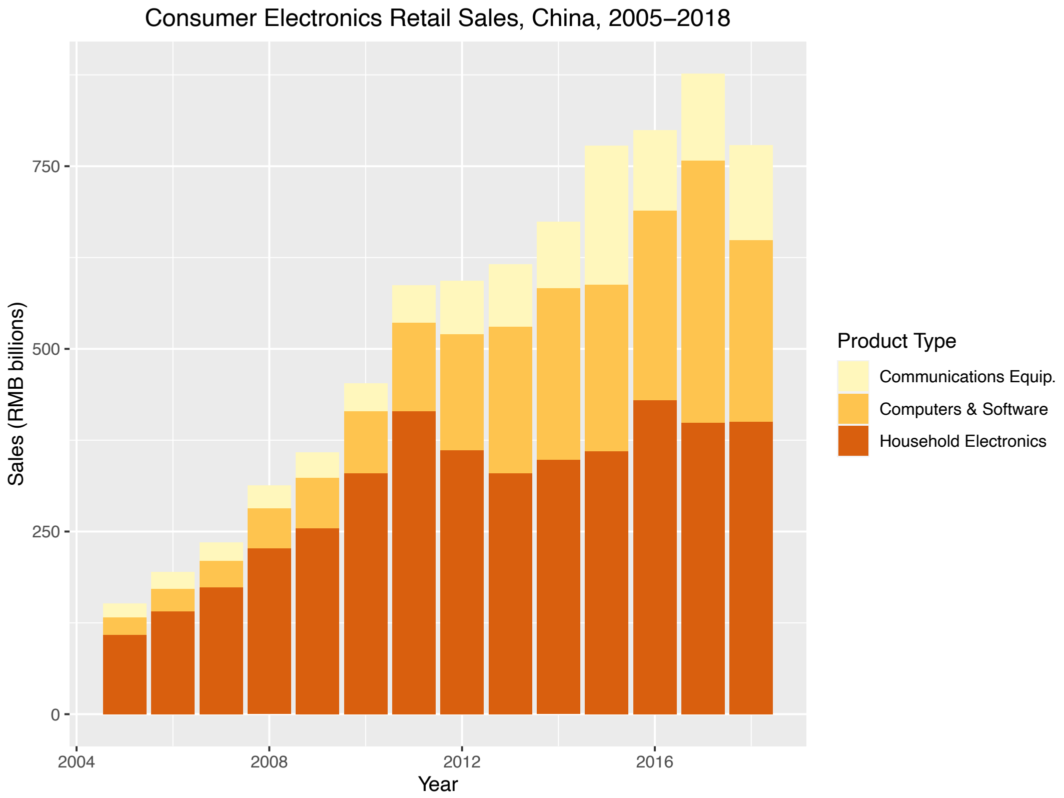

Figure 6.4: **Consumer Electronics Retail Sales, China, 2005-2018**: China's domestic market for finished consumer electronics goods grew nearly six-fold between 2005-2017, before declining slightly in 2018. Source: NBS.

mix.[20] The National IC Investment Fund, launched in September 2014 with $21 billion in state-backed financing, undoubtedly accelerated this shift by further expanding Chinese demand for a range of semiconductor-related products and machinery.[21]

The rise of Chinese final consumption of semiconductor-related goods shifted China decisively downstream of value chains in the sector, transforming it from an intermediary processing hub in production networks that ended in consumer markets in the United States and Europe into a predominately downstream final demand center. As China's reliance on processing trade declined,

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[20] Consistent with this, Varas et al. (2021) find that in 2019, China's share of global semiconductor end-use sales (24 percent) exceeded its share of global semiconductor imports (22 percent). As of 2016, Chinese semiconductor firms accounted for only 13% of final IC consumption in China, so there is no realistic scenario in which the share of imports tied to processing rebounded after 2013, with domestic production making up the difference between imports tied to final consumption and overall final demand.

[21] Semiconductor Industry Association, July 13, 2021, "Taking Stock of China's Semiconductor Industry," Retrieved May 4, 2023, *https://www.semiconductors.org*.

so too did its relative dependence on access to overseas markets for semiconductor-related products. As one semiconductor industry executive told me, this shift "changed China's bargaining power," giving it much more leverage over foreign chipmakers desperate to seize a piece of the Chinese market and reap the resulting profits and economies of scale.[22] With the balance of dependence shifting in China's favor, Chinese authorities did not hesitate to apply their improved leverage towards acquiring foreign chip technology, albeit largely by means other than formal market access restrictions. Below, I look at two major channels through which China pursued technology transfers in semiconductors after 2008.

Technology Transfer Efforts in Semiconductors after 2009

Since 2009, China has pursued foreign semiconductor technology through a variety of channels. In this section, I examine two of those channels at greater length: (1) state support for outward FDI by Chinese firms, and (2) indirect or informal pressures on foreign investors to share technology with local firms. I then discuss why China by and large refrained from overt technology extraction policies in semiconductors even as its bargaining power over foreign firms improved in the 2010s.[23]

Outward Direct Investment

The first major channel through which China has sought to acquire foreign IC technology in recent years is outward FDI by Chinese firms. Although comprehensive transaction level data on Chinese outward FDI in semiconductors is not available, data from the American Enterprise Institute's China Global Investment Tracker on Chinese FDI in technology provides a reasonable approximation. According to the Tracker, 63 Chinese firms or entities have engaged in technology-related outward direct investment since 2005. The list includes such well-known names Huawei (14 distinct investments), China Mobile (9), Lenovo (7), Tencent (4), Tsinghua Unigroup (4).

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[22] Interview, Zoom, December 20, 2021.

[23] I do not examine industrial and cyber espionage or talent acquisition efforts in semiconductors. Though both potentially meaningful channels of technology transfer, neither reveals much about China's bargaining relationship with foreign firms, and as such are not particularly relevant to the theoretical arguments I examine here.

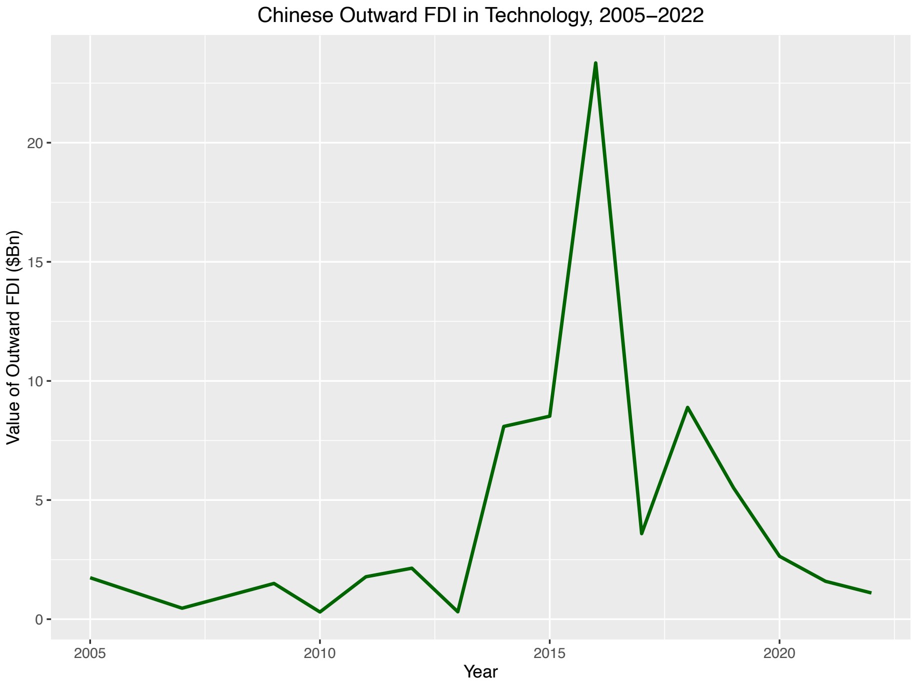

Figure 6.5: **Chinese Outward FDI in Technology, 2005-2022**: Chinese technology-related outward FDI surged to unprecedented levels between 2014-2016, fueled in part by the National IC Fund. Source: China Global Investment Tracker.

Most Chinese outward FDI has taken the form of equity investments and mergers and acquisitions (M&A) of foreign firms. According to the Tracker, roughly 11 percent of Chinese technology-focused FDI is greenfield. The United States is by far the largest recipient of this FDI, accounting for one-third by value, followed by the United Kingdom at 12 percent. Although Chinese firms did invest overseas before 2014, nearly 90 percent of Chinese outbound FDI in technology took place between 2014-2020. As Figure 5 shows, the vast majority of that FDI occurred from 2014-2016. After 2016, a combination of slowing growth in China and increased investment screening by the Committee on Foreign Investment in the United States (CFIUS) and its counterparts in Europe and Japan led to a sharp contraction on outward FDI in technology sectors, including semiconductors design and fabrication.

The first major policy document to encourage IC-related outward FDI by Chinese firms was a “State Council Notice on the Issuance of Several Policies to Further Encourage the Development of the Software Industry and Integrated Circuit Industry” (国务院关于印发进一步鼓励软件产

业和集成电路产业发展若干政策的通知), issued in January 2011 as a revision to Document 18 from 2000. Known colloquially as Document 4, the Notice encouraged Chinese semiconductor companies to "go out" and "establish overseas marketing networks and R&D centers (支持企业"走出去" 建立境外营销网络和研发中心). But the true turning point, both in terms of policy and Chinese firms' overseas investment behavior, came with 2014 issue of the "Guidelines for the Promotion of the National Integrated Circuit Industry" (国家集成电路产业发展推进纲要), known colloquially as the National IC Guidelines.

Describing ICs as a "strategic, fundamental, and pioneering industry" (略性、基础性和产业) critical to supporting "socio-economic development and national security" (支撑经济社会发展和保障国家安全), the Guidelines outlined a series of measures to nurture indigenous IC capabilities. These included tax breaks and other fiscal incentives; stepped-up training and efforts to "introduce overseas high-level human capital" (引进海外高层次人才); and the formation of the National Integrated Circuit Industry Development Leading Small Group (国家集成电路产业发展领导小组). Notably, Ma Kai, who led the NDRC from its inception in 2003 through 2008, was put "personally in charge of China's efforts to upgrade its chip industry," including chairing the Leading Small Group (Miller, 2022, 256).

By far the most significant measure in the Guidelines, however, was the aforementioned Big Fund, formally called National IC Investment Fund (国家集成电路产业投资基金), created to support domestic and outward investment in semiconductors. Established "under the guidance" of MIIT, the Fund counts among its top investors state agencies and state-owned financial institutions like the MOF, which owns a 25.95 percent stake, and the China Development Bank, which owns 23.07 percent.[24] Although it is unclear what share of Chinese semiconductor-related FDI the Fund accounts for, the timing of the surge in Chinese investment strongly suggests the Fund played a major role. Media coverage, secondary sources, and my own interviews all indicate as much.

VerWey (2019) identifies 34 Chinese IC investments in the U.S. between July 2006 and February 2018, 27 of which appear to have been completed, and all of which involved the Chinese

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[24] USTR, Section 301 Report, pg. 93.

firm acquiring or buying a stake in an existing U.S. company. Notably, most of the successful transactions were relatively small, valued at well under \$1 billion and often under \$100 million, and involved less well-known U.S. companies. Accoding to data collected by VerWey (2019), only one investment over \$1 billion was successful, the \$1.9 billion acquisition in January 2016 of OmniVision Technologies, a chip design firm, by a consortium of Chinese investment funds. Other high-profile investments were blocked by CFIUS or terminated when it became clear CFIUS approval was unlikely. These include Tsinghua Unigroup's attempt to purchase Micron Technology, the leading U.S. memory chip producer, for \$23 billion and its bid for a 15 percent stake in Western Digital, another memory chip maker, for \$3.8 billion in July and August 2015, respectively.[25] They also include Datang Telecom's \$2 billion bid for Marvell Technology Group in June 2016 and a \$1.3 billion bid for Lattice Semiconductor by a Chinese private equity firm called Canyon Bridge Capital Partners in November 2016. In each case, the Chinese side enjoyed state backing through the Big Fund; Tsinghua Unigroup alone received \$1 billion of the Fund's original \$21 billion tranche (Miller, 2022). And in all cases, the prospect of a Chinese state-backed entity acquiring a controlling stake in a U.S.-based industry leader was a non-starter for American officials.[26]

The Big Fund was renewed in 2019 with an additional \$35 billion in financing. Given the dramatic decline in Chinese outward FDI in semiconductors after 2016, we can conclude that what has been invested thus far has been spent almost completely within China. Though this casts doubt on the long-term viability of outward FDI as a vehicle for technology transfer, it has likely further boosted Chinese final demand for semiconductors, and in turn China's bargaining power over foreign firms wishing to sell or invest there. And of course, the National IC Fund is just the tip of the iceberg when it comes to state-backed financing in the sector; as of 2021, 15 local

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[25] Ironically, one of the few areas where China has made significant progress in recent years is in flash memory chips – the focus of Tsinghua's two largest failed U.S. acquisitions, Micron and the 15% stake in Western Digital. Almost immediately after those bids were dropped, Tsinghua created Yangtze Memory Technologies Corp. (YMTC) with \$24 billion in support from Hubei province and the National IC Fund. YMTC was formed on the basis of and drew its leadership from Wuhan-based XMC, which it formally acquired shortly after its founding.

[26] Chinese firms, including Tsinghua, have been more successful in acquiring smaller stakes, which do not typically trigger CFIUS review, in well-known U.S. semiconductor firms. In April 2016, Tsinghua purchased a 6 percent stake in Lattice for \$41.6 million, which it sold shortly thereafter. A month later, it bought an undisclosed share in Marvell Technology Group for at least \$78.2(VerWey, 2019).

governments had established their own funds with a combined total of $25 billion in financing.[27]

Informal Inducements and Other Indirect Measures

Chinese central authorities have also sought to acquire foreign technology through a combination of fiscal incentives to open or expand local operations and various indirect or informal inducements to share technology. Since the release of Document 18 in 2000, China has offered tax breaks and other subsidies for semiconductor firms of all ownership types, including WFOEs. As noted above, the National IC Guidelines reinforced these incentives, though following 2011's Document 4, which scrubbed some of Document 18's language welcoming inward FDI in favor of the more ambiguous encouragement to "introduce overseas high-level human capital," it is unclear whether and to what extent these incentives applied to foreign firms. In 2020, China announced that foreign technology companies with at least 15 years' experience in ICs and with the ability to produce sub-28 nanometer (nm) chips would be exempt from paying corporate income tax for 10 years, while those making chips between 28- and 65-nm would receive five years' tax exemption and a 50 percent discount on corporate income taxes in the next five years.

Informal inducements to share technology are hard to measure systematically, but a closer look at the experiences of individual foreign chipmakers in China suggests such pressures became substantially more intense after 2013. Moreover, these experiences point to a very tight relationship between foreign firms' growing dependence on China as a downstream market, on the one hand, and China's ability to secure technology transfer agreements, on the other.

One of the earliest and most vivid illustrations of this dynamic came in March 2015, when IBM CEO Ginny Rometty announced, during a visit to Beijing, that henceforth the firm's strategy in China would center on partnering with local companies to help build up China's home-grown information technology (IT) industry. As Rometty put it, foreign firms "need to collaborate with Chinese companies to grow new industries – nowhere is this truer than in the I.T. sector."[28] She

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[27] Semiconductor Industry Association, July 13, 2021, "Taking Stock of China's Semiconductor Industry," Retrieved May 4, 2023, *https://www.semiconductors.org*.

[28] Mozur, Paul. April 19, 2015, "IBM Venture With China Stirs Concerns," *The New York Times*, Retrieved May 9, 2023, *https://www.nytimes.com*.

added that whereas “some firms” may find the prospect of helping strengthen Chinese technology companies “frightening. We, though, at IBM...find that to be a great opportunity.”[29]

These remarks were not made in a vacuum. Rometty spoke on the heels of one of the U.S. technology giant’s worst years in recent memory. Following the leak of top-secret documents by the U.S. defense contractor Edward Snowden in June 2013, IBM’s sales in China had plummeted more than 20 percent. This was hardly surprising. Of the major American tech firms, “none had a closer relationship to the U.S. government than IBM,” which had long built “advanced computer systems for America’s most sensitive national security applications” and whose staff had “deep personal relationships with officials in the Pentagon and in U.S. intelligence agencies” (Miller, 2022, 256). The revelation of the sweeping scope of U.S. foreign electronic surveillance activities sent shock waves through China, where private companies and government entities alike depended on U.S.-designed servers and networking equipment. Although IBM was not directly implicated in the Snowden leaks, in August 2013, China launched a probe of the company, causing its revenues to tumble and stock price to drop 22 percent from June 2013 to March 2015.

In this context, Rometty’s remarks looked like calculated bid to check IBM’s declining position in China by means of commitments to share technology.[30] In fact, her March 2015 pledge to “actively help build China’s industry”[31] capped a monthslong charm offensive by IBM officials aimed at winning back Chinese leaders’ support. In November 2014, Rometty met privately with Vice Premier Ma Kai – the former NDRC commissioner tasked with upgrading China’s semiconductor industry – where, according to Xinhua, the two sides “exchanged views on enhancing cooperation in areas including integrated circuit, software and fusion of industrialization and information technology.”[32] Nor were these commitments empty rhetoric. In January 2014,

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[29] Miller, Matthew and Gerry Shih. March 23, 2015, “IBM to share technology with China in strategy shift: CEO,” *Reuters*, Retrieved May 9, 2023, *https://www.reuters.com*.

[30] Interestingly, Intel’s sales in China rose from $9.8 billion (18.7 percent of its total revenue) in 2013 to $11.1 billion (20 percent of total revenue) in 2013. Qualcomm, another competitor in data center chips, also saw sales in China increase slightly over the same period. These results could reflect their dominant in the personal computer (Intel) and mobile (Qualcomm) markets).

[31] Miller and Shih, *Reuters*.

[32] *Xinhua*, November 12, 2014, “ Vice-premier meets IBM president,” Retrieved May 10, 2023, *http://english.www.gov.cn*.

IBM brought two Chinese organizations, Suzhou PowerCore Technology Co. and the Research Institute of Jiangsu Industrial Technology, into its OpenPOWER program, under which IBM gave partner companies access to its "Power" processor chip architecture.[33] And following Rometty's meeting with Ma Kai in November, the company announced a new joint venture with a Beijing-based startup called Teamsun in which IBM would provide "a partial blueprint of its higher-end servers and the software that runs on them" and help its Chinese partner "develop a full supply chain of computers and software atop IBM's technology."[34]

The Teamsun partnership drew particular attention because the Chinese executive charged with leading cooperation with IBM, Shen Changxiang, had been a vocal critic of China's reliance on American technology. Not incidentally, Shen was also one of China's leading cybersecurity experts who, prior to joining Teamsun, had "supervised the cybersecurity of China's strategic missile arsenal and spearheaded computer security research for the navy," according to the *New York Times*. Against the backdrop of the "Made in China 2025" program, which was launched May 2015 and which explicitly called for the country to wean itself off of foreign semiconductor technology, IBM's partnerships with Chinese firms like Teamsun and Suzhou Power Core and Rometty's comments looked dangerously short-sighted. In exchange for a short-term boost in sales, a U.S. technology company was actively cooperating in creating its own Chinese substitute.

In IBM's defense, the deals made some commercial sense for the firm. IBM's Power chip architecture "had once played a major role in corporate servers but had lost out in the 2010s" to x86 chips from Intel and AMD (Miller, 2022, 256). By 2014, IBM's Power chip technology was "seen as second rate," and with the dominance of x86 chips and growing competition in the data center market from Nvidia chips and ARM-based processors, IBM was unlikely to "reverse its post-Snowden market shrinkage" save for support from Beijing (Miller, 2022, 257). Quite apart from Snowden, IBM had been attempting to shift away from a business model focused on hardware and traditional services towards one oriented around cloud and mobile applications, so it had less

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[33] *PR Newswire*, January 19, 2014, "Suzhou PowerCore Technology Co. Intends To Use IBM POWER Technology For Chip Design That Pushes Innovation In China," Retrieved May 10, 2023, *https://www.prnewswire.com*.

[34] Mozur, Paul. *The New York Times*.

to lose than rivals like Intel and Qualcomm from Chinese competition in the market for data center chips. Indeed, from IBM's perspective, deals with China killed two birds with one stone: they gave the company a short-term boost in sales and market share in a segment it planned to exit anyway and potentially undercut its rivals in more core domains to them in the long run. Nonetheless, that IBM could rationalize transfers in this way does not change either the timing of the deals and Rometty's remarks or the fact that but for the threat of terminally reduced sales in China, the firm would likely not have felt compelled to "trade technology" for the market in the first place.

According to one interviewee, IBM's course-correction sparked a flurry of deals in China by Intel, AMD, and Qualcomm aimed at shoring up their market position in core business segments while using technology transfer agreements to undermine foreign rivals in segments where they themselves lagged. Thus, although Intel could not begin to entertain sharing sensitive technology for data server and PC chips – the company's foundation – nonetheless, to signal its commitment to China, in December 2014 it invested $1.6 billion to upgrade a major testing and assembly facility for these chips in Chengdu.[35] Meanwhile, in October 2014, Intel invested $1.5 billion in in two companies owned by Tsinghua Unigroup "with the aim of jointly developing and marketing smartphone chips," a segment in which Qualcomm dominated and Intel lagged.[36] And in October 2015, Intel announced it would spend a whopping $5.5 billion to upgrade a plant in Dalian that fabricated 3D NAND memory chips, a segment in which Intel lagged far behind leaders like Samsung and Micron. As one Intel executive said of the deals, "[d]eploying our newest advanced [semiconductor] technology in China shows our commitment to innovating jointly with China."[37]

By the mid-2010s, AMD's finances were in far worse shape than those of its much larger archrival, Intel, which earned roughly eleven times more globally than the Santa Clara-based chip designer. Strapped for cash and reportedly nearing bankruptcy, AMD was more willing than Intel to license potentially sensitive technology related to its x86 processor chips in exchange for Chinese

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[35] *Reuters*, December 4, 2014, "Intel to invest $1.6 billion in China factory," Retrieved May 10, 2023, *https://www.reuters.com*.

[36] *Reuters*, October 13, 2014, "Intel gains a new ally in China's chip wars – Beijing," Retrieved May 10, 2023, *https://www.reuters.com*.

[37] *Reuters*, December 4, 2014.

capital and market share. In early 2016, AMD formed a JV with a Chinese consortium called Tianjin Haiguang Advanced Technology Investment Co., or THATIC, in order "to support our expansion into the server and workstation product market in China."[38]

As part of the partnership, AMD agreed to "license certain of our intellectual property"[39] – essentially a modified version of an x86 processor chip – to an AMD majority-owned Chinese subsidiary. This AMD-controlled subsidiary would strip the chip of sensitive IP and license it to another Chinese company in which AMD retained a minority share. That company would "design" the top layer of the processor and return it to the first, AMD-controlled subsidiary, which would add the sensitive IP back in and export the design to GlobalFoundries, formerly AMD's fabrication arm, to be produced. The final chip would be sent back to the AMD-controlled subsidiary and then to the second JV for testing and assembly. This complicated workaround gave AMD a degree of control over the most sensitive technology while providing Chinese companies hands-on experience with chip design and giving them insight into how to integrate chip design and fabrication processes. Conveniently, it also allowed the Chinese subsidiaries to claim the final product as "indigenous."

Cash infusions from this and an October 2015 deal to sell an 85 percent stake in its testing and assembly operations in China and Malaysia to a Chinese firm did not "save" AMD (credit for that goes to its "Zen" processors, released in 2017). But there can be little doubt that by licensing x86 chip technology, AMD hoped to shore up its weakened position in the Chinese market. After steadily rising through the 2000s, AMD's China sales began to fall in 2012 before plummeting in 2015; from 2014 to 2015, sales globally declined by 27 percent, driven by a whopping 50 percent drop in China.[40] For a company that as recently as 2012 had derived fully 57 percent of global revenues from China, this was potentially catastrophic. For Lisa Su, who visited Beijing three weeks after taking over as AMD's CEO in October 2014, repairing the company's relationship

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[38] Advanced Micro Devices, Inc. 2017. "Annual Report Pursuant to Section 13 and 15(b) (From 10-k)," Retrieved May 10, 2023, *https://ir.amd.com.*

[39] Ibid.

[40] I have been unable to find any clear explanation for this drop. It could be related to the fallout from Snowden, but the fact that the decline began before those revelations and accelerated more than a year after casts doubt on this explanation. More likely, AMD's declining fortunes after 2012 reflects slowness in its response to competition from companies like Intel, which moved aggressively to expand its China market share with a string of major investments in the mid-2010s.

with China was a top priority. It worked. After bottoming out in 2017, AMD's sales in China rose thereafter, peaking in 2022 at 5.2 billion, or 22 percent of the firm's total revenues.

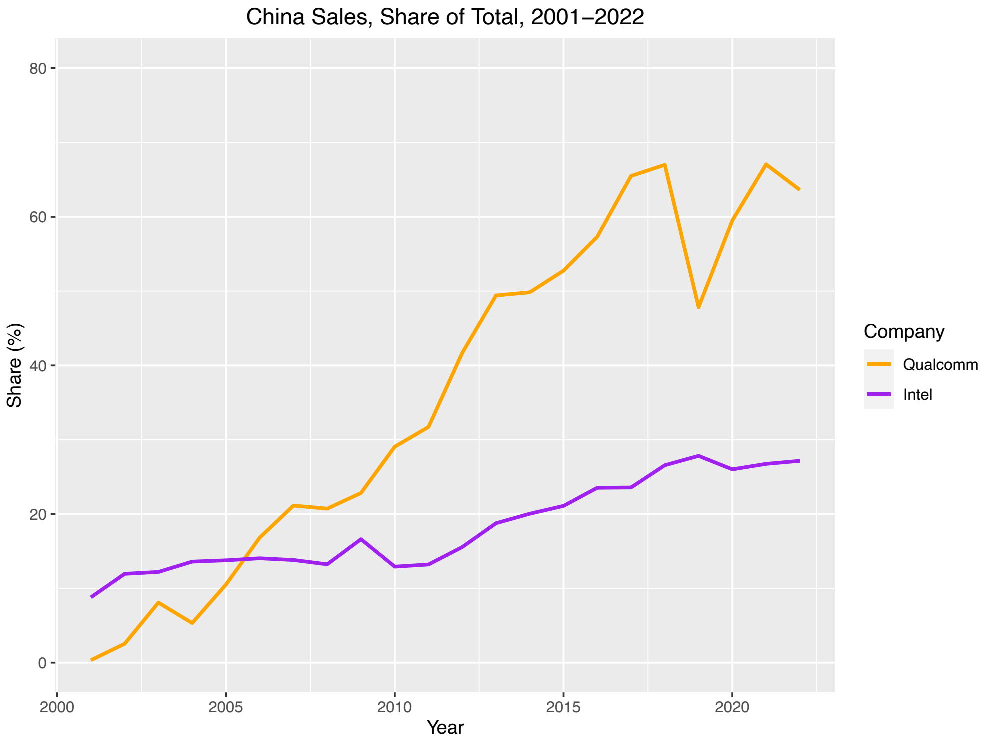

Figure 6.6: **China Sales, Share of Total, 2001-2022**: In the decade after the 2008-2009 global financial crisis, Qualcomm became far more dependent on the Chinese market than Intel, driven largely by growth in China's smartphone market. Source: 10-K reports for each company.

Perhaps the most blatant example of China leveraging a foreign chipmaker's dependence on its market to strong arm it into sharing technology concerned Qualcomm. To a far greater extent than any of its rivals, the San Diego-based designer of chips for mobile communications came to rely on China after the financial crisis as a final demand center for its goods. As Figure 6 (next page) shows, this reliance increased sharply with the growth of the Chinese consumer electronics market in the 2010s. On the eve of WTO accession, China accounted for less than one percent of Qualcomm's final sales. By 2010, that share had risen to 29 percent. In 2017, a whopping 66 percent of Qualcomm's global revenues came from China, compared with 23 percent for Intel. Although China, like the rest of the world, certainly depended on Qualcomm chips to power its smartphones, these figures underscored the singularly high "adjustment costs" the San Diego chipmaker would face in the event of a disruption to its China business.

It was in this context that the NDRC in November 2013 launched an investigation, under the auspices of the Anti-Monopoly Law (AML), into whether Qualcomm had abused its dominant market position to charge above-market royalties on technology licensed to Chinese customers. In March 2015, Qualcomm settled the case, agreeing to pay a record $975 million fine and to lower the basis for royalties to 65 percent of the sales price.[41] More interesting than the settlement, however, was the announcement three months later that Qualcomm, via a Singapore-based affiliate called Qualcomm Global Trading (QGT), would form an equity joint venture with Semiconductor Manufacturing International Corp. (SMIC), China's leading foundry, Huawei, and the Belgium-based organization imec to pursue "research and development for integrated circuits, including complementary metal-oxide semiconductor (CMOS) logic."[42] According to a press release on Qualcomm's website, the JV would "develop 14-nanometer CMOS technology for mass production, which will be based on imec's advanced semiconductor processing technology," with the aim to "to boost China's semiconductor capabilities."[43] As Qualcomm President Derek Aberle put it, the partnership "reinforces Qualcomm's commitment to the continued growth of the vibrant semiconductor ecosystem in China."

Perhaps the most glaring example of "forced" technology transfer in the aftermath of the settlement was a $280 million joint venture formed in early 2016 between Qualcomm and the Guizhou provincial government to make "advanced server technology."[44] Long-dominant in the market for mobile communications chips, in 2015 Qualcomm had made known its plans to enter the data center market with a new ARM-based server chip.[45] The joint venture, named Guizhou Huaxintong Semiconductor Technology Co Ltd., appeared designed to dovetail on this shift in

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[41] Cleary Gottlieb, March 16, 2015, "China's NDRC Concludes Qualcomm Investigation, Imposes Changes in Licensing Practices," Retrieved May 10, 2023, *https://www.clearygottlieb.com*.

[42] OnQ Blog, June 24, 2015, "Qualcomm's affiliate, QGT, SMIC, Huawei, and imec create equity joint-venture company in China," Retrieved May 11, 2023, hrefhttps://www.qualcomm.com/news/onq/2015/06/qualcomms-affiliate-qgt-smic-huawei-and-imec-create-equity-joint-venture-company*https://www.qualcomm.com*.

[43] Ibid.

[44] *Reuters*, January 17, 2016, "Qualcomm unveils $280 million joint venture with Chinese province," Retrieved May 10, 2023, *https://www.reuters.com*.

[45] Niccolai, James. October 8, 2015, "Qualcomm enters server CPU market with 24-core ARM chip," Retrieved May 10, 2023, *https://www.pcworld.com*.

Qualcomm's strategy. Under its agreement with the Guizhou government, Qualcomm would license its server technology to Huaxingtong, assist with research and development, and "supply expertise to implement the project." As with the SMIC and Huawei JV, Qualcomm President Derek Aberle described the deal and a separate pledge to establish a Guizhou-based technology investment company as "important steps for Qualcomm as it deepens its cooperation and investment in China," which underscored "our commitment as a strategic partner in China."[46] When asked whether Qualcomm was coerced into the Guizhou JV, one interviewee who previously worked at Qualcomm and was involved in standing up the venture replied "one-hundred percent."

To summarize, with the growth of Chinese final demand for consumer electronics and data center chips and networking equipment in the 2010s, China shifted from a firmly intermediate to an increasingly downstream position in semiconductor supply chains. Although the export-processing trade in electronics remained large in absolute terms, its significance relative to final demand in China diminished. As a result, foreign chipmakers' reliance on China began to outweigh China's reciprocal reliance on them to drive export growth. This shifted the balance of power in China's favor, enabling more assertive pursuit of foreign technology transfers. Although foreign semiconductor firms had long been accustomed to informal inducements to share technology with local partners, the available evidence and my interviews indicate such pressures became far more intense after the global financial crisis. These pressures often manifested in the formation of Sino-foreign joint ventures, underscoring the JV's enduring importance as a vehicle for technology transfer in China. However, despite China's growing bargaining power, they did not translate into overt, sector-wide joint venture or local content requirements. Why not?

Simply put, just as China's bargaining power in semiconductors began to improve in the mid-2010s, increased foreign, and in particular American, governmental scrutiny of Chinese trade and foreign investment practices, especially with respect to technology, had made overt sector-specific market access conditions increasingly untenable.[47] This was only compounded by the

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[46] *Reuters*, January 17, 2016.

[47] Waters, Richard, September 11, 2015, "US-China: High-Tech Diplomacy," *Financial Times*, Retrieved May 10, 2023, *https://www.ft.com*.

surge in Chinese outbound FDI in technology industries, which quickly sensitized Chinese officials to the risks of negative reciprocity by trade partners frustrated by the lack of an "even playing field" for their companies in China. Even absent market access restrictions in China, rising Chinese overseas investment in high-technology industries like semiconductors was bound to provoke foreign concern; the persistence of such barriers only made the situation worse. Against this backdrop, it is hardly surprising that China began to remove tech extractors in most after 2014, or that in sectors like semiconductor design and fabrication it opted to wield its growing leverage not with the imposition of tech extractors, but rather in less easily-monitored ways. By making it harder for outside observes to police its technology transfer activities, informal and indirect inducements very possibly slowed foreign governments' responses. This was especially true in a world where foreign firms like Qualcomm, concerned not to upset regulators in China, were reticent to take their grievances directly with U.S. authorities. As one interviewee, a former industry executive put it, "all of us knew something was wrong, but nobody really said anything, all the American tech executives in China – I mean, Qualcomm went through that whole process and barely uttered a word. I don't think they ever even complained to the U.S. government."

Alternative Explanations

In chapter three, I addressed several potential alternative explanations for the low incidence of technology extractors in strategic high-technology industries like semiconductors. These included technical complexity and the pace of innovation in a given sector, the degree of international industry concentration, the presence of export-controls on dual-use technologies, and opposition to market access restriction from local officials in China. As I noted, these arguments are compelling and undoubtedly help solve some part of the puzzle; the world is multidimensional, even if the norms of contemporary social science incentivize us to produce mono-causal theories about it. At the same time, I argued, all four accounts are unsatisfying because they struggle to distinguish between semiconductors and other industries, such as commercial aircraft manufacturing, which share similar values on the independent variables of interest but which experienced radically different outcomes when it comes to the use of technology extractors.

Here, I would briefly emphasize that the fourth approach, far from an "alternative explanation" to my own, in fact illuminates one potential pathway by which bargaining between foreign firms and central authorities unfolds – namely, foreign firms' alliances with local officials whose economic growth and "employment maximization" imperatives incentivize them to lobby (on behalf of foreign investors) against FDI ownership restrictions. My theory is agnostic as to whether the downstream risks to growth and employment from technology extractors reach central decision-makers through local officials, through direct lobbying of central officials by foreign firms like Intel, some other mechanism, or all of the above. What matters for my theory is that the decision not to issue policies that might provoke foreign opposition or exit or deter future investment be rooted in *growth and employment* concerns, and further that such concerns will be most pronounced in industries in which foreign investment not only serves domestic consumption but drives exports – that is, in industries heavily dependent on foreign firm-controlled export processing trade.

Conclusion

In May 2019, the United States Department of Commerce opened a new a phase in the history of Chinese semiconductor policy when it added Huawei to the Entity List, thus requiring American firms to obtain a license to export to the Chinese telecom giant. The next year, the United States followed up with tighter restrictions on the ability of Huawei and its chip design subsidiary, HiSilicon, to access American EDA equipment, and by halting the shipment of EUV lithography equipment to SMIC. By targeting key chokepoints in China's semiconductor supply chains, these moves threatened to cripple two of the country's most successful technology companies.

Significant as these steps were, however, they paled in comparison to sweeping new controls introduced in October 2022 on the export to China of technology, software, equipment, commodities, and services related to manufacturing high-end semiconductors.[48] Since then, U.S. government

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[48] Gibson Dunn, October 13, 2022, "United States Creates New Export Controls on China for Semi-Conductor Man-

officials have repeatedly stated that the export controls do not aim to contain or roll back China's broader economic and technological development but instead seek only to limit its access to and ability to produce a narrow class of advanced chips needed to run large-scale AI applications. U.S. officials may sincerely believe this argument. At the same time, if, as the U.S. government has said, advanced semiconductors and AI are "foundational technologies" control over which will define economic competition in the 21st century, then this is a distinction without a difference.

Whatever U.S. officials' intention, the more relevant question is how Chinese leaders understand Washington's actions. In the long run, the direct effects of export controls, even those issued in October 2022, on China's capabilities may be less important than their impact on the CCP leadership's worldview. U.S. export controls have been described as China's "Sputnik Moment" – and rightly so, for they have prompted a mobilizational campaign of unprecedented, even Quixotic, proportions to make China self-reliant at almost every stage in the semiconductor supply chain (Wang, 2021; Segal, 2021; Fuller, 2021). This campaign, in turn, has emerged as the hard core of a broader reorientation in China's development strategy towards what Xi Jinping calls a "dual circulation" system (Herrero, 2021). This strategy, enshrined as official doctrine in the 14th Five Year Plan in March 2021, amounts to a policy of at least limited economic decoupling from the West. In place of deep interdependence with advanced industrial societies in the United States and Europe, dual circulation envisions a China fueled by internal demand and closer integration with (and support for nurturing) consumer markets in the developing world.

As China's leaders understand well, true semiconductor self-sufficiency is not a realistic goal in the next five or even ten years. Achieving even a modicum of self-reliance in the production of advanced chips will require enormous investments and continued access, however obtained, to leading edge firms at every step of the IC design and manufacturing process. The "inroduction, digestion, absorption, and re-innovation" of foreign technology will thus remain a key, if quiet, pillar of Chinese semiconductor policy. This being said, China is unlikely to embrace formal technology extractors in ICs, and even outward FDI will likely not reclaim its once-integral role as

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ufacturing Technology, Advanced Semiconductors, and Supercomputers in New Phase of Strategic Tech Competition," Retrieved May 11, 2023, *https://www.gibsondunn.com*.

a means to acquire foreign know-how. Instead, the future of technology transfer policy in China will lie in the "grey zone" of increasingly intrusive informal pressures on foreign firms operating there, ambiguous regulations such as national and data security reviews, and industrial espionage like that reported in February 2023 by the Dutch lithography firm ASML.[49] This will make monitoring and policing Chinese technology transfer behavior far harder than it was in the first two decades after China joined the WTO.

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[49] Gross, Anna, February 15, 2023, "ASML reveals intellectual property theft by China employee," Retrieved May 12, 2023, *https://www.ft.com*.

Chapter 7

Technology Extraction in Aviation

Manufacturing commercial aircraft is among the most technologically and organizationally demanding activities humans have ever undertaken – second only, perhaps, to producing cutting-edge semiconductors. Each plane that rolls off the final assembly lines of Boeing and Airbus, which have held a virtual duopoly in the large commercial aircraft (LCA) market since Boeing acquired McDonnell Douglas in 1997, is the condensation of a century of painstaking advances and accumulated expertise in materials science, engine design, avionics,[1] and what is known as "systems integration," the dizzyingly complex process of piecing together millions of components sourced from thousands of suppliers spanning a dozen or more countries in several continents into a seamless, reliable and, above all, safe whole. It is no wonder that building commercial aircraft has been described as "the world's premier expression of manufacturing excellence" (Robison, 2021, 1).

This chapter examines China's efforts to nurture a homegrown aircraft manufacturing industry. In particular, it traces the party-state's decades-long campaign to build a large commercial aircraft able to compete with offerings from Boeing and Airbus not only in China but on the global stage. As we will see, foreign firms have played an integral role in this campaign. Driven by a desire to tap the world's most important growth market for commercial aircraft in recent decades, foreign aviation firms have formed joint ventures (JVs) with Chinese counterparts, sent thousands of engineers

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[1] Avionics is a portmanteau of "aviation electronics" and encompasses communications, navigation, flight control and other key electronics systems on an aircraft.

and managers to China to train local staff (and brought many hundreds more Chinese engineers to the U.S. and Europe for additional training), invested heavily in local research and development (R&D) and co-production of aircraft components, opened final assembly lines (FALs) in China, and licensed or transferred vast quantities of – in some cases quite advanced – technology. It is difficult to overstate the importance of foreign technology transfers, broadly understood, to the development of China's commercial aviation industry.

In many ways, aircraft manufacturing exemplifies this project's core argument about when China uses technology extractors[2] in strategic high-technology industries. Since the earliest days of foreign participation in China's aviation sector, foreign firms have consistently looked to China as an important final market for their goods. Although they have also used China as base for manufacturing or processing intermediate inputs for consumption elsewhere, foreign airplane makers' overriding priority has long been to capitalize on the once-in-a-lifetime boom in Chinese demand for commercial aircraft that has taken place in recent decades.[3] China, in turn, has used the leverage afforded by this position to condition market access on foreign firms' willingness to partner with local businesses and nurture domestic capabilities at every stage of the aircraft manufacturing and civil aviation supply chains. Between 1995-2020, Chinese authorities issued no fewer than 29 distinct technology extraction policies in aircraft manufacturing, the most of any single industry. Importantly, these policies cover not only the production of finished aircraft but a wide range of intermediate systems, subsystems, and components spanning everything from engine design and avionics to specialized bearings, aircraft landing gear, and more.

Likewise, aircraft design and manufacturing conforms to my theory's prediction about when China removes technology transfer policies. Aircraft production is one of a very few strategic high-technology sectors in which China maintained formal joint venture requirements on inward foreign direct investment (FDI) throughout virtually all of the 1995-2020 study period. China only removed FDI ownership restrictions in aircraft production in 2018, when the country, under

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[2] I define these as policies that condition foreign firms' access to the Chinese market on their willingness to partner with and transfer technology and expertise to domestic businesses.

[3] From 1997-2006, less than 1 percent of average annual aircraft manufacturing-related imports into China were tied to processing trade.

pressure from foreign governments, abandoned the more restrictive FDI Catalogue in favor of a more streamlined and permissive "Negative List" (though the Negative List retained ownership restrictions in "General Aviation Services" through 2020). As I discuss later in the chapter, China's relatively slow progress towards the world technological frontier in commercial aircraft (and in particular in systems like jet engines and avionics) has relieved pressures from foreign firms, and in turn foreign governments, to remove technology extractors in the sector.

But if aircraft manufacturing shows how China can leverage its market to condition foreign access on compliance with technology transfer policies, it also reflects a more nuanced story about when such policies lead to meaningful technology transfers and when they do not. As I explore in the final part of the chapter, formal compliance with technology extractors does not always equate to real technology extraction, at least not to the extent desired by Chinese authorities. Not surprisingly, foreign firms often tightly control what they share with local partners even in sectors where China theoretically enjoys enormous leverage. Instead, effective tech extraction is most likely when China is able to exploit certain characteristics of the global market structure in an industry. Specifically, as comparisons of the experiences of McDonnell Douglas, Boeing, Airbus, as well as two different GE Aviation subsidiaries in China all illustrate, Sino-foreign partnerships are most successful (where tech extraction is concerned) when they involve not global industry leaders, but relative laggards or newcomers eager to capture market share. This dynamic is especially pronounced in industries like aircraft and semiconductors, where high barriers to entry and huge economies of scale make competition for marginal global market share especially fierce.

The chapter builds on more than a dozen interviews with industry insiders and experts, current and former executives at aerospace companies like Boeing, GE Aviation, and the Commercial Aircraft Corporation of China (COMAC), current and former U.S. government officials, and experts at think tanks and universities in the United States. It also draws on close analysis of Chinese-language Chinese central state regulations, Chinese-language media and scholarship on the industry, and English-language media, scholarship, and other secondary sources.

The remainder of the chapter is organized as follows. Section 2 discusses why commercial aircraft manufacturing provides a valuable test of my theory. Section 3 traces the evolution of Chinese aircraft industry policy from 1972 to the present. In section 4, I look more closely at the development of the C919 narrow-body jetliner, China's answer to the Boeing 737-MAX and Airbus A320-neo. This section argues that the slow progress of the C919 has relieved foreign corporate and governmental pressure to remove technology transfer policies in the sector. Section 5 then examines three episodes – McDonnell Douglas's failed foray into China in the 1980s and 1990s, Boeing-Airbus competition for Chinese market share in the early post-WTO period, and the divergent trajectories taken by two GE Aviation subsidiaries in China in the 2010s – that illustrate how global market structure shapes granular dynamics of bargaining over technology transfer within industries in which China energetically enforces tech extractors.

Why Study Aircraft Manufacturing?

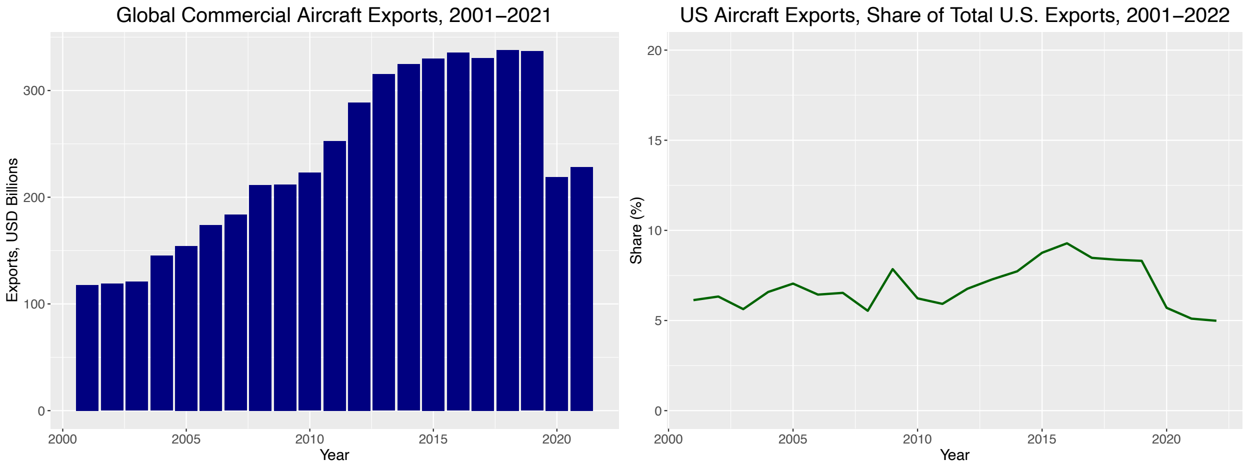
Aircraft manufacturing offers a good test of my theory for three main reasons. First, it is a substantively important industry. Beyond its sheer economic scale, aircraft manufacturing has played a major role U.S.-China relations since the start of Reform and Opening. Given the pervasiveness of "dual-use" technologies – systems and components with both military and civilian applications – in the sector, it is also one of a handful of industries in which commercial advances have potentially significant military and strategic implications. Against this backdrop, documenting how China has sought to extract technology from companies like Boeing, Airbus, and GE Aviation constitutes a valuable empirical contribution quite apart from what it says about my theory.

Second, aircraft manufacturing provides additional inferential leverage on several aspects of the theory examined in chapters 5 and 6. Whereas China removed most tech extractors in wind power by 2012, it used them for another six years in aircraft. Comparing the trajectories of tech extraction efforts in wind turbine and aircraft manufacturing can thus provide insight into when China rescinds these policy tools in strategic high-technology industries. More importantly, aircraft manufacturing offers an ideal testing ground for alternative explanations for the low incidence of tech extractors in semiconductor design and fabrication. This is because perhaps no industry more closely resembles semiconductor production across a broad range of theoretically relevant variables than aircraft manufacturing. That two such “most similar” cases display radically different outcomes when it comes to the use of tech extractors casts doubt on these alternative approaches.

Finally, the commercial aircraft industry offers an opportunity to extend the theory to consider under what conditions technology extraction policies lead to meaningful technological cooperation between Chinese and foreign firms. Put another way, it provides insight into how effective tech extractors are at facilitating actual technology extraction, and when and why they are more or less so. Aircraft manufacturing is uniquely well-suited to this task because it is an industry in which China theoretically enjoys enormous leverage over foreign firms, and indeed in which it has enforced formal tech extractors energetically. As such, it offers a window into the factors that shape granular bargaining over technology transfer *within* industries in which policies like JV and local content requirements are prevalent. The unrivaled depth and longevity of foreign participation in China’s aerospace industry has the added benefit of allowing us to trace patterns in these bargaining dynamics over several decades.

The Importance of Aircraft Manufacturing

Independent of my theory, understanding China’s efforts to secure foreign technology transfers in commercial aircraft manufacturing should be of substantive interest to scholars of international relations and political economy for several reasons. The first is the sector’s huge commercial significance. Globally, aircraft and related parts are among the top twenty most traded goods and top ten most traded manufactured goods, by value, according to data from UNCTAD. In terms of high value-added export industries, only semiconductors, autos, and pharmaceuticals are larger in dollar terms. In particular, aircraft manufacturing plays an outsized role in the economies (and politics) of advanced industrial democracies like the United States, France, and United Kingdom. Firms like Boeing and Airbus not only directly employ hundreds of thousands of engineers and mechanics in these countries, but anchor vast ecosystems of suppliers employing millions more.



(a) Global Aircraft Exports (USD Bn)

(b) U.S. Aircraft Exports (% of Total)

Figure 7.1: **Global Commercial Aircraft Exports, 2001-2021** and **US Aircraft Exports, Share of Total, 2001-2022**: In the seven years prior to the COVID-19 pandemic, global commercial aircraft exports averaged over $300 billion per year. Commercial aircraft exports have consistently averaged between 7-9 percent of total U.S. exports, by value. Source: UNCTAD.

These ecosystems are one way in which aircraft manufacturing, like many other strategic and high-technology sectors, generates positive economic and technological spillovers to other high value-added industries, and in turn helps lift entire national economies up (and sustain them at top of) the global division of labor. This leveling-up effect helps explain why Japanese conglomerates, with support from the Japanese government, pursued a deliberate strategy of inserting themselves into global aircraft supply chains as suppliers to “prime” manufacturers like Boeing in the postwar period (Friedman and Samuels, 1993). It is also one of the motives behind Chinese leaders’ longstanding interest in nurturing the country’s homegrown aircraft manufacturing capacity.

Another motive stems from the close relationship between commercial aircraft manufacturing prowess and military aerospace capabilities. Most strategic and high-technology sectors entail systems, components, manufacturing processes, or technical expertise that can be applied to both commercial and military use cases. But in few other strategic industries are such dual-use technologies as ubiquitous as aircraft design and manufacturing. As one RAND study put it, many “aerospace systems are inherently dual-use or can provide a basis for the development of military systems...[and] many of the skills and technologies required to produce commercial and dual-use aerospace products are also applicable to purely military systems" (Cliff, Ohlandt and Yang, 2011, Xiii). Against this backdrop, it is hardly surprising that the top four U.S. defense contractors are aerospace companies (Boeing is number two), or that China's civilian aircraft sector is directly descended from and maintains close institutional ties to its defense industrial complex.

Beyond the underlying adaptability of the technologies themselves, these institutional linkages create natural pathways for technology and expertise shared with commercial aircraft companies in China to be "spun on" to military applications. As the RAND report concluded, there is "no question...that foreign involvement in China's aviation manufacturing industry is contributing to the development of China's military aerospace capabilities" (Cliff, Ohlandt and Yang, 2011, 37). In theory, export controls should limit the extent to which technology transfer in commercial aviation spills over into the military domain; on at least one occasion, an American aerospace company was forced to remove a piece of technology transferred to China after it was discovered the technology had ended up in a Chinese defense contractor's facility (Crane et al., 2014). In practice, however, export controls appear to have had little real impact on U.S. and other foreign aviation companies' ability to cooperate with China. This is at least partly because such rules have been narrowly crafted around sales to military end-users or parts designed specifically for military aircraft.[4] China has been able to reduce its exposure to such controls by formally separating its leading commercial and military aviation companies, even as informal linkages between them persist and the former continue to source a wide array of components from the latter.

Finally, and closely related, the commercial aircraft industry merits closer scrutiny in a study of Chinese foreign technology transfer efforts because of the unique role U.S. aircraft manufacturers, above all Boeing, have played in U.S.-China relations throughout the post-Mao period. As the single largest U.S. exporting firm for many decades (whose primary export market remains China), Boeing led the American business community's efforts to win Congressional support for China's WTO accession, mobilizing its vast network of "10,000 suppliers...spread across 420 of the nation's

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[4] Holland & Knight, November 2008, "International Aviation Transactions: Compliance With U.S. Export and Embargo Restrictions," Retrieved May 18, 2023, *https://www.hklaw.com*.

435 congressional districts" to lobby on China's behalf.[5] To this day, Boeing spends far more lobbying the U.S. government on China-related trade issues than any other firm – over $150 million from 2007-2016 according to data from LobbyView, more than double the next largest spender, Microsoft. Boeing's deep relationships with the U.S. government and defense establishment, as well as with generations of senior Chinese leaders, have positioned its executives as unofficial emissaries between Washington and Beijing, or as one interviewee put it, "designated hostages" in any U.S.-China dispute.

Aircraft in Comparison to Wind and Semiconductors

In addition to its intrinsic significance, aircraft manufacturing constitutes a valuable test of my theory because it provides additional inferential leverage on several aspects of the arguments examined in chapters 5 and 6. Like wind energy, commercial aircraft manufacturing illustrates how China is able to leverage foreign dependence on its market to secure compliance with tech extractors in strategic sectors in which it is largely downstream of GVCs. But whereas China lifted virtually all formal technology transfer policies in wind power by 2012, it maintained them in various aerospace-related industries as late as 2020. Comparing the trajectories of technology extraction efforts in wind turbine and commercial aircraft manufacturing provides support for my argument about the relationship between increased Chinese competitiveness and the decision to remove tech extraction policies. Rapid gains in China's wind energy capabilities simultaneously reduced the utility of and increased the risk of negative reciprocity associated with these tools. China's slower progress in aircraft manufacturing has implied a different balance between costs and benefits of tech extractors, and in turn different tech extraction behavior.

More importantly, aircraft manufacturing offers an opportunity to test my theory against a range of alternative explanations for the low incidence of tech extractors in strategic high-technology industries like semiconductor design and fabrication. This is because more than any

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[5] Bradsher, Keith. May 21, 2000. "Rallying Round the China Bill, Hungrily," in *The New York Times*, Retrieved June 7, 2022, *https://www.nytimes.com*.

other industry, aerospace closely resembles high-end semiconductor production across a range of theoretically relevant dimensions. As with semiconductors, aircraft manufacturing is among the most internationally concentrated industries in the world, with each industry segment dominated by a small number of large MNEs. The extensive use of tech extractors in aircraft thus suggests that the oligopolistic position of foreign chipmakers and equipment manufacturers does not explain why China refrains from imposing technology transfer policies in integrated circuits.

Also like advanced ICs, aircraft production is characterized by high barriers to entry due to huge R&D requirements, cumulative learning effects, patent concentration, and rapid innovation in key industry segments such as jet engines and avionics. This suggests that although technical barriers to entry may explain why China has struggled to reach the technological frontier in semiconductor design and fabrication, they likely do not account for the absence of measures like JV and local content requirements to begin with. Finally, China uses tech extractors not only in the development of finished aircraft, but for a range of intermediate products and components used in the aircraft manufacturing process. This suggests that intermediateness as a product-level characteristic, while associated with the non-use of technology extractors, does not determine when China issues these policies. Rather, the correlation between intermediateness and the presence or absence of tech extractors reflects where China sits in value chains in an industry – that is, whether those intermediate inputs are ultimately consumed in China or are destined for export elsewhere. Overall, that two such "most similar" industries experience divergent outcomes when it comes to China's use of overt technology transfer policies strongly suggests that industry characteristics do not fully account for variation in China's policy behavior.

Examining Granular Bargaining Dynamics

The primary outcome of interest in this project is China's decision to issue formal technology extractors. Understanding these decisions matters because China's use of these policies has shaped both its economic rise and the trajectory of its relations with the United States in recent decades. More generally, these decisions provide insight into when and why states wield coercive leverage over, and can thus extract policy concessions from, prospective foreign investors. In particular, as the previous chapters have shown, examining China's use of tech extractors sheds light on the ways in which domestic institutional capacity and industry-level variation in states' position in global production networks limits their bargaining power vis-à-vis foreign firms, in turn constraining their access to the technology needed to move up the global division of labor in strategic industries.

At the same time, a focus on decisions to introduce technology transfer policies has limits. Most importantly, as previous scholarship has pointed out, there is often a gap between the presence of technology transfer requirements, on the one hand, and the degree of actual Sino-foreign technological cooperation, on the other. This is to say nothing of the much larger question of why China has made rapid technological progress in some industries but not in others, including some in which it uses technology transfer policies energetically. The latter question is beyond the scope of this project, and in all likelihood depends principally on non-political factors that put it beyond the scope of political science and international relations more generally. But the narrower question of when the presence of tech extractors leads to real commitments to share technology merits attention because it can help illuminate more granular dynamics of bargaining over technology between China and foreign firms. That is, it can shed light on variation in state-firm bargaining dynamics not only across industries (the focus of this project), but across segments in the same industry, firms in the same segment, and even different deals involving the same foreign firm.

The aircraft manufacturing industry is well-suited to examining these dynamics for two main reasons. First, as I explore at length in section 5, although all aircraft makers engaged in China have at some point shared technology with Chinese counterparts, there is wide and in some cases puzzling variation in the extent to which they do so both across and within industry segments, as well as within individual firms. Second, with some minor changes due industry consolidation, the same small band of Western aircraft makers have dominated the industry in general and its engagement with China for most of the past four decades. This allows me to trace longer-term patterns in how the same companies deal with China over time, and in turn to control for firm-level idiosyncrasies that might explain changes in bargaining dynamics.

Chinese Aircraft Industry Policy, 1972-Present

This section surveys the development of Chinese aircraft industrial policy since 1972. It makes two main points. First, consistent with my argument about the relationship between enforcement capacity and China's bargaining power, the consolidation of aircraft industrial policy authority in the post-WTO period led to gains in both the number of tech extractors in place and the intensity with which they were enforced in the industry. Second, due to sectoral idiosyncrasies this consolidation proceeded through somewhat different institutional channels and on a slightly different timeline from other strategic industries.

With the exception of *ad hoc* leading small groups, most strategic industries (including wind energy and semiconductors) have been governed in the post-WTO period by "mainstream" macroeconomic policy bodies like the NDRC, MIIT, and Ministry of Finance. These institutions also play important roles in aircraft industrial policy, especially where foreign participation and technology transfers are concerned. But the sector's origins in and historical ties to China's defense industrial complex, and subsequently the need to more cleanly separate commercial from military aerospace production (in no small part in order to facilitate foreign participation and technology transfers), have fueled the creation of distinctive sector-specific policy actors. The most important of these is COMAC, a centrally-administered state-owned enterprise which has led the country's efforts to develop a large commercial aircraft since its creation in 2008. Although COMAC does not issue policies, its formation should be understood, I argue, as part of a process of institutional reform and consolidation that bolstered China's bargaining power over foreign firms in aircraft manufacturing. It did so primarily by creating a unified front in and focal point around which negotiations with foreign investors over market access would revolve.

The remainder of the section is divided into two parts. The first part summarizes the evolution of major state institutions involved in the aircraft manufacturing and civil aviation industries. The second part reviews key central-level industrial policies in the sector, paying special attention to the relationship between institutional changes and consolidation over time, on the one hand, and variation in the tempo and enforcement of technology extraction policies, on the other.

Evolution of Aircraft Policy Institutions

In contrast to most other strategic high-tech industries in China, which emerged largely out of civilian-led programs and institutions, the commercial aircraft sector is a direct descendant of China's defense industrial complex. The history of the sector has thus been defined by its steady, if incomplete, institutional separation from that complex.

Throughout the Mao era, responsibility for manufacturing aircraft in China fell to the Third Ministry of Machine Building (第三机械工业部), which in turn answered to the People's Liberation Army Air Force (PLAAF) and the Central Military Commission (CMC). As such, although China made several attempts to build civil aircraft in the 1970s – most notably, the ill-fated Y-10 narrow-body jetliner – properly speaking, it lacked a commercial aircraft industry during this period. In 1982, the Third Ministry was reorganized as the Ministry of Aviation Industry (航空工业部), which in turn was moved from the CMC to the State Council in 1986 (Dougan, 2002). This marked the start of efforts to formally separate commercial aircraft production (and associated policy) from national defense. Even so, the CMC continued to exert considerable, if indirect, influence over civil aircraft development through the Commission on Science, Technology and Industry for National Defense (COSTIND). Created in 1982 to coordinate production activities across the various defense-related industrial ministries, COSTIND simultaneously reported jointly to the CMC and the State Council and, alongside the latter, enjoyed "parallel authority" over the Ministry of Aviation Industry (Dougan, 2002, 97).

Between 1988-1993, the Ministry of Aviation Industry (MAI) was folded into a larger Ministry of Aviation and Aerospace Industry (MAAI). But a more consequential reorganization came in 1993, when the MAI was split off again and renamed the Aviation Industry Corporation of China (中国航空工业总公司). Created as part of broader administrative reforms aimed at separating the state from enterprises, in its first iteration AVIC was a holding company tasked with managing various aviation industry assets, for example SOEs like the Xian Aero-Engine Corporation and Chengdu Aircraft Industry Group. Meanwhile, industrial planning and administrative functions that were formerly the purview of the MAI were shifted to COSTIND (Dougan, 2002, 97).

The decision to shift planning and administrative functions to COSTIND reflected the fact that the PLAAF was AVIC's and its subsidiaries' only real aerospace client at the time.[6] Indeed, one goal behind AVIC's creation was to make it more responsive to the PLAAF's needs than the MAI had been (Crane et al., 2014, 8). Nonetheless, PLAAF frustration with AVIC capabilities continued, and in 1999 AVIC was split into two companies. This decision appeared designed to improve performance by rationalizing business operations and stimulating limited competition, as well as by facilitating foreign cooperation with the more commercial aviation-focused AVIC II (Crane et al., 2014; Dougan, 2002; Cheung, 2022). For various reasons, the split failed to achieve its goals, and in 2008 AVIC was re-merged and COMAC was formed as an entirely separate entity tasked with managing commercial aircraft production, including development of the narrow-body jetliner that would come to be known as the C919.

At the same time, in order to more fully separate commercial aircraft policy from defense and consolidate civilian administrative authority over the sector, COSTIND was downgraded from a commission to an office with the newly-formed MIIT. It is unclear how much influence this office has on aircraft industrial planning today, but it certainly does not enjoy the same powers as its predecessor, nor is it institutionally linked to defense. Instead, both AVIC and COMAC are now among the fifty or so "important backbone state-owned enterprises" (重要骨干国有企业) managed by the State-owned Assets Supervision and Administration Commission (SASAC), which emerged from the same reforms that created the NDRC in 2003 (Leutert, 2018; Brødsgaard, 2012).

Today, AVIC is a sprawling conglomerate with more than 400,000 employees and dozens of subsidiaries engaged R&D, design, and manufacture of both commercial and military aircraft and related systems. It also sponsors a number of research institutes, co-owns at least one airline, and despite its continued ties to the defense industry operates a number of JVs with foreign aircraft makers. By comparison with AVIC , COMAC is relatively small and tightly organized. This reflects its strict focus on commercial aircraft production, a decision which, as noted earlier, aimed to facilitate foreign participation in COMAC projects, especially the C919.

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[6] Like much of China's defense industrial complex in this period, AVIC derived most of its income from outside its core businesses.

Over the past two decades, as both AVIC and COMAC have come to resemble the kinds of diversified business conglomerates seen in other countries, responsibility for high-level aircraft industrial policy has been concentrated among a small number of peak bureaucratic agencies, including the NDRC, MIIT, and MOF (SASAC is not generally involved in formulating industrial policies). This continues the trend begun with the transfer of planning and administrative functions from the Ministry of Aviation Industry to COSTIND in 1993. It is also part and parcel of a broader shift from sector-specific industrial policies issued by specialized bureaucracies with limited cross-agency coordination to cross-sectoral initiatives designed by macroeconomic planning bodies tasked with guiding the long-term development of the economy as a whole (Heilmann and Shih, 2013). Naturally, as the aircraft industry has come to be seen as part of an increasingly institutionalized effort to foster domestic capabilities in strategic industries, aircraft industrial policy has come under the control of agencies like the NDRC and MIIT.

Evolution of Aircraft Industry Policies

China's efforts to build a commercial aircraft industry date back as early as 1972. As part of President Nixon's visit in February of that year, China purchased ten Boeing 707 planes. A few years later, Boeing executives reported that one of the ten planes had disappeared from service, fueling speculation that China was attempting to reverse engineer the aircraft to use as a reference for its own model (Dougan, 2002). This speculation was confirmed in 1980, when the Shanghai Aircraft Research Institute (SARI) tested a prototype aircraft dubbed the Yun Shi (运十), or Y-10.[7] At an estimated cost of $300 million, the Y-10 was an enormous financial undertaking for a central state then on the verge of bankruptcy. But despite this support and huge efforts by China's top aerospace engineers (as well as contributions from Rolls Royce and Pratt & Whitney), the aircraft was far too heavy and inefficient to be commercially viable.

Shortly after initial test flights, the Y-10 was abandoned. In its place, China adopted a "three-step strategy" (三步走战略) to develop the sector on the basis of cooperation with foreign aircraft

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[7] Some sources suggest a Pakistani Boeing 707 that crashed over Xinjiang provided the model for the Y-10.

firms. Accounts differ as to what, precisely, was entailed in each step, but generally speaking the goal was to proceed from local production and assembly of foreign aircraft designs (with training and oversight from foreign firms), to joint development of regional aircraft with foreign firms, and finally to independent development, by 2010, of a domestically-designed long-haul commercial aircraft (Dougan, 2002; Crane et al., 2014). One Chinese commentary from 2007 characterized this as "the 'Santana' developmental path for China's aircraft manufacturing industry: first produce with foreign cooperation, then gradually localize production," referring to a 1984 JV between Shanghai's SAIC Motor and Volkswagen to produce the Volkswagen Santana.[8]

Although I have not found a central-level document that contains the exact phrase "three-step strategy," this concept clearly undergirds the first major commercial aircraft industrial policies of the post-Mao period. Issued on March 25, 1985, the Notice of the General Office of the State Council Forwarding Minutes of the Meeting on Accelerating the Development of Domestic Civil Aircraft,[9] hereafter the Notice, called for China to "actively introduce advanced foreign technology" in aircraft production (积极引进国外先进技术) and to "produce civilian aircraft with foreign cooperation" (与国外合作生产民用飞机). It also encouraged the state to "boldly use foreign capital, [and] actively introduce advanced technology through various channels; use various forms (including joint ventures and cooperative production) to develop international technical cooperation, and strive to improve the level of the domestic civil aircraft industry" (大胆利用外资，通过多种渠道，积极引进先进技术；采用多种形式（包括合资经营、合作生产），发展国际间的技术合作，努力提高我国民用飞机工业的水平).[10]

In July 1985, the Ministry of Aviation Industry followed-up with a set of "Interim Measures for the Administration of Science and Technology Progress Awards,"[11] which called for China

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[8] Zhang Tianyi. 2007. "The History of China's Large Aircraft" (中国大飞机问世始末), retrieved March 21, 2023 (*http://m.wyzxwk.com*). Original: "这也被称为中国飞机制造业的'桑塔纳'发展道路—先与国外合作生产, 逐步国产化."

[9] 国务院办公厅转发关于加速发展国产民用飞机问题的会议纪要的通知

[10] The Notice refers to a November 1984 meeting co-chaired by then-Vice Premier Premier Li Peng to discuss a "Report on Accelerating the Development of Domestic Civil Aircraft" (关于加速国产民用飞机发展的报告) issued by the newly-created Ministry of Aviation Industry, but I have not be able to locate this report. Section 5 of Chapter 17 of the Sixth Five Year Plan, 1981-1985, discusses the development of civil aviation in China (民用航空建设) but does not touch on manufacturing.

[11] 航空工业部科学技术进步奖管理暂行办法

"digest, absorb, and apply imported foreign technologies" (消化、吸收、应用引进国外技术) in order to build domestic capabilities in aircraft manufacturing.

The March 1985 Notice and subsequent Interim Measures are not only consistent with the three-step strategy, but also indicate that as early as 1985 Chinese leaders saw foreign technology extraction as central to the country's aircraft industrial policy strategy. Importantly, the Notice was issued less than three weeks before the Shanghai Aviation Industrial Corporation (SAIC) signed the country's first commercial aircraft co-production agreement with a foreign partner, McDonnell Douglas. As I discuss in more detail in section 5, as part of the deal, McDonnell Douglas agreed to transfer huge amounts of technology and train local engineers and mechanics. Indeed, in many ways the company's commitments amounted to building up China's commercial aircraft manufacturing industry from scratch. As *The Wall Street Journal* reported in 1996, "when Douglas officials first visited their Shanghai partner's sprawling factory...they found it woefully ill-equipped...only a handful of the factory's 4,000 workers had experience building anything more complex than aluminum-sided buses."[12] To rectify this situation and ensure that aircraft produced in Shanghai would receive FAA certification, McDonnell Douglas "completely renovated SAIC's facilities, provided huge amounts of technical data, and had U.S.-based McDonnell Douglas employees provide 55,000 man-hours of technical training in engineering, tooling, and other areas" (Cliff 2001, 24). The *Financial Times* described the arrangement as "the largest transfer programme in China both in terms of technological content and value."[13]

Throughout the 1990s, aircraft industrial policy followed the path sketched out in 1985. Central state agencies issued policies saluting efforts to "better utilize and digest foreign intellectual resources" (更好地利用和消化国外智力资源) and the sector received mentions in each of the Seventh (1986-1990), Eighth (1991-1995), and Ninth (1996-2000) Five Year Plans. But during this period, policymakers focused less on issuing new directives and more on meeting targets laid down in the three-step plan. Consistent with the first of those steps, in addition to the SAIC-McDonnell

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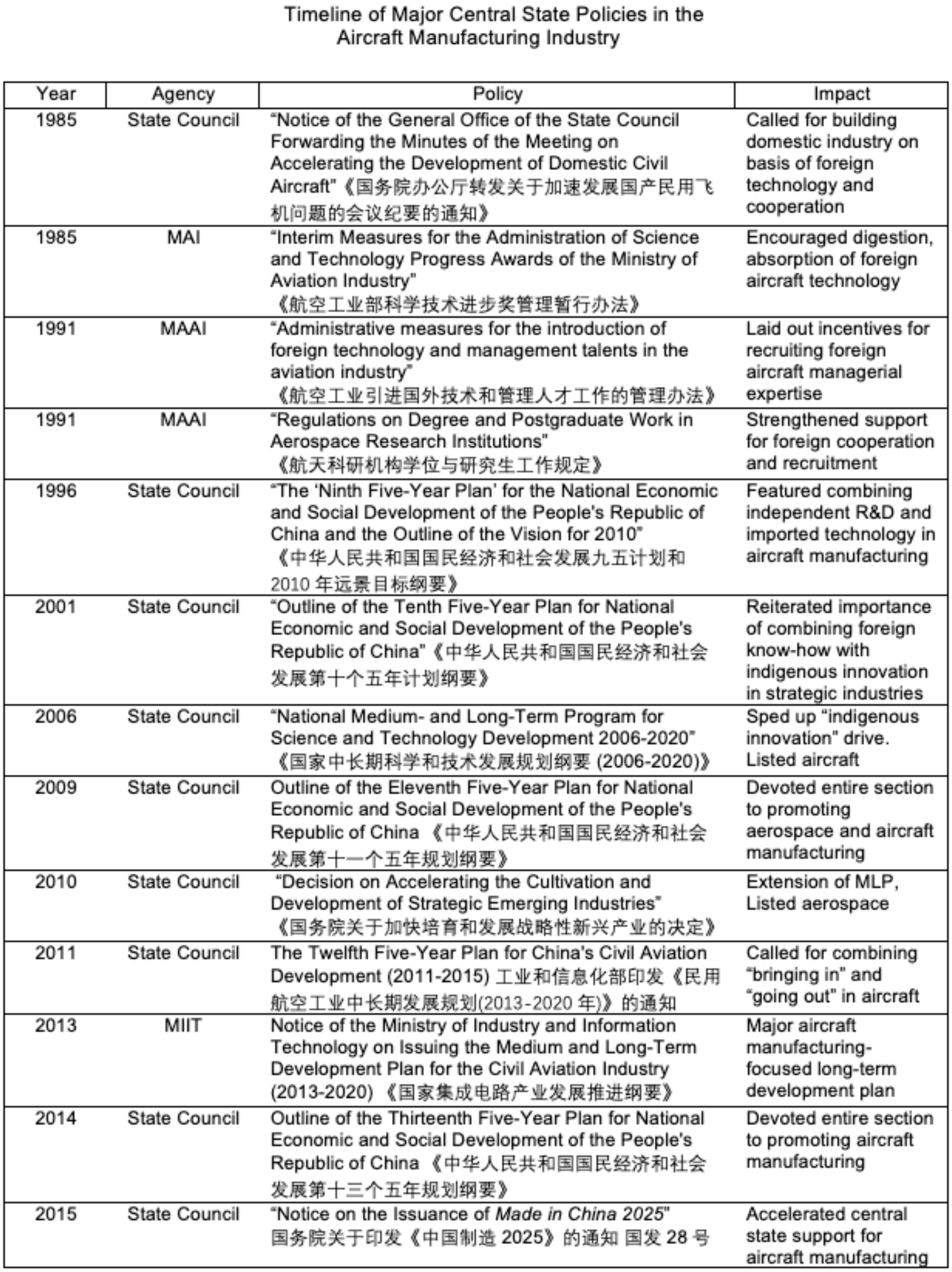
[12] Kahn, Joseph. May 22, 1996. "McDonnell's Hopes in China Never Got Off the Ground," in the *Wall Street Journal*, Retrieved March 21, 2023, *https://www.wsj.com*.

[13] Pauley, Robin. December 18, 1987. "Each Side Blames the Other," Retrieved February 10, 2023 from LexisNexis Academic.



Timeline of Major Central State Policies in the Aircraft Manufacturing Industry

Year	Agency	Policy	Impact
1985	State Council	"Notice of the General Office of the State Council Forwarding the Minutes of the Meeting on Accelerating the Development of Domestic Civil Aircraft"《国务院办公厅转发关于加速发展国产民用飞机问题的会议纪要的通知》	Called for building domestic industry on basis of foreign technology and cooperation
1985	MAI	"Interim Measures for the Administration of Science and Technology Progress Awards of the Ministry of Aviation Industry"《航空工业部科学技术进步奖管理暂行办法》	Encouraged digestion, absorption of foreign aircraft technology
1991	MAAI	"Administrative measures for the introduction of foreign technology and management talents in the aviation industry"《航空工业引进国外技术和管理人才工作的管理办法》	Laid out incentives for recruiting foreign aircraft managerial expertise
1991	MAAI	"Regulations on Degree and Postgraduate Work in Aerospace Research Institutions"《航天科研机构学位与研究生工作规定》	Strengthened support for foreign cooperation and recruitment
1996	State Council	"The 'Ninth Five-Year Plan' for the National Economic and Social Development of the People's Republic of China and the Outline of the Vision for 2010"《中华人民共和国国民经济和社会发展九五计划和 2010 年远景目标纲要》	Featured combining independent R&D and imported technology in aircraft manufacturing
2001	State Council	"Outline of the Tenth Five-Year Plan for National Economic and Social Development of the People's Republic of China"《中华人民共和国国民经济和社会发展第十个五年计划纲要》	Reiterated importance of combining foreign know-how with indigenous innovation in strategic industries
2006	State Council	"National Medium- and Long-Term Program for Science and Technology Development 2006-2020"《国家中长期科学和技术发展规划纲要 (2006-2020)》	Sped up "indigenous innovation" drive. Listed aircraft
2009	State Council	Outline of the Eleventh Five-Year Plan for National Economic and Social Development of the People's Republic of China 《中华人民共和国国民经济和社会发展第十一个五年规划纲要》	Devoted entire section to promoting aerospace and aircraft manufacturing
2010	State Council	"Decision on Accelerating the Cultivation and Development of Strategic Emerging Industries"《国务院关于加快培育和发展战略性新兴产业的决定》	Extension of MLP, Listed aerospace
2011	State Council	The Twelfth Five-Year Plan for China's Civil Aviation Development (2011-2015) 工业和信息化部印发《民用航空工业中长期发展规划(2013-2020 年)》的通知	Called for combining "bringing in" and "going out" in aircraft
2013	MIIT	Notice of the Ministry of Industry and Information Technology on Issuing the Medium and Long-Term Development Plan for the Civil Aviation Industry (2013-2020) 《国家集成电路产业发展推进纲要》	Major aircraft manufacturing-focused long-term development plan
2014	State Council	Outline of the Thirteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China 《中华人民共和国国民经济和社会发展第十三个五年规划纲要》	Devoted entire section to promoting aircraft manufacturing
2015	State Council	"Notice on the Issuance of *Made in China 2025*" 国务院关于印发《中国制造 2025》的通知 国发 28 号	Accelerated central state support for aircraft manufacturing

Figure 7.2: **Timeline of Major Central State Policies in Commercial Aircraft Manufacutring**: In a signal of the aircraft industry's high strategic value, the State Council, China's highest state body, has taken direct control over most major aircraft manufacturing-related industrial policies since the late-1990s.

Douglas deal, in 1985 China began talks with Boeing and Airbus to purchase aircraft in exchange for pledges to manufacture some parts locally with foreign assistance. Although Boeing was already well-established in the Chinese market and had been engaged in small-scale manufacturing partnerships with Chinese firms since at least the early-1980s, after 1985 rising competition from McDonnell Douglas pushed the company to expand its assembly operations and use of Chinese production offsets. Airbus also made its first foray into China at this time, entering “exploratory negotiations” in May 1984 to manufacture parts of the (then-new) A320 airliner in the country.

These deals put the first step of the three-step plan into action: local production and assembly, with foreign assistance, of foreign-designed aircraft and aircraft components. But the SAIC-McDonnell Douglas partnership went beyond this, laying grounds for the envisioned second step of co-producing a regional aircraft with a foreign firm. Up to this point, western aircraft makers had agreed to manufacture and assemble individual parts in China. McDonnell Douglas now agreed to fully co-produce the MD-82 and MD-83, variants of the company’s MD-80 single-aisle jet, with SAIC – a first for a western aircraft manufacturer. Over the next nine years, the SAIC-McDonnell Douglas JV built 35 aircraft, all but five of which were sold to Chinese airlines.

As I discuss in section 5, McDonnell Douglas was also integral to China’s first attempt at step three of the three-step plan: indigenous development of a long-haul large commercial aircraft. In the early 1990s, McDonnell Douglas beat out Boeing to become the main partner in developing a proposed “trunkliner” (干线) aircraft after pledging to co-produce the MD-90, its answer to the 737 and A320, with SAIC. The agreement fell through after Boeing acquired McDonnell Douglas in 1997, but had it come to fruition, it would have involved even deeper cooperation and technology sharing than the MD-80 series ventures. According to the deal, Chinese workers would produce essentially everything but the aircraft’s avionics and engines (Cliff, 2001, 25).

Following the demise of the trunkliner program, Premier Zhu Rongji paused aircraft industrial policy. This decision was in line with similar steps away from top-down industrial policy in other high-technology industries like semiconductors and nuclear power at the time (Chen and Naughton, 2016, 2140). It also likely drew momentum from Zhu’s ongoing efforts to secure U.S.

support for China's WTO entry. Although the Tenth Five Year Plan (2001-2005) highlighted aircraft manufacturing and related technologies as focus areas for "raising indigenous innovation capabilities" (提高自主创新能力), no new sector-specific policies were issued for the remainder of Zhu's term, which ended in early 2003.

Many factors contributed to the demise of the trunkliner program in the 1990s. However, consistent with my argument about the impact of bureaucratic fragmentation on China's enforcement capacity in the pre-WTO period, an in-depth report published by the *Wall Street Journal* provides suggests that competition for policy influence between the Ministry of Aviation Industry and the Civil Aviation Administration of China (CAAC), China's equivalent of the FAA, contributed.[14] According to the report, McDonnell Douglas's China strategy centered on forging close ties to the Ministry and its successor, AVIC. This was a reasonable strategy given the latter's ostensible authority over the sector. But McDonnell Douglas failed to foresee that as commercial aviation demand grew in China and state-owned commercial airlines became both more numerous and more powerful, their bargaining power as customers would increase relative to AVIC. In line with this shift, CAAC, as the airlines' main regulator and de facto representative, saw its influence over procurement decisions rise. The CAAC, which had longstanding ties to and reportedly favored Boeing, used this influence to push back against the McDonnell Douglas trunkliner deal, which it argued would lead to inflated costs for the country's already-struggling airlines. According to the *Wall Street Journal*, CAAC opposition forced the Ministry of Aviation Industry in 1992 to scale back the trunkliner deal from the originally-planned 150 aircraft to just 40. SAIC and McDonnell Douglas built no more than a few units before the program was canceled.

The pause on major new aircraft industrial policy initiatives under Zhu Rongji was short lived. Almost immediately after taking office, Premier Wen Jiabao initiated the policy formulation process for the Medium- and Long-Term Program (MLP), of which building a large passenger aircraft was an early and central pillar. When the MLP launched in February 2006, what would become the C919 was among the 16 "megaprojects" (重大专项) anchoring the program. Two

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[14] Kahn, Joseph. "McDonnell's Hopes in China Never Got Off the Ground."

years later, AVIC I and II were re-merged, COSTIND was renamed and put under the newly-created MIIT, and COMAC was formed with a mandate to build a home-grown LCA by 2020.

As the above discussion makes clear, foreign technology extraction has been a central theme of aircraft industrial policy throughout the Reform and Opening period. After 2003, and especially with the launch of the C919 program in 2008, these efforts increased in scale and became far more systematic. An early sign of this escalation came in December 2005, when the NDRC negotiated a massive purchase of 150 Airbus aircraft for $10 billion on the condition that Airbus set up its first FAL outside of Europe in Tianjin, establish and staff an engineer center with 200 Airbus engineers, agree to source more parts from Chinese suppliers, give Chinese firms at least 5 percent of the work on its new A350 model, and set up a joint venture with an AVIC subsidiary to develop composite materials and other advanced components, among other concessions.[15]

More importantly, when the NDRC formally approved the C919 in 2009 (recall that after 2005, the NDRC gained power of approval for all large-scale infrastructure projects), the project's mandate stipulated that all foreign suppliers form joint ventures with COMAC or one of its or AVIC's subsidiaries (Cliff, Ohlandt and Yang, 2011). As of 2014, at least fourteen foreign aircraft manufacturers had formed joint ventures to supply parts to the C919 (Crane et al., 2014). Another source records that by 2020, no fewer than 48 aviation companies from the United States, 26 from Europe, and 6 from elsewhere in Asia were working with the C919, though it is unclear if all of these partnerships took the form of a JV with COMAC.[16] In addition to the actual number of JVs formed, the 2000s saw a steady increase in the number of distinct FDI ownership restrictions in place in aircraft manufacturing, from one in 1995 to six in 1997, 8 in 2002, and 11 after 2007.

As noted earlier, from 2006 on the defining characteristic of aircraft industrial policymaking was its integration into an increasingly institutionalized, cross-sectoral effort to nurture indigenous innovation across strategic industries. Thus, between 2006-2015 the three key aircraft-related

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[15] Wall, Robert. December 12, 2005. "Airbus to Decide by Summer on Chinese Production Line," Retrieved January 12, 2023 from *Aviation Week Intelligence Network* via MIT Libraries. See also Karp, Aaron. November 27, 2007. "Airbus, China Reach Accord on Massive Aircraft Order, A350 Cooperation," Retrieved January 12, 2023 from *Aviation Week Intelligence Network* via MIT Libraries.

[16] Kennedy, Scott. December 7, 2020. "China's COMAC: An Aerospace Minor Leaguer," *Center for Strategic and International Studies*, Retrieved March 21, 2023, *https://www.csis.org*

industrial policies were the megaprojects component of the MLP, the Strategic Emerging Industries (战略新兴产业, SEI) initiative launched in 2010, and Made in China 2025 (中国制造2025) launched in 2015, all of which name civil aviation as a priority sector but none of which focus solely on aircraft (the same goes for the Eleventh through Fourteenth Five Year Plans). The only major dedicated aircraft industrial policy issued after 2006 is the Medium- and Long-Term Development Plan for the Civil Aviation Industry (民用航空工业中长期发展规划2013-2020年), announced by the MIIT in May 2013. But the preamble to this policy explicitly frames it as an effort to translate the MLP, as a programmatic statement, into concrete industry policies.

In this sense, aircraft industrial policy exemplifies the shift from sector-specific plans issued by myriad industrial ministries (prevalent through the 1990s) to cross-sectoral programs developed by a small number of peak agencies with policy authority over large swaths of the economy. This centralization took a somewhat different form in aircraft because of the decision to create COMAC as a national monopoly provider of commercial aircraft. COMAC itself does not make policy. But as a core central SOE whose chief executives hold vice-ministerial rank and often sit on the Central Committee of the Chinese Communist Party (CCP), its actions reflect and to some extent "create" policy in a way very different from even the largest domestic wind turbine manufacturers, which operate at greater distance from the central state. One implication is that although, consistent with my theory about enforcement capacity, we do see an uptick in the use of JV requirements and other technology extractors in the early post-WTO period, in practice these formal requirements are less significant than the provision that C919 suppliers enter into JVs with COMAC subsidiaries. That provision, of course, came into being in 2009, when the NDRC approved the C919, rather than in 2003-2004 following the creation of the NDRC itself.

The C919 and the Persistence of Tech Extractors

This section explores the development of the C919 narrow-body jetliner in more detail. It makes two main points. First, consistent with my argument about the factors shaping the removal of tech extractors, the slow progress of the C919, and in particular China's ongoing struggles to master key systems like jet engines and avionics, likely best explains why China maintained these policies in aircraft manufacturing longer than it did in most other strategic high-technology industries in which it used them. Simply put, COMAC, AVIC, and their subsidiaries do not yet pose a serious threat to global industry leaders in the highest value-added segments of the commercial aircraft supply chain. As such, throughout the study period foreign firms continued to believe the benefits of JVs and other forms of cooperation with Chinese counterparts outweigh the risks, all else equal. These firms (and their home governments) have therefore not pushed as hard for trade and investment reciprocity in this sector as they have in others, such as wind turbine manufacturing. Absent such pressure, and given the continued utility of Sino-foreign partnerships from COMAC's and AVIC's perspective, China opted to maintain tech extractors in more parts of the commercial aviation industry for longer than in other high-technology industries.

Second, although the C919 program has not been a ringing success, neither has it been the blunder it is sometimes portrayed as. It is true that the C919 is significantly behind schedule. It is also true that COMAC remains heavily reliant on foreign suppliers for many of the most complex and highest value-added parts of the C919. As Richard Aboulafia, a leading industry analyst, put it bluntly, the C919 is a "tube with the national flag on the back. . . a chunk of metal onto which all the real value added is inserted by Western suppliers" (Fallows, 2012, 157). This may be an overstatement, but it has some merit. The reality is that if U.S. and European governments barred their firms from working with COMAC, they could ground the C919 indefinitely.

But if the C919 aircraft remains dependent on Western partners for now and may never compete with offerings from Boeing and Airbus outside the Chinese market, the C919 program has nonetheless contributed significantly to China's aircraft manufacturing capabilities. Viewed in terms of its role as a catalyst for foreign technology extraction and domestic technological upgrading, the C919 project is far from a total failure. More accurately, it has been a costly and inefficient but nonetheless potentially effective crash course in how to create an aircraft industrial ecosystem, a task at which only a handful of countries have ever succeeded. Focusing on the C919's repeated delays (a real problem, but Chinese officials' early projections were always unrealistically rosy) and underwhelming technical specifications misses the tremendous amount of learning it has made possible. For our purposes, the key point is that foreign firms have been integral to this learning process. To be sure, many of these firms trained and shared technology with Chinese partners long before the C919 and would have continued doing so regardless. At the same time, by providing a focal point for foreign investors – essentially telling them, "if you want to succeed in the Chinese market, help us with this project" – the C919 almost certainly led to more extensive cooperation than would have been the case otherwise.

Origins, Deals, and Development

COMAC was created in 2008, but its policy and institutional roots run deeper. From the Y-10 to the trunkliner program, fielding a domestically-developed large commercial aircraft has been a consistent priority of China's top leaders since the early-1970s. The C919 is only the latest iteration of this ambition. Nor was COMAC formed *sui generis* institutionally. All of its major subsidiaries preceded it, and through these subsidiaries it inherited ongoing projects.

The most important of these is the ARJ21, a 90-seat regional jet which began development in 2002 and is modeled on the MD-80 series and MD-90 designs previously licensed to AVIC. Like the C919, the ARJ21 faced repeated delays and only entered into service in 2016.[17] However, although both projects have faced similar challenges and delays, they differ in important respects. To begin, as one of sixteen megaprojects authorized by the State Council and CCP Central Committee, the C919 is a vastly higher priority initiative than the ARJ21. It is unclear how much AVIC I and COMAC have invested in the ARJ21, but it is certainly a small fraction of the estimated $50-72 billion the C919 has received in state support, which in turn is between two and three times what Airbus received in subsidies for the A320.[18]

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[17] Richard Aboulafia described the plane, in characteristically vivid style, as an "overweight and stunningly obsolete product that has no relevance outside of China's tiny regional airline sector," in Aboulafia, Richard. 2020. "COMAC C919," *Teal Group*.

[18] Alim, Arjun Neil. July 20, 2022. "China's Comac reliant on 'captive domestic market' for sales," in *Financial Times*, Retrieved March 21, 2023 (*https://www.ft.com*)

More importantly for our purposes, although both projects rely heavily on foreign suppliers, they do so under different conditions. As Cliff, Ohlandt and Yang (2011) observe, AVIC I companies formed some foreign JVs to supply parts for the ARJ21. But for the most part, China "sourced directly from Western suppliers" through arms-length trade relationships – that is, purchasing and assembling finished equipment absent any commitment to share technology or co-produce with local companies. This meant that the ARJ21 provided Chinese aerospace firms comparatively few opportunities to learn from foreign firms. The ARJ21 was "meant to be a standard-bearer for Chinese aerospace development, but because so little of the high-value work has been done in China or by Chinese firms, so far it has essentially been an elaborate container for expensive components made by European, North American, and Japanese companies" (Fallows, 2012, 157).

With the C919, China's leaders were determined not to make the same mistake. From the start, COMAC executives "made it explicitly clear that foreign bidders on the C919 program are expected to form joint ventures with Chinese partners, especially in high-technology areas such as advanced materials and flight control systems," a move Cliff, Ohlandt and Yang (2011) called a potential "turning point" for Chinese technology transfer efforts in the sector (Cliff, Ohlandt and Yang, 2011, 43). In the next section, I discuss how in practice the extent of real cooperation entailed by these JVs varied. But at the level of deal formation, the decision to condition participation on partnerships with Chinese companies was a resounding success. As I noted earlier, within a few years of the C919 program's start, no fewer than 14 foreign aerospace firms had formed JVs with COMAC, AVIC or their subsidiaries. This included agreements which went much further in terms of co-production of critical systems than anything signed for the ARJ21.

Perhaps the two most important such deals concerned jet engines and avionics. On December 21, 2009, CFM International, a JV between GE Aviation and France's Safran, signed a Memorandum of Understanding (MOU) to "establish a world-class final assembly line and engine test facility" in China for the LEAP-1C engine selected to power the C919.[19] Aounrd the same time, GE Aviation entered talks with AVIC to form a 50-50 avionics JV; the deal to create the new company,

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[19] GE. December 21, 2009. "CFM and ACAE Sign MOU for LEAP-X1C Assembly Line In China," Press Release. Retrieved March 21, 2023, *https://www.ge.com*.

later named Aviage Systems, was formally announced January 21, 2011.[20]

To be sure, opening an FAL and testing facility in China by no means equated to a wholesale transfer of the most sensitive jet engine technologies.[21] Nonetheless, the FAL would give AVIC Commercial Aircraft Engine Company (ACAE), China's main commercial jet engine maker, unprecedented insight into the systems integration practices of the world's leading engine provider for single-aisle commercial aircraft.[22] Meanwhile, the test facility would give AVIC engineers much deeper insight into the performance of key engine modules such as fans, combustors, and compressors. Just as important, high-end engine test facilities are technological and engineering marvels in themselves; ability to operate a commercial engine test facility would almost certainly have spillovers for military jet engine development.[23]

For reasons I discuss below, China's ambitions for transfer of LEAP-1C engine technologies appear to have gone largely unfulfilled. The same cannot be said for its avionics JV, for which GE gave AVIC access to virtually the full suite of its avionics capabilities and agreed to collaboratively develop a new Integrated Modular Avionics (IMA) platform[24] along with specific systems like navigation, communication, cockpit displays, and flight recorders.[25] As one industry insider told me, "That is actually new technology and everyone is f***ing pissed at GE for doing it."[26]

Between 2009-2010, COMAC secured similar agreements with virtually every major Western aerospace company, including many that had previously avoided setting up joint ventures in China partly out of concerns over IP protection (Cliff, Ohlandt and Yang, 2011, 44). In 2009, Rockwell

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[20] GE Aerospace. January 21, 2011. " GE and AVIC Sign Agreement for Integrated Avionics Joint Venture," Press Release. Retrieved March 21, 2023, *https://www.geaerospace.com*.

[21] There is a vast gulf between assembling and testing final products and mastering the materials science, precision manufacturing, and other techniques required to design and produce key jet engine components themselves.

[22] The LEAP-1C belongs to the same family of engines that powers the 737-MAX and A320-neo. The LEAP series engines are CFM International's most advanced for narrow-body large commercial jetliners.

[23] ACAE appears to be a division of Aero-Engine Corporation of China (AECC), which in turn is jointly controlled by AVIC and COMAC. AECC (along with AVIC as a whole) was among a list of 31 Chinese companies the Trump administration barred U.S. firms from investing in on November 12, 2020.

[24] IMA platforms replace traditional federated avionics architectures. In the latter set up, systems (navigation, communication, etc.) operate separately and have their own processors. IMA platforms integrate data from sensors across systems on a single central processing unit. This is supposed to reduce weight, improve efficiency, and lower maintenance and updating expenses.

[25] George, Fred. June 18, 2015. "Aviage Working to Earn Trust," *Aviation Week Intelligence Network*, Retrieved February 10, 2023.

[26] Interview, Zoom, February 2023.

Collins signed deals with China Electronics Technology Avionics to develop communications and navigation equipment and with China Leihua Electronics Technology Research Institute to produce an integrated surveillance system for the C919.[27] That same year, Eaton completed a JV with the Shanghai Aircraft Manufacturing Company (SAMC) to build fuel and hydraulic conveyance systems for the aircraft. Eaton also signed a "strategic cooperation agreement" with Shanghai Aviation Electric Company (SAE) and COMAC to design and manufacturing cockpit assemblies and a dimming control system.[28] Honeywell likewise agreed to collaborate with Hunan Boyun New Materials and Changsha Xinhang Wheel and Brake to develop the C919's break control system and wheels and brakes; these deals came on top of earlier agreements to co-develop the aircraft's auxiliary power unit and starter and generator. These are just a few of the JVs formed to supply the C919, but they illustrate the breadth of Sino-foreign cooperation on the aircraft.

Despite, and to some extent because of, COMAC's ability to lock in JVs involving often meaningful collaboration with industry leaders in every major aircraft subsystem, the C919 program quickly fell behind schedule. The plane was originally slated for a first test flight in 2014, with deliveries beginning in 2016. In 2014, first flight was delayed to 2015, with certification and deliveries beginning in 2018. After two more delays in 2015 and 2016, the C919 had its first test flight in May 2017. After a "highly unusual" five-month hiatus, its second flight took place in late-September 2017.[29] It took another five years for the CAAC to certify the plane, with deliveries finally beginning in December 2022.

Several factors appear to have contributed to the C919's halting progress, all rooted in the basic difficulty of integrating design and production activities and managing far-flung suppliers. Thus, for example, although a preliminary design review for the C919 was declared complete in December 2011, "the design was not in fact stable," "important issues had to be sorted out," and "some aspects of the approved design" were later changed.[30] These adjustments in turn caused

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[27] Mecham, Michael. July 19, 2010. "More U.S. Suppliers on C919 Team," *Aviation Week Intelligence Network*, Retrieved March 21, 2023.

[28] Ibid.

[29] Aboulafia, Richard. "COMAC's C919."

[30] Perrett, Bradley. August 13, 2013. "Inexperience, Engineering Shortages Combining in C919 Program's Stumble," *Aviation Week Intelligence Network*, Retrieved March 21, 2023.

difficulties for suppliers, who had to tweak specifications for their products, leading to additional problems and delays when it came to integrating components. Foreign suppliers accustomed to managing their own operations also routinely "underestimated the time they would need to form joint ventures" with AVIC and COMAC.[31] Production could not begin until the JVs were up and running, but in China's heavily bureaucratized system there was often a lag of several years between signing a memorandum of understanding and standing up a new venture. Indeed, given the number of new companies being formed and the risk for setbacks across domains to compound, it is a small wonder delays were not worse.

Another issue was the CAAC's inexperience. Previous aircraft manufactured or assembled in China contained almost exclusively foreign-produced parts and systems, which allowed the CAAC to outsource certification to the FAA or, in the ARJ21's case, the European Aviation Safety Agency (EASA). Because the C919 would contain far more Chinese or co-produced content, it would require more elaborate inspections to ensure systems and components met design specifications and integrated properly.[32] From China's perspective, this presented a unique opportunity to strengthen the CAAC as a regulatory body, and by all accounts the CAAC has indeed become a much larger and more sophisticated agency through working on the C919. At the same time, this institution-building necessarily slowed the C919's progress.

Taken together, these and other factors ensure that AVIC, COMAC and their subsidiaries do not yet pose a serious challenge to global industry leaders in any major industry segment. Publicly at least, Boeing executives have shrugged off the C919 as a competitive threat.[33] In 2021, Airbus chief Guillaume Faury said the company is "taking [COMAC] seriously and watching carefully what's happening there," but added that it was "too early to say" whether the C919 "will be able to compete with Boeing and Airbus."[34] Industry analysts have been less sanguine, calling the aircraft

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[31] Ibid.

[32] Perrett, Bradley. "Inexperience, Engineering Shortages Combining in C919 Program's Stumble."

[33] McIntosh, Andrew. November 20, 2020. "Boeing CEO shrugs off threat from China's $8.8B C919 jet – then it flew at a Jiangxi air show," *Puget Sound Business Journal*, Retrieved March 21, 2023, *https://www.bizjournals.com*.

[34] Boon, Tom. February 19, 2021. "Airbus CEO Taking Competition From COMAC's C919 Seriously," *Simple Flying*, Retrieved March 21, 2023, *https://simpleflying.com*.

"yesterday's technology today"[35] and "goofy as hell,"[36] and warning that "the best that can be hoped for...is that the 919 isn't as big a disaster as the ARJ21. The best-case scenario: mediocrity."[37] As another industry executive put it in 2005, "the idea of China competing with Boeing and Airbus is one that I'm old enough not to lose a lot of sleep over."[38]

China's weak position in the industry is similarly reflected in its trade data. Over the past two decades, aircraft have consistently ranked as one of China's top ten net imports; in 2018, they were its seventh largest net import, and by far the biggest among final goods. Chinese state-owned aerospace companies have invested over $1.1 billion overseas in recent years, but almost all of this has been in acquisitions aimed at acquiring foreign technology, not greenfield investment to exploit new markets. By contrast, foreign aviation investment in China is almost entirely greenfield, aimed at penetrating the Chinese market.[39]

Against this backdrop, although foreign aircraft manufacturing firms are "all fully aware that Chinese joint-venture partners...[are] interested in absorbing technologies and know-how," they see little need to adjust their longstanding approach to dealing with such pressures (Crane et al. 2014, 43). This typically amounts to a combination of "continuously improving their [own] products and processes" and engaging in the "passive aggressiveness you associate with transfer of obsolete technology."[40] What it does not yield are public calls by foreign aircraft makers and their home governments for the removal of ownership restrictions and other tech extractors. Instead, firms like Boeing and GE publicly opposed the U.S.-China trade war and export controls on things like commercial jet engines to China. This is because for these firms, China's market remains a supreme prize. As one GE executive said in 2010, "China is the world's fastest-growing aviation market and we need to ensure GE and the U.S. are part of this growth."[41]

The result is that unlike in industries like renewable energy technology, China faced little in

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[35] Bogaisky, Jeremy. September 20, 2022. "China Preps To Launch Its First Big Passenger Jet. It's No Threat To Boeing Or Airbus – Yet," *Forbes*, Retrieved March 21, 2023, *https://www.forbes.com*.

[36] Interview, Zoom, February 2023.

[37] Aboulafia, Richard. "COMAC's C919."

[38] Wall, Robert. "Airbus to Decide by Summer on Chinese Production Line."

[39] Rhodium Group, "US-China Investment Hub," Retrieved March 21, 2023, *https://www.us-china-investment.org*.

[40] Interview, Zoom, February 2023.

[41] Mecham, Michael. "More U.S. Suppliers on C919 Team."

the way of external pressure to remove tech extractors in aircraft manufacturing before the escalation of U.S.-China trade tensions in 2018. But although China's aviation sector is not ready to compete on the domestic let alone global stage, it is still, as Airbus chief executive Faury observed, "too early to say" what kind of competitive challenge China will pose not three or five, but ten or fifteen years down the road. As the former Boeing employee who later worked for COMAC told me, "analysts say the C919 is a failure and it won't come out on time. So what? It will come eventually, and China is learning very quickly. They are already catching up with a 100 year-old and a 50 year-old company," referring to Boeing and Airbus. "But once they have the basic system, then to replace bits and parts and to optimize that will be much faster."[42] Of course, China's leaders would have liked the industry to be further along than it is by now. And to be sure, many of the JVs supplying the C919 have not and may not meet the CCP leadership's expectations, at least in the foreseeable future. But the delta between where Chinese capabilities are now and where they were in 2005 is almost certainly larger than it would have been in a counterfactual world where it never launched the C919 or did not require foreign suppliers to the aircraft to partner with local companies. As the Boeing-turned-COMAC engineer said to me, "the Chinese take a very long view."

Market Structure and Bargaining Over Technology Transfer

This section looks at three episodes that illustrate how global market structure shapes foreign technology extraction efforts in China. These episodes suggest that even in industries such as aircraft manufacturing, where China theoretically enjoys huge leverage and uses formal tech extractors aggressively, its ability to secure meaningful technology transfers can vary widely depending on competitive dynamics among foreign firms in a given segment. Specifically, the episodes provide evidence that technology extraction is most successful when it targets not global industry leaders, but relative laggards or newcomers eager to capture market share and willing to trade better technology in exchange for greater market access.

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[42] Interview, Zoom, January 2023.

Below, I look at each episode sequentially, beginning with McDonnell Douglas's doomed bid to salvage its position in the aircraft industry by tying its fate to China. In an attempt to supplant Boeing as China's main foreign partner and capitalize on the boom in Chinese commercial aviation that began in the 1990s, McDonnell Douglas agreed to an enormous commercial technology transfer program. I then turn to Airbus's far more successful efforts to grow its share of the Chinese market starting in the late-1990s and accelerating in the post-WTO period. Although Airbus did not go as far as McDonnell Douglas, it likewise used commitments to share production know-how – commitments that outstripped anything rival Boeing had done – to bolster its position in China. Finally, I examine the divergent trajectories taken by two GE-controlled ventures to supply the C919, one for jet engines and one for avionics, which illustrate how different market dynamics can lead the same company to approach technology transfers differently in two industry segments.

McDonnell Douglas's 'Hail Mary' in China

On April 12, 1985, after six years of negotiations, St. Louis-based aircraft manufacturer McDonnell Douglas sealed a deal to sell 26 MD-82 narrow-body passenger jetliners to China. According to the deal, all but one of the aircraft would be assembled in Shanghai in partnership with the Shanghai Aircraft Manufacturing Company (SAMC), a subsidiary of the Shanghai Aviation Industry Corporation (SAIC). Assembly of the aircraft was set to begin in January 1986, with the plane due to enter service a year later.

The deal, valued at between $600 million and $1 billion, seemed like a godsend for the company, which had fallen badly behind Boeing and was quickly losing ground to Airbus. With little chance of unseating Boeing or beating out Airbus in the established markets of North America and Europe, McDonnell Douglas's best – perhaps only – shot at growing its global footprint and gaining the economies of scale needed to turn a profit lay in China, which was already the world's fastest growing passenger aircraft market and was expected to become one of the largest in the 1990s and 2000s. As one executive from Douglas, the firm's commercial arm, remarked, "China was our savior,"[43] the market that would turn the company's fortunes around and put it back on track to reclaim its once-dominant global share. Against this backdrop, Douglas's then-president James Worsham "told executives to carve out a place [in China's market] – 'whatever it takes'."

At the time, there was no precedent in aviation for a deal of this sort, which traded privileged access to the Chinese market for a huge and sustained commitment to share technology with Chinese companies. Although Boeing had subcontracted some minor assembly work to local partners in the past, it had never attempted anything on the scale of Douglas's proposed venture, in China or in any other country. After years of negotiations and "considerable hand-wringing," Douglas agreed to let Chinese workers assemble the aircraft, but only if China held up its half of the "quid pro quo," guaranteeing the firm a "commanding market share in narrow-body aircraft" in China. As one Douglas executive told the *Wall Street Journal*, "that condition came up in every meeting we had...The Chinese agreed."

Once the deal was signed, Douglas set to revamping SAMC's facilities right away. The task proved gargantuan. When Douglas officials arrived in Shanghai, they found SAMC's factories "woefully ill-equipped" and largely derelict, with grass growing "waist-high" on the tarmac. In order to accommodate assembly equipment, "factory floors covering 10 football fields had to be leveled and resurfaced," the first step towards turning SAMC's main facility, Dachang, into a "mirror image" of the company's Long Beach final assembly plant, "down to the numbers assigned to hammers and screws." Meanwhile, SAMC's workers lacked virtually any experience in building actual aircraft. Thus, in addition to "fully renovating" SAMC's factories, Douglas "provided enough technical data to fill a library" and "55,000 man-hours of technical training" (Cliff, 2001, 25), with "Chinese engineers and aviation experts by the score [receiving] training in California."

In effect, Douglas "had agreed to one of the largest technology transfers in history, essentially to pass China 80 years of accumulated aircraft-manufacturing expertise." It would all be worth it, executives reasoned, if it paved the company's way to market dominance in China. As Douglas's

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[43] Unless otherwise specified, quotes and other details in this section come from Kahn, Joseph. May 22, 1996. "McDonnell's Hopes in China Never Got Off the Ground," in *The Wall Street Journal*, Retrieved March 21, 2023, *https://www.wsj.com.*

president for China stated in 1995, "We're in the business of making money for our shareholders...If we have to put jobs and technology in other countries, then we go ahead and do it."[44] For "the weakest of the three major manufacturers" of civil aircraft, there was no real alternative (Crane et al., 2014, 29). Given Boeing's stronger reputation and commanding lead in the Chinese market – Boeing controlled upwards of 80 percent of the Chinese market well into the 1980s; as late as 1995, even as competition from McDonnell Douglas and Airbus heated up, it retained a 57 percent market share[45] – it is "doubtful that McDonnell Douglas would have successfully sold aircraft to China without the joint venture it set up to assemble the MD-80" (Crane et al., 2014, 39).

According to the *Wall Street Journal*, the assembly deal "never made economic sense," because "teaching China to build aircraft required a long, expensive learning curve." By 1987, quality control problems and production delays spurred tensions between the two sides. SAIC accused Douglas of slow pedaling the shift of production activities from Long Beach to Shanghai. According to SAIC, under the original contract China was to provide final assembly for the first three units, after which manufacture of various non-avionics technical pieces – including landing gear doors, nose fuselages, horizontal stabilizers, and cabin floors – would move to China. As of December 1987, this had not happened. Douglas tried to assuage Beijing by promising that local manufacture of these parts would begin from the seventh unit, but acknowledged that problems with coordinating between Long Beach and Shanghai had caused delays.

McDonnell Douglas lost money on the MD-82 assembly deal, but company leaders rationalized these losses as a down payment on a long-term relationship that, they hoped, would bring future dividends. As one Douglas senior executive put it, "the Chinese people like to deal with old friends. . . So we concluded that the way we could get an entry into the China market was by offering to work with the factories to co-produce airplanes." When Chinese officials announced plans to select a foreign technology partner for the "trunkliner" large passenger aircraft project in 1989, Douglas's leaders saw an opportunity to finally reap that long-anticipated windfall. Over the

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[44] Tyler, Patrick E. February 25, 1995. "Western Lift for China's Air Plans," *The New York Times*, Retrieved March 21, 2023, *https://www.nytimes.com*

[45] Ibid.

next two years, McDonnell Douglas and Boeing fought fiercely for the trunkliner contract, with each offering varying levels and kinds of technological cooperation and production offsets. As the *Financial Times* predicted, “competition between McDonnell Douglas and Boeing for new contracts” during this period was “intense,” leaving China well-positioned “to squeeze the maximum technological involvement out of both.”[46]

McDonnell Douglas won the competition. On June 29, 1992, it announced a contract to supply 40 MD-90s, Douglas’s answer to the 737 and A320, to China for an estimated $1.2 billion. As part of the agreement, Chinese manufacturers, with Douglas’s help, would manufacture 70 percent of the aircraft’s components – everything but the engine and avionics (Cliff, 2001, 25). This work, in turn, would lay the foundation for “step three” of China’s three-step plan: domestic development of an indigenously-designed trunkline aircraft. According to the announcement, China said it would consider purchasing as many as 130 additional MD-90 jetliners later in the decade if all went well with the first 40. Had China made good on that pledge, Douglas’s share of the Chinese market would have approached, if not quite eclipsed, Boeing’s by 2000.

As it happened, only one MD-90 would be built in China. That aircraft, and the knowledge and skills accrued during its development, would indeed form the basis for a future Chinese plane – not the C919 trunkliner, but the ARJ21 regional jet. By the time work on the ARJ21 began, however, McDonnell Douglas would be history; Boeing acquired the company in 1997.

In reality, Douglas’s trunkliner dreams were a non-starter. The company marketed the deal to supply 40 MD-90s as a victory, but in fact this represented a dramatic downsizing of the original plan, which was to supply 150 aircraft for anywhere from $5 to $10 billion. That larger deal might have been enough to save Douglas, but as one former employee told the *Wall Street Journal*, “at that [lower production] level” of 40 units, “the trunk is dead,” because it lacked the needed economies of scale. “In the end,” said another former Douglas China executive, “we were betrayed.”

Bureaucratic competition cost McDonnell Douglas the deal it wanted and gave the company the deal it got. As the *Wall Street Journal* put it, Douglas had “backed the wrong horse,” aligning

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[46] Pauley, Robin. *Financial Times*.

itself with the Ministry of Aviation Industry and (after 1993) AVIC rather than the increasingly influential CAAC. The Ministry had final say over to whom to grant the contract and was thus able to override the CAAC's objections to Douglas and lobbying on behalf of Boeing. At the same time, as the airlines' regulator, the CAAC was in effect the sole buyer. As demand for passenger air travel boomed (far outstripping growth on the military side), the CAAC could leverage its growing purchasing power to whittle down the McDonnell Douglas deal. This, the CAAC argued, would free precious foreign exchange reserves to purchase what it considered superior Boeing and Airbus aircraft. With China's central state in dire financial straits[47] and against a backdrop of ongoing efforts to separate ministerial and enterprise functions and bend the latter towards market forces, the CAAC's arguments proved compelling.

What lessons can we learn from the McDonnell Douglas saga? Two stand out. First, Douglas's weak market position made it far more willing to transfer technology and know-how to Chinese partners in exchange for market access than Boeing, the market leader. Chinese officials appear to have actively exploited this weakness "to squeeze the maximum technological involvement" from it.[48] Second, although media stories describing the deals as passing "80 years of accumulated aircraft-manufacturing expertise" to China were overblown, the agreements nonetheless led to real and meaningful technology transfers. No, these transfers did not allow China to conjure an aircraft manufacturing industry out of thin air in a decade or two. But given its extraordinarily low starting point and the extraordinary difficulty of mastering even basic aircraft assembly operations, China evidently benefited enormously from the technology, machine tools, data, training and more that Douglas provided. At any rate, it seems unlikely China would have made more progress than it did in a counterfactual world without a weak and desperate market player like McDonnell Douglas. It is almost certainly the case that absent cooperation with McDonnell Douglas in the 1990s, China could not have fielded an aircraft like the ARJ21, whatever its shortcomings, in the early 2000s.

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[47] The central state's critical fiscal condition in the late-1980s and early-1990s would spur an overhaul and dramatic recentralization of China's fiscal system in 1994.

[48] Pauley, Robin. "Each Side Blames the Other."

Airbus Takes on Boeing

On May 11, 1984, Airbus Industrie, a European aerospace consortium formed in 1970 to compete with U.S. aviation giants Boeing, McDonnell Douglas, and Lockheed, announced it had begun "exploratory discussions" with Chinese officials to produce components for the A320, a 150-seat narrow-body aircraft due for release in 1988, in China.[49] Airbus denied these talks were part of a larger deal involving Chinese purchases in exchange for giving Chinese firms "a share in the workload." Nonetheless, media coverage of the talks pointed out that an "agreement on partial construction," perhaps involving jointly making aircraft doors, "would certainly increase Airbus's chances of winning further orders from China."[50] This speculation was confirmed as, over the course of 1984-1985, Airbus finalized a $150 million deal to sell three A310 wide-body jetliners and a delegation West German officials to China in September 1985 pledged "technical support and training programmes to help China build up its aircraft expertise."[51]

If McDonnell Douglas's failed campaign to snatch the Chinese market from Boeing was the axis around which China's aviation industry turned in the 1980s and early-1990s, Airbus's much more successful bid to match and overtake Boeing has defined the sector's progress since the mid-1990s. Although Airbus made its first tentative foray in the Chinese market in 1984-1985, it was not until the years after the 1989 Tiananmen Crisis – and, perhaps, as the writing on the wall for McDonnell Douglas became clearer – that the European conglomerate put efforts to unseat its American rival into high gear. High stakes as competition with Boeing for the China market is, however, it was never as existential for Airbus as for McDonnell Douglas. Moreover, Airbus enjoyed tailwinds Douglas did not: the vicissitudes of U.S.-China relations, freedom from many U.S. export controls, and Chinese officials' desire not to become too dependent on American

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[49] Marsh, David. May 11, 1984. "China may build parts for new European Airbus," *Financial Times*, Retrieved February 10, 2023, LexisNexis Academic.

[50] Ibid.

[51] Marsh, David. September 25, 1985. "W. Germans to Seek More Airbus Orders in Visit to Peking," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic. See also Donne, Michael. December 19, 1984. "China 'To Buy Three Airbus A-310 Jets'," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic; and Donne, Michael. April 17, 1985. "Airbus Wins Foothold in China with $150 million Order," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic.

suppliers. These factors gave Airbus more leverage vis-à-vis China than Douglas ever had, and allowed it exert correspondingly tighter control over its technology. Even so, like Douglas before it and like counterparts in other strategic high-technology industries, Airbus's path to success in China was paved by promises to transfer technology, share production, train the local workforce, and more.

Airbus's first major breakthrough in the Chinese market came in October 1991, when it said it had reached "preliminary agreements" to sell five A330 and six A340 wide-body aircraft in a deal valued at an estimated $1 billion.[52] The next year, China Eastern Airlines finalized a deal to buy five A340s for $555 million, and in November 1993, China Aviation Supplies Corporation agreed to buy another six A340s for $700 million. It was also announced that Shenyang Aircraft Corporation and Xian Aircraft Company would supply doors, wing ribs, and other parts for the A340s.[53] A year later, Airbus followed up with a $25 million investment to open a flight crew training center in Beijing, which the company's managing director called "only the first step" in the company's efforts to "help China acquire advanced engineering and aircraft servicing skills" and, in doing so, "strengthen its presence in the fast-growing Chinese market."[54]

Despite these successes, Airbus lagged far behind its American counterparts. In the early 1990s, McDonnell Douglas's aggressive efforts to secure the trunkliner agreement put "greater pressure on Boeing and Airbus to further 'sweeten' deals negotiated with China." Boeing responded by signing a $600 million agreement to co-produce the aft section for 737 wings in China, opening a new service center in Beijing, and donating a 737 flight simulator to China. But by 1995, McDonnell Douglas's China ventures began to sink under the weight of years of accumulated problems. In Douglas's wake, a "fierce battle" between Boeing and Airbus broke out for dominance of the Chinese

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[52] Betts, Paul. October 31, 1991. "China in Talks to Buy 11 Wide-Body Airbuses," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic.

[53] Betts, Paul. October 14, 1992. "Chinese Carrier Orders Five A340s," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic. See also Betts, Paul. November 17, 1993. "China Signs Dollars 700m Order for Six A340s," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic; and Skapinker, Michael and Tony Walker. September 21, 1995. "The Scramble for China's Skies," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic.

[54] Walker, Tony. November 7, 1994. "Airbus Moves to Strengthen Links with Chinese Market," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic.

market. As the *Financial Times* reported in September of that year, Boeing and Airbus were hard at work "persuading the Chinese that they can help improve the country's high technology industrial base and its aviation employees' skills."[55] In its most ambitious move yet to counter Boeing's lead – in 1995, Boeing had nearly ten times as many plans in service in China – Airbus offered to supply the design and key technologies for a 100-seat aircraft to be jointly produce with a consortium of Chinese and Korean aerospace firms.

That project never materialized, but it did not need to. In the summer of 1995, what became the Third Taiwan Strait Crisis erupted after Taiwanese President Lee Teng-hui accepted an invitation to speak at Cornell University, his alma mater. The ensuing crisis brought U.S.-China relations to their lowest point since 1989 and disposed China's leaders to look for other ways to show their displeasure with Washington. As the backbone of U.S.-China economic cooperation in the post-Reform and Opening era, the aerospace industry, and in particular Boeing, was a perfect target. The result was a $1.5 billion deal to buy 30 Airbus A320s, agreed to during a visit by Chinese Premier Li Peng to France in April 1996.[56]

Airbus's "period of dominance" in China was short-lived. In October 1997, a newly re-elected President Clinton invited Chinese General Secretary Jiang Zemin to the United States in an effort to repair the relationship. China reciprocated this gesture by announcing plans to purchase 50 Boeing aircraft for $3 billion, its single largest aircraft purchase yet.[57] But in a clear signal of their intent to balance the two aerospace giants against each other, the next year China agreed to purchase another 28 Airbus planes for $1.8 billion. In response, in November 2000 Airbus and AVIC I signed an MOU to jointly manufacture wings for Airbus's single-aisle aircraft. This was by far Airbus's most significant commitment to share technology and know-how with China yet, and arguably the most important such transfer by any foreign aerospace company save McDonnell Douglas. In announcing the agreement, Airbus's president pledged "to partner with China through the delivery

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[55] Skapinker, Michael and Tony Walker. "The Scramble for China's Skies."

[56] Faison, Seth. May 16, 1997. "China to Buy 30 Planes for $1.5 Billion from Airbus Industrie," *The New York Times*, Retrieved March 21, 2023, *https://www.nytimes.com*.

[57] Skapinker, Michael. October 31, 1997. "China Signs $3bn Order for 50 Boeings: Seattle Team Jubilant After Period of Dominance by Airbus," *Financial Times*, Retrieved March 21, 2023, LexisNexis Academic.

of advanced aircraft, comprehensive support to the airlines and mutually beneficial industrial and technological cooperation with Chinese aircraft manufacturers." Of the joint manufacturing program, AVIC deputy manager Shi Chuan said it "has enhanced our technological edge, boosted our manufacturing capabilities and drawn us closer to the international aviation market."[58]

Over the next four years, technology cooperation between Airbus and China deepened. In August 2001, the company's acting president reiterated that Airbus's "goal is not only to sell plans to China, but also to strengthen industrial cooperation," predicted that Shenyang Aircraft Corporation would "grasp the related technology [for manufacturing wings] in five to seven years," and lauded the company's other partnerships with firms in Xian, Chengdu, and Guizhou. Meanwhile, the CAAC thanked Airbus for providing China "with not only funds and opportunities, but also advanced skills in plane manufacturing."[59] In June 2002, the two sides achieved a "new milestone" in cooperation when A320 wing parts manufactured in Shenyang and Xian, "with the active involvement of Airbus experts," were successfully installed on assembled wings in Britain. Following the news, Airbus's China president said the company wished to "build up [a] long-term strategic partnership with China and gradually transfer wing manufacturing and assembly capability to China."[60] In April 2003, Airbus announced a new partnership with Chengdu Aircraft Corporation to jointly produce nose landing gear for single-aisle aircraft and airframes for both medium- and long-range jets.[61] A year later, the company reaffirmed its commitment to "transfer technology to China and conduct technological cooperation with China."[62] Finally, in December 2004, Airbus announced it would give China a 5 percent workshare on the long-range, wide-body A350 aircraft then in development.[63] This move would provide Chinese firms an unprecedented window into the entire

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[58] Xinhua General News Service. November 7, 2000. "Airbus and AVIC I Herald New Stage in Cooperation," Retrieved March 21, 2023, LexisNexis Academic.

[59] Xinhua General News Service. August 27, 2001. "Airbus Vows to Strengthen Co-Op with China," Retrieved March 21, 2023, LexisNexis Academic.

[60] Xinhua General News Service. June 25, 2002. "Sino-European Aviation Cooperation Achieves Milestone," Retrieved March 21, 2023, LexisNexis Academic.

[61] Xinhua General News Service. April 4, 2003. "Airbus Subcontracts Three Projects to Chinese Manufacturers," Retrieved March 21, 2023, LexisNexis Academic.

[62] Xinhua General News Service. June 27, 2004. "Airbus Expects to Build Partnership with China," Retrieved March 21, 2023, LexisNexis Academic.

[63] South China Morning Post. December 8, 2004. "China Firms Offered Key Role in New Airbus Jet," Retrieved March 21, 2023, LexisNexis Academic.

engineering life-cycle of a new large commercial aircraft.

The steady accrual of cooperative agreements culminated in a December 2005 MOU signed by Airbus and the NDRC – which in 2004-2005 secured power of approval over all inward FDI projects in China – laying the basis for what would become by far China's largest aircraft order to-date.[64] The final deal, details of which became clear in November 2007, involved sales of 150 aircraft, including 110 A320s and 40 A330s, for an estimated $15 billion. In exchange, Airbus promised to open its first final assembly line outside of Europe, in Tianjin, to assemble A320 aircraft, open a new engineering center in China staffed with 200 Airbus engineers, carry out "high-level industrial cooperation" on "development and manufacturing" of the A350, and form a new joint venture to produce "composite material parts and components" for the A350.[65] The sale cemented Airbus's position as Boeing's equal in the Chinese market; by 2011, the European consortium had overtaken its American rival as the top commercial aircraft supplier to China, a lead which it has maintained (and extended) since.[66]

Boeing was by no means asleep at the wheel during this period. But with a few exceptions – notably, a JV in Tianjin to produce composite structures and interior parts – its new partnerships in China focused less on sharing manufacturing know-how than on activities like maintenance, repair and overhaul (MRO) and working with regulatory authorities to improve safety, reliability, and efficiency of airline operations – in short, support operations for sales of finished aircraft (Cliff, Ohlandt and Yang, 2011, 47). This focus likely not only reflected Boeing's long dominance of the China market, but also its close institutional ties to Chinese airlines and the CAAC.

As it happened, 2005-2007 deals represented the high-water mark for formal technology transfer arrangements between China and the big two aircraft makers. With the formation of COMAC and launch of the C919 in 2008, the focus of Chinese technology extraction efforts shifted decisively away from aircraft structures and systems integration – the bread and butter of Boeing

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[64] Airbus. December 04, 2005. "Airbus to Extend Industrial Cooperation With China," Press Release, Retrieved March 21, 2023, *https://www.airbus.com*

[65] Karp, Aaron. "Airbus, China Reach Accord on Massive Airbus Order, A350 Cooperation."

[66] Kotoky, Anurag and Danny Lee. October 5, 2022. "Boeing's China Orders Dry Up on US Tensions in Boost for Airbus," *Bloomberg*, Retrieved March 21, 2023, *https://www.bloomberg.com*.

and Airbus – to the design and manufacture of internal systems. In no small part, this is because by the 2010s, thanks to their partnerships with Airbus, McDonnell Douglas, and to a lesser extent Boeing, Chinese firms had gained enough experience with key structural components for narrow-body aircraft to build them independently.[67] For its part, once Airbus had leveled the playing field with Boeing, it had less need to broker additional technology sharing agreements.

But as the above discussion makes clear, Airbus's path to parity with Boeing went through technology transfers. To be sure, even absent such transfers, the shifting winds of U.S.-China relations and Chinese leaders' interest in not being too reliant on one American firm would have assured Airbus a larger share of the Chinese market over time. But whereas this seems clear in retrospect, it surely was not to Airbus executives in the 1980s and 1990s, when Boeing's reputation and deep relationships with Chinese leaders (along with those leaders' interest in stable ties with the hegemon) made its market dominance look unassailable to new entrants. As its actions indicate, Airbus, like Douglas before it, saw promises to share technology as integral to putting distance between Beijing and Boeing. And as it had done with Douglas, Beijing used its leverage to extract technology that Airbus would not have – and elsewhere has not – transferred otherwise.

Two GE Ventures Take Different Paths

Few foreign firms have been more integral to the C919's development than GE. By way of Aviage Systems, its 50-50 joint venture with AVIC, the American technology conglomerate supplies the aircraft's core avionics framework, the electronic "brain" responsible for ensuring a plane's myriad internal systems collect and communicate flight data properly. And via CFM International, a 50-50 joint venture between GE and Safran, it makes the engine that powers the C919. These systems' status as the main sources of value-add in an aircraft and the key technological bottlenecks in any effort to develop a new jetliner arguably give GE unrivaled influence over the future not only of the C919, but of China's entire civil aviation industry.

As noted earlier, GE's cooperative ventures with China in avionics and engine technology

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[67] It is no coincidence that the C919 bears a striking resemblance to the A320.

ultimately took very different paths. In engines, the available reporting and my interviews with industry experts suggest that the extent of technology transfer has been relatively limited. In avionics, it has been deep and broad. At first glance, this divergence is surprising for two reasons. To begin, as my conversations with industry analysts and former GE executives make clear, given both projects' importance and potential scale, key strategic choices – including over the extent of technology sharing – would have required sign off from the very top of the GE corporate hierarchy.[68] That is, despite the ventures' different ownership structures, they were downstream of a single decision-making process. Put another way, the same company with the same basic goal, selling to China, made different choices in different segments of its business.

Second, though the agreements were never exactly comparable in terms of promised technology transfers, the gap between them was certainly larger in the end than at first seemed to be the case. When CFM International, in a press release published on GE's website, announced it had signed an MOU with China's ACAE to open a final assembly line and engine test facility in China for the state-of-the-art LEAP-1C engine, this was a major concession which, if fulfilled, would give ACAE far more insight into advanced engine technology than it could ever obtain from reverse-engineering a finished product. It would not bring China over the finish line, but it would give a meaningful boost to ACAE's efforts to develop its indigenous jet engine, the CJ-1000A (Cliff, Ohlandt and Yang, 2011, 50). However, as I discuss below, in the end no assembly line was built and the status of the test facility remains unclear. Meanwhile, with GE's support, Aviage Systems now knows how to design, build, and operate one of the more sophisticated integrated avionics architectures on the market – the same core technology used in Boeing's 787 Dreamliner.

The two ventures' divergent trajectories are much less surprising when viewed in context of the foreign partners' respective market positions. As the world's leading narrow-body commercial jet engine maker, CFM International was well-positioned to dial back its original commitments in the face of what it felt were excessive demands for access to internal data.[69] CFM's position was

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[68] Interview, Zoom, February 2023.

[69] Norris, Guy. December 19, 2011. "Flood of Commercial Engine Orders Breaks Records," *Aviation Week Intelligence Network*, Retrieved January 12, 2023 via MIT Libraries.

made even stronger by the fact the LEAP-1C is a variant of the same engine that powers the C919's main rivals, the 737-MAX and the A320-neo. This left CFM much less reliant on the success of its C919 partnership than Aviage Systems, which as of yet has only one major client, COMAC. These factors help explain why as early as December 2011 industry publications were already reporting that "assembly of the LEAP-1C in China...is now looking quite unlikely."[70] As Richard Aboulafia, the industry analyst, put it, GE "pushed back against any kind of serious...effort to gain access" to proprietary engine technology, and "when there was pushback [from China], they said, 'Sorry, that's the best we can do."' As a result, "besides some maintenance, repair, and overhaul work, nothing is being transferred" from CFM International to ACAE.[71]

"At the other extreme," says Aboulafia, was the deal to create Aviage Systems. That deal had its origins in GE's 2007 acquisition of Smiths Aerospace, a British firm seen as the fourth major player in the avionics market after Honeywell, Rockwell Collins, and Thales.[72] According to one former GE executive, the company acquired Smiths for the express purpose of supplying avionics to the C919.[73] But because the acquisition only put GE in a (fairly distant) fourth place, winning China's business meant going above and beyond what competitors like Honeywell and Rockwell Collins could countenance in terms of technology transfers.

This strategy was viable precisely because in avionics GE had less to lose than its bigger rivals, for whom protecting core avionics technology was integral to the firm's core business proposition. By comparison, GE's avionics division was ancillary and nascent, and far less important to its bottom line than jet engines. If sharing technology meant positioning itself, via a joint venture in which it retained part ownership, as the key avionics supplier for China's indigenous aircraft fleet for a generation, that was a more than acceptable tradeoff from GE's perspective, especially if revenues gained could be reinvested into new products for the likes of Boeing and Airbus. When asked whether GE used expansive technology transfer commitments to beat out its rivals for C919

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[70] Ibid.

[71] Interview, Zoom, February 2023.

[72] An earlier GE bid to acquire Honeywell was blocked by the European Commission on anti-trust grounds in 2001.

[73] Interview, Zoom, February 2023.

contracts, a former GE executive simply replied, “Yeah, that’s business. That’s how it is.”[74]

Discussions over a potential JV between GE and AVIC began almost immediately after GE acquired Smiths’ aerospace in March 2007. The JV deal was completed in January 2011, with the name Aviage Systems (昂际航电 in Chinese) registered in March 2012. Aviage’s core mission was to jointly develop an integrated modular avionics (IMA) architecture for the C919 – essentially, a platform that would integrate and provide a central interface for all the disparate forms of data collected by the aircraft’s numerous avionics subsystems, some of which Aviage itself would supply and others of which would come from JVs with Honeywell and Rockwell Collins. According to a former GE executive, it was “exactly the same” product – namely, a core avionics architecture – as that on the 787 Dreamliner, but with a number “holes” where GE engineers had removed certain export-controlled components or proprietary technologies from Boeing. The task for Aviage was to fill these holes, which it did with assistance from roughly 30 expatriate GE engineers who worked onsite in Shanghai.

The two main pieces of equipment Aviage developed for the C919 were the IMA and cockpit displays, but in some ways these discrete projects were less important, from a technology sharing perspective, than the firm’s role as an avionics systems integrator. As the former GE executive said, “the real learning on top of all that [equipment] was for the 400 or so [Chinese] engineers I had, not just to develop the product and software but to then integrate it across the system of packages, the display, the IMA, the onboard maintenance system, the other packages – make sure they were integrated together and could just slot in.”[75] As technology analysts often argue, when it comes to highly sophisticated technologies like avionics and jet engine design, this kind of process knowledge is priceless, and in many ways harder to replicate than hardware itself. It is also precisely what is missing from so many of China’s less successful joint ventures. It is still too early to tell just how successful Aviage will be, though the fact that the C919 can fly offers some basis for confidence. As the former GE executive told me, “you can’t fast-track this, you have to have people in place” and learning these technologies “for ten years.”

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[74] Interview, Zoom, February 2023.

[75] Interview, Zoom, February 2023.

Why did two joint ventures involving entities controlled by the same foreign partner ultimately follow such different paths when it comes to technology transfers? Unfortunately, I have not been able to gain access to individuals involved in CFM International's decision not to open the jet engine FAL in China. Meanwhile, public reporting on the subject is limited. But one report from the industry publication *Aviation Week* provides clues to the firm's calculus. As it notes, the CAAC in 2011 – two years after the original MOU was signed – determined that if assembly of the LEAP-1C engines took place in China, the airlines regulator "must control the production certification of the engine – and, to do so, it has demanded an extraordinary amount of information about its design and manufacturing processes."[76] From CFM International's perspective, this blatant sign that "the [CAAC] is acting as an agent for AVIC...in its quest for foreign technology" was a step too far. "As a result of the CAAC's demands," CFM apparently opted to keep final assembly of the LEAP-1C in its factories in the United States.[77]

CFM could do this because of its superior position in the market for jet engines for narrowbody aircraft. In 2014, the earliest year for which I could find data, CFM International controlled 68 percent of the market in this segment, followed by International Aero Engines (19 percent), Pratt & Whitney (9 percent), and Rolls Royce (5 percent).[78] As the market leader, CFM was well-placed to push back on pressure from the CAAC to share core jet engine technology despite its formal partnership with ACAE.

Why, then, did China choose to work with CFM International and not one of the other three jet engine makers, which, given their weaker position, would presumably have been more willing to share sensitive technologies? A few potential answers stand out. Most importantly, the C919 is mirrored on the A320 and meant to compete with that aircraft and the 737-MAX, both of which use LEAP-class engines designed by CFM International. This has at least two implications. First, it means that the C919 design, given its similarities to the A320, was well-tailored to the LEAP-class

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[76] Perrett, Bradley. February 27, 2012. "Comac hiring foreigners as C919 Design Details Emerge," *Aviation Week Intelligence Network*, Retrieved February 10, 2023.

[77] Ibid.

[78] Flight Global, "Commercial Engines 2014 Year-End Update," Retrieved March 22, 2023, *https://www.flightglobal.com*.

engines to begin with, which reduces integration issues. Second, that LEAP-class engines would be used not only in the C919 but in the two most widely-sold aircraft models in the world gave CFM huge economies of scale and resulting cost advantages over its competitors. If China really wanted the C919 to compete with the A320 and 737-MAX on international markets, it had few real alternatives to the LEAP-class engines.

In addition to CFM's position in the jet engine market, the structure of the market itself mattered. Pratt & Whitney, the third largest narrowbody engine producer, owns a 50 percent interest in International Aero Engines, the second largest. Against this backdrop, it is unlikely either firm would have entered into negotiations to supply China engines without at least tacit coordination with the other. In effect, for purposes of bargaining with China over technology transfers, Pratt & Whitney and International Aero Engines could be regarded as a single actor. At any rate, they were more likely to collude than compete, reducing China's leverage over either. Rolls Royce, the fourth narrowbody jet engine maker, likely lacked the economies of scale in this segment to even attempt a bid; its area of expertise is widebody jet engines. Whereas for CFM International, the similarities between the LEAP-1C and its sister engines reduced barriers to entry and generated scale economies, for Rolls Royce introducing a new engine for a single aircraft in an industry segment where it had little presence would likely have been unappealing. This stands in contrast to avionics, where the position, capabilities and resources of industry leaders were not so far beyond GE as to eliminate the latter as a serious option for China.

Conclusion

This chapter surveyed the development of China's commercial aircraft manufacturing industry from the early 1970s to the present. It presented evidence on behalf of three key points. First, China's position downstream of GVCs as a final market gave it substantial bargaining power with which to extract technology transfer concessions as a condition of foreign firms' access to its market. Moreover, China used this leverage more aggressively over time as decision-making over the use of technology extractors like formal joint venture requirements was centralized, and especially after the creation of COMAC and launch of the C919 program in 2008-2009.

Second, the relatively slow progress of the C919, and more generally the halting growth of Chinese capabilities in key parts of the aircraft manufacturing supply chain, relieved pressure from foreign firms for the removal of technology transfer policies. Because Chinese firms do not yet threaten global industry leaders in any aircraft industry segment, foreign firms see the benefits of cooperation with China as outweighing the risks. Absent foreign pressure to remove tech extractors, China maintained these policy tools much longer in aircraft manufacturing than in most other strategic high-technology industries.

Finally, even in an industry where China's importance as a final market gives it enormous leverage over foreign investors, allowing it to require foreign firms to form JVs with local companies as a condition of market access, it ability to extract meaningful technology transfers in practice varies widely. Specifically, China is best positioned to secure tangible technology transfers when it partners not with industry leaders, but with relative laggards or newcomers eager to steal market share from their more established rivals. This suggests that although industry structure does not determine when China imposes tech extractors, it does shape more granular bargaining dynamics between Chinese authorities and prospective foreign investors.

Chapter 8

Conclusion

Overview of the Project

The economic and technological rise of China is arguably the most important change in international politics since the end of the Cold War. It may well prove to be the defining geopolitical event of the 21st century. Technology transfer policies contributed powerfully to this rise, helping transform China, in the span of a single generation, from an impoverished technological backwater into an economic superpower and world leader in advanced sectors like high-speed rail and artificial intelligence. Despite this, there previously has been little effort in the scholarly literature to systematically document and analyze Chinese technology transfer activities in the post-Cold War period, and in particular in the years after it joined the WTO in 2001.

This project aimed to help fill that gap by developing and testing a theoretical framework to explain China's use of a set of measures I call *technology extraction policies*, or technology extractors, for short. I defined these as policy tools that condition foreign firms' access to the Chinese market on their willingness to partner and share technology and expertise with local businesses. Concretely, the project answered two main questions regarding China's use of tech extractors. First, what accounts for the rise and fall in the number of tech extraction policies in place in China after it entered the WTO? Second, what explains variation across industries in the enforcement of tech extractors? In particular, why did China use them energetically in some strategic high-technology industries but not in others?

My core argument was that top-down national power and regime security concerns lead China to pursue technology extraction in strategic industries, but that China is constrained in doing so, even in the most strategically vital sectors, by its bargaining power vis-à-vis the foreign firms that invest there. Building on realist approaches to political economy, I suggested that the Chinese central party-state's interest in bolstering China's international standing and in enhancing the security of the governing CCP regime provide the core motivation behind Chinese industrial and technology transfer policies. That motive, simply put, is to make China a preeminent economic and military power by seizing the commanding heights of technological competition in the 21st century.

However, whereas top-down security interests determine when China would like to use tech extractors, they do not fully explain when China actually issues these policies – and when it does not. As I showed, although China imposed numerous formal technology transfer policies in many high value-added and high-technology sectors identified as targets for "indigenous innovation" development in authoritative industrial policies it used them much less often, and sometimes not at all, in a number of equally vital high-tech industries highlighted in those same authoritative documents. These include many forms of precision measurement and navigational equipment, battery and accumulator technologies, and perhaps most puzzling, semiconductor design and fabrication – a sector whose development China's leaders have both long prioritized and long understood would require enormous transfers of foreign technology and expertise. Despite this, in the two decades after WTO accession, China never once imposed sector-wide FDI ownership restrictions or local content requirements in any part of the semiconductor supply chain, and only sparingly used preferential government procurement policies in the sector.

I argued that China's bargaining power over foreign firms explains this industry-level variation in the use of tech extractors across similarly strategic industries. China's bargaining power, in turn, rests on two key pillars. The first I call the central state's policy *enforcement capacity*. By this I mean the state's ability to effectively coordinate and implement national policy priorities on a nationwide basis. I suggested that a series of administrative reforms in the late 1990s and early 2000s consolidated economic policy authority in the hands of a small number of powerful central agencies, bolstering China's enforcement capacity. This, in turn, paved the way for a broad-based increase in China's use of tech extractors across strategic industries in the first decade after WTO entry, and especially after the launch of the Medium- and Long-Term Program for National Science and Technology Development in 2006.

The second pillar of China's bargaining power I call the *balance of dependence* between China and foreign investors. I use this term to denote whether, in a given industry, China depends more on foreign firms as suppliers or employers than the latter depend on it as a market for their goods. I argued that this balance rests principally on where China sits in global value chains in an industry. When China is downstream of GVCs as a final market, such that most of what foreign firms import into China is actually consumed there, this balance will generally favor China. In these industries, foreign firms depend heavily on the Chinese market and typically lack powerful sources of countervailing leverage they can use to resist market access restrictions. This leaves foreign firms with little option but to comply with technology transfer mandates as a condition for selling or investing in the Chinese market.

The situation changes, however, when China sits in the middle of GVCs not as a final production and consumption site, but instead as an intermediate hub for the processing and assembly of imported foreign inputs into more finished goods which are exported back out to consumers in other countries. In such industries, two factors shift the balance of dependence in foreign firms' favor. First, because most of what foreign firms import into China is not ultimately consumed there, they depend less on China as a final market. Second, China in these sectors depends heavily on foreign firms to sustain export growth and associated employment. This latter reliance was especially pronounced in the first decade after China joined the WTO, when exports as a share of China's GPD peaked and when foreign firm-dominated export processing trade accounted for a whopping 50 to 60 percent of total Chinese exports by value. I suggested that the combination of reduced foreign firm reliance on China as a final market and increased Chinese dependence on foreign firms and the value chains they control to guarantee its access to overseas consumers bolsters foreign firms' bargaining power over Chinese authorities. The result is that China is less likely to stringently enforce market access controls, even in the most strategically important sectors, when it occupies an intermediate position in value chains.

Finally, regarding the fall of technology extractors, I argued that a confluence of factors made it such that by 2014-2015, the costs of these policies began to outweigh their anticipated benefits, leading China to shift away from them in favor of less easily policed activities. In the decade after the 2008-2009 global financial crisis, Chinese firms quickly gained ground on foreign competitors (including their former JV partners), capturing domestic and international market share in many industries in which China had used technology extractors most energetically in earlier years. China's increased competitiveness both reduced tech extractors' utility and stoked heightened foreign corporate and government opposition to them, especially from the United States. At the same time, as Chinese firms became more competitive, they began to seek opportunities for overseas expansion. This sensitized Chinese firms and officials alike to the risk of reciprocal restrictions on Chinese investment by major trade partners frustrated by limits on their own companies' ability to penetrate the Chinese market. Taken together, I argued, tech extractors' declining utility for future industrial upgrading and the desire to avoid reciprocal restrictions on Chinese overseas exports and investment led China to abandon formal, publicly-documented technology transfer policies in most industries by the time the Trump administration launched its trade war on China in 2018. I expected the pace at which China removed tech extractors in a given sector to vary as a function of the speed with which Chinese firms became competitive and, in turn, the intensity of foreign backlash to Chinese market access restrictions.

I evaluated these arguments using a multi-method research design that combined statistical analysis of an original industry-level dataset on tech extractors from 1995-2020 with qualitative case studies of Chinese tech extraction efforts in three strategic industries. In Chapter 4, I described how I created my dataset on tech extractors, along with original measures of the strategic status of an industry and China's position in global value chains by industry and year. I then ran a series of statistical tests of the relationship between industry strategic status and China's position in GVCs, on the one hand, and the number of distinct tech extractors in place by industry and year, on the other. To measure China's use of tech extractors, I manually analyzed over 500 pages of Chinese-language Chinese central state laws and regulations on three policies which formed the backbone of China's efforts to "introduce, digest, absorb, and re-innovate" foreign technology after WTO. These include JV requirements and other ownership restrictions on inward FDI, local content requirements, and preferential government procurement policies. My data revealed that strategic industries account for 85 percent of the increase in China's use of tech extractors after 2001. At the same time, multiplicative interaction models showed that China is more than twice as likely to use these tools in strategic industries in the bottom 10 percent in terms of imports tied to processing trade as in those in the top 10 percent, equivalent to roughly one standard deviation. This suggests a strong association between position in GVCs, measured using the share of imports tied to processing trade by industry-year, and China's decision to use tech extractors.

To probe the mechanisms behind my arguments, I then conducted detailed qualitative case studies of the evolution of Chinese technology transfer efforts in wind turbine production, semiconductor design and fabrication, and aircraft design and manufacturing. The case studies drew on interviews with more than two dozen industry executives, current and former government officials in the United States and China, and policy and academic experts. They also built on careful analysis of Chinese-language central state policies, as well as a wide range of other primary and secondary sources including memoirs by former officials, media reports, and scholarly and policy publications. Overall, the cases provided strong support for my arguments against a range of alternative explanations focused on bottom-up interest group pressures, the degree of industry concentration and pace of innovation, and more.

In Chapter 5, I examined the rise and fall of tech extraction efforts in wind power. The analysis demonstrated a close link between gains in enforcement capacity following the concentration of economic policy authority in the NDRC's hands and the increasingly assertive and effective use of tech extractors in wind turbine manufacturing. It also explored how, as Chinese wind turbine makers became more competitive and gained market share both at home and abroad, Chinese authorities swiftly responded to foreign demands for the removal of JV and local content mandates in an effort to head off negative reciprocity by major trade partners. The wind power industry thus encapsulates my arguments about both the rise of tech extraction in strategic industries and the factors that led to their decline in the 2010s.

Chapter 6 looked at China's efforts to extract foreign technology in semiconductor design and fabrication. I first traced Chinese officials' efforts to acquire foreign technology in the sector in the 1980s and 1990s, including through a number of high-profile joint ventures negotiated with input from the highest levels of the CCP leadership. I then showed how despite this history, China's increasingly central position as an intermediate node in global electronics supply chains after WTO entry paradoxically weakened rather than bolstered the country's bargaining power over foreign chipmakers, constraining future tech extraction efforts. Interviews with industry insiders and executives provided strong evidence that foreign firms' reduced reliance on China as a final market and China's reliance on those firms to drive electronics exports undercut its leverage, leading it to refrain from imposing technology transfer mandates in ICs even as it ramped up their use in other strategic high-tech sectors. The chapter then explored how the growth in China's domestic consumer electronics market in the 2010s bolstered its bargaining power over foreign chipmakers, leading to more aggressive technology extraction efforts in the latter part of the decade. However, increased foreign scrutiny of Chinese trade and investment practices during this time meant that these efforts took the form of outbound FDI into foreign technology companies and informal or indirect inducements to share technology rather than formal JV or local content requirements.

In Chapter 7, I turned to the aircraft manufacturing industry. The bulk of the chapter examined how, as in wind power, institutional reforms that consolidated policy authority over the sector led to more energetic use of technology transfer requirements in commercial aircraft development. But unlike wind energy, in which China removed most tech extractors by 2012, Chinese authorities maintained JV requirements in aircraft production as late as 2018. Consistent with my argument about the removal of tech extractors, I provided evidence that China's relatively slow progress in the sector lowered foreign pressure to lift these policies in aircraft manufacturing. In short, China did not pose a serious threat to foreign incumbents in most industry segments, so foreign firms continued to see the benefits of working with Chinese companies, in market access terms, as outweighing their potential costs in the form of Chinese competition. The final part of the chapter looked at how, even in an industry like aircraft manufacturing in which China enjoyed substantial leverage and enforced tech extractors, there has been surprisingly wide variation in the extent to which Sino-foreign partnerships yield meaningful technology cooperation. Through detailed studies of the experiences of McDonnell Douglas, Airbus, GE Aviation, and CFM International in China, I made the case that global market structure and firms' position in that structure shapes granular dynamics of bargaining over the scale of tech transfer between Chinese and foreign firms.

Implications for the Literature

My arguments and findings have implications for a diverse set of scholarly literatures in political science and international relations. Below, I touch on three sets of contributions it makes.

First, as highlighted in the Introduction and discussed in Chapter 2, the project contributes to our knowledge of great power transitions by focusing attention on the important but understudied question of how rising powers like China actually rise. The existing literature on power transitions largely elides this question, treating the causes behind differential growth rates – the driving force behind systemic change – as largely exogenous to politics. But as the cases of China and other rising powers attest, the emergence of a new great power is not inevitable. At the very least, I argue, variables like factor endowments and exogenous technological change struggle to explain the speed with which new powers rise or why some countries rise while similarly endowed countries do not.

Focusing attention on the "how" of rising powers' rise matters for international relations theory because when it comes to understanding the mechanics and trajectories of power transitions – including when they lead to hegemonic war – timing is everything. The speed with which a new great power rises powerfully influences how effectively incumbent powers respond to it. It does so in part by determining the severity of the disjuncture between incumbent powers' short- and long-term interests vis-à-vis the rising power (Edelstein, 2017). If an incumbent power's short-term interest in economic cooperation with a rising power leads it to delay efforts to contain the latter's rise by 10 years, the scale of this blunder depends largely on how quickly the rising power grows its industrial base (and thus its latent military power) in that period. A rising power that grows 10 percent per year for 10 years will have an economy roughly 60 percent larger at the end of that decade than one which grows at 5 percent per year. The implication is that to understand (and predict) when and how rising and status quo powers will come into conflict, as well as how that conflict is likely to unfold, we must first examine the factors shaping the rising power's rise. In the modern era, this means above all the choices determining the its ability to scale the commanding heights of the global industrial and technological division of labor.

Second, the project contributes both empirically and theoretically to our knowledge of Chinese industrial policy and the political economy of China more generally. On the empirical front, it represents the first effort to systematically document China's use of technology transfer policies in the post-Cold War period. The project also sheds new light on the evolution of Chinese official thinking about technology transfer and its relationship to the "indigenous innovation" paradigm. Previous works have tended to assume a break between the eras of "trading the market for technology" and "indigenous innovation," with the former, foreign-oriented program giving way to the latter, more domestically-focused model sometime in the early 2000s. My research shows that the decline of "trading the market" as a slogan did not herald a turn inward in China's industrial policy strategy. Rather, it signaled a reassessment of how best to use foreign capital and technology to advance China's technological ambitions. The result was an effort to move beyond "blind duplication" towards a genuine ability to internalize and build on foreign insights embodied in the phrase "introduce, digest, absorb, and re-innovate." Crucially, from the start this concept was intimately tied to "indigenous innovation," and indeed was written into the very definition of the latter offered in the MLP.

On the theoretical front, the project makes two main and related contributions to China studies. First, much research and writing on Chinese politics during the Hu Jintao-Wen Jiabao era portrays the central party-state as relatively weak during this period. This view in part explains the scholarly literature's focus on the activities of subnational governments and non-state actors during this period. My findings contribute to recent research that locates the start of the "resurgence" of central state activism embodied in the phrase *guojin mintui* from the post-financial crisis years and Xi Jinping's ascendance to the early-to-mid-2000s (Chen and Naughton, 2016; Tan, 2021). In fact, my research indicates this reassertion of the central state has even deeper origins than the launch of the Medium- and Long-Term Program in 2006, but instead was grounded in a longer process of institutional consolidation undertaken in anticipation of and response to WTO accession.

A second contribution to China studies is to explore the relationship between institutional reforms and the Chinese state's market power, understood as the ability to use its market to shape the incentives and actions of foreign firms (Drezner et al. 2022). In this respect, the project builds on recent work by Kalyanpur and Newman (2019) which shows how the centralization of stock market governance in the European Union bolstered European market power, leading many non-U.S. firms to delist from U.S. stock exchanges rather than comply with the 2002 Sarbanes-Oxley Act. I show how an analogous process of regulatory harmonization, embodied in the elimination of industrial ministries and rise of the NDRC, bolstered China's market power, and in turn its ability to bargain with foreign firms over the terms of market access. This increase in China's enforcement capacity facilitated the expansion of technology extraction efforts after WTO entry.

The final set of scholarly contributions the project makes concerns research on IPE. To begin, just as my study aims to bring the central state back into the study of Chinese political economy in particular, it aspires to help bridge a similar gap in the IPE field in general. Once upon a time, realist or "statist" approaches to political economy, which examine the state's independent role in shaping international commercial relations, were central to debates in IPE. In recent decades, the state-as-actor has given way to a conception of the state as no more than a mechanism for aggregating and arena for adjudicating the conflicting preferences of economic interest groups. This approach dominates not only research on democracies, which anchor most of our theories of trade politics, but also non-democracies. One goal of my project has been to show the limits of this dominant approach when it comes to explaining important trade-related policies in the world's largest trading nation, and in doing so reinforce the enduring relevance of realism in political economy research. With the revival of industrial policy in the United States and Europe, I expect realism to gain new currency in future IPE research on authoritarian states like China as well as liberal democracies like the United States and European countries.

In this effort, I am of course standing on the shoulders of giants. This includes not only IR theorists like Robert Gilpin and Stephen Krasner, but also the literature on developmental states in East Asia. Indeed, China's experience closely mirrors those of postwar Japan, South Korea, and Taiwan. This is no surprise given that Chinese leaders self-consciously modeled their industrial policy strategy on the former. But although China's developmental path resembles these countries' in many respects, it also differs in ways that have implications for research on "the developmental state" paradigm, as well as for work on trade and foreign investment politics in the age of global production. One of the most critical differences between China and its predecessors, I argue, is that the latter rapidly (re)industrialized as Cold War allies of the United States at a time when global capital flows were restricted and barriers to foreign market access were commonplace among leading market economies. By contrast, China rose against the backdrop of the Cold War's end and the consolidation of a "Washington Consensus" dedicated to removing barriers to MNEs' global expansion. This left China with no option for acquiring the foreign technology needed to kickstart industrialization but to open its market to outside capital.

This decision would embed China's technology transfer efforts in the global economy in ways very different from its forebears and with implications that reach well beyond either China or technology transfers. Most fundamentally, China's experience points to the manifold ways in which the rise of global production networks has reshaped the international politics of trade and foreign investment. It has done so by shifting the set of relevant actors – namely, by enabling the rise of firms that oversee complex, globe-spanning supply chains – and altering the dynamics of bargaining over market access between them.

On the one hand, the rise of transnational production creates tremendous new opportunities for firms in developing economies like China's to learn from the world's most innovative and productive businesses. In this way and with sufficient policy support, it can contribute powerfully to countries' efforts to shift up the value chain. On the other hand, as I explored throughout this project, the globalization of production can create unexpected and potentially durable new sources of power for foreign investors over states in countries where they invest. This is not necessarily a bad thing. If embeddedness in GVCs constrains tech extraction, it may also constrain other coercive actions by host states, thus partly resolving the "obsolescing bargain" problem at the heart of FDI politics. But by giving firms more leverage over states and limiting what the latter can demand from the former in exchange for market access, it may also reinforce the existing global division of labor. If firms can leverage control over GVCs to limit China's ability to pursue its developmental goals, then it is doubtful countries with smaller economies and weaker states will fare much better.

Managing the Future of Technology Extraction

I began research for this project in 2019 as the corrosive effects of the U.S.-China trade war on the broader bilateral relationship were coming into full view. The deterioration of relations between Beijing and Washington over the course of 2018-2019 prompted me to revisit the origins of the Trump administration's decision to impose trade sanctions on China. This, in turn, led me to the document widely credited with launching the war, the Section 301 Report issued by the USTR in March 2018. In reading the report, I was struck to learn that it almost never mentioned the trade balance, President Trump's rhetorical bête noir. Instead, as its full title indicated, the report was about technology.[1] Specifically, it was concerned with the threat to American technological preeminence posed by Chinese "forced" technology transfer and intellectual property theft. Against this backdrop, technology transfer policy seemed like a good place to start in order to understand how the U.S. and China got where they were and where their relationship might go next.

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[1] United States Trade Representative (USTR). 2018. "Report on China's Acts, Policies, and Practices Related to Technology Transfer, Intellectual Property, and Innovation," Retrieved June 7, 2022, (*https://ustr.gov*).

As much as the research for this project sensitized me to the fissures in U.S.-China relations, I did not anticipate just how bad they would become by the time I finished. Bilateral ties are not only worse now than they were then, but worse in a different and more dangerous way. In 2019, the decline still seemed, to some extent, conditional. It was not absurd to think a deal could be reached to restore trade and investment relations to something like what they were before 2018, with Washington lifting tariffs on Chinese goods and moderating controls on Chinese investment in return for serious steps by Beijing to create a "level playing field" for foreign firms – namely, by ending coercive technology transfer practices and strengthening intellectual property protections. Such a possibility was implicit in the "Phase One" trade agreement reached January 15, 2020. It was the explicit goal of the more ambitious "Phase Two" deal, negotiations over which stalled as bilateral communications broke down amidst the COVID-19 pandemic.

Five years after the trade and tech wars' opening salvos, the possibility of a conditional reset looks remote. It is unclear what change, if any, in China's behavior could lead the U.S. to remove tariffs on Chinese goods or lift export controls on advanced semiconductors and related equipment. In fact, if the October 2022 export controls and an April 2023 speech by National Security Advisor Jake Sullivan on the Biden administration's foreign economic policy are any indication,[2] it increasingly appears that nothing short of a reworking of China's political economic system or the collapse of Chinese power will alter the direction of travel in U.S. policy towards it. If true, this would constitute a sea change in the foreign policy orientation of the dominant state in the international system, and possibly in the character of the system itself. It would mean an order premised on the partial but unconditional exclusion of its second largest economy.

What does this shift mean for Chinese technology transfer policy? As I argued elsewhere in the project, the era of formal, publicly-documented technology extraction policies is largely over. But even as tech extractors have declined, the underlying dynamics of bargaining between China and foreign firms have not changed fundamentally. Nor are they likely to change as long as Chinese firms lag foreign rivals in strategic high-technology sectors and foreign MNEs have reason to be in

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[2] Sullivan, Jake. April 27, 2023. "Remarks by National Security Advisor Jake Sullivan on Renewing American Economic Leadership at the Brookings Institution," Retrieved May 25, 2023, (*ttps://www.whitehouse.gov*).

China. The pathways to technology extraction will continue to evolve, but the motives behind and reality of tech extraction will endure.

Going forward, I expect bargaining over technology transfer in China to take three main forms. The first two, informal inducements to share technology with Chinese firms and formal but indirect measures that compel such partnerships, will be familiar from the case studies. Informal pressures to license IP to local firms have always been part of the Chinese investment landscape, and this is unlikely to change in sectors where foreign firms retain a lead over Chinese competitors and are not barred by export controls from working in China. Likewise, I expect formal but indirect actions like the NDRC's 2013 anti-monopoly investigation of Qualcomm, the settlement of which was accompanied by a string of announcements of new technology transfer agreements between the American company and Chinese counterparts, to continue and become more varied in form. In the future, data security evaluations, product certification processes, and data localization requirements will all become more prominent venues for this kind of bargaining.

A third approach China may employ more often in the future is what we might call the Tesla or Apple model. When both firms first established operations in China, Chinese authorities not only offered them subsidies, but granted them wide operational autonomy and refrained from heavy-handed inducements to share technology up front. Tesla's opening of an electric vehicle (EV) assembly facility in Shanghai in 2019 was especially noteworthy because China has long strictly enforced JV requirements on foreign investment in auto manufacturing. Tesla was the first major foreign automaker allowed to establish a wholly foreign-owned enterprise (WFOE) in China.

In granting these companies autonomy, China's strategy appears to have been two-fold. First, it sought to use their entry to prod domestic firms to become more competitive – a tactic known in China as the "catfish effect."[3] Second, at least in Tesla's case Chinese officials appear to have consciously seen the company as a catalyst for developing a broader EV supply ecosystem, not by forming JVs and licensing technology, but by working with and nurturing Chinese suppliers at

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[3] Crane, Brent. May 9, 2021, "Tesla's China Endgame," *The Wire China*, Retrieved May 25, 2023, (*https://www.thewirechina.com*).

every step of the value chain.[4] In effect, China's leaders viewed Tesla as a rising tide that would lift all boats by simultaneously challenging local competitors and nurturing local supply chains on which those same competitors could draw.

In Apple's case, I am not aware of a conscious strategy to this effect, but the parallels are unmistakable. More likely, Chinese officials applied lessons learned from the experience of Apple, which began manufacturing and assembling in China in the early 2000s in partnership with Taiwan-based Foxconn, to the Tesla case. By all accounts, it has worked. Within a year of the Shanghai facility's opening, Tesla reported it sourced 86 percent of non-Tesla produced components in Chinese-made vehicles from Chinese suppliers. By comparison, vehicles made at Tesla's California facility contained only 73 percent North American content.[5] Tesla CEO Elon Musk has repeatedly praised the company's Shanghai factory as its "best quality, lowest cost and also low drama" facility. For its part, Apple's enormous investments in cultivating a vast network of Chinese suppliers became the cornerstone of its spectacular growth in the fifteen years after the launch of the first iPhone in 2007.[6] By 2020, nearly all iPhones, iPads, AirPods, and Mac computers were manufactured and assembled in China,[7] with Chinese firms providing over 25 percent of the value-add in iPhones and a growing share of other devices.[8]

To the best of my knowledge, Apple has yet to face serious pressure from Chinese authorities to share proprietary IP. In no small part, this is likely because even as China has become a key final market for the company, the country still depends on Apple and the manufacturing ecosystem it anchors to drive a sizeable chunk of its consumer electronics export engine. Another important factor may be China's need for influential advocates in Washington, especially given the current mood on China there. Nonetheless, the balance of dependence between China and Apple has

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[4] Li Yuan. November 30, 2021. "In China, Tesla Is a Catfish, and Turns Auto Companies Into Sharks," *The New York Times*, Retrieved May 25, 2023, (*https://www.nytimes.com*).

[5] Tesla, "Impact Report 2020," Retrieved May 25, 2023, (*https://www.tesla.com*).

[6] McGee, Patrick. January 17, 2023, "How Apple tied its fortunes to China," *Financial Times*, Retrieved May 25, 2023, (*https://www.ft.com*).

[7] McGee, Patrick. January 18, 2023. "What it would take for Apple to disentangle itself from China," *Financial Times*, Retrieved May 25, 2023, (*https://www.ft.com*).

[8] Mickle, Tripp. September 7, 2022. "How China Has Added to Its Influence Over the iPhone," *The New York Times*, Retrieved May 25, 2023, (*https://www.nytimes.com*).

evened out considerably in recent years, driven by a combination of China's rise as a final demand center and its growing monopoly on the capacity to manufacture products with the precision and consistency and at the scale Apple needs. Going forward, this can only complicate bargaining dynamics between the two parties. It is notable in this context that in early 2023 Apple said it will begin manufacturing some iPhones with mainland China-based Luxshare instead of Taiwan-based Foxconn.[9] Whatever this decision's manifold motives, it marks a clear step towards even deeper localization of Apple's China supply chains.

What should governments in other countries do about technology extraction and localization measures in China and elsewhere in the coming years? I would make two observations. First, policymakers in advanced industrial societies should recognize the international distributional conflicts that underpin foreign technology transfer policies in developing economies. Access to and mastery over leading technologies is arguably the single most important determinant of a country's position in both the global division of labor and the international balance of power. As Friedrich List observed as early as the 1840s, less developed countries will not – nor should they have to – accept a permanent place at the bottom of the global economic ladder simply because they got a later start than their wealthy counterparts (List, 1841). Against this backdrop, efforts to regulate flows of technology, unless genuinely multilateral in a way that gives adequate voice to the interests of less developed countries, are bound to feed distrust and insecurity between rich countries whose firms control that technology and poor countries that do not. Unilateral and even "plurilateral" efforts to restrict developing countries' ability to "introduce, digest, absorb, and re-innovate" cutting-edge technologies, so long as they appear motivated by power politics or rent-seeking by incumbent firms (as they almost certainly will), will at best drive technology transfer behavior further "underground." At worst, as Monteiro and Debs (2020) suggest, it could lead to war, or at least powerfully exacerbate existing tensions.

It is not too late to pause the spiral of insecurity that risks pulling China's and the United States' economies apart and forcing companies and countries to choose between them or attempt a

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[9] Liu, Qianer. January 4, 2023. "Foxconn's biggest Chinese rival wins premium iPhone contract," *Financial Times*, Retrieved May 25, 2023, (*https://www.ft.com*).

precarious balancing act. But this will require both sides to take real steps to reassure the other that its long-term economic interests will not be harmed if it makes concessions. For the United States, this means convincing Beijing it will not be permanently denied access to what Jake Sullivan calls "foundational technologies" *if* it creates a more fully level playing field for foreign firms and curbs coercive technology transfer practices. For China, it means convincing Washington it will enforce protections for foreign businesses and comply with the letter and spirit of its WTO obligations *if* the U.S. agrees to lift tariffs and relax (if not eliminate) export controls on high-end semiconductors and related equipment. The October 2022 export controls could prove highly effective in changing China's behavior, but only if they are made conditional. As currently framed, they offer no pathway out, and thus do nothing to address the distributional conflicts that brought us to this point.

Though less escalatory and more productive than unconditional restrictions or outright containment, tit-for-tat steps like export controls, even if conditional, are not an optimal long-term solution to the challenges posed by behavior like China's. In an ideal world, governments would work towards reconciling the intellectual property concerns of firms that own technology (and the interests of their home governments) with the distributional concerns of less developed countries in a genuinely multilateral forum like the failed Doha round of WTO negotiations or more recent efforts to forge a multilateral framework on climate change. Unfortunately, this is probably unrealistic in the current climate. As rising barriers to entry in strategic high-technology industries bolster the returns to control over critical IP, the increasingly small number of firms that own these technologies can be expected to guard their property ever more jealously. When the power political concerns of these firms' home states are layered on top, the prospects for a settlement that genuinely democratizes control over "foundational technologies" look truly limited.

This brings me to the second observation. Recognizing that technology transfer pressures are here to stay and their distributional wellsprings are unlikely to be resolved anytime soon, policymakers in countries like the United States should think hard about what actions actually help their companies resist these pressures and which might prove counterproductive. The findings in this project suggest that current efforts by the United States and other Western governments to compel their companies to “re-shore” or “friend-shore” production away from China could backfire, leaving firms more, not less, vulnerable to coercive economic pressures, including over technology transfer. So long as foreign firms depend on China as a final market, China will be able to leverage control over market access to extract concessions from them. Firms that lack countervailing sources of leverage will be poorly equipped to resist these demands, and thus more likely to concede. As the vignettes in chapters 6 and 7 suggest, incentives to share technology will be especially strong for newcomer and laggard firms looking to capture market share by gaining an asymmetric advantage in China, even if this means assisting Chinese companies that may one day replace them.

Many variables shape a given foreign investor’s bargaining power vis-à-vis a host government. My findings regarding the impact of intermediacy to global value chains on China’s behavior point to an underappreciated and perhaps counterintuitive source of leverage for foreign firms. They suggest it is in precisely those sectors in which China is most deeply integrated into global production networks that it is most constrained in pursuing technology extraction. Put another way, foreign firms appear best positioned to resist or avoid technology transfer pressures when they use China not only as a market for their goods and services but as a production base for servicing customers elsewhere. In these industries, foreign firms of course depend on China in a variety of ways. But China also depends on them not only as a vendor but as a contributor to export-led growth and associated employment. This reciprocal reliance may not always outweigh firms’ dependence on China, but it can help tip the balance, sometimes decisively.

This is not to suggest policymakers should abandon efforts to re-shore production in strategic industries. As supply chain disruptions during the COVID-19 pandemic made clear, there are good reasons for countries to want the capacity to make certain products at home that have nothing to do with competition with China. If re-shoring helps revitalize communities hit hardest by offshoring in the 1990s and 2000s, then that is all the better. But as governments push firms to shift production away from China, they should proceed with caution and with a clear eye to the potential unintended consequences of doing so. The same goes for foreign firms as they (quite understandably, given events in recent years) rethink their China strategies. Interdependence is not a panacea, but it does have sometimes unexpected benefits.

To conclude, the goal of this project was to explain when, why, and how China pursued foreign technology transfers in the post-Cold War period, and especially in first ten-to-fifteen years after it joined the WTO in 2001. My hope in doing so was to help illuminate a key but underappreciated – at least in the scholarly literature – aspect of the most significant development in world politics since at least the fall of the Soviet Union: the economic and technological rise of China. Secondarily, I hoped that studying Chinese technology transfer policy in this period might shed new light on the specific form of globalization in which China rose, and in particular the implications of the globalization of production for bargaining dynamics between multinational corporations that own most of the world's critical technologies and states that want access to those technologies.

The trajectory of U.S.-China relations in recent years, and more generally the reorientation American foreign economic policy reflected in everything from the decision to leave the Trans-Pacific Partnership in 2017 to the revival of industrial policy unabashedly aimed at reasserting American economic and technological preeminence, suggest we have passed the high-water mark of the form of globalization discussed above. Many factors contributed to this shift, but none more, I would argue, than China's rise itself, the relative decline of the United States, and the stark imbalances both within and between countries caused by these conjoined processes. Indeed, one need look no further for evidence of the intimate relationship between hegemony and international openness, and in turn of the loss of American confidence in its own hegemony, than the foreign economic policy vision laid out in Sullivan's April 2023 speech.

To be sure, there are reasons to welcome the end of the post-Cold War era. Many aspects of the economic order that emerged starting in the 1980s were unsustainable regardless of their long-term implications for American power. Surely, it cannot be the case that the best form of global economic organization is one that leads to levels of wealth and income inequality unseen since the eve of World War I and of political polarization unheard of since the interwar period. The question is whether the new, more zero-sum arrangement emerging in place of the post-Cold War order will be less flawed and self-defeating. American policymakers have a special responsibility to answer this question. As the most powerful state in the international system, the United States' choices will do more than any other variable to shape world order in the 21st century.

Chapter 9

Appendix

Appendix A - Coding Tech Extractors

One of the major challenges in creating an industry-level measure of the number of technology extractors in place is correctly identifying the industry to which a given policy corresponds. Fortunately, this task is made easier by the fact that Chinese-language policies like the FDI Catalogues often use very similar language to industry descriptions in the China Standard Industrial Classification (CSIC) system, which in turn has been harmonized by the General Administration of Quality Supervision, Inspection and Quarantine (国家质量监督检验检疫总局) with the International Standard Industrial Classification (ISIC). In most cases, this makes coding policies by industry simple and straightforward. For example, FDI catalogues and other policies related to high-speed rail invariably use the term 高速铁路, which appears verbatim in the Chinese-language description for CSIC industry “3711 – 高铁车组制造," or in English, “Manufacture of high-speed trains." This in turn corresponds to ISIC industry “3020 – 铁道机车及其拖曳车辆的制造," or in English, “Manufacture of railway locomotives and rolling stock." Although some information is lost in the correspondence from CSIC industry 3711 to ISIC industry 3020, we can at least be confident that 3020 is the correct ISIC industry code for restrictions containing the term 高速铁路.

In some cases, coding industries is more difficult because the policies in question are highly specific or use language that does not directly correspond to the language used in CSIC. For example, the 2006 FDI Catalogue includes a joint venture requirement for 10万千瓦及以上燃气-蒸汽联合循环发电设备, in English “Gas-steam combined cycle power generation equipment with capacity of 100,000 tons and above," under the sector heading 火电, or “thermal power." For restrictions like this, I first search CSIC for terms closely associated with the restriction, in this case 发电机, or power generator. In most cases, this quickly yields a close match. For example, the CSIC industry description for industry “3811 – 发电机及发电机组制造" reads, 指发电机及其辅助装置、发电成套设备的制造, or in English “Refers to the manufacture of generators and their auxiliary devices and complete sets of power generation equipment," which clearly captures the intent of the original JV requirement. Finally, CSIC codes this as corresponding to ISIC industry “2710 – Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus." Although in CSIC, each 4-digit industry is harmonized to only one ISIC 4-digit industry, in some cases I find that a single restriction plausibly corresponds to more than one ISIC 4-digit industry. In this case, I code the policy as also applying to ISIC industry “2513 – Manufacture of steam generators, except central heating hot water boilers." According to the ISIC description, this industry includes “manufacture of steam or other vapour generators," “manufacture of auxiliary plant for use with steam generators," and similar activities that closely correspond to the original JV requirement.

Appendix B - Strategic Industries

B.1 - Main Measure

The table below lists all industries coded as “strategic" in my dataset. As a reminder, I identify three main classes of strategic industry: (1) Industries with high barriers to entry due to significant research and development (R&D) requirements, cumulative learrning effects, or economies of scale in production, (2) basic infrastructure, and (3) critical industrial inputs. Data on the first category of industry is drawn from the “Global Innovation 1,000" index developed by the consultancy

Strategy&. This dataset records the 1,000 top corporate spenders on R&D from 2012-2017 and categorizes them by sector and industry. For the second category, I hand coded a short list of 13 ISIC 4-digit industries covering traditional basic infrastructure assets like roads and railways, ports, power generation and supply, and other basic utilities. Finally, I code the the third type of strategic industry using the United States Defense Logistics Agency's Strategic Materials list, which includes 66 raw material inputs considered "critical to national security" by the Department of Defense. All of these materials fall under two ISIC 4-digit industry codes: "0721 – Mining of uranium and thorium ores," and "0729 – Mining of other non-ferrous metal ores."

Although the vast majority of industries on the list below match the conventional wisdom regarding what counts as "strategic," a few may surprise readers. For example, "1200 – Manufacture of tobacco products," "1701 – Manufacture of pulp, paper and paperboard," "1811 – Printing." I would note that firms in these industries ranked among the top 1,000 corporate R&D spenders globaally between 2012-2017. As such, consistently applying my coding scheme requires that I code them as strategic, even though doing so arguably hurts rather than helps my argument given that China seldom introduces technology extractors in these industries. This being said, one could make a principled argument that these industries are, in fact, strategically important. For example, in China as in many countries, tobacco production is a significant source of central state revenue.

Table 9.1: List of Strategic Industries

ISIC	Industry	Sector
510	Mining of hard coal	Mining and quarrying
520	Mining of lignite	Mining and quarrying
610	Extraction of crude petroleum	Mining and quarrying
620	Extraction of natural gas	Mining and quarrying
710	Mining of iron ores	Mining and quarrying
729	Mining of other non-ferrous metal ores	Mining and quarrying
899	Other mining and quarrying n.e.c.	Mining and quarrying
910	Support activities for petroleum and natural gas extraction	Mining and quarrying
990	Support activities for other mining and quarrying	Mining and quarrying
1061	Manufacture of grain mill products	Manufacturing
1062	Manufacture of starches and starch products	Manufacturing
1079	Manufacture of other food products n.e.c.	Manufacturing
1104	Manufacture of soft drinks; production of mineral waters and other bottled waters	Manufacturing
1200	Manufacture of tobacco products	Manufacturing
1701	Manufacture of pulp, paper and paperboard	Manufacturing
1702	Manufacture of corrugated paper and paperboard and of containers of paper and paperboard	Manufacturing
1709	Manufacture of other articles of paper and paperboard	Manufacturing
1811	Printing	Manufacturing
1812	Service activities related to printing	Manufacturing
1910	Manufacture of coke oven products	Manufacturing
1920	Manufacture of refined petroleum products	Manufacturing
2011	Manufacture of basic chemicals	Manufacturing
2012	Manufacture of fertilizers and nitrogen compounds	Manufacturing
2013	Manufacture of plastics and synthetic rubber in primary forms	Manufacturing
2023	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Manufacturing
2029	Manufacture of other chemical products n.e.c.	Manufacturing
2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products	Manufacturing
2211	Manufacture of rubber tyres and tubes; retreading and rebuilding of rubber tyres	Manufacturing
2394	Manufacture of cement, lime and plaster	Manufacturing
2410	Manufacture of basic iron and steel	Manufacturing
2420	Manufacture of basic precious and other non-ferrous metals	Manufacturing
2431	Casting of iron and steel	Manufacturing
2432	Casting of non-ferrous metals	Manufacturing
2512	Manufacture of tanks, reservoirs and containers of metal	Manufacturing
2513	Manufacture of steam generators, except central heating hot water boilers	Manufacturing
2591	Forging, pressing, stamping and roll-forming of metal; powder metallurgy	Manufacturing
2599	Manufacture of other fabricated metal products n.e.c.	Manufacturing
2610	Manufacture of electronic components and boards	Manufacturing
2620	Manufacture of computers and peripheral equipment	Manufacturing
2630	Manufacture of communication equipment	Manufacturing
2640	Manufacture of consumer electronics	Manufacturing
2651	Manufacture of measuring, testing, navigating and control equipment	Manufacturing
2660	Manufacture of irradiation, electromedical and electrotherapeutic equipment	Manufacturing
2670	Manufacture of optical instruments and photographic equipment	Manufacturing
2680	Manufacture of magnetic and optical media	Manufacturing
2710	Manufacture of electric motors, generators, transformers and electricity distribution and control apparatus	Manufacturing
2720	Manufacture of batteries and accumulators	Manufacturing
2731	Manufacture of fibre optic cables	Manufacturing
2732	Manufacture of other electronic and electric wires and cables	Manufacturing
2733	Manufacture of wiring devices	Manufacturing
2740	Manufacture of electric lighting equipment	Manufacturing
2750	Manufacture of domestic appliances	Manufacturing
2790	Manufacture of other electrical equipment	Manufacturing
2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines	Manufacturing
2812	Manufacture of fluid power equipment	Manufacturing
2813	Manufacture of other pumps, compressors, taps and valves	Manufacturing
2814	Manufacture of bearings, gears, gearing and driving elements	Manufacturing
2815	Manufacture of ovens, furnaces and furnace burners	Manufacturing
2816	Manufacture of lifting and handling equipment	Manufacturing
2818	Manufacture of power-driven hand tools	Manufacturing
2819	Manufacture of other general-purpose machinery	Manufacturing
2821	Manufacture of agricultural and forestry machinery	Manufacturing
2822	Manufacture of metal-forming machinery and machine tools	Manufacturing
2824	Manufacture of machinery for mining, quarrying and construction	Manufacturing
2829	Manufacture of other special-purpose machinery	Manufacturing
2910	Manufacture of motor vehicles	Manufacturing
2930	Manufacture of parts and accessories for motor vehicles	Manufacturing
3011	Building of ships and floating structures	Manufacturing

Table 9.2: List of Strategic Industries, Cont...

ISIC	Industry	Sector
3020	Manufacture of railway locomotives and rolling stock	Manufacturing
3030	Manufacture of air and spacecraft and related machinery	Manufacturing
3040	Manufacture of military fighting vehicles	Manufacturing
3091	Manufacture of motorcycles	Manufacturing
3099	Manufacture of other transport equipment n.e.c.	Manufacturing
3250	Manufacture of medical and dental instruments and supplies	Manufacturing
3315	Repair of transport equipment, except motor vehicles	Manufacturing
3510	Electric power generation, transmission and distribution	Electricity, gas, steam supply
3520	Manufacture of gas; distribution of gaseous fuels through mains	Electricity, gas, steam supply
3530	Steam and air conditioning supply	Electricity, gas, steam supply
3600	Water collection, treatment and supply	Water supply, sewerage
3700	Sewerage	Water supply, sewerage
3811	Collection of non-hazardous waste	Water supply, sewerage
3812	Collection of hazardous waste	Water supply, sewerage
3900	Remediation activities and other waste management services	Water supply, sewerage
4100	Construction of buildings	Construction
4210	Construction of roads and railways	Construction
4220	Construction of utility projects	Construction
4290	Construction of other civil engineering projects	Construction
4721	Retail sale of food in specialized stores	Wholesale
4722	Retail sale of beverages in specialized stores	Wholesale
4759	Retail sale of electrical household appliances, furniture, lighting equipment	Wholesale
4911	Passenger rail transport, interurban	Transportation
4912	Freight rail transport	Transportation
4921	Urban and suburban passenger land transport	Transportation
4923	Freight transport by road	Transportation
4930	Transport via pipeline	Transportation
5011	Sea and coastal passenger water transport	Transportation
5012	Sea and coastal freight water transport	Transportation
5021	Inland passenger water transport	Transportation
5022	Inland freight water transport	Transportation
5110	Passenger air transport	Transportation
5120	Freight air transport	Transportation
5221	Service activities incidental to land transportation	Transportation
5222	Service activities incidental to water transportation	Transportation
5223	Service activities incidental to air transportation	Transportation
5310	Postal activities	Transportation
5510	Short term accommodation activities	Accomodation
5820	Software publishing	Publishing
5911	Motion picture, video and television programme production activities	Publishing
5912	Motion picture, video and television programme post-production activities	Publishing
5913	Motion picture, video and television programme distribution activities	Publishing
5914	Motion picture projection activities	Publishing
6110	Wired telecommunications activities	Publishing
6120	Wireless telecommunications activities	Publishing
6130	Satellite telecommunications activities	Publishing
6190	Other telecommunications activities	Publishing
6202	Computer consultancy and computer facilities management activities	Publishing
6311	Data processing, hosting and related activities	Publishing
6312	Web portals	Publishing
6419	Other monetary intermediation	Financial Services
6430	Trusts, funds and similar financial entities	Financial Services
6491	Financial leasing	Financial Services
6492	Other credit granting	Financial Services
6499	Other financial service activities, except insurance and pension funding activities, n.e.c.	Financial Services
6612	Security and commodity contracts brokerage	Financial Services
6619	Other activities auxiliary to financial service activities	Financial Services
7210	Research and experimental development on natural sciences and engineering	Professional, scientific, technical activities
7410	Specialized design activities	Professional, scientific, technical activities
8610	Hospital activities	Human health and social services

B.2 - Alternative Measure

To ensure my argument captures Chinese leaders' beliefs about what constitutes a strategic industry, I created an alternative measure of strategic using three authoritative central industrial and technology policies: the MLP, the Strategic Emerging Industries initiative, and Made in China 2025. The Figure below shows the marginal effect of strategic status on tech extraction using this alternative measure. As the figure shows, using this measure does not substantially alter the result.

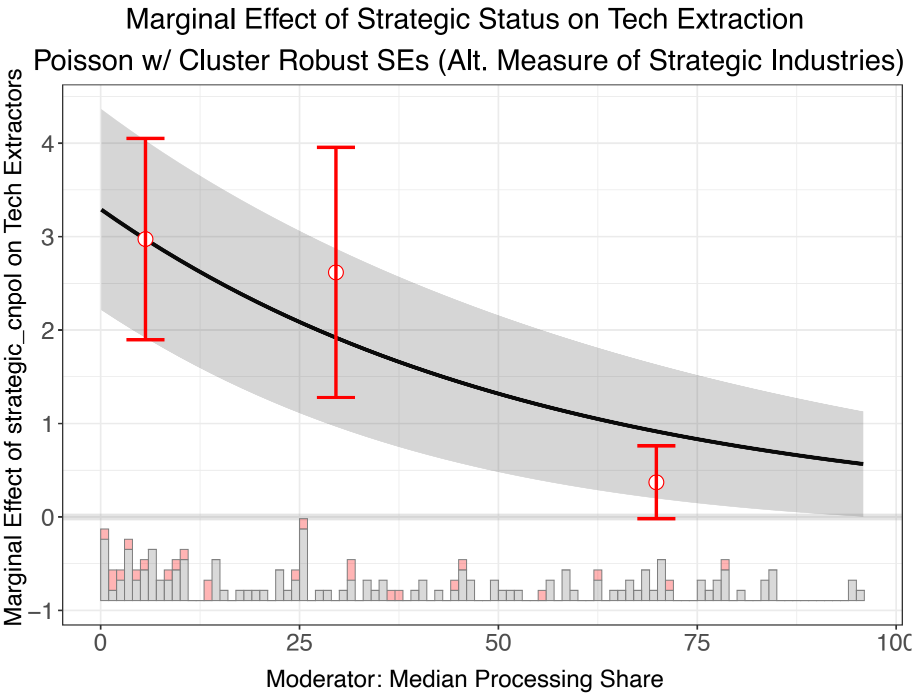


Figure 9.1: **Marginal Effect of Strategic Status on Tech Extraction**:

Table 1 provides Chinese- and English-language descriptions of the industries included in each of these policies.

Table 9.3: Strategic Industries, Alternative Measure

Industry (Chinese)	**Industry (English)**	**Policy**
生物技术	Biotechnology	MLP
信息技术	Information Technology	MLP
新材料技术	New Material Technology	MLP
先进制造技术	Advanced Manufacturing Technology	MLP
先进能源技术	Advanced Energy Technology	MLP
海洋技术	Marine Technology	MLP
激光技术	Laser Technology	MLP
空天技术	Aerospace Technology	MLP
节能环保产业	Energy Saving and Environmental Protection Industry	SEI
新一代信息技术产业	New Generation Information Technology Industry	SEI
生物产业	Bio Industry	SEI
高端装备制造产业	High-end Equipment Manufacturing Industry	SEI
新能源产业	New Energy Industry	SEI
新材料产业	New Material Industry	SEI
新能源汽车产业	New Energy Vehicle Industry	SEI
新一代信息技术产业	New Generation Information Technology Industry	MIC 2025
高档数控机床和机器人	High-end CNC Machines and Robots	MIC 2025
航空航天装备	Aerospace Equipment	MIC 2025
海洋工程装备及高技术船舶	Offshore Engineering Equipment and High-Tech Ships	MIC 2025
先进轨道交通装备	Advanced Rail Transit Equipment	MIC 2025
节能与新能源汽车	Energy Saving and New Energy Vehicles	MIC 2025
电力装备	Electrical Equipment	MIC 2025
农机装备	Agricultural Machinery and Equipment	MIC 2025
新材料	New Material	MIC 2025
生物医药及高性能医疗器械	Biomedicine and High-Performance Medical Devices	MIC 2025

Table 9.4: Industry Codes, Strategic Industries

ISIC	**Industry Description**
2100	Manufacture of pharmaceuticals, medicinal chemical and botanical products
2610	Manufacture of electronic components and boards
2620	Manufacture of computers and peripheral equipment
2630	Manufacture of communication equipment
2660	Manufacture of irradiation, electromedical and electrotherapeutic equipment
2670	Manufacture of optical instruments and photographic equipment
2680	Manufacture of magnetic and optical media
3011	Building of ships and floating structures
3020	Manufacture of railway locomotives and rolling stock
3030	Manufacture of air and spacecraft and related machinery
3040	Manufacture of military fighting vehicles
2811	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
2812	Manufacture of fluid power equipment
2813	Manufacture of other pumps, compressors, taps and valves
2814	Manufacture of bearings, gears, gearing and driving elements
2816	Manufacture of lifting and handling equipment
2818	Manufacture of power-driven hand tools
2819	Manufacture of other general-purpose machinery
2513	Manufacture of steam generators, except central heating hot water boilers
2011	Manufacture of basic chemicals
2012	Manufacture of fertilizers and nitrogen compounds
2013	Manufacture of plastics and synthetic rubber in primary forms
1910	Manufacture of coke oven products
1920	Manufacture of refined petroleum products
2910	Manufacture of motor vehicles

Table 2 lists relevant ISIC codes and English-language industry descriptions used to create this alternative measure.

Appendix C - Full Results and Additional Interflex Figures

C.1 - Full Results w/ Controls

Table 9.5: Full Results from Regression with OLS, Poisson, Zero-inflated Poisson (w/ Controls)

	Dependent variable:								
	TE by Industry-Year, Sq. Rt. (1-3)			TE by Industry-Year (4-8)					Total TE (9)
		OLS			*Poisson*		*FE Poisson*	*Zero-inflated Poisson*	*Zero-inflated Poisson*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Strategic	0.431^{***}	0.248^{***}	1.049^{***}	2.838^{***}	2.789^{***}	2.974^{***}	2.977^{***}	0.803^{***}	1.668^{***}
	(0.082)	(0.082)	(0.238)	(0.043)	(0.072)	(0.093)	(0.430)	(0.097)	(0.191)
Post-2006		0.046^{***}							
		(0.018)							
Strategic x Post-2006		0.384^{***}							
		(0.079)							
Median Processing Share			-0.001		0.001	0.002		0.012^{***}	0.022^{***}
			(0.001)		(0.002)	(0.002)		(0.002)	(0.004)
Processing Share							0.009		
							(0.008)		
Median HHI			0.0001			0.0001^{***}	0.00002	0.00001	0.0001
			(0.0002)			(0.00003)	(0.0001)	(0.00002)	(0.00003)
Median SOE Share			0.092			-0.652^{***}	-0.052	-2.055^{***}	-1.101^{***}
			(0.345)			(0.081)	(0.260)	(0.128)	(0.181)
Strategic x Med. Processing Share			-0.012^{***}		-0.019^{***}	-0.025^{***}		-0.020^{***}	-0.034^{***}
			(0.004)		(0.002)	(0.002)		(0.002)	(0.004)
Strategic x Processing Share							-0.016^{*}		
							(0.009)		
sigma							1.687^{***}		
							(0.030)		
Constant				-2.313^{***}	-1.622^{***}	-1.612^{***}	-2.023	1.582^{***}	1.648^{***}
				(0.041)	(0.068)	(0.097)	(6.589)	(0.097)	(0.193)
Year FE	Yes	No	Yes				Yes		
Industry FE (ISIC 2-digit)	Yes	Yes	No				Yes		
Controls	No	No	Yes	No	No	Yes	Yes	Yes	Yes
Observations	8,820	8,820	3,045	8,820	4,347	3,045		3,045	145
Adjusted R^2	0.310	0.320	0.207						

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

C.2 - Additional Interflex Figures

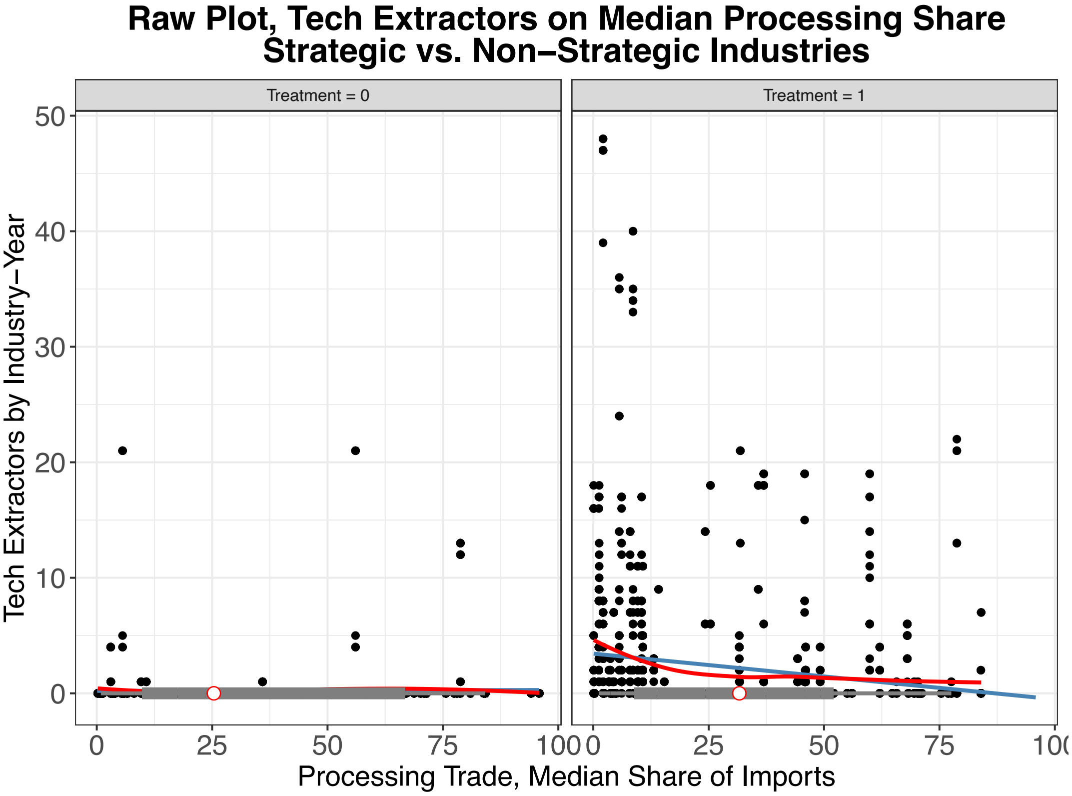


Figure 9.2

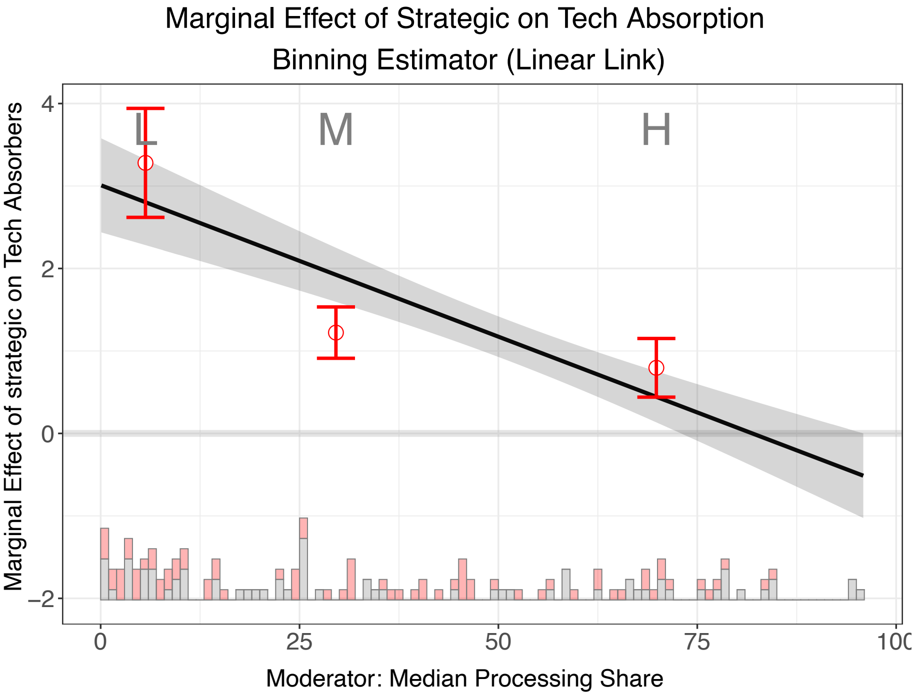


Figure 9.3

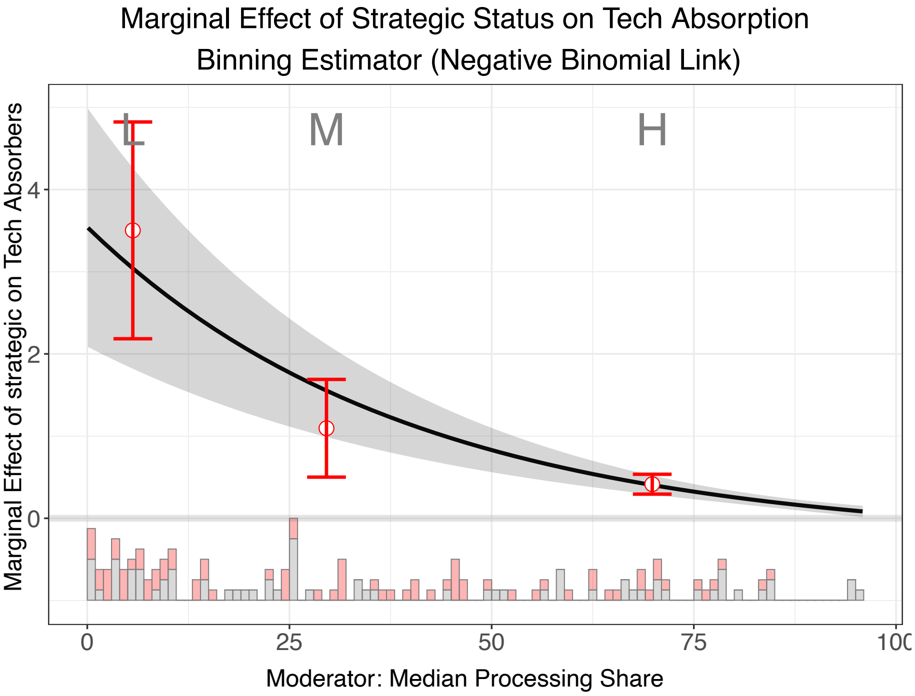


Figure 9.4

Appendix D - Full Results by Type of Technology Extractor

D.1 - Results excluding 2012-2015 Government Procurement

Table 9.6: Results using Government Procurement 2009-2011 Only

	Dependent variable:								
	TE by Industry-Year, Sq. Rt. (1-3)			TE by Industry-Year (4-8)					
	OLS				*Poisson*		*Negative Binomial*	*Zero-inflated Poisson*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Strategic	0.307^{***}	0.283^{***}	0.679^{***}	2.900^{***}	2.631^{***}	3.512^{***}	3.622^{***}	1.545^{***}	2.097^{***}
	(0.062)	(0.062)	(0.150)	(0.096)	(0.173)	(0.302)	(0.359)	(0.228)	(0.328)
Post-2006		0.015							
		(0.009)							
Strategic x Post-2006		0.042							
		(0.036)							
Median Processing Share			−0.0003		−0.008	0.005		0.021^{***}	0.023^{***}
			(0.001)		(0.007)	(0.008)		(0.004)	(0.006)
Processing Share							0.011		
							(0.007)		
Median HHI			0.0001			0.0001^{**}	0.0001	-0.00004^{*}	0.00000
			(0.0001)			(0.0001)	(0.0001)	(0.00002)	(0.00004)
Median SOE Share			0.284			0.045	0.190	-1.229^{***}	-0.697^{***}
			(0.250)			(0.233)	(0.279)	(0.141)	(0.201)
Strategic x Med. Processing Share			-0.008^{***}		−0.009	-0.025^{***}		-0.023^{***}	-0.033^{***}
			(0.003)		(0.007)	(0.008)		(0.004)	(0.006)
Strategic x Processing Share							-0.022^{***}		
							(0.008)		
Constant				-2.903^{***}	-2.097^{***}	-3.107^{***}	−2.980	0.210	0.796^{**}
				(0.081)	(0.151)	(0.298)	(4.154)	(0.229)	(0.332)
Year FE	Yes	No	Yes				Yes		
Industry FE (ISIC 2-digit)	Yes	Yes	No				Yes		
Controls	No	No	Yes	No	No	Yes	Yes	Yes	Yes
Observations	10,920	10,920	3,770					3,770	145
Adjusted R^2	0.277	0.258	0.200						

Note: *p<0.1; **p<0.05; ***p<0.01

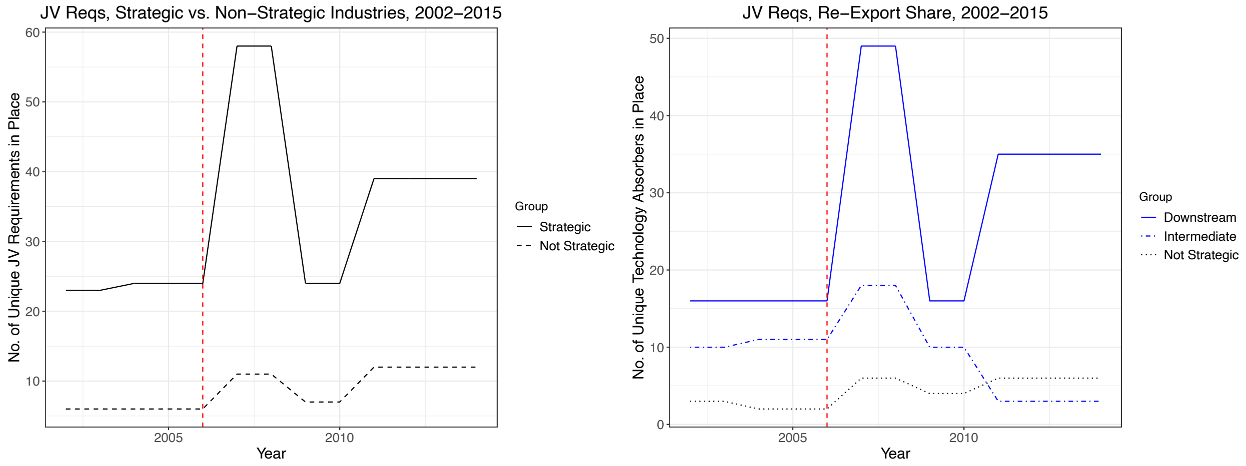
D.2 - Full Results excluding Infrastructure and Resource Strategic Industries (R&D Intensive Industries Only)

Table 9.7: Full Results using R&D Intensive Industries Only

	Dependent variable:								
	TE by Industry-Year, Sq. Rt. (1-3)			TE by Industry-Year (4-8)					
	OLS			*Poisson*			*Negative Binomial*	*Zero-inflated Poisson*	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
Strategic	0.422*** (0.077)	0.306*** (0.077)	0.843*** (0.187)	2.617*** (0.115)	2.611*** (0.208)	2.760*** (0.307)	3.107*** (0.420)	1.067	1.746*** (0.209)
Post-2006		0.021 (0.014)							
Strategic x Post-2006		0.203*** (0.057)							
Median Processing Share			−0.001 (0.001)		−0.002 (0.006)	−0.00004 (0.006)		0.018	0.024*** (0.004)
Processing Share							0.009 (0.008)		
Median HHI			0.0002 (0.0001)			0.0002*** (0.0001)	0.0001 (0.0001)	0.0001	0.0002*** (0.00005)
Median SOE Share			0.192 (0.251)			−0.416* (0.238)	0.014 (0.287)	−1.972	−1.186*** (0.199)
Strategic x Med. Processing Share			−0.009** (0.003)		−0.012* (0.006)	−0.019*** (0.007)		−0.024	−0.035*** (0.004)
Strategic x Processing Share							−0.020** (0.009)		
sigma							1.595*** (0.032)		
Constant				−2.246*** (0.102)	−1.729*** (0.190)	−1.963*** (0.308)	−2.177 (6.758)	0.977	1.272*** (0.243)
Year FE	Yes	No	Yes				Yes		
Industry FE (ISIC 2-digit)	Yes	Yes	No				Yes		
Controls	No	No	Yes	No	No	Yes	Yes	Yes	Yes
Observations	10,920	10,920	3,770					3,770	145
Adjusted R^2	0.280	0.261	0.202						

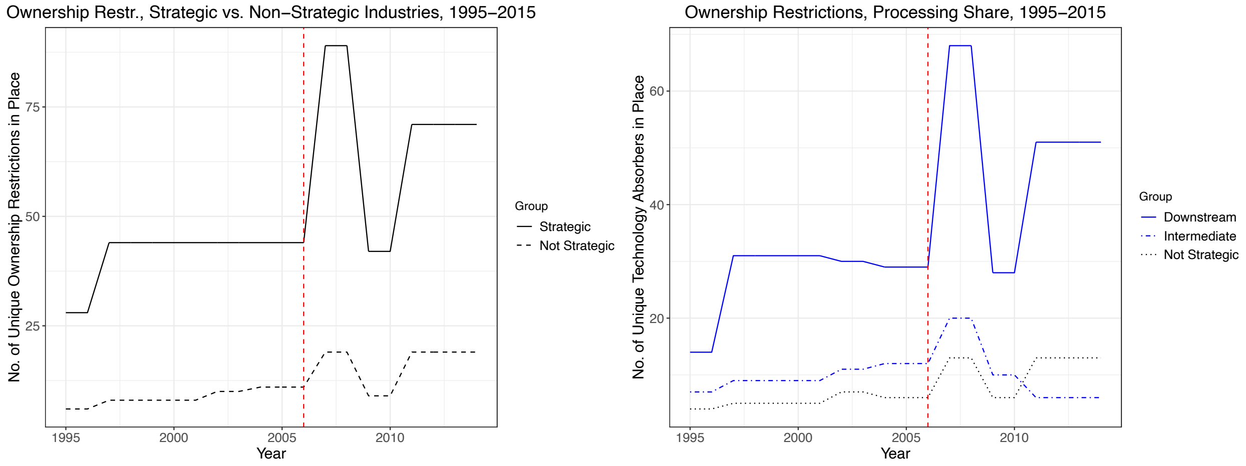
Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

D.3 - Trends by Type of Technology Extractor



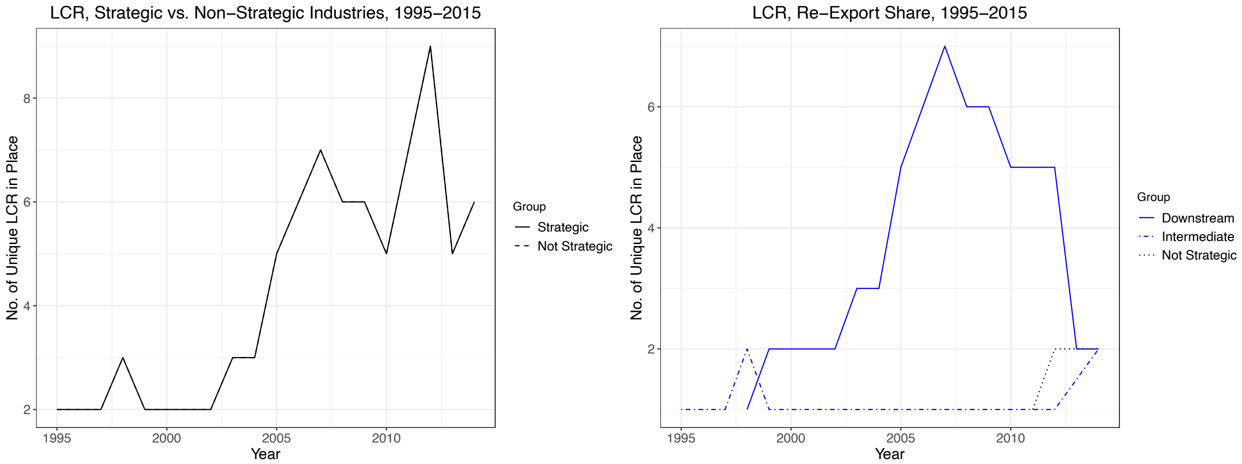
(a) Strategic vs. Non-Strategic Industries (b) High vs. Low Re-Export Share

Figure 9.5: Joint Venture Requirements



(a) Strategic vs. Non-Strategic Industries (b) High vs. Low Re-Export Share

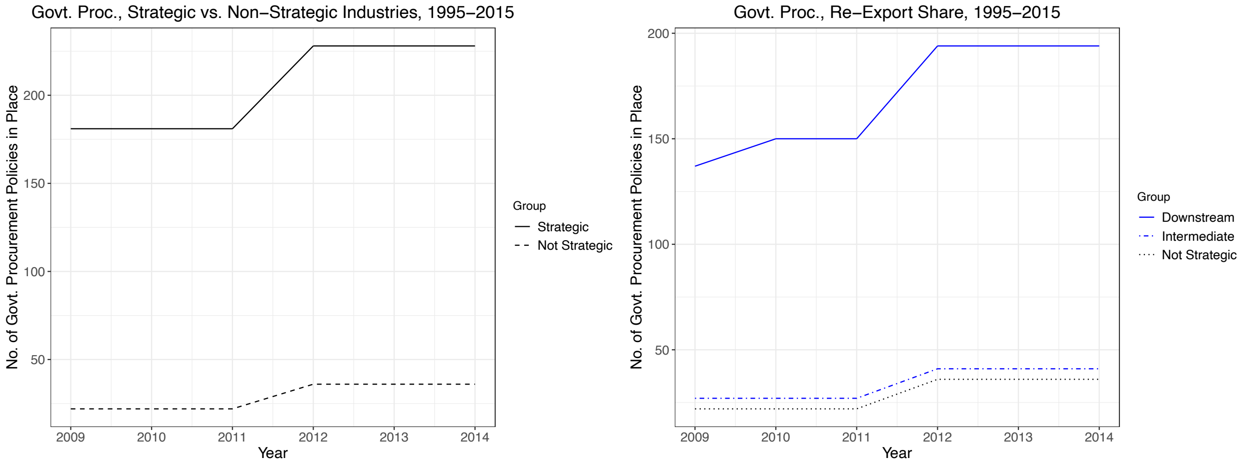
Figure 9.6: All Ownership Restrictions



(a) Strategic vs. Non-Strategic Industries

(b) High vs. Low Re-Export Share

Figure 9.7: Local Content Requirements



(a) Strategic vs. Non-Strategic Industries

(b) High vs. Low Re-Export Share

Figure 9.8: Preferential Government Procurement

D.4 - Main Results by Type of Technology Extractor

Table 9.8: FDI Ownership Restrictions as Outcome

	Dependent variable:			
	TE by Industry-Year, Sq. Rt. (1)			TE by Industry-Year (2-4)
	OLS	*Poisson*	*FE Poisson*	*Negative Binomial*
	(1)	(2)	(3)	(4)
Strategic	0.512^{***}	3.733^{***}	4.313^{***}	3.701^{***}
	(0.120)	(0.269)	(0.380)	(0.268)
Median Processing Share	-0.0002	-0.007		-0.007
	(0.001)	(0.006)		(0.006)
Processing Share			0.012^{**}	
			(0.006)	
Median HHI	0.0001	0.0004^{***}	0.0003^{***}	0.0005^{***}
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Median SOE Share	0.475^{**}	1.108^{***}	1.290^{***}	1.538^{***}
	(0.233)	(0.154)	(0.200)	(0.156)
Strategic x Median Processing Share	-0.006^{***}	-0.010^{*}		-0.012^{*}
	(0.002)	(0.006)		(0.006)
Strategic x Processing Share			-0.021^{***}	
			(0.007)	
sigma			15.668^{***}	
			(1.797)	
Constant		-4.531^{***}	-5.011^{***}	-4.798^{***}
		(0.272)	(0.461)	(0.278)
Year FE	Yes	No	Yes	
Industry FE (ISIC 2-digit)	Yes	Yes	No	
Observations	3,770			
R^2	0.222			
Adjusted R^2	0.216			
Residual Std. Error	0.507 (df = 3739)			
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 9.9: Local Content Requirements as Outcome

	Dependent variable:			
	TE by Industry-Year, Sq. Rt. (1)			TE by Industry-Year (2-4)
	OLS	*Poisson*	*FE Poisson*	*Negative Binomial*
	(1)	(2)	(3)	(4)
Strategic	0.090***	2.172***	2.357***	2.239***
	(0.015)	(0.446)	(0.662)	(0.428)
Median Processing Share	−0.0002	−0.014		−0.016
		(0.011)		(0.010)
Processing Share			−0.004	
			(0.014)	
Median HHI	0.00001	0.0002**	0.0002**	0.001***
		(0.0001)	(0.0001)	(0.0001)
Median SOE Share	−0.064***	−1.768***	0.086	−2.484***
		(0.490)	(0.459)	(0.479)
Strategic x Median Processing Share	−0.001	−0.008		−0.008
		(0.013)		(0.012)
Strategic x Processing Share			−0.013	
			(0.015)	
sigma			23.595**	
			(10.487)	
Constant		−4.164***	−4.976***	−4.637***
		(0.407)	(0.632)	(0.378)
Year FE	Yes	No	Yes	
Industry FE (ISIC 2-digit)	Yes	Yes	No	
Observations	3,770			
R^2	0.040			
Adjusted R^2	0.032			
Residual Std. Error	0.198 (df = 3739)			
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 9.10: Government Procurement as Outcome

	Dependent variable:			
	TE by Industry-Year, Sq. Rt. (1)	TE by Industry-Year (2-4)		
	OLS	*Poisson*	*FE Poisson*	*Negative Binomial*
	(1)	(2)	(3)	(4)
Strategic	0.445^{***} (0.045)	2.670^{***} (0.398)	3.058^{***} (0.607)	2.906^{***} (0.395)
Median Processing Share	-0.0002	0.003 (0.007)		0.008 (0.008)
Processing Share			0.017 (0.013)	
Median HHI	-0.00003	-0.0001 (0.0001)	-0.0003^{*} (0.0002)	0.001^{***} (0.0001)
Median SOE Share	-0.373^{***}	-2.534^{***} (0.513)	-2.189^{***} (0.605)	-2.400^{***} (0.463)
Strategic x Median Processing Share	-0.004	-0.022^{***} (0.008)		-0.033^{***} (0.009)
Strategic x Processing Share			-0.027^{**} (0.013)	
sigma			0.053^{***} (0.002)	
Constant		-1.363^{***} (0.377)	-1.815 (171.291)	-2.471^{***} (0.306)
Year FE	Yes	No	Yes	
Industry FE (ISIC 2-digit)	Yes	Yes	No	
Observations	3,045			
R^2	0.146			
Adjusted R^2	0.139			
Residual Std. Error	0.754 (df = 3019)			

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Appendix E - Product Characteristics Models

To further probe my argument about the moderating effect of China's intermediate position in GVCs on its use of technology extractors in strategic industries, I ran a battery of tests of the relationship between my variables of interest and various measures of product characteristics. If China's position in GVCs shapes its propensity to impose these policy tools, then we might expect China to use them more often in industries characterized by certain kinds of goods than others.

For example, if China is most prone to introduce tech extractors in industries in which it sits downstream of GVCs, we should observe a positive relationship between the relative "downstreamness" of industries and the number of tech extractors used. By the same token, we might expect China to impose fewer of these policies in industries with a preponderance of upstream goods. In addition, we might anticipate China to pursue tech extraction intensively in finished capital goods, which are downstream of GVCs and for which, because they are primarily consumed by firms, the Chinese state is particularly well-positioned to shape demand levels through policy interventions. By contrast, because it is harder for the state to influence ordinary consumers' consumption preferences, China may use fewer of these tools in industries where household goods predominate.

To examine these possibilities, I constructed several measures of product-level characteristics by industry. First, using the UN's Broad Economic Categories (BEC) table, which sorts HS 6-digit level products into household consumption, intermediate, and capital goods, I calculated the number of products in each category for each ISIC 4-digit industry. This yielded three variables which count the number of household, intermediate, and capital goods, respectively, in each industry. To reduce variance, I log each variable.[1]

Second, I used the `concordance` package from Liao et al. (2020) to calculate levels of upstreamness, downstreamness, and intermediateness by industry. `Concordance` calculates upstreamness and downstreamness at the ISIC 2-digit level for specific countries and years based on measures from Antras (2018). For both measures, I set the country to China and year to 2008. To

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[1] To be safe, I repeated this process using an original measure of product type by HS 6-digit level product based on analysis of US import transaction data from Panjiva, a trade research database. I developed this measure jointly with collaborators for a separate project. This measure yields similar results to the BEC data.

assess intermediateness, `concordance` calculates the proportion of products containing keywords associated with intermediate goods (e.g. “part(s)", “component(s)") for each input code. I calculate the proportion by HS 4-digit heading and aggregate to the ISIC 4-digit level.

After creating these measures, I re-ran my main model specification (model 6 in Table 1) six times, each time controlling individually for one product-level characteristic. My goal was to assess (1) the sign and significance of the relationship between each product characteric measure and my outcome variable, and (2) whether controlling for product-level characteristics substantially altered the association between my main variables of interest. In addition, I ran simple bivariate regressions of the outcome on each product type measure to ensure the main results hold absent controls. Based on the above discussion, I expected the coefficients on the BEC capital goods and `concordance` downstreamness measures to be positive and significant. In turn, the coefficient on upstreamness should be negative and significant. I did not have strong a prior about the coefficients on either measure of intermediateness because industries in which China is both intermediate in and downstream of GVCs rely heavily on intermediate inputs. Similarly, I did not have strong priors about household consumption goods. Household consumption goods themselves are downstream of GVCs, but my measure may be too aggregated to capture fine distinctions in trade data between finished consumer goods and inputs into them. In addition, there are not many strategically important industries where household consumption goods predominate.

Although one measure of intermediate goods based on the `Concordance` package shows a negative and significant relationship between the intermediateness of a product and the use of technology extractors (Table 4), the sign and significance of intermediateness varies significantly depending on the measure and modeling strategy. For example, the same measure of intermediateness from `Concordance` is positive and significantly associated with tech extraction in Zero-inflated Poisson regression (Table 6) and not significantly associated with tech extraction in Negativ Binomial regression (Table 5). Meanwhile, an alternative measure of intermediateness based on the United Nations’ Broad Economic Categories (BEC) measure is positively but not significantly associated with tech extraction under Poisson regression, positively and significantly associated under

Negative Binomial regression, and negatively (but not significantly) associated under Zero-inflated Poisson. Meanwhile, the sign and significance on *Strategic* and on *Strategic x Median Processing Share* are significant and maintain the expected signs in every model.

Table 9.11: Poisson Regression with Cluster Robust SEs, Product Char. Models

	Dependent variable:					
	TE by Industry-Year					
	(1)	(2)	(3)	(4)	(5)	(6)
Strategic	2.973	2.769^{***}	2.536^{***}	2.795^{***}	3.124^{***}	2.672^{***}
	(2.973)	(0.093)	(0.093)	(0.095)	(0.093)	(0.093)
Median Processing Share	0.002	0.002	0.008^{***}	0.003^{*}	0.002	−0.002
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Intermediate Good (BEC)	0.009					
	(0.009)					
Consumer Good (BEC)		-0.253^{***}				
		(0.020)				
Capital Good (BEC)			0.392^{***}			
			(0.013)			
Intermediateness (Concordance)				-8.457^{*}		
				(5.093)		
Upstreamness					-0.664^{***}	
					(0.026)	
Downstreamness						1.526^{***}
						(0.060)
Median HHI	0.0001	0.0001^{***}	0.0001^{***}	0.0002^{***}	0.0002^{***}	0.0003^{***}
	(0.0001)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)
Median SOE Share	−0.655	-0.705^{***}	0.351^{***}	-0.550^{***}	0.081	0.130
	(−0.655)	(0.080)	(0.088)	(0.083)	(0.084)	(0.089)
Strategic x Median Processing Share	−0.026	-0.024^{***}	-0.025^{***}	-0.023^{***}	-0.026^{***}	-0.026^{***}
	(−0.026)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	−1.629	-1.252^{***}	-2.120^{***}	-1.677^{***}	0.047	-6.816^{***}
	(−1.629)	(0.099)	(0.103)	(0.099)	(0.121)	(0.233)
Observations	3,045	3,045	3,045	3,045	3,045	3,045
Log Likelihood	−7,295.835	−7,208.945	−6,840.827	−7,217.428	−6,942.607	−6,925.683
Note:						*p<0.1; **p<0.05; ***p<0.01

Appendix F - Lagged Outcome Variable Models

To guard against the risk that previous values of the outcome variable explain future use of technology extractors, I re-ran my main model specification including 2- and 3-year lagged outcome variables on the right hand side. The figures below show that including a lagged outcome variable does not meaningful alter the association between the interaction of strategic status and processing share and China's use of technology extractors. I use 2- and 3-year lagged outcome variables because this reflects the intervals between revisions of relevant policies. For example, China issued the Foreign-Invested Industry Guidance Catalogue, which contains industry-specific JV requirements and other ownership restrictions on inward FDI, in 1995, 1997, 2002, 2004, 2007, 2009, 2011, 2015, and 2017.

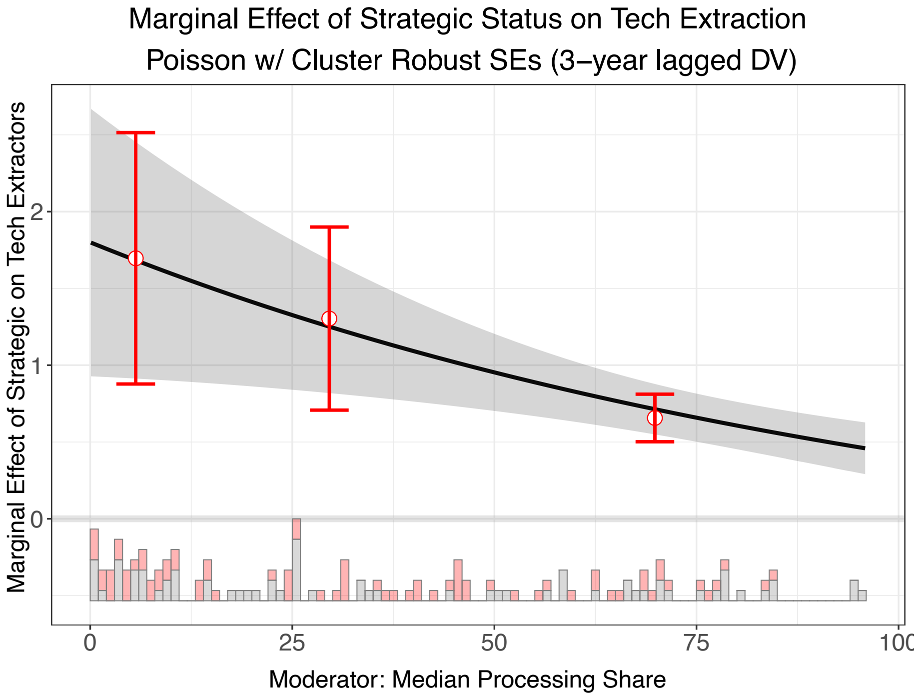

Figure 9.9: Marginal Effect of Strategic Status on Tech Extraction (2-Year lagged DV)

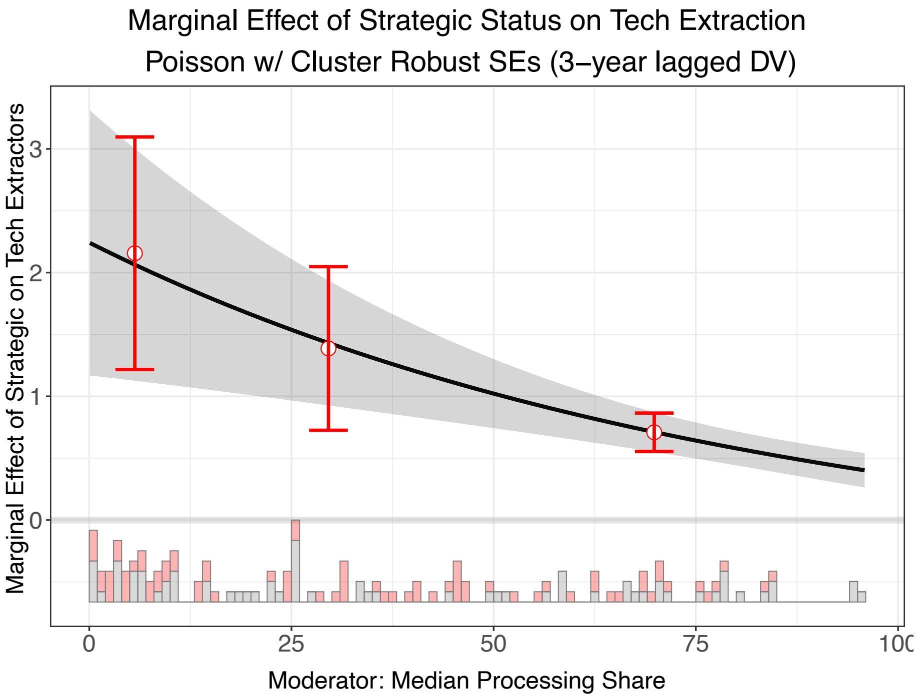

Figure 9.10: Marginal Effect of Strategic Status on Tech Extraction (3-Year lagged DV)

Appendix G - Market Size Models

To formally test my claim that position in GVCs, not market size, explains cross-industry variation in Chinese technology extraciton, I examined the impact of market size on tech extraction using an approximate measure of China's share of global imports by ISIC 4-digit industry after subtracting processing trade-related imports. To calculate this quantity, I multiplied the measure of median industry-level processing share obtained from CCD (in decimal form) by total Chinese imports per industry based on data from UN Comtrade. I then divided this figure by total world imports per industry. I use data on Chinese and world imports from UN Comtrade because CCD calculates import value in RMB, not USD, so directly comparing Chinese import values from CCD to world import values in UN Comtrade is not feasible.[2] I then calculated, for each ISIC 4-digit industry, China's median share (in percent terms) of world imports from 2001-2008, excluding processing trade-related imports. I choose 2001-2008 because this covers the key post-WTO years during which Chinese tech extraction surged. I use both logged and unlogged measures.

Figure 10 replicates model 6 from Table 1 but includes a control for China's logged median global market share by industry, excluding processing trade. Controlling for market size does not meaningfully affect the size or statistical significance of the coefficients on `Strategic` or `Strategic x Median Processing Share` across any of my main model specifications. Moreover, I find that the direct relationship between market size and technology extraction is surprisingly sensitive to modeling choices, the inclusion of controls, and the measure used, with the log of market size positive and significant in most models and the unlogged measure negative and insignificant in several. Nonetheless, although the results suggest the impact of market size is weaker and less consistent than that of my main explanatory variables of interest, market size does appear to be positively associated with tech extraction and to have a positive impact on the marginal effect of strategic importance.

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[2] Per Hao Zhang, CCD and UN Comtrade figures for trade volume are highly similar: For 95 percent of HS 6-digit products, there is less than 5 percent difference in reported trade volumes between the two sources.

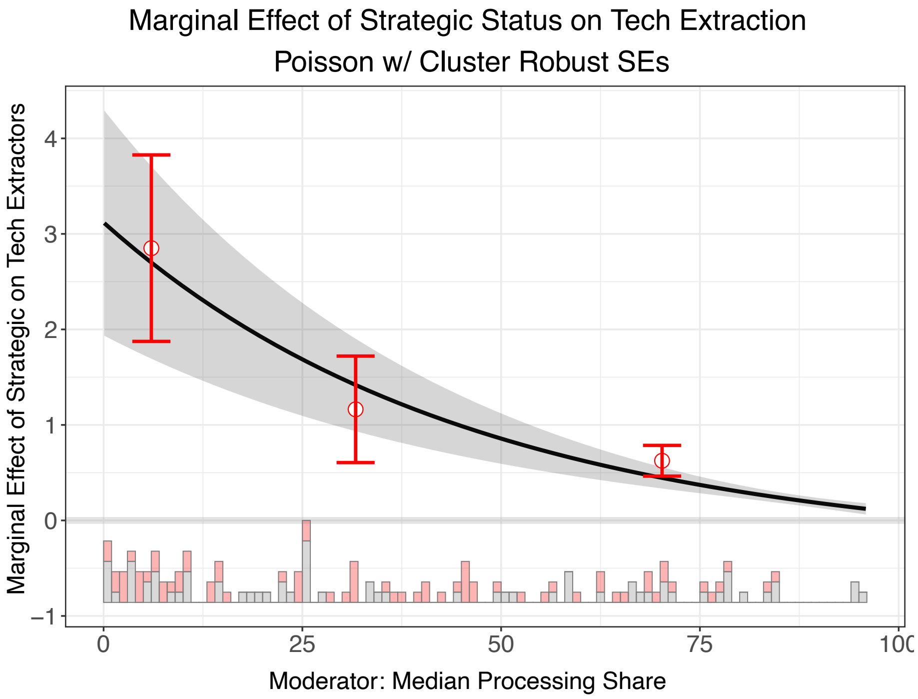

Figure 9.11: **Marginal Effect of Strategic Status on Tech Extraction (w/ Market Size)**: After controlling for market size, measure as China's share of global imports excluding processing trade (logged), the coefficient on the interaction between strategic status and processing is somewhat smaller, but remains positive and significant across all three bins.

Overall, the results reinforce my argument that existing approaches to bargaining power are insufficient. In focusing on the size of a country's consumer base, previous works ignore important variation *across industries* in bargaining power, as well as the role of expectations about future market growth in China in shaping the balance of dependence between China and foreign investors. More importantly, existing research does not consider transnational production constrains bargaining power's use.

Table 9.12: Models w/ control for Global Market Share (Logged)

	Dependent variable:							
	TE by Industry-Year, Sq. Rt. (1-3)			TE by Industry-Year (4-8)				
	OLS			*Poisson*			*Negative Binomial*	*Zero-inflated Poisson*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Strategic	0.442*** (0.108)	0.273** (0.108)	0.818*** (0.170)	3.033*** (0.076)	1.215*** (0.094)	2.797*** (0.095)	2.520*** (0.217)	0.370*** (0.099)
Post-2006		0.070** (0.029)						
Strategic x Post-2006		0.321*** (0.080)						
Median Processing Share			−0.0003 (0.001)	0.002 (0.002)		0.003* (0.002)	0.0004 (0.003)	0.010*** (0.002)
Median Global Share (logged)			0.029 (0.071)		−0.274*** (0.103)	0.219*** (0.024)	0.377*** (0.095)	0.470*** (0.034)
Median HHI			0.0001 (0.0001)		−0.0001*** (0.00003)	0.00001 (0.00003)	0.001*** (0.0001)	−0.00001 (0.00002)
Median SOE Share			0.181 (0.297)		0.304*** (0.086)	−0.256*** (0.088)	0.343 (0.350)	−1.056*** (0.123)
Strategic x Median Processing Share			−0.010*** (0.003)	−0.025*** (0.002)		−0.026*** (0.002)	−0.025*** (0.004)	−0.016*** (0.002)
Strategic x Market Size					0.811*** (0.106)			
Constant				−1.595*** (0.072)	−0.938*** (0.096)	−1.588*** (0.099)	−2.644*** (0.252)	1.202*** (0.100)
Year FE	Yes	No	Yes					
Industry FE (ISIC 2-digit)	Yes	Yes	No					
Observations	3,743	3,743	2,660	3,743	2,660	2,660	2,660	2,660
R^2	0.327	0.330	0.228					
Adjusted R^2	0.316	0.322	0.221					
Log Likelihood				−7,550.141	−7,061.676	−6,742.394	−2,762.028	−3,801.618
Residual Std. Error	0.561 (df = 3681)	0.558 (df = 3697)	0.670 (df = 2635)					

Note: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

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