The Structural Preconditions for Maximizing FDI Spillovers in Colombia


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ABSTRACT

Do multinational corporations (MNCs) crowd out domestic firms in developing countries, or is foreign direct investment (FDI) complementary to domestic firm profitability, productivity, and employment? Empirical literature has identified diverse channels through which FDI facilitates aggregate spillovers to the host economy—including total factor productivity (TFP) transfers, employment generation, as well as backward and forward linkages—however there is much less consensus regarding the structural preconditions that maximize the net gains from such spillovers. In this work, I quantify the trade-offs from FDI across ten expansive sectors of the Colombian economy, combining econometric and inter-industry linkage analyses to capture the impact of FDI on industry output, labor payments, firm productivity, and productive diversification.

I first apply fixed effects multivariate regression models to a rich longitudinal panel of Colombian and foreign firm financial statements to capture the marginal effect of a 1% increase in MNC sector output share on domestic industry output and labor payments (as a proxy for employment). Combining this dataset with information from the Colombian national accounts, I construct annual input-output tables distinguishing domestic from MNC intermediate purchases, improving on the proxy for backward linkages proposed by Javorcik (2004). I then test for total factor productivity (TFP) spillovers by sector controlling for factor inputs at the firm level, and instrument for FDI using average wage data on sending countries to improve causal inference.

I find a negative and statistically significant correlation between foreign share of sector output and domestic sector revenue—a 1.8% average decrease in domestic revenue for a given 1% increase in MNC sector output share. The impact on wages at the industry level yields a similar result—a 1% increase in foreign share of output is associated with a 2.3% decrease in average domestic labor payments. The results also suggest countervailing positive and statistically significant (causal) TFP spillovers—a 1% increase in MNC causes a 2.2% increase in average domestic firm revenue through horizontal TFP spillovers, and a 160% increase in firm revenue through backward TFP spillovers to the manufacturing sector. Further decomposing these effects by industry reveals that specific sectors drive the overall results. We observe that the magnitude of FDI spillover depends on sector-specific structural characteristics that may or may not be conducive to growth—perhaps warranting strategic industrial, competitiveness, and FDI targeting policies that are differentiated by the unique role FDI plays in each sector.

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<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BanRep</td>
<td>Banco de la República (Colombian Central Bank)</td>
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<tr>
<td>BEA</td>
<td>United States Bureau of Economic Analysis</td>
</tr>
<tr>
<td>BLS</td>
<td>United States Bureau of Labor Statistics</td>
</tr>
<tr>
<td>COP</td>
<td>Colombian Pesos</td>
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<td>CPC</td>
<td>Consejo Privado de Competitividad</td>
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<td></td>
<td>(Colombian Private Council for Competitiveness)</td>
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<tr>
<td>DANE</td>
<td>Departamento Nacional Administrativo de Estadistica</td>
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<td></td>
<td>(Colombian National Statistics Administration)</td>
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<tr>
<td>DNP</td>
<td>Departamento Nacional de Planeación</td>
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<tr>
<td></td>
<td>(Colombian National Planning Department)</td>
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<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
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<td>ILO</td>
<td>International Labor Organization</td>
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<td>I-O</td>
<td>Input-Output</td>
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<td>ISIC</td>
<td>International Standard Industrial Classification</td>
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<tr>
<td>IPA</td>
<td>Investment Promotion Agency</td>
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<tr>
<td>IV</td>
<td>Instrumental Variable</td>
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<tr>
<td>LaborSta</td>
<td>Database of Labor Statistics (ILO)</td>
</tr>
<tr>
<td>MNC</td>
<td>Multinational Corporation</td>
</tr>
<tr>
<td>NAICS</td>
<td>North American Industry Classification System</td>
</tr>
<tr>
<td>OES</td>
<td>Occupational Employment Survey (BLS)</td>
</tr>
<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<tr>
<td>SITC</td>
<td>Standard International Trade Classification</td>
</tr>
<tr>
<td>SDS</td>
<td>Superintendencia de Sociedades</td>
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<tr>
<td></td>
<td>(Colombian National Business Registry)</td>
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<tr>
<td>TFP</td>
<td>Total Factor Productivity</td>
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1. Introduction

The extent to which foreign direct investment (FDI)—foreign equity in local firms and multinational corporation (MNC) investments—positively impact the economies of host countries is highly contested, and has profound implications for the economic livelihoods of low-income citizens in developing countries. Under optimal conditions, economic models suggest that MNC entry generates net gains for the host economy, however this assertion is not fully substantiated by empirical evidence. Despite being proffered to developing country policymakers as having a universally positive net impact on emerging economies (World Bank Group, 2010), there is no broad consensus regarding FDI’s overall effect on local economic outcomes. While econometric analyses have identified fragmented channels through which FDI facilitates local economic growth in successful cases—highlighting direct employment generation, total factor productivity (TFP) transfers, and backward linkages to local suppliers—the magnitude and net effect of FDI vary by both country and sector, and complex intertemporal trade-offs are often ignored in favor of more parsimonious models.\(^1\) The empirical literature’s failure to explain such wide variation in the impact of FDI warrants both deeper analysis, and alternatively framed questions that posit new hypotheses about the preconditions that maximize local FDI spillovers.

While recent studies have begun to examine the role of institutions in catalyzing positive FDI spillovers (Du, Harrison, and Jefferson, 2011), this work focuses on testing whether the structural and sectoral characteristics of net winning sectors from FDI can partially explain the conditions under which local spillovers are maximized. What impact, if any, do the structural (between sector) and sectoral (within sector) characteristics of an FDI-receiving industry have on its capacity to capture FDI spillovers? To answer this question, I combine econometric and inter-industry linkage analysis methods to quantify the trade-offs from FDI across ten sectors of the Colombian economy, and explore structural characteristics may explain the variation in FDI spillovers observed across sectors.

In order to classify the within sector impact of FDI, I first apply fixed effects multivariate regression models to a rich longitudinal panel of Colombian and foreign firm financial

\(^1\) The terms “sector” and “industry” are used interchangeably in this paper, as are “output” and “revenue”.
To capture both horizontal (within sector) and backward (between sector) TFP spillovers, I follow the specifications outlined in Aitken and Harrison (1999) and Javorcik (2004) respectively. I further combine the financial firm panel dataset from the Colombian national business registry Superintendencia de Sociedades (SDS) with intermediate purchase information from the Colombian national accounts, and construct annual input-output (I-O) tables distinguishing domestic from MNC intermediate purchase structures, improving on the proxy for backward linkages proposed by Javorcik. In testing for TFP spillovers by controlling for factor inputs at the firm level, I also instrument for FDI using average wage data on sending countries from the International Labor Organization (ILO) and Bureau for Labor Statistics (BLS) to improve causal inference. To complement these direct effects with more structural analysis, I also conduct an inter-industry linkage analysis to quantify backward and forward linkages from FDI in each sector using the same means for differentiating domestic and MNC intermediate purchase structures described above. Such separation enables an analysis of FDI’s position in the local industrial structure, as compared to the counterfactual of how domestic firms in the same industries relate to domestic productive structure. From this analysis, I make sector-specific inferences about the conditions that have led to FDI’s unique impact in each industry, and draw implications for industrial, competitiveness, and FDI targeting policies in the context of each sector, suggesting possible routes for future policies depending on national and local economic growth priorities and strategies.

1.1 The Dynamic Effects of FDI

While FDI is a relatively new phenomenon in the spectrum of international trade and as a driver of economic growth, its impact on the local economy has been theorized to have broad-ranging effects depending on the context of a given investment. Under optimal scenarios, firm theory
suggests that foreign equity investments increase local firm competitiveness (own-firm effect) while MNC investments generate direct employment opportunities at varying magnitudes according to the firm’s factors of production. MNC entry may also proliferate local spillovers in the form of backward linkages—increased demand for domestic supplier inputs that boosts local upstream production and incentivizes employers to bring on new hires or increase wages in the short run. Depending largely on whether the MNC is export-oriented and its position relative to the host country’s industrial structure, foreign firms may further facilitate forward linkages by providing low-cost or new inputs downstream. In the long run, MNCs at the technological frontier may also transfer technical and managerial knowledge to domestic suppliers (learning spillovers) or may place competitive pressure on local firms in the same industry through market share acquisition (demonstration effect), forcing them to become more productive or exit the market. If these well defined but hard-to-measure positive externalities exist, FDI may ultimately improve local firm competitiveness in exports or enable global market penetration in the long run.

On the other hand, FDI entry may also substitute rather than complement local economic activity, seizing both natural resources and the opportunity to produce away from the host country. MNCs may outcompete local firms in the same sector (competition effect) and crowd out domestic enterprises entirely by using monopolistic price-setting power, dumping, or engaging in other forms of imperfect competition that undercut local downstream output. A persistent FDI openness policy may also dominate the policy discourse in such a way that infant industries stay perpetually stagnant. Such policies may also result in a “race to the bottom” among developing countries and municipalities that compete for FDI and effectively bid down local spillovers. Furthermore, MNCs concentrated in extractive commodities and other low value added sectors may never exhibit strong linkages to the local economy but rather stunt local multiplier effects by repatriating profits away from the host economy, resulting in insular enclave economies.

Empirical literature has identified backward linkages to suppliers as the channel through which known MNC knowledge spillovers and other gains from FDI are facilitated,\(^2\) however has not

\(^2\) The most convincing empirical cases are Javorcik (2004) and Kugler (2006), however as I discuss in Chapter 4, the authors’ use of input-output matrices in measuring total factor productivity spillovers between sectors does not take into account the different inter-industry purchase structures between domestic and MNC firms.
yet resolved whether there is any single "overall" effect of FDI on local economic outcomes, prompting several authors to call for a deeper analysis of the conditions under which FDI entry is welfare-maximizing for the host economy (Harrison and Rodríguez-Clare, 2009). For example when technology, finance, access to export markets, or productive and diversification are identified as major binding constraints to growth, MNCs may play a special and strategic role in economic development regardless of their first-order effects on the economy. The more recent implications that "not all FDI is created equal" has led to callings for a more nuanced search for the conditions under which foreign firm entry generates net spillovers, and a deeper understanding of when industrial and competitiveness policies that attempt to enhance the net benefits from FDI are warranted and appropriately designed.

While there is strong evidence that foreign equity enhances local firm productivity, in this work I focus on the costs and benefits associated with MNC investments exclusively—investments for which the empirical literature has reached no overarching consensus. I define MNCs as foreign firms with greater than 50% foreign equity and measure their effect on domestic firms with less than 50% foreign equity. This is done for three major reasons: (1) the majority of FDI inflows to Colombia over the period observed (1995 – 2009) have been Greenfield or “new” multinational corporation investments rather than foreign equity investments in domestic firms (SDS, 2010); (2) the effect of FDI on productivity usually takes place when the foreign parent company has managing control over the board of directors and thus influence over major operational decisions—a controlling share which is usually defined at the 50% equity threshold; and (3) the data required to analyze the impact of foreign equity on domestic firm productivity are confidential in Colombia, and were not made available for this study.

1.2. FDI in the Context of Colombian Economic Growth

Colombia is an ideal country for studying FDI because it contains rich firm level data, detailed national accounts, as well as a strong history of FDI attraction policies. In 1991, Colombia overhauled its constitution and abandoned the import-substitution-industrialization (ISI) policies

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3 The “binding constraints” framework is defined in Hausmann R., Rodrik D., and Velasco A. (2005), “Growth Diagnostics”
of the previous twenty years in favor of a new export-led strategy aimed at improving the country's competitiveness via structural adjustments and pareto gains in the economy's productive structure (Eslava and Melendez, 2009). Part of the associated 5-year plans were deliberate efforts to attract export-oriented FDI to the region—with simultaneous goals of boosting growth, employment, exports, and increasing local firm competitiveness via long-run learning spillovers to local firms. Law 9 of 1991 eliminated all restrictions on FDI (except for in media), inviting an unprecedented surge in both foreign equity and MNC investments (see Figure 1.1), which until the 2008 global financial crisis tracked reasonably well with economic growth.

Figure 1.1 FDI Net Inflows to Colombia (Millions of Current US$) Against GDP Growth Rate, 1970 - 2010

Source: World Bank Development Indicators Database 2011

While Colombia experienced modest growth throughout the 1990s, from 2002 to 2010 (a period of record FDI inflows and improved security due to the quelling of the long-standing armed conflict), the economy exhibited some of the highest growth rates of the region—including 7.5% GDP growth in 2007. From 2002 to 2010, FDI also accounted for between 2% and 7% of nominal GDP, highlighting its importance in economic growth. Yet the extent to which FDI is associated with or even a causal factor for growth is questionable, as roughly half of FDI inflows are invested in extractive commodities, such as petroleum, mining, and minerals (see Figure 1.2).
Increased concentration in petroleum and mining sectors is not specific to foreign firms however. The need to encourage economic diversity in Colombia has become a high priority for policymakers due to the imminent *boom minero-energético* (energy-mining boom)—a term used to encapsulate the current gush of new petroleum reserve and mineral deposit discoveries in the Amazon basin and elsewhere in the country—likely to dominate a large share of Colombia’s growth trajectory in the future. Familiar with neighboring Venezuela’s economic performance and associated dependency on volatile petroleum exports, Colombian policymakers have been cautious and deliberate in instituting measures to diversify production. As shown in Figure 1.3, evidence from exports and industrial diversification indicate that some of Colombia’s recent growth has been in non-traditional sectors (whether due to explicit diversification policies or not), however the country is far from reorienting production toward a more processed set of goods.  

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5 It is important to note that while South America as a whole has undergone a commodities boom due to increased demand (and prices) largely driven by emerging East Asian economies, when disaggregating Colombia’s export composition by destination, these new exports do not appear to be driven by new demand in China. This suggests that recent export growth is not a direct result of exogenous demand for commodities from emerging markets (like China), but rather a more permanent feature of the economy.
Two specific programs—the Fiscal Rule Program and the Productive Transformation Program—have been designed to both redistribute rents from the high paying petroleum sector and encourage the development of new industries (Private Council for Competitiveness, 2011). The Productive Transformation Program is an industrial policy whereby government targets emerging industries and incentivizes their development by having firms compete to participate. Once selected, the government attempts to alleviate barriers to firm success—market failures that may have inhibited their growth—granting firms both subsidies and a forum through which enterprises can create joint ventures to overcome supply-chain costs and challenges by achieving economies of scale, or correct coordination and regulatory failures through direct dialogue with policymakers. Participants are then subject to standards and may be expelled if underperforming. FDI’s role in these dual goals of growth and diversification (and their associated policies) however, is not well articulated nor understood. But despite the uncertainty over FDI’s impact, Colombian policymakers continue to encourage FDI inflows and engage its policy framework to include FDI in encouraging growth, diversification, and productivity—all with the ultimate goal of improving the dismal unemployment and poverty rates that intensified during the armed
conflict and still persist today. As Figures 1.4 and 1.5 show however (when matched to the previous growth and FDI figures), the association between recent economic growth, FDI inflows, and reduction of extreme poverty, inequality, and unemployment, is modest at best.

**Figure 1.4 Colombia Unemployment Rate**

![Graph showing unemployment rate from 2002 to 2009 with data points for each year]

*Source: World Bank Development Indicators Database 2011*

**Figure 1.5 Colombia Extreme Poverty and Inequality**

![Graph showing Gini Coefficient and extreme poverty rate from 2002 to 2009]

*Source: Colombian National Statistics Agency (DANE-MESEP)*

Note: Missing data for 2006 and 2007 due to sampling problems during the national census, however indicators relative to the national poverty line indicate a flat shaped curve until the 2007 recession leading to a spike which resulted in higher poverty and inequality measurements in 2008.
The underlying premise espoused by Colombian policymakers (and most notably President Alvaro Uribe’s policy from 2002 – 2010) is that volatility precludes stable growth, and growth encourages employment and poverty reduction (Colombian Ministry of Foreign Affairs, 2009). The Colombian Department of National Planning statistics division (Departamento Nacional de Planeación) estimates that an annual 4.5% increase in GDP growth (the forecast for 2011) causes a 4.3 percent reduction in extreme poverty, and a .016 reduction in the Gini coefficient—an indexed indicator of inequality (Colombian Department of National Planning, Poverty Reduction Report 2011). Accordingly, Colombian policymakers have imposed measures to increase macroeconomic stability, consumer confidence, and improve the investment climate to be more conducive to economic growth.

Since 2006 Colombia has also been lobbying for a US-Colombia free trade agreement, the Tratado de Libre Comercio (TLC), which was ratified by the Colombian government and is currently under review by the Obama administration before it is sent for congressional approval in 2011. Furthermore, in March of 2011, Standard & Poor’s upgraded Colombia’s sovereign risk rating to BBB-, signaling that the country’s macroeconomic investment climate is comparable to Brazil’s (Bloomberg Businessweek, 2011). This coupled with the pending passage of the TLC in 2011 will likely further boost MNC entry and encourage even greater FDI inflows in the future, further emphasizing the need to understand its impact. Lastly, investment promotion agencies (IPAs) have emerged in all of the major metropolitan areas (Bogotá, Medellín, Barranquilla, Cali) and the country has a national agency mandated to promote Colombian exports abroad and lead the country’s national FDI attraction strategy. There is thus a clear agenda and allocation of resources dedicated to promoting foreign investment in Colombia, and figuring MNCs into national strategies regarding economic growth, poverty alleviation, and unemployment reduction.

But as policymakers advance FDI attraction policies (including the TLC) on the premise that the theoretical benefits from FDI openness outweigh the costs, specific impact analyses on how MNCs affect host-country economic outcomes remain sparse and largely underexplored. This work intends to test the trends discussed above, make explicit the role of FDI in each sector, and propose recommendations based on firm-level empirical evidence of FDI’s local impact.

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6 Since 1998, over 103 countries have adopted polices that offer investment subsidies to MNCs (Hanson 2001, 1)
1.3 Research Questions, Counterfactuals, and Hypotheses

This paper follows five distinct research questions aimed at quantifying the spectrum of local economic outcomes related to FDI entry in Colombia. To answer questions 1 – 3, I apply fixed effects multivariate regression methods to a panel of firm-level financial statements for the complete population of formal (incorporated) domestic and foreign firms operating in Colombia from 1995 to 2009. To answer question 4, I build national input-output tables from the Colombian national accounts using a method developed by Guilhoto (2005) for the Brazilian economy, however focus specifically on isolating MNC from domestic intermediate purchases structures using the most recent table (for 2007). Finally, question 5 is aimed at explaining the structural explanations for the outcomes observed in the previous questions:

1. As an initial exploratory question for subsequent analysis, what is the association between MNC entry and the probability of domestic firm exit in the same industry, and does this effect vary by sector? (Results in Table 6.1)

2. At the industry level, what is the marginal impact of a 1% increase in foreign share of total sector output on domestic industry revenue and wages (as a proxy for employment)? (Results in Tables 6.2 and 6.3 respectively)

3. At the firm level, what is the average marginal effect of a 1% increase in foreign share of total sector output on domestic firm revenue as a result of total factor productivity (TFP) spillovers (both horizontal and backward) from MNCs? (Results in Table 6.4)

4. What is the impact of MNC investments on the rest of the economy as measured through inter-industry (backward and forward) linkages, and which MNC investments exhibit the strongest linkages to the local economy? (Results in Tables 7.1 and 7.2)

5. Given the results of the previous questions, are the overall relationships between MNC entry and domestic firm economic outcomes robust across all sectors, or is the effect differentiated by sector type, economic structure, or other conditions? If differentiated by
sector, what explains the variation in outcomes and what are the policy implications for future MNC targeting, industrial, and competitiveness policies? (Discussion in Chapter 8)

Given previous empirical evidence and past studies' implications in the Colombian context, I hypothesize that there is an overall small and negative association between MNC entry and domestic industry revenue and wages, but that the magnitude and sign of this relationship vary by sector. I further hypothesize that there are modest but positive TFP spillovers to domestic firms due to MNC entry and that the larger spillovers occur through backward linkages rather than horizontally. I also postulate that the net gains from FDI are more concentrated among non-extractive rather than extractive sectors. Furthermore, I posit that the sectors which perform best along the metrics discussed are those which both have deliberate policies that require or encourage interaction between the MNC and local firms, or those sectors in which MNC investments have broad ranging inter-industry linkages.

It is important to note that each research question is posited with respect to the counterfactual of no or limited MNC investments, and the results should be interpreted accordingly. In other words, what is the impact of MNC investments along these indicators versus a scenario under which no such investment occurs? It would be difficult to compare what would have happened had Colombia taken a divergent trajectory, protecting infant industries and increasing the role of the State in industrial development. However Colombia is pursuing what is broadly considered "new industrial policy"\(^7\) which aims to correct coordination and market failures by creating an entrepreneurship-enabling agenda to encourage innovation, and protect intellectual property rights among emerging industries. So the implications for this study relate to policies that promote unconditional MNC entry versus no MNC entry whatsoever regardless of the economic growth strategy being pursued concurrently. The results should be interpreted with this in mind.

1.4 Methodological Overview and Research Outline

This study makes use of two methodological frameworks—fixed effects multivariate regression models and applied input-output analysis—to analyze the impact of MNC investments on several

\(^7\) Based on the definition in Rodrik (2004) "Industrial Policy for the Twenty-First Century".
local economic indicators across ten broad sectors of the Colombian economy. The paper continues as follows: Chapter 2 reviews the relevant literature—conceptual, empirical, and methodological—and concludes with a summary of the study’s unique research contribution. Chapter 3 overviews the different data sources and peculiarities of each source as applied in both the econometric and inter-industry linkage analysis sections. Chapter 4 discusses the econometric regression specifications and proxies used in the paper, and Chapter 5 examines the input-output model and its specific application to FDI impact analysis through distinguishing MNC from domestic technologies. Chapters 6 and 7 discuss the overall results from the econometric and input-output analyses respectively, and Chapter 8 decomposes these overall results sector by sector, comparing all quantifiable trade-offs and highlighting sectors that are net winners and net losers from FDI entry. Finally, in Chapter 9 I summarize the results from the sectoral analysis in Chapter 8, and draw parallels across sectors driven by the data, leading to policy recommendations regarding how industrial, competitiveness, and MNC targeting policies can be better adjusted to maximize the net gains from FDI according to sector.
2. Literature Review

Although FDI itself is a relatively new phenomenon, there is both theoretical and empirical literature that explains how foreign investment impacts the host economy. In this section, I present the standard FDI model, followed by an overview of the current empirical literature as well as its accomplishments and shortcomings. I then follow with a discussion of this paper's unique research angle and how it improves on previous methodological and data limitations.

2.1 Conceptual Framework and FDI Models

Economists modeling the effect of FDI have first and foremost been interested in the impact on local firm productivity between and across sectors. Authors generally describe the MNC’s profit-maximizing decision to invest abroad, followed by its dynamic effect on the local economy. Markusen and Venables (1998) explain that MNCs locate to minimize rent erosion, and will thus choose locations where domestic firms in the same industry have low absorptive capacity for their technical information. In Markusen and Venables (1999), the authors model the ensuing effect of FDI as a two-fold process that is devoid of productivity spillovers (at least in the short run): 1) First the entry of FDI induces a competition effect whereby only the most competitive local firms within the same industry survive by increasing their own productivity, while other firms are crowded out of the market. 2) But this can be offset by a backward linkage effect, whereby upstream suppliers to FDI firms specialize and increase productivity to capture the FDI firm’s business. Deliberate technology transfers from the MNC however, can help facilitate this second effect. Other authors model how a forward linkage effect may set in as suppliers become so efficient that their specialized inputs can be sold in new markets. This type of linkage analysis is generalizable to any firm (not just foreign), and the terms “backward” and “forward” linkages can be originally traced to Hirschman (1958), who coincidentally began his analysis using the Colombian economy as his initial case study. Hirschman used linkages to propose economic development strategies and explain the location of economic activity.

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8 This is especially the case since productivity and technology growth have become central parameters in economic growth models.

9 Such work was simultaneously developed alongside other important pioneers such as Chenery and Watanabe (1958), and Rasmussen (1956).
Markusen and Venables (1999) also model this *forward linkage effect* in the context of FDI as leading to a new availability of cheap inputs downstream.

More recently however, the majority of FDI models have shifted to focus on MNC productivity spillovers to local firms. Kugler (2000) models FDI productivity spillovers as being inter-sectoral rather than intra-sectoral, due to the fact that MNCs are likely to share technology and management techniques among their own local suppliers in other sectors while discouraging the dissemination of their tacit knowledge among sectors within the same industry. While most of the current debate revolves around long-run productivity spillovers, fewer authors discuss the conditions under which FDI impacts host economies in the short-run (perhaps due to the long run steady-state emphasis in neoclassical and endogenous growth models.) Regarding sector-specific winners and losers from FDI, Moran (2006) concludes that FDI is more likely to lead to host-country spillovers in non-extractive sectors, however this is supported by case study evidence rather than econometric analysis at the firm level. Through a development economics lens, FDI also can play a special role when access to finance is considered a binding constraint to growth in countries trapped in low-level equilibrium (poverty traps). Imbs and Wacziarg (2003) further propose that economic growth and diversification are highly correlated, which, while not an FDI model in itself, may have profound implications for FDI if it is framed explicitly as a diversification strategy. Finally, in a survey piece on empirical FDI and industrial policy studies, Harrison and Rodríguez-Clare (2009, 75) conclude “Industrial Policy through FDI promotion may be more successful than intervention in trade, in part because FDI promoting policies focus on new activities rather than on protecting (possibly unsuccessful) incumbents.” The implication is that there is indeed an overlap between industrial, competitiveness, and MNC targeting policies, especially as economic development and diversification strategies converge. The question thus becomes, under which context is each policy most appropriate?

Overall, the theoretical literature remains largely unable to answer this question or generate a model that explains the variation in local economic outcomes across countries and sectors due to different FDI configurations, policies, and other possible confounding factors. New models are being developed which explore the interaction between institutions, policies, and foreign and local firm performance, however at this point there is no widely accepted theoretical FDI model.
2.2 Empirical Literature

Early foundational papers that attempted to measure the impact of FDI on the host economy were pioneering, however most lacked a clear identification strategy, statistical power, and a means to eliminate the endogeneity bias associated with MNC firms choosing more or less productive sectors for their investments. Caves (1974) and Globerman (1975) researched the effect of foreign companies on local production functions in Australia and Canada respectively and found positive productivity spillovers, however their conclusions were flawed in three ways: their analyses were not causal, the data were limited to cross-sections, and the studies were performed at a time with historically low levels of FDI inflows which was typical of the 1970s—leading to plausibly sparse data and hard to detect effects. Blomstrom (1983) also used cross-sectional data from the Mexican manufacturing industry to determine a positive correlation between domestic enterprise productivity and MNC presence, however the author uses a simple binomial regression analyzing how foreign firm presence impacted the cross-sectional results rather than integrating foreign share of revenues directly into his econometric specification.

More recently, three sets of authors have conducted rigorous analyses of firm-level panel data that attempt to avert the problems faced by previous authors. Aitken and Harrison (1999) analyze Venezuela’s Annual Manufacturing Census and find that foreign investment is negatively correlated with the productivity of local firms while controlling for sector fixed-effects. However Aitken and Harrison only analyze horizontal TFP spillovers, do not focus on short-run outcome variables, and only have associational evidence (not causal). Kugler (2006) uses data from the Colombian manufacturing census, to refute Aitken and Harrison’s findings and suggest that the specification lacked external validity due to its limitation in identifying *intra*-sector productivity spillovers rather than what he argues is the more realistic mechanism for TFP spillovers—*inter*-sector knowledge transfers. However his evidence is limited to the manufacturing sector.

Javorcik (2004) goes a step further in identifying a proxy for backward TFP spillovers, however her metric does not account for different purchase structures among foreign and domestic firms, instead just scaling one year’s aggregate national input-output table by foreign share of output without distinguishing the likely diverse technological structures that differentiate the two. (I
explain this in greater detail in Chapter 4.) I thus follow Aitken and Harrison’s (1999) base specification to capture horizontal TFP spillovers at the firm level, and alter Javorcik’s backward TFP spillover measurement using firm-level data on annual MNC and domestic intermediate purchases to capture TFP spillovers through backward linkages at the firm level.

It is also worth noting that while both authors are careful in their identification strategy, both studies present associational rather than causal evidence of FDI’s spillover effects on the local economy. However as Banerjee (2005) points out, “in most of what we do as social scientists, we assume that there is some constancy in nature, so that we can parametrize the contexts according to a limited number of dimensions.” In other words, we may still be able to learn something from associations when randomized controlled trials or natural experiments are unavailable or external validity is questionable. It is also important to highlight that the major studies in this area have been designed around annual manufacturing census data to infer to the population, rather than using a randomly selected sub-sample of the entire economy. This paper contributes more complete data by considering an entire population of financial statements and full set of industries at the 2-digit ISIC level, as well as a vector of instrumental variables (IV) to increase confidence in the association between the main predictor and outcome variables—and arguably attain a casual interpretation of the impact of FDI on various outcome variables.

Regarding the Colombian context, Eslava and Melendez (2009) discuss the political economic history of Colombia and regress policy outcomes on the political influence of business actors in the policymaking process. The authors first discuss how import-substitution-industrialization (ISI) became politically acknowledged as a market distorting process in Colombia, leading to a refocus toward property rights and market allocation efficiency policies to encourage growth. They suggest that the 1991 pro-market reforms only resulted in modest growth throughout the 1990s however, because the market was not fully purged of groups with coercive political influence that demanded special sectoral protections (furthering ISI policies). These authors use econometric evidence to show how the political strength of business groups has influenced trade, tax, export, and governance policies, however do not analyze deeply the role of FDI—instead highlighting market failures as reasons for why full liberalization has not led to overwhelmingly positive growth outcomes in the country (with only tangential implications for the impact of FDI
In terms of case studies, Moran (2006) argues that FDI can be beneficial for host economies under the condition that the business climate and worker training institutions are conducive to the emergence of local suppliers (p.2). According to Moran, there are significant payoffs from building institutions that develop even modest capacity for country workforce skills. Moran further contends that in more protected economies, foreign-owned plants fail to spur internationally competitive operations among domestic firms. According to Moran, joint venture and domestic content requirements lead to fewer linkages and less technology transfer from FDI than countries with export-oriented growth strategies. However Moran’s evidence is overly general, and relies on case studies with possible selection bias that cannot reasonably capture the representativeness of the impact of FDI under different contexts (lacking external validity). Overall, there are many case studies relating to the impact of FDI that are not listed here. Their general conclusions mostly point to both the political popularity of a given foreign investment and whether there is negotiating power among both local governments and laborers working for MNCs, as predictive variables for whether positive local spillovers are captured. Such literature however, rarely observes the first and second order impacts on the economy, and while providing insight as to what relationships merit testing, can be anecdotal rather than empirical.

Finally, regarding the use of input-output models in analyzing the impact of foreign investment on a given economy, there is little formal evidence of any such application in this way. This could be due to a lag in the literature, whereby FDI’s increasing importance in global trade has not yet been fully examined with all available methods. It is also possible that analysts are not able to isolate the ratio of FDI inter-industry trade purchased locally or internationally along sector lines (isolating imports)—or that the data is simply unavailable. Overall, the absence of input-output analyses that create two distinct sets of technology (two tables) toward this end—one for foreign firms and one for domestic firms—warrants novel applications of input-output tailored to analyze and understand how FDI impacts the local economy.

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2.3 Research Contribution

Building on the current literature discussed above, this work offers a distinct methodological lens that contributes to the previous literature in four ways:

1. The paper takes advantage of a unique firm-level data set that encompasses the entire population of domestic and foreign firms in Colombia, offering a more representative sample and more confidence in the results.

2. The paper builds on the Javorcik (2004) metric for backward TFP spillovers described briefly above, and create two sets of technology combining firm-level data with input-output tables derived from the national accounts, yielding a new application of input-output analysis by analyzing the impact of foreign firms on other industries.

3. As will be discussed in Chapter 4, the paper also leverages a unique instrument for FDI to attain an arguably casual interpretation of the impact of MNCs on local economic outcomes.

4. Finally, by focusing on interactions by sector and decomposing overall effects by sector and between industries, this work offers a more nuanced framework for analyzing the impact of FDI that circumvents the risk of overgeneralizing the macro impact in favor of a more sector-specific approach that places emphasis on the conditions that facilitate FDI spillovers rather than the overall effects.
3. Data

This paper combines three general classes of data to quantify FDI trade-offs by sector:

3.1. Firm-Level Data for Econometric Analysis

The main data source for the econometric analysis portion of this paper is a dataset of public financial statements from Colombia’s national business registry—la Superintendencia de Sociedades—an organization that provides public panel data containing annual information from 1995 to 2009 on all legally registered domestic and foreign firms in the country. The panel is unbalanced, ranging from 9,284 firms in 1995 to 24,674 firms in 2009, with a total of 209,260 observations over the entire time period—203,875 total observations of 31,159 domestic firms, and 5,385 total observations of 1,160 MNC firms. It is important to reiterate that this portion of the analysis considers the impact of MNC firms (>50% FDI) on non-MNC firms (<50% FDI) rather than the effect of foreign equity on individual firm performance. While the data to analyze the latter (percent foreign equity) does exist at the firm-by-year level, it is confidential and was not made accessible for this study.

Overall, the data contain typical information found in a neoclassical production function. The outcome variable output represents the operational revenue of the firm filed annually in thousands of Colombian pesos (where $US 1 is approximately $COP 2000 throughout the time period with very little variation in real exchange rates). Either way, when the variable is logged and applied in a regression model, $\text{log}(\text{output})$ can be interpreted as a percentage change in output—eliminating currency and inflation difficulties. During initial data cleaning, 2 firms were dropped from the dataset for having negative output values (likely due to measurement error), while 2,453 firms were dropped for having output values equal to zero. These latter firms were likely those which had incorporated, but had not yet begun operations (and were thus irrelevant to this study). Tests for normality also confirm that OLS residual assumptions continue to hold after this initial cleaning (see Appendix A), resulting in the tracking of a sub-sample of 35,930 domestic firms comprising of 181,905 observations. In addition to output, the data contain firm level controls for

\footnote{Foreign firms are labeled explicitly and can be assigned a 1/0 indicator variable at the firm level.}
short-term and long-term labor payments \((labor)\)^{12}, capital controls for property, plants, and equipment \((capital)\) as well as intermediate inputs, raw materials, and short-term inventories \((inputs)\). There are 86,048 observations of 15,427 domestic firms with non-zero values for all factor inputs. While this specific sub-sample is only used to test firm-level TFP spillovers and the effect of MNC entry on industry labor payments, normality tests confirm that OLS residual assumptions still hold without selection bias (see Appendix B).

The data set also contains an indicator for which department \((region)\) received the investment \((dept)\) which is used later in the post-estimation analysis and the development of Geographic Information System (GIS) maps which may help explain the regional variation in the impact of FDI, as well as 66 International Standard Industrial Classification (ISIC) sector codes at the 2-digit level which classify the entire economy and every firm-level observation by sector. For specification and comparative purposes presented later, I also group the 2-digit level ISIC sectors into ten 1-digit ISIC sector codes according to the ten groupings frequently used by the Colombian Central Bank \((BanRep)\) to report direct employment and other important FDI-related indicators for the Balance of Payments. Sectors at the 2-digit level which did not receive any FDI throughout the entire dataset,\(^{13}\) or firms which “flipped” sectors from one year to the next without any identifiable “mode sector” over all years observed were also dropped, resulting in a final sample of 34,592 domestic firms and 176,238 observations over 15 years.

In addition to the firm-level data set, I merge data on Colombia’s top FDI-sending countries’ annual average wages by 1-digit ISIC sector code and year from the International Labor Organizaiton’s \(LaborSta\) database to instrument for MNC sector revenue share. The available data includes average annual wages collected by each country’s respective statistics bureau, reported in each country’s nominal currency from 1997 to 2005.\(^{14}\) These countries include the United States, United Kingdom, France, Spain, the Netherlands, Canada, Japan, Mexico, Costa Rica, and Chile, and their wage data are logged for currency consistency across the vector of instruments. All values for the United States were replaced with the United States Bureau of

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^{12} When used as an outcome variable, I rename the variable \(wages\) or \(lwages\) when logged.

^{13} These sectors include: tobacco, leather manufacturing, wood and wood products, glass products, postal services, forestry, and ferry transportation.

^{14} As discussed in Chapter 4, these instruments are essential for a causal interpretation of FDI’s impact.
Labor Statistics Occupational Employment Survey (OES) data by corresponding NAICS code and year to ensure complete information since US investment represents such a large share of inward FDI to Colombia. The ten countries whose data is sampled represent on average between 70% and 80% of all inward FDI flows to Colombia, with the United States representing on average between 20% and 30% of all inward FDI between 1995 and 2009.\textsuperscript{15}

3.2. Econometric Analysis Summary Statistics

To test for robustness, I analyze three different subsets of the remaining sample after initial data cleaning: (1) I generate an indicator for domestic firms that survive the entire 1995 to 2009 dataset—the \textit{balanced sample}. Any analysis of this dataset would ultimately generate external validity for domestic firms that entered or began tracking in 1995, which potentially represent the most competitive set of domestic firms as they survive the entire time period. (2) I generate an additional indicator for domestic firms that are censored after 2009 and backfilled—the \textit{censored sample}—allowing for firms to enter late but never exit the data set. (3) I also generate an indicator for domestic firms that are censored after 2005 for analyzing the set of years spanned by the instrumental variables—the \textit{censored IV sample}. In Table 3.1, I display firm counts by 2-digit ISIC sector for each of these three groups. Note that the \textit{balanced sample} is displayed, however is not used in subsequent analyses due to its sparse observations by sector. The highlighted sectors—namely transportation parts, maritime and river transportation, air transportation, and pipeline transportation—are dropped due to sparse data in both the \textit{censored} and \textit{censored IV} samples, leaving a final sample of 34,446 domestic firms and 175,389 observations recorded in 50 sectors from 1995 to 2009 (without violating normality assumptions).

In Table 3.2, I list summary statistics for the range of variables analyzed in the subsequent econometric analysis. The mean firm output among the entire data set of domestic Colombian firms was approximately 14 billion Colombian Pesos, which is approximately 7 million USD Dollars per year, however it is important to note the standard deviation of 161,000,000 Colombian Pesos, which points to great variation among domestic firm profits.

\textsuperscript{15} Colombian Central Bank Balance of Payments Office, \textit{Inward FDI Flows by Country Destination}
Table 3.1 Firm Count by ISIC Sector Level and Sub-Sample (Post Initial Firm and Sector Cleaning*)

<table>
<thead>
<tr>
<th>SECTOR GROUPINGS</th>
<th>1-DIGIT ISIC SECTOR GROUPINGS</th>
<th>Total Sample (entries, exits, and survivors)</th>
<th>Balanced Sample* (firms surviving entire time period)</th>
<th>Censored Sample (firms backfilled from 2009 censoring)</th>
<th>Censored Sample (firms backfilled from 2003 censoring)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Export-Oriented Agriculture</td>
<td>Agriculture, Fishing, Forestry</td>
<td>1,143</td>
<td>96</td>
<td>721</td>
</tr>
<tr>
<td>2</td>
<td>Coal and Derivatives</td>
<td>Mining &amp; Minerals</td>
<td>93</td>
<td>4</td>
<td>66</td>
</tr>
<tr>
<td>3</td>
<td>Petroleum and Natural Gas Extraction</td>
<td>Petroleum &amp; Derivatives</td>
<td>87</td>
<td>11</td>
<td>51</td>
</tr>
<tr>
<td>4</td>
<td>Extraction of Other Minerals</td>
<td>Mining &amp; Minerals</td>
<td>147</td>
<td>7</td>
<td>95</td>
</tr>
<tr>
<td>5</td>
<td>Food Products</td>
<td>Manufacturing</td>
<td>1,009</td>
<td>114</td>
<td>687</td>
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<tr>
<td>6</td>
<td>Beverages</td>
<td>Manufacturing</td>
<td>98</td>
<td>13</td>
<td>53</td>
</tr>
<tr>
<td>8</td>
<td>Fabric Production (Textiles)</td>
<td>Manufacturing</td>
<td>233</td>
<td>31</td>
<td>136</td>
</tr>
<tr>
<td>9</td>
<td>Clothing</td>
<td>Manufacturing</td>
<td>730</td>
<td>33</td>
<td>410</td>
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<td>11</td>
<td>Footwear</td>
<td>Manufacturing</td>
<td>123</td>
<td>5</td>
<td>65</td>
</tr>
<tr>
<td>13</td>
<td>Paper, Cardboard, Derivatives</td>
<td>Manufacturing</td>
<td>120</td>
<td>19</td>
<td>77</td>
</tr>
<tr>
<td>14</td>
<td>Stationary and Printing</td>
<td>Manufacturing</td>
<td>531</td>
<td>44</td>
<td>337</td>
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<tr>
<td>15</td>
<td>Chemical Products</td>
<td>Manufacturing</td>
<td>682</td>
<td>85</td>
<td>492</td>
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<tr>
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<td>Rubber Products</td>
<td>Manufacturing</td>
<td>83</td>
<td>6</td>
<td>58</td>
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<tr>
<td>17</td>
<td>Plastics</td>
<td>Manufacturing</td>
<td>503</td>
<td>55</td>
<td>365</td>
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<tr>
<td>19</td>
<td>Non-Metalic Mineral Products</td>
<td>Manufacturing</td>
<td>171</td>
<td>16</td>
<td>119</td>
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<td>20</td>
<td>Cement Products</td>
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<td>8</td>
<td>53</td>
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<td>21</td>
<td>Basic Metals</td>
<td>Manufacturing</td>
<td>138</td>
<td>9</td>
<td>81</td>
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<td>22</td>
<td>Metalmechanic Products</td>
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<td>546</td>
<td>38</td>
<td>382</td>
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<tr>
<td>23</td>
<td>Automobile Motors</td>
<td>Manufacturing</td>
<td>222</td>
<td>21</td>
<td>147</td>
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<tr>
<td>24</td>
<td>Transportation Parts</td>
<td>Manufacturing</td>
<td>29</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>25</td>
<td>Other Manufactures</td>
<td>Manufacturing</td>
<td>605</td>
<td>34</td>
<td>425</td>
</tr>
<tr>
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<td>Electricity, Gas, Water</td>
<td>Electricity, Gas, Water</td>
<td>74</td>
<td>2</td>
<td>48</td>
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<tr>
<td>27</td>
<td>Residential Construction</td>
<td>Construction</td>
<td>2,019</td>
<td>49</td>
<td>854</td>
</tr>
<tr>
<td>28</td>
<td>Local Transportation Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>1,523</td>
<td>80</td>
<td>996</td>
</tr>
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<td>29</td>
<td>Wholesale Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>5,820</td>
<td>248</td>
<td>3,825</td>
</tr>
<tr>
<td>30</td>
<td>Retail Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>3,262</td>
<td>76</td>
<td>2,259</td>
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<td>31</td>
<td>Housing, Lodging</td>
<td>Commerce, Services, Tourism</td>
<td>304</td>
<td>14</td>
<td>198</td>
</tr>
<tr>
<td>32</td>
<td>Freight Transportation by Land</td>
<td>Transportation, Communications, Storage</td>
<td>249</td>
<td>3</td>
<td>108</td>
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<tr>
<td>34</td>
<td>Investment in Services</td>
<td>Financial Services</td>
<td>1,841</td>
<td>69</td>
<td>803</td>
</tr>
<tr>
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<td>Land Development</td>
<td>Financial Services</td>
<td>2,504</td>
<td>59</td>
<td>1,625</td>
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<td>37</td>
<td>Education</td>
<td>Public Services</td>
<td>195</td>
<td>1</td>
<td>134</td>
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<td>38</td>
<td>Social Services and Health</td>
<td>Public Services</td>
<td>182</td>
<td>2</td>
<td>73</td>
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<tr>
<td>39</td>
<td>Other Community Services</td>
<td>Public Services</td>
<td>591</td>
<td>14</td>
<td>364</td>
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<tr>
<td>41</td>
<td>Combustibles Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>505</td>
<td>4</td>
<td>377</td>
</tr>
<tr>
<td>42</td>
<td>Other Agricultural Sectors</td>
<td>Agriculture, Fishing, Forestry</td>
<td>170</td>
<td>3</td>
<td>105</td>
</tr>
<tr>
<td>43</td>
<td>Cattle and Hunting</td>
<td>Agriculture, Fishing, Forestry</td>
<td>849</td>
<td>49</td>
<td>553</td>
</tr>
<tr>
<td>46</td>
<td>Other Textile Manufactures</td>
<td>Manufacturing</td>
<td>173</td>
<td>8</td>
<td>103</td>
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<tr>
<td>47</td>
<td>Newspaper Publications</td>
<td>Manufacturing</td>
<td>63</td>
<td>8</td>
<td>41</td>
</tr>
<tr>
<td>48</td>
<td>Equipment and Machinery Production</td>
<td>Manufacturing</td>
<td>361</td>
<td>45</td>
<td>255</td>
</tr>
<tr>
<td>49</td>
<td>Maritime and River Transportation</td>
<td>Transportation, Communications, Storage</td>
<td>41</td>
<td>0</td>
<td>7</td>
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<tr>
<td>50</td>
<td>Air Transportation</td>
<td>Transportation, Communications, Storage</td>
<td>71</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>52</td>
<td>Other Transportation</td>
<td>Transportation, Communications, Storage</td>
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<td>1</td>
<td>49</td>
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<td>Pipeline Transportation</td>
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<td>5</td>
</tr>
<tr>
<td>54</td>
<td>Storage, Cargo, Containers</td>
<td>Transportation, Communications, Storage</td>
<td>331</td>
<td>11</td>
<td>175</td>
</tr>
<tr>
<td>55</td>
<td>Telephones and Communication</td>
<td>Transportation, Communications, Storage</td>
<td>415</td>
<td>5</td>
<td>226</td>
</tr>
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<td>56</td>
<td>Radio and Television</td>
<td>Transportation, Communications, Storage</td>
<td>157</td>
<td>17</td>
<td>93</td>
</tr>
<tr>
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<td>Fishing</td>
<td>Agriculture, Fishing, Forestry</td>
<td>83</td>
<td>3</td>
<td>31</td>
</tr>
<tr>
<td>60</td>
<td>Information Services</td>
<td>Commerce, Services, Tourism</td>
<td>382</td>
<td>8</td>
<td>274</td>
</tr>
<tr>
<td>61</td>
<td>Other Entrepreneurial Activities</td>
<td>Commerce, Services, Tourism</td>
<td>2,331</td>
<td>61</td>
<td>1,551</td>
</tr>
<tr>
<td>62</td>
<td>Civil Construction</td>
<td>Construction</td>
<td>1,118</td>
<td>36</td>
<td>786</td>
</tr>
<tr>
<td>63</td>
<td>Maintenance</td>
<td>Construction</td>
<td>656</td>
<td>17</td>
<td>406</td>
</tr>
<tr>
<td>64</td>
<td>Petroleum and Gas Derivatives</td>
<td>Petroleum &amp; Derivatives</td>
<td>202</td>
<td>18</td>
<td>129</td>
</tr>
<tr>
<td>65</td>
<td>Restaurants, Food, Beverage</td>
<td>Commerce, Services, Tourism</td>
<td>328</td>
<td>4</td>
<td>219</td>
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<tr>
<td>66</td>
<td>Tourism</td>
<td>Commerce, Services, Tourism</td>
<td>214</td>
<td>2</td>
<td>148</td>
</tr>
</tbody>
</table>

Total: 34,592 1,572 21,664 17,402

*Initial cleaning included dropping firms with output < 0 or = 0, sectors with FDI, share = 0 at every year, and firms that flipped sectors and could not be classified.

Sectors highlighted in grey were subsequently dropped due to the scarce number of observations in the two censored samples.

Balanced sample includes firms which survived entire time period, 1995 to 2009, and is only included to demonstrate the sparse data and to justify not analyzing this sample.

Note: subsequent firm counts for the subset of firms which contain factor inputs exhibit analogous distributions that warrant eliminating the same sectors highlighted here.
Table 3.2 Summary Statistics for Econometric Analysis

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>OBS</th>
<th>MEAN</th>
<th>S.D.</th>
<th>MIN</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>output*</td>
<td>175,389</td>
<td>14,600,000</td>
<td>161,000,000</td>
<td>1</td>
<td>52,800,000,000</td>
</tr>
<tr>
<td>loutput*</td>
<td>175,389</td>
<td>14.5322</td>
<td>2.0313</td>
<td>0</td>
<td>24.6890</td>
</tr>
<tr>
<td>Horizontal**</td>
<td>175,389</td>
<td>0.0264</td>
<td>0.0421</td>
<td>0.0001</td>
<td>0.7049</td>
</tr>
<tr>
<td>Backward**</td>
<td>175,389</td>
<td>0.1265</td>
<td>0.2872</td>
<td>0</td>
<td>1.3508</td>
</tr>
<tr>
<td>labor*</td>
<td>157,953</td>
<td>647,981</td>
<td>5,388,191</td>
<td>0</td>
<td>1,040,000,000</td>
</tr>
<tr>
<td>llabor*</td>
<td>157,953</td>
<td>11.3317</td>
<td>2.1515</td>
<td>0</td>
<td>20.7668</td>
</tr>
<tr>
<td>capital*</td>
<td>163,229</td>
<td>3,161,848</td>
<td>34,900,000</td>
<td>0</td>
<td>4,190,000,000</td>
</tr>
<tr>
<td>lcapital*</td>
<td>163,229</td>
<td>12.6880</td>
<td>2.1114</td>
<td>0</td>
<td>22.1565</td>
</tr>
<tr>
<td>inputs*</td>
<td>123,661</td>
<td>1,928,912</td>
<td>10,400,000</td>
<td>0</td>
<td>913,000,000</td>
</tr>
<tr>
<td>linputs*</td>
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<td>13.07968</td>
<td>1.947183</td>
<td>0</td>
<td>20.63227</td>
</tr>
<tr>
<td>lUS</td>
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<td>3.030086</td>
<td>0.2867766</td>
<td>2.145931</td>
<td>3.370606</td>
</tr>
<tr>
<td>lUK</td>
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<td>5.048928</td>
<td>0.6273577</td>
<td>2.32679</td>
<td>5.802738</td>
</tr>
<tr>
<td>lFrance</td>
<td>118,382</td>
<td>5.413833</td>
<td>2.215484</td>
<td>2.317474</td>
<td>9.574636</td>
</tr>
<tr>
<td>lSpain</td>
<td>134,649</td>
<td>3.837908</td>
<td>2.100114</td>
<td>2.057962</td>
<td>7.685244</td>
</tr>
<tr>
<td>lJapan</td>
<td>140,476</td>
<td>12.63114</td>
<td>0.1202401</td>
<td>12.49687</td>
<td>12.91632</td>
</tr>
<tr>
<td>lCanada</td>
<td>146,179</td>
<td>8.024918</td>
<td>0.5884514</td>
<td>6.432619</td>
<td>8.959305</td>
</tr>
<tr>
<td>lMexico</td>
<td>146,179</td>
<td>8.024918</td>
<td>0.5884514</td>
<td>6.432619</td>
<td>8.959305</td>
</tr>
<tr>
<td>lChile</td>
<td>143,631</td>
<td>12.56573</td>
<td>0.3477843</td>
<td>11.90928</td>
<td>13.47868</td>
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<tr>
<td>lHolland</td>
<td>89,370</td>
<td>7.265311</td>
<td>0.9423829</td>
<td>3.183456</td>
<td>8.086642</td>
</tr>
</tbody>
</table>

*Numbers recorded are for domestic firms, counted in thousands of current Colombian Pesos ($COP)

**The variables Horizontal and Backward are defined in greater detail in Chapter 4
3.3. Sector-Level National Accounts Data

The Colombian National Accounts Division of the Colombian National Statistics Agency (DANE Cuentas Nacionales) collects detailed information on 59 sectors of the economy at the 2-digit ISIC level. These are maintained in annual Supply and Use (Oferta y Utilización) tables for Colombia from 1990 to 2007 according to two different base years—1994 and 2000. Table 3.3 provides a sector listing as well as aggregations into the ten 1-digit ISIC industries used in subsequent analysis. The 1994 base was discontinued in 2005, and therefore this study focuses on the 2000 base to account for the higher share of FDI inflows to Colombia that entered between 2006 and 2010 relative to previous years. The change of base covers slightly different sectors measured between the two data sets (perhaps reflecting increased economic diversification between the two base years), however associated ISIC classification digits for each sector make them easily comparable. Under the 1994 base, negative values appear in the component representing Commerce goods produced by the Petroleum sector, violating one of the central conditions (Hawkins-Simon) that permits the invertibility (non-singularity) of the Leontief matrix—explained further in Chapter 5. These negative values reflect reinvested petroleum earnings and as per the recommendation of the Colombian National Statistics Agency, I merge these values into the Petroleum sector production of Petroleum goods component, which remains overwhelmingly positive despite this edit.

When values from these tables are converted to Leontief matrices using the \((I-DB)^{-1}\) conversion discussed in Chapter 5, we are able to attain annual input-output tables and total requirement matrices for Colombia. By combining these tables with the previously discussed SDS firm-level database which contains indicators for intermediate purchases at the firm level (for foreign and domestic firms) as well as 2-digit ISIC sector codes, we can match percent of MNC and domestic sector output spent on intermediate purchases, and can thus divide the national input-output table (which normally would aggregate foreign and domestic purchases) into two “technologies” according to this data.

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16 CIIU Rev. 3 A.C. refers to the corresponding Colombian acronym for the ISIC Rev. 3 sector codes outlined by the United Nations Department of Economic and Social Affairs, Statistics Division.
Table 3.3 National Accounts 1 and 2-digit Sector Classifications

<table>
<thead>
<tr>
<th>#</th>
<th>CIU Rev 3 A.C. 2-Digit</th>
<th>CIU Rev 3 A.C. 1-Digit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coffe Beans</td>
<td>Agriculture, Fishing, Forestry (1)</td>
</tr>
<tr>
<td>2</td>
<td>Other Agricultural Goods</td>
<td>Agriculture, Fishing, Forestry (1)</td>
</tr>
<tr>
<td>3</td>
<td>Live Animals and Animal Goods</td>
<td>Agriculture, Fishing, Forestry (1)</td>
</tr>
<tr>
<td>4</td>
<td>Forestry and Wood</td>
<td>Agriculture, Fishing, Forestry (1)</td>
</tr>
<tr>
<td>5</td>
<td>Fishing Goods</td>
<td>Agriculture, Fishing, Forestry (1)</td>
</tr>
<tr>
<td>6</td>
<td>Coal</td>
<td>Mining and Minerals (2)</td>
</tr>
<tr>
<td>7</td>
<td>Petroleum, Natural Gas, Uranium</td>
<td>Petroleum and Derivatives (3)</td>
</tr>
<tr>
<td>8</td>
<td>Metallic Minerals</td>
<td>Mining and Minerals (2)</td>
</tr>
<tr>
<td>9</td>
<td>Non-Metalic Minerals</td>
<td>Mining and Minerals (2)</td>
</tr>
<tr>
<td>10</td>
<td>Meat and Fish Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>11</td>
<td>Oils, Animal and Vegetable Grease Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>12</td>
<td>Lactose Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>13</td>
<td>Milled Products and Starches</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>14</td>
<td>Coffee Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>15</td>
<td>Sugar and Cane Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>16</td>
<td>Cacao, Chocolate, and Jam Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>17</td>
<td>Food Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>18</td>
<td>Beverages</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>19</td>
<td>Tobacco Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>20</td>
<td>Fabrics and Fiber Textiles</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>21</td>
<td>Textile Articles</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>22</td>
<td>Clothing Textiles</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>23</td>
<td>Leather Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>24</td>
<td>Wood Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>25</td>
<td>Paper and Cardboard Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>26</td>
<td>Printing and Editing Machines</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>27</td>
<td>Petroleum, Refining, Nuclear Combustion</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>28</td>
<td>Chemical Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>29</td>
<td>Plastic and Rubber Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>30</td>
<td>Non-Metalic Mineral Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>31</td>
<td>Metallurgical Products</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>32</td>
<td>Machinery and Equipment</td>
<td>Manufacturing (4)</td>
</tr>
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<td>33</td>
<td>Other Machinery and Electronic Applicances</td>
<td>Manufacturing (4)</td>
</tr>
<tr>
<td>34</td>
<td>Transportation Equipment</td>
<td>Manufacturing (4)</td>
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<tr>
<td>35</td>
<td>Furniture</td>
<td>Manufacturing (4)</td>
</tr>
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<td>36</td>
<td>Other Manufactured Goods</td>
<td>Manufacturing (4)</td>
</tr>
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<td>37</td>
<td>Waste and Recycling</td>
<td>Manufacturing (4)</td>
</tr>
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<td>Electric Energy</td>
<td>Electricity, Gas, and Water (5)</td>
</tr>
<tr>
<td>39</td>
<td>Gas</td>
<td>Electricity, Gas, and Water (5)</td>
</tr>
<tr>
<td>40</td>
<td>Water</td>
<td>Electricity, Gas, and Water (5)</td>
</tr>
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<td>41</td>
<td>Private Construction</td>
<td>Construction (6)</td>
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<tr>
<td>42</td>
<td>Public Construction</td>
<td>Construction (6)</td>
</tr>
<tr>
<td>43</td>
<td>Commerce Services</td>
<td>Commerce (7)</td>
</tr>
<tr>
<td>44</td>
<td>Repair Services</td>
<td>Commerce (7)</td>
</tr>
<tr>
<td>45</td>
<td>Tourism, Hotels, Restaurants</td>
<td>Commerce (7)</td>
</tr>
<tr>
<td>46</td>
<td>Land Transport Services</td>
<td>Transportation, Communications, Storage (8)</td>
</tr>
<tr>
<td>47</td>
<td>Water Transport Services</td>
<td>Transportation, Communications, Storage (8)</td>
</tr>
<tr>
<td>48</td>
<td>Air Transport Services</td>
<td>Transportation, Communications, Storage (8)</td>
</tr>
<tr>
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<td>Other Transport Services</td>
<td>Transportation, Communications, Storage (8)</td>
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<td>Mail and Telecommunication Services</td>
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<td>51</td>
<td>Financial Intermediary Services</td>
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</tr>
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<td>52</td>
<td>Rental Services</td>
<td>Financial Services (9)</td>
</tr>
<tr>
<td>53</td>
<td>Business Services</td>
<td>Financial Services (9)</td>
</tr>
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<td>54</td>
<td>Public Administration and Defense</td>
<td>Public and Social Services (10)</td>
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<td>55</td>
<td>Educational Services</td>
<td>Public and Social Services (10)</td>
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<tr>
<td>56</td>
<td>Social and Health Services</td>
<td>Public and Social Services (10)</td>
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<td>57</td>
<td>Sewage Services</td>
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<td>58</td>
<td>Cultural Services</td>
<td>Public and Social Services (10)</td>
</tr>
<tr>
<td>59</td>
<td>Domestic Services</td>
<td>Public and Social Services (10)</td>
</tr>
</tbody>
</table>

Source: Colombian National Statistics Agency, National Accounts (DANE Cuentas Nacionales)
4. Econometric Specifications

In this chapter I discuss various econometric specifications to address the first three research questions proposed in Chapter 1. I first define three proxies that will be central to subsequent regression specifications. Following Aitken and Harrison (1999), I define the variable *Horizontal* as the share of MNC output in a given 2-Digit ISIC sector:

\[
Horizontal_j = \frac{\sum_{i \in MNC} MNC\_output_{ij}}{\sum_{i \in Total} Total\_output_{ij}}
\]

Here, \(i\) indexes each firm while \(j\) indexes a given sector, where \(i \in j\). In qualitative terms, *Horizontal* represents the market share of multinational investments in a given sector.\(^{17}\) Next, following Javorcik (2004) I define the variable *Backward* as the sum of MNC firm purchases by sector \(k\) from supplier sector \(j\) for a given unit of output of sector \(k\). The original Javorcik *Backward* proxy is flawed in its application of input-output tables however, as it simply scales the components of the input-output table by *Horizontal*—the foreign share of output in a sector—without capturing how foreign and domestic firms may have different purchasing structures. Using the SDS panel data discussed above, I thus create the following metric to correct for this problem by defining the foreign to total purchase ratio of a given sector \(k\) in year \(t\) as follows:

\[
IntermediateShare_{kt} = \frac{\sum_{i \in MNC} MNC\_IntermediatePurchases_{ik}}{\sum_{i \in Total} Total\_IntermediatePurchases_{ik}}
\]

\(^{17}\) While a variable name such as “FDI Share” may have been a more representative name for analyzing how the change in this variable affects firm-level output and labor payments (as described in equations 4 through 7), the term “Horizontal” is more appropriate nomenclature for analyzing total factor productivity (TFP) spillovers when controlling for firm level inputs, as will become clear in the succeeding discussion.
Here, IntermediateShare measures the share of intermediate purchases made by multinational corporations with respect to all firm intermediate purchases in a given sector \( k \) where \( i \in k \). This can then be easily applied in the Javorcik proxy, improving upon what was previously an oversimplified use of the input-output table.\(^{18}\) I therefore define Backward in the following way:

\[
\text{Backward}_{j,t} = \sum_{k} \alpha_{jkd} \text{IntermediateShare}_{k,t}
\]  

(3)

Here, Backward is intended to capture the sum of all domestic sector \( j \)'s sales to multinational firms in sector \( k \) in a given year \( t \) as a share of sales to all firms. An important condition is placed on the proxy whereby \( k \neq j \), to ensure that the proxy captures purchases between rather than within sectors. Here, \( \alpha_{jkd} \) represents sector \( k \) purchases of sector \( j \) inputs, taken from annual input-output table in year \( t \). With this metric defined, we can estimate changes in local economic outcomes due to changes in Backward (amount of domestic sales to foreign firms) controlling for inputs at the firm level, leading to a means to measure TFP spillovers from MNCs through backward linkages.\(^{19}\)

4.1 Exploratory Logistic Regression to Estimate MNC Impact on Domestic Firm Exit Rate

Given the number of potential samples to analyze, I use a logistic regression (logit) model to examine whether an increase in foreign share of sector revenue is associated with a change in the probability that a firm exits the sample (goes out of business). To test whether firms are at greater risk of exiting as FDI share increases, I fit the following discrete time-survival (Cox-hazard) base specification:

\(^{18}\) Another feature of the Colombian national accounts is that there are detailed annual input-output tables by year, permitting the use of more accurate data as opposed to generalizing one year's input-output table across many years of panel data as was done in the original Javorcik metric.

\(^{19}\) It is worth noting that when technical coefficients such as those discussed here are applied in input-output analysis, they are done so with respect to 1 unit of output of sector \( k \), however in this case this condition is not necessary since the context is regression analysis.
Here, $\lambda_t$ is a vector of year dummies (time fixed-effects) that permit an annual probability interpretation of $P(\text{firm}_\text{exit})$. $\beta_1$ represents the log-odds that a firm exit (logit) due to a 1% increase in $\text{Horizontal}$ (hypothesized to be positive), where the anti-log of $\beta_1$ represents the odds ratio that a firm exits versus survives for a given 1% increase in $\text{Horizontal}$. By fitting the model and plugging in prototypical values across the minimum-maximum range of $\text{Horizontal}$, we can track how the probability of firm exit changes as foreign presence increases from its minimum to maximum value observed the data. If the results show that $\text{Horizontal}$ is associated with a change in exit probability, then any subsequent analysis of the entire data set is subject to selection bias—firms that did not drop out due to MNC entry would be more heavily weighted in the analysis—justifying the use of a censored sample where firm exit is not permitted.

4.2 Base Specification for Identifying Impact on Industry Revenue and Labor Payments (Wages)

Using the sample of firms censored after 2009 and backfilled, this study applies a sector fixed-effects multivariate regression model to panel data to control for the endogeneity bias associated with MNC firms choosing more (or less) productive domestic sectors for their investments, and controls for time-specific factors that may affect firm behavior in a fixed way:

$$\ln Y_{jt} = \beta_0 + \beta_1 \text{Horizontal}_{jt} + \alpha_j + \lambda_t + \phi_{st} + \epsilon_{ijt}$$

(5)

Here, $Y_{jt}$ is a vector of outcome variables (revenue and labor payments) in sector $j$ and year $t$, $\alpha_j$ are sector fixed-effects at the 2-Digit ISIC level, and $\lambda_t$ are year fixed-effects. In this base specification, I also include $\phi_{st}$ as year-by-sector fixed effects, which are indexed at the $s$ level—aggregated at the 1-Digit ISIC sector level to avoid colinearity with the main predictor at the 2-Digit ISIC sector level. If $\beta_1 < 0$ then a 1% marginal increase in foreign share of sector output ($\text{Horizontal}$) is inferred to be associated with an average decrease in the outcome variable. I also conduct post-estimation tests to determine whether the resulting relationship is robust
across all sectors, decomposing the main effect by both 1- and 2-digit ISIC interactions.

4.3 Base Specification for Identifying Horizontal and Backward TFP Spillovers

In addition to the industry level impact of MNC entry on sector revenue and wages (hypothesized to be negative on average), I test for productivity spillovers at the firm level to better understand and weigh the intertemporal trade-offs between output and wages in the short-run, and productivity in the long run. The initial set up for these equations is similar to (5):

\[ \ln Y_{ijst} = \beta_0 + \beta_1 \text{Horizontal}_{jt} + \beta_2 \ln X_{ijst} + \delta_t + \lambda_r + \phi_{st} + \epsilon_{ijst} \]  

(6)

\[ \ln Y_{ijst} = \beta_0 + \beta_1 \text{Backward}_{jt} + \beta_2 \ln X_{ijst} + \delta_t + \lambda_r + \phi_{st} + \epsilon_{ijst} \]  

(7)

Here however, we observe \( Y_{ijst} \) at the firm level and include firm fixed effects \( \delta_t \) instead of sector fixed effects (although the former should pick up any variation in the latter). This specification also includes a vector of factor inputs \( X_{ijst} \) at the firm level, including controls for labor, capital, and intermediate inputs. Thus, any interpretation of the outcome for firm revenue (output) in this model can be attributed to a total factor productivity (TFP) spillover either within (Horizontal) or between (Backward) sectors.

4.4 Two-Stage Least Squares (2SLS) Instrumental Variable (IV) Applications

In each of the two previous specifications, I include an instrumental variable (IV) estimation model to improve causal inference. I use the following first-stage IV equation, which would also contain either firm fixed-effects or sector fixed-effects (omitted here) depending on which variant of equations (5) – (7) are being tested in the second stage:

\[ (\text{Horizontal})_{jt} = \hat{\gamma}_0 + \hat{\gamma}(\text{ForeignAverageWages})_{st} + \lambda_r \]  

(8)
Here, \textit{ForeignAverageWages} is a vector of average wages in sector $s$ and year $t$ in the top 10 FDI-sending countries to Colombia (as discussed previously). The IV relevance assumption that foreign average wages are highly correlated with the main regressor \textit{Horizontal}, is tested with a joint F-test of the vector of instruments. The intuition follows that as average wages in FDI-sending countries increase, MNCs are more likely to move operations to developing countries (including Colombia) to take advantage of the wage differential (abundant labor). The exogeneity assumption (exclusion restriction) that \textit{ForeignAverageWages} only impact local economic outcomes through \textit{Horizontal} also appears to hold. While there may be concern that as foreign wages in these countries increase, the demand for Colombian exports also increase, this exogenous export variable should already be controlled for through the inclusion of firm and sector fixed-effects which take into account the export-orientation of the firm as long as it is assumed to be constant. This issue could be fully resolved in future research by controlling for exports at the firm or sector level, however the data was not available for this study. A more serious issue concerns the heterogeneity among compliers with the instruments. Due to missing data across all countries or different compliance rates in specific sectors, the instruments may only be correlated with a small portion of the dependent variable’s variation. As discussed later when interpreting the results from these analyses, the causal interpretation of using this instrument may thus only be valid for testing TFP spillovers in (6) and (7).

\footnote{The IV data is only available at the $s$ level (1-Digit ISIC, however there should still be enough identification of a relationship between the more aggregate sector’s average wages and the disaggregated sectors foreign output share.}
5. Inter-Industry Linkage Analysis

While the previous section discussed econometric methods that allow for interpretations of the marginal effect of MNC entry on domestic industry output, labor payments, and firm productivity, the following section applies input-output (I-O) analysis to the Colombian national accounts in order to classify the magnitude and breadth of forward and backward linkages from multinational firms. In this section I outline the general input-output framework followed by specific applications to the Colombian data, including a thorough discussion of the task of splitting each I-O table into two distinct technologies—reflecting both foreign and domestic firm purchase structures. I-O analysis permits an analyst to forecast the (past or future) impact of an exogenous demand shock on an economy, modeled through iterative intermediate purchases often referred to as direct and total requirements in the literature (employing what is known as the Leontief Inverse matrix). One feature of most countries’ national accounts data is that their statistics agencies generally aggregate domestic and MNC firm purchases together, forcing analysts to take extra steps to apply the I-O model appropriately in the context of FDI impact analysis.

In the general input-output framework, we intend to solve for the total direct and indirect input requirements in each sector for one unit of final demand from any given sector—this can be expressed as a system of linear equations that is solvable through matrix algebra. We begin by classifying the entire 59-sector Colombian economy under a simple accounting identity, whereby the output of any given sector $x_i$ is the summation of its sales to all other sectors $z_{ij}$, and sales to final demand $y_i$ (purchases from households, governments, and exports):

$$
\begin{align*}
  x_1 &= z_{11} + z_{12} + \ldots + z_{1n} + y_1 \\
  x_2 &= z_{21} + z_{22} + \ldots + z_{2n} + y_2 \\
  &\vdots \\
  x_n &= z_{n1} + z_{n2} + \ldots + z_{nn} + y_n 
\end{align*}
$$

\[ (9) \]

21 For a more detailed derivation of the input-output model, see Miller and Blair (2009)

22 Note that this is unrelated to what was done in the previous section, where we observed TFP spillovers via backward linkages but did not quantify the linkages themselves.
We then calculate direct input requirements (technical coefficients) by first dividing the total input from sector $i$ to sector $j$ by the total output of sector $j$ using the following identity:

$$a_{ij} = \frac{z_{ij}}{x_j} \rightarrow z_{ij} = a_{ij}x_j$$

(10)

This technical coefficient definition can be thought of as a normalizing procedure that computes the amount of direct input from the sector at the very left of each row required for 1 unit of total output (in monetary terms) of the sector at the top of each column (Polenske & Fournier, 1993). Or in other words, we develop a means to assess the supplies required to produce one unit of output in every sector. By converting the technical coefficients according to (10) and substituting into (9) we can attain the following matrix of technical coefficients (which we call the $A$ matrix):

$$x_1 = a_{11}x_1 + a_{12}x_2 + \ldots + a_{1n}x_n + y_1$$
$$x_2 = a_{21}x_1 + a_{22}x_2 + \ldots + a_{2n}x_n + y_2$$
$$\vdots$$
$$x_n = a_{n1}x_1 + a_{n2}x_1 + \ldots + a_{nn}x_n + y_n$$

(11)

After the technical coefficients matrix, we consider the identity matrix—a square matrix with ones across the top-left to bottom-right diagonal and zeroes for all other components—and subtract the technical coefficients matrix from the identity matrix:

$$x_1(1-a_{11}) - a_{12}x_2 - \ldots - a_{1n}x_n = y_1$$
$$-a_{21}x_1 - x_2(1-a_{22}) - \ldots - a_{2n}x_n = y_2$$
$$\vdots$$
$$-a_{n1}x_1 - a_{n2}x_1 - \ldots + x_n(1-a_{nn}) = y_n$$

(11)

Steps 9 through 11 can be summarized in more compact matrix notation:

$$X = Z + Y$$
$$A = Z/X \Rightarrow Z=AX$$
\[
X = AX + Y \\
X - AX = Y \\
(I - A)X = Y
\]

From here, it naturally follows that to solve the system of linear equations (solving for the vector \(X\)), we can take the inverse of what is called the \(I-A\) matrix (just calculated), and effectively solve for the total direct and indirect input requirements (infinitely iterated) for one unit of final demand in each sector. Or in matrix notation, \(X = (I-A)^{-1}\) provides the solution.

The resulting matrix on the right hand side of the equation that solves for \(X\) is called the *Leontief Inverse* or *Direct and Indirect Requirements* matrix, and represents the amount of total output (direct and indirect) from each sector on the very left required to meet 1 unit of final demand from the sector at the top of each column. By summing each column we can directly observe the total output multiplier (in monetary terms) as a response to stimulating the final demand of the sector at the top of the column, and can easily compare which stimulated sector creates the biggest overall output multiplier effect and to which sectors. While one could also attain the total monetary amount (total backward linkage) for each sector by simply scaling each component of the Leontief matrix by the total stimulus—which in this case depends on the vector of total FDI demand per year—there are three core assumptions which have to be addressed first.

Because the Leontief Inverse is linear in any given change in \(Y\) (the exogenous demand shock), the model assumes Constant Returns To Scale production technology based on the annual technical coefficients derived from the national accounts. However the application of the I-O framework in analyzing direct and total requirements for 1 unit of final demand is not subject to this assumption since there is no such scaling involved in this case. Therefore, subsequent analysis avoids the problem of returns to scale by focusing on a linkage classification of direct and total requirements rather than using the Leontief Inverse to predict the scaled up impact of a given exogenous FDI demand shock. The second assumption that must be considered is that the I-O model assumes fixed proportion technology throughout the year observed, however this assumption may be relatively realistic given the slow speed at which technology adoption takes place. Lastly, the original formation of the I-O model assumes no joint production—one sector
can only produce goods from one sector. Fortunately however, the Colombian statistics agency (DANE) keeps track of Supply and Use tables that allow analysts to circumvent this assumption. While these assumptions imply that input-output analysis is relatively static and inadaptable, its application to inter-industry linkage analysis remains unchallenged despite these limitations. We can thus proceed to create input-output tables based on the available data.

By transposing the Supply matrix taken from the national accounts into a Make matrix, we observe industries along the rows producing commodities along the columns, whereas the Use matrix describes industries along the columns using (or purchasing) commodities along the rows. Finally, calculations analogous to the Leontief Inverse method just derived lead us to a set of Make and Use industry-by-industry (I-DB)$^1$ matrices—where DB can be thought of as exactly identical to the A matrix (Miller and Blair, 249, 2009). Following the routine outlined by Guilhoto and Filho (2005), we can thus calculate A matrices for each of the years available in the Colombian tables. The Guilhoto and Filho framework also allows one to estimate imports, further reassuring that all inter-industry purchases are of domestic commodities.

**5.1 Dividing the Input-Output Table into MNC and Domestic Technologies**

While the above process outlines the general I-O framework, specific adaptations must be made to account for the fact that MNCs and domestic firms engage in different intermediate purchasing patterns. Case study and financial statement evidence strongly suggests that MNCs and domestic firms may have different purchasing structures—even within the same sector—highlighting the need to model the unique role of FDI in inter-industry impact analyses. Without being able to effectively differentiate the A matrix by foreign firm direct requirements, there would be no means to understand how MNCs generate unique requirements (including backward and forward linkages), in terms of foreign firm demand from host country suppliers. To analyze two distinct sets of technologies, I thus develop the following proxies that make use of the firm-level data discussed previously:

---

$^1$ This paper will continue to reference the A matrix instead of the DB matrix for clarity.
\[ a_{ij}^{\text{foreign}} = \frac{a_{ij}}{\text{IntermediateShare}_{jt}} \]  
\[ a_{ij}^{\text{domestic}} = \frac{a_{ij}}{(1 - \text{Horizontal}_{jt})} (1 - \text{IntermediateShare}_{jt}) \]  

These equations are similar to what was defined in (2) and (3) in Chapter 4, however to understand them better it is useful to consider an example. Suppose that 1 unit of total (MNC and domestic firm) output in the agricultural sector generates .2 units of direct manufacturing requirements from domestic suppliers \( a_{1} = .2 \). Scaling this technical coefficient by a proxy like \text{IntermediateShare} (as defined in Chapter 4) would result in direct input requirements by the \text{Manufacturing} sector from foreign firms in \text{Agriculture}, but only relative to the share of agricultural output produced by foreign firms (\text{Horizontal}). Therefore, by dividing by \text{Horizontal} (which is itself a proportion), we can effectively scale the metric back up to represent foreign firm direct requirements per one unit of MNC output as apposed to a fraction of 1 unit—which is what was represented previously. This metric thus provides a unique means to generate foreign firm technical coefficient matrices, which can then be put through the Leontief inversion process to determine the total requirements generated by 1 unit of MNC final demand in a given sector.\(^{24}\)

5.2 Linkage Analysis Measurements

Once the previously discussed matrices are calculated, we can classify each industry in any given year by magnitude of backward and forward linkage relative to average linkages across the economy. We start with measuring the direct requirement backward and forward linkages—the total direct requirements generated by one unit of output in a given sector. For this, we follow the classic Chenery and Wantanabe (1958) measurements of backward and forward linkages that sum up the column components of the technical coefficients matrix to measure backward

\(^{24}\) A mathematical result of this proxy is that the denominator \text{Horizontal} may not by construction be equal to zero. In such cases where there is zero foreign share of a sector’s output, such columns are replaced by the regular input-output table column, which occurs in 8 out of 59 sectors.
linkages and row components of the technical coefficients matrix scaled by total output of a given sector \( j \) to measure forward linkages:

\[
BL^C_j = \sum_{i=1}^{n} a_{ij} \quad FL^C_i = \sum_{j=1}^{n} b_{ij}
\] (14)

Here, \( BL \) and \( FL \) denote backward and forward linkages where \( C \) indicates that we are using Chenery and Watanabe indicators. Here \( a_{ij} \) represents the standard technical coefficient metric defined previously, and \( b_{ij} = z_{ij} / x \) represents the share of output sold from sector \( i \) to sector \( j \) per unit of output of sector \( i \) (forward linkages). We can further classify the linkage of each sector relative to the average total backward and forward linkages, classifying each as high or low relative to the average. However on top of direct classifications of linkages, it is also important to classify the total requirements (total backward and forward linkages) generated by one unit of final demand as described in the I-O model. These can be thought of as the first order supply requirements, summed in addition to the second order requirements for such supplies, and so on.\(^{25}\) For this we turn to two classifications considered the Rasmussen or Hirschman-Rasmussen classifications of backward and forward linkages:

\[
BL^R_j = \sum_{i=1}^{n} a_{ij} \quad FL^R_i = \sum_{j=1}^{n} b_{ij}
\] (15)

Again, \( BL \) and \( FL \) denote backward and forward linkages that sum up column and row components of the \( A \) and \( B \) matrices respectively, where \( R \) indicates that we are applying Rasmussen measurements and are thus using the \((I-A)^{-1}\) or \((I-B)^{-1}\) Leontief matrix, whereby each individual component classifies the total requirements generated by one unit of final demand in sector \( j \). Analogously, we can again classify the total requirement linkages of each sector relative to average total backward and forward linkages across all sectors. Combined with previous analyses, these linkage classifications allow the analyst to get a better sense of the dynamic

\(^{25}\) This iterative process is precisely what the Leontief Inverse matrix approximates.
effects of MNC investments in a given sector as measured by its linkage to other sectors. Combined with the econometric analysis, this should provide a relatively complete picture of the trade-offs associated with MNC entry, and the magnitude of positive relative to negative spillovers as a consequence of FDI entry.
6. Econometric Estimation Results

The results from the econometric specifications explained in Chapter 4 are discussed below in three parts, quantifying the impact of MNC entry on domestic firm exit, industry revenue and labor payments, and firm productivity:

6.1 Impact of MNC Entry on Domestic Firm Exit Rate by Sector

In Table 6.1, I estimate the probability that domestic firms exit the dataset due to foreign firm entry (indicating that the firm is no longer registered in the country). The sub-sample includes 67,905 observations of 7,795 firms that were present in the first year (1995) of the data, allowing firms to either drop out before the last year (2009) or be censored. The logit estimate for the unconditional model’s intercept (Model 1) can be plugged in for $\beta_0$ in the hazard probability function described in equation (2), resulting in a statistically significant annual probability of .094 (9.4%) that a firm exits the sample when there is no MNC present in the sector ($\text{Horizontal}=0$). This indicates that some firms, as expected, are not competing regardless of FDI.

When adding the covariate $\text{Horizontal}$ in Model 2, the intercept remains virtually unchanged and statistically significant, however the coefficient on $\text{Horizontal}$ does not have a statistically significant association with firm exit probability. While the initial interpretation may be that MNC entry has no influence on firm exit, Model 2 can be misleading. Decomposing $\text{Horizontal}$ by sector interactions in Model 3 shows that there is a negative and statistically significant association between $\text{Horizontal}$ and the probability of firm exit in the construction, financial services, and public services sectors. Alternatively, there is a positive and statistically significant association between $\text{Horizontal}$ in manufacturing and the probability that a firm exits the data set. The results from Model 3 suggest that MNC entry is associated with firm exit. By plugging the full range of prototypical values for $\text{Horizontal}$ by sector into the fitted model, we can estimate the extent to which firm exit probabilities change over the range from minimum foreign share of output to maximum foreign share of output in each sector.
<table>
<thead>
<tr>
<th></th>
<th>Unconditional Logit Model</th>
<th>Logit Model with Horizontal Sector Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-2.256***</td>
<td>-2.259***</td>
</tr>
<tr>
<td></td>
<td>(0.038)</td>
<td>(0.038)</td>
</tr>
<tr>
<td>Foreign Share of Total Sector Revenue (Horizontal)</td>
<td>0.268</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.312)</td>
<td></td>
</tr>
<tr>
<td>Horizontal * agr-forestry</td>
<td></td>
<td>-0.238</td>
</tr>
<tr>
<td>Horizontal * mining-mineral</td>
<td></td>
<td>0.912</td>
</tr>
<tr>
<td>Horizontal * petroleum</td>
<td></td>
<td>-0.833</td>
</tr>
<tr>
<td>Horizontal * manufacturing</td>
<td></td>
<td>-1.393***</td>
</tr>
<tr>
<td>Horizontal * construction</td>
<td></td>
<td>3.934***</td>
</tr>
<tr>
<td>Horizontal * elec-gas-water</td>
<td></td>
<td>2.377</td>
</tr>
<tr>
<td>Horizontal * commerce-services</td>
<td></td>
<td>-1.309</td>
</tr>
<tr>
<td>Horizontal * transport-comms</td>
<td></td>
<td>4.463</td>
</tr>
<tr>
<td>Horizontal * financial-services</td>
<td></td>
<td>10.83***</td>
</tr>
<tr>
<td>Horizontal * public-services</td>
<td></td>
<td>4.016***</td>
</tr>
</tbody>
</table>

Year Fixed Effects\textsuperscript{d} Yes Yes Yes

| Number of Domestic Firms | 7,995 | 7,995 | 7,995 |
| Number of Observations\textsuperscript{e} | 67,609 | 67,609 | 67,609 |
| Pseudo-R\textsuperscript{2} | .0126 | .0126 | .0149 |
| -2LL | 33,214 | 33,214 | 33,137 |

\textsuperscript{***} p<0.01, \textsuperscript{**} p<0.05, \textsuperscript{*} p<0.10 (p-values calculated from asymptotically normal Z-distribution)

\textsuperscript{a}Robust Standard Errors denoted in parantheses.

\textsuperscript{b}Horizontal varies at the 2-Digit ISIC sector level.

\textsuperscript{c}Interactions use aggregated sector groupings at the 1-Digit ISIC sector level.

\textsuperscript{d}Year Fixed Effects include annual year dummies from 1995 to 2009.

\textsuperscript{e}Sample tracks firms observed in the first time period (1995) and subsequent years in the dataset.
The probability that domestic manufacturing firms exit ranges from .057 at minimum \textit{Horizontal} to .050 at maximum \textit{Horizontal} —a net change of -.007—indicating that the entry of MNCs in \textit{manufacturing} actually decreases the annual probability of exiting the data set. In analogous calculations for \textit{construction, financial services,} and \textit{public services,} MNC entry is associated with an increase in the probability of firm exit by .041, .037, and .042 respectively. These results suggest that the probability of firm exit (either going out of business or not reregistering in Colombia) is associated with \textit{Horizontal}, however the magnitude of the effect varies by sector and is largely driven by just a handful of industries. Overall, the logistic regression also suggests that subsequent models be analyzed using only a sample of firms that are censored after the end of the time period of interest, freeing the data of “exiting firms” that might bias the results.

\textbf{6.2 Impact on MNC Entry on Revenue and Labor Payments at the Industry Level}

In Table 6.2 Model 1, I regress the logarithm of domestic industry output (\textit{loutput\_sector}) on the foreign share of total sector output (\textit{Horizontal}) controlling for sector and time fixed-effects. The results suggest that for a given 1\% increase in MNC share of total sector output, there is a statistically significant 1.8\% average decrease in domestic sector revenue. The inclusion of time-by-sector fixed effects in Model 2 has little impact on this relationship (although sectors are observed at a more aggregate level to avoid colinearity). When the main effect is decomposed into 1-digit ISIC sector interactions in Model 3 (dropping the main effect), we find that some sectors rather than others drive the overall results. Notably, \textit{transportation} and \textit{financial services} sectors tend to perform very poorly in the presence of increasing FDI, while the \textit{mining and minerals} sector actually exhibits higher revenues as MNC share increases.\footnote{This has important implications as Colombia is in the midst of a mining and petroleum boom.} These sector-specific effects are further disaggregated into 50 2-digit ISIC sector groupings displayed in Appendix C. Contrary to prior findings, there appears to be no statistically significant association between MNC entry and domestic \textit{petroleum} sector revenues. In other words, the change in domestic revenue due to MNC entry in not statistically different from zero. In Models 4 and 5 however, instrumental variable regressions indicate that there is zero causal effect in any sector (although the magnitude of the effect in Model 4 is very close to the value of the coefficient from the associational regression in Model 2). This is likely due to the hard to detect (small) effect size.
combined with low statistical power due to the limited number of industry-level observations available. Furthermore, only certain interactions are listed in Model 5 since not all IV countries contain average wage data for all sectors—which may have led to listwise deletion and a low “take” rate of the instruments among certain sectors. For this reason, it is prudent to interpret the association results in Model 3 rather than the plausibly causal results in Models 4 and 5.

Analogous calculations can be made for the industry impact of MNC share of output on domestic sector labor payments (wages). In Table 6.3 Model 1, I regress the logarithm of domestic industry wages ($iwages\_sector$) on the foreign share of total sector output ($Horizontal$) controlling for sector and time fixed-effects. The results suggest that for a given 1% increase in MNC share of total sector output, there is an associated statistically significant 1.9% average decrease in domestic sector wages. The inclusion of time-by-sector fixed effects in Model 2 does have a small impact on this relationship (although sectors are observed at a more aggregate level to avoid collinearity), resulting in a statistically significant 2.3% average decrease in domestic wages associated with every 1% increase in MNC share of output.

When the main effect is decomposed by sector in Model 3, we again find that the overall results are driven by specific sectors. Labor payments in the petroleum, manufacturing, utilities, transportation, and financial services sectors all decrease at varying orders of magnitude—while financial services and transportation/communications are the most negatively affected industries. Domestic commerce and service firms however, experience an average 1.1% increase in sector wages associated with a 1% increase in MNC share of sector output. These sector-specific effects are also disaggregated into 50 2-digit ISIC sector groupings in Appendix D. In contrast to the previous table, the Model 5 instrumental variable regression picks up a causal negative effect along the same order of magnitude of the Model 3 regression—indicating a negative and statistically significant causal effect of MNC entry on the utilities sector (electricity, water, gas) labor payments (wages).
### TABLE 6.2—IMPACT OF FOREIGN SHARE OF TOTAL SECTOR REVENUE (OUTPUT) ON COLOMBIAN SECTOR REVENUE (OUTPUT)

<table>
<thead>
<tr>
<th>Dependent Variable: Colombian Sector Log Output at 2-Digit ISIC Sector Level (loutput_sector)</th>
<th>OLS with sector and year fixed effects</th>
<th>OLS with sector, year, and sector-by-year fixed effects</th>
<th>OLS including sector-by-Horizontal interactions</th>
<th>2SLS (IV: vector of FDI-sending-country average wages) with interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Share of Total Sector Revenue (Horizontal)</td>
<td>-0.0181*** (0.0262)</td>
<td>-0.0185*** (0.0418)</td>
<td>-0.0103 (0.0211)</td>
<td></td>
</tr>
<tr>
<td>Horizontal * agr-forestry</td>
<td>-0.0187*** (0.0262)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * mining-mineral</td>
<td>0.0274*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * petroleum</td>
<td>-0.0158</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * manufacturing</td>
<td>-0.0153*** (0.0211)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * construction</td>
<td>-0.0453*** (0.0262)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * elec-gas-water</td>
<td>-0.0209*** (0.0262)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * commerce-services</td>
<td>0.04194 (0.0211)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * transport-communications</td>
<td>-0.1555*** (0.0211)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * financial-services</td>
<td>-0.1114*** (0.0211)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * public-services</td>
<td>0.0468</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sector Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sector-by-Year Fixed Effects</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Number of Domestic Sectors</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>750</td>
<td>750</td>
<td>750</td>
<td>300</td>
</tr>
<tr>
<td>R² (within)</td>
<td>0.686</td>
<td>0.823</td>
<td>0.7035</td>
<td></td>
</tr>
<tr>
<td>F-test for IV strength</td>
<td>23.1</td>
<td>23.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*** p<0.01, ** p<0.05, * p<0.10

- All specifications use robust standard errors clustered at the 2-digit ISIC sector level (in parentheses).
- The main predictor Horizontal varies at the 2-Digit ISIC sector level.
- Interactions displayed here use aggregated sector groupings at the 1-Digit ISIC sector level. See Appendix 2 for disaggregated interactions at the 2-digit ISIC sector level.
- Year Fixed Effects include annual year dummies from 1995 to 2009.
- Sector-by-Year Fixed Effects use 1-Digit ISIC sector level groupings to avoid collinearity problems.
- The low number of observations in models (4) and (5) reflect limited instrumental variable data. Data were only available between 1997 and 2004, and contained missing values for some sectors leading to listwise deletion.
- First stage F-statistic tests the joint significance of the effect of FDI-sending country average wages on Horizontal.

Note: Horizontal estimates and standard errors are divided by 100 for a 1% marginal effect interpretation.
<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>OLS with sector and year fixed effects</th>
<th>OLS with sector, year, and sector-by-year fixed effects</th>
<th>OLS including sector-by-\textit{Horizontal} interactions</th>
<th>2SLS (IV: vector of FDI-sending-country average wages)</th>
<th>2SLS (IV: vector of FDI-sending-country average wages) with interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Share of Total Sector</td>
<td>-0.0194***</td>
<td>-0.0233***</td>
<td>-0.0299</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Revenue (\textit{Horizontal})b</td>
<td>(0.0046)</td>
<td>(0.0062)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\textit{Horizontal} \times \textit{agr-forestry}c
\textit{Horizontal} \times \textit{mining-mineral}
\textit{Horizontal} \times \textit{petroleum}
\textit{Horizontal} \times \textit{manufacturing}
\textit{Horizontal} \times \textit{construction}
\textit{Horizontal} \times \textit{elec-gas-water}
\textit{Horizontal} \times \textit{commerce-services}
\textit{Horizontal} \times \textit{transport-comms}
\textit{Horizontal} \times \textit{financial-services}
\textit{Horizontal} \times \textit{public-services}

| Sector Fixed Effects | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effectsd | Yes | Yes | Yes | Yes | Yes |
| Sector-by-Year Fixed Effectsd | No | Yes | No | No | No |

| Number of Domestic Sectors | 50 | 50 | 50 | 50 | 50 |
| Number of Observationsd | 750 | 750 | 750 | 300 | 300 |
| \(R^2\) (within) | 0.6344 | 0.8198 | 0.6583 | | |

F-test for IV strength\textsuperscript{e} 23.1 23.1

\textsuperscript{a} All specifications use robust standard errors clustered at the 2-digit ISIC sector level (in parentheses).
\textsuperscript{b} The main predictor \textit{Horizontal} varies at the 2-Digit ISIC sector level.
\textsuperscript{c} Interactions displayed here use aggregated sector groupings at the 1-Digit ISIC sector level. See Appendix 3 for disaggregated interactions at the 2-digit ISIC sector level.
\textsuperscript{d} Year Fixed Effects include annual year dummies from 1995 to 2009.
\textsuperscript{e} Sector-by-Year Fixed Effects use 1-Digit ISIC sector level groupings to avoid collinearity problems.
\textsuperscript{f} The low number of observations in models (4) and (5) reflect limited instrumental variable data. Data were only available between 1997 and 2004, and contained missing values for some sectors leading to listwise deletion.
\textsuperscript{g} First stage F-statistic tests the joint significance of the effect of FDI-sending country average wages on \textit{Horizontal}.

Note: \textit{Horizontal} estimates and standard errors are divided by 100 for a 1% marginal effect interpretation.
6.3 Results for Impact on Firm Revenue due to TFP Spillovers

Following Aitken and Harrison (1999), in Table 6.4 I regress Colombian log output at the firm level (\textit{loutput\_firm}) on the foreign share of total sector output (\textit{Horizontal}) controlling for factor inputs \textit{l\_labor}, \textit{l\_capital}, and \textit{l\_inputs}. Models 1 and 2 suggest that there is no statistically significant association between MNC entry and domestic output growth due to TFP spillovers, however when the main effect is decomposed by sector in Model 3, we find a number of statistically significant positive TFP spillovers and no statistically significant negative spillovers associated with MNC entry. Specifically, these include mining, public services, and commerce and (private) services. When disaggregating Model 3 even further into 50 2-digit ISIC sector groupings in Appendix E however, we find that there are number of statistically significant associations depending on each sector (even when clustering standard errors at the 2-digit ISIC sector level).

These results confirm findings contrary to the prevailing literature—all three “extractive” sectors (coal mining and derivatives, petroleum and natural gas extraction, and other mineral extraction) have positive and statistically significant associations with MNC entry while basic metal manufacturing shows a notable output growth rate of over 100% due to TFP spillovers—perhaps associated with extractive sectors as well. It is conceivable that MNCs in this sector shared technology in such a way that local manufacturers make dramatic marginal productivity improvements. Regarding a causal interpretation of productivity spillovers, with 30,505 observations of 4,563 domestic firms, from Model 4 I determine that for every 1% increase in MNC share of total sector output, there is a commensurate 2.1% increase due to total factor productivity spillovers. Overall, there tend to be positive horizontal (within sector) productivity spillovers in both the associational and causal models.

Following Javorcik (2004), in Table 6.5 I regress Colombian log output at the firm level on the proxy for backward linkages (\textit{backward}) defined previously. Models 1 and 2 initially suggest that domestic suppliers to multinational firms actually become less productive due to a marginal increase in the share of MNC intermediates purchased from them. However when including the instrumental variable regression models which present a more realistic and causal MNC productivity spillover channel to domestic suppliers, there is no detectable effect. While the
overall backward TFP spillover effect is not statistically different than zero, the manufacturing sector appears to benefit immensely. The results suggest that for a 1% increase in the share of supplies domestic manufacturing firms sell to multinationals, they experience a 160% total factor productivity increase.

TABLE 6.4—HORIZONTAL IMPACT OF FOREIGN SHARE OF TOTAL SECTOR REVENUE (OUTPUT) ON COLOMBIAN FIRM PRODUCTIVITY

<table>
<thead>
<tr>
<th>Dependent Variable = Colombian Firm Log Output (loutput firm)</th>
<th>OLS with firm and year fixed effects</th>
<th>OLS with firm, year, and sector-by-year fixed effects</th>
<th>OLS including sector-by-Horizontal interactions</th>
<th>2SLS (IV: vector of FDI-sending-country average wages)</th>
<th>2SLS (IV: vector of FDI-sending-country average wages) with interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Share of Total Sector Revenue (Horizontal)²</td>
<td>0.0006 (0.0021)</td>
<td>0.0010 (0.0021)</td>
<td>0.0216*** (0.0068)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of labor (labor)²</td>
<td>0.0714*** (0.0037)</td>
<td>0.0726** (0.0041)</td>
<td>0.0714*** (0.0037)</td>
<td>0.0714*** (0.0069)</td>
<td>0.0732*** (0.0073)</td>
</tr>
<tr>
<td>Log of capital (capital)²</td>
<td>0.1474*** (0.0152)</td>
<td>0.1443*** (0.0136)</td>
<td>0.1474*** (0.0153)</td>
<td>0.141*** (0.0133)</td>
<td>0.1378*** (0.0119)</td>
</tr>
<tr>
<td>Log of inputs (inputs)²</td>
<td>0.2152*** (0.0206)</td>
<td>0.2116*** (0.0218)</td>
<td>0.2152*** (0.0216)</td>
<td>0.257*** (0.0244)</td>
<td>0.2635*** (0.0242)</td>
</tr>
<tr>
<td>Horizontal * agr-forestry²</td>
<td>0.0045</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horizontal * mining-mineral</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Horizontal * petroleum</td>
<td>0.0014</td>
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<tr>
<td>Horizontal * manufacturing</td>
<td>-0.002</td>
<td></td>
<td></td>
<td>0.1148</td>
<td></td>
</tr>
<tr>
<td>Horizontal * construction</td>
<td>-0.0051</td>
<td></td>
<td></td>
<td>0.0131</td>
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<tr>
<td>Horizontal * elec-gas-water</td>
<td>-0.0005</td>
<td></td>
<td></td>
<td>-0.0084</td>
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<tr>
<td>Horizontal * commerce-services</td>
<td>0.0110*</td>
<td></td>
<td></td>
<td>0.0513</td>
<td></td>
</tr>
<tr>
<td>Horizontal * transport-comms</td>
<td>-0.0022</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Horizontal * financial-services</td>
<td>0.003</td>
<td></td>
<td></td>
<td>0.2329</td>
<td></td>
</tr>
<tr>
<td>Horizontal * public-services</td>
<td>0.019***</td>
<td></td>
<td></td>
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<tr>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Sector-by-Year Fixed Effects</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Number of Domestic Firms</td>
<td>15,427</td>
<td>15,427</td>
<td>15,427</td>
<td>4,563</td>
<td>4,563</td>
</tr>
<tr>
<td>Number of Observations</td>
<td>86,048</td>
<td>86,048</td>
<td>86,048</td>
<td>30,505</td>
<td>30,505</td>
</tr>
<tr>
<td>R²</td>
<td>0.5677</td>
<td>0.5646</td>
<td>0.5708</td>
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</tr>
<tr>
<td>F-test for IV strength</td>
<td>23.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* * * p<0.01, ** p<0.05, * p<0.10

*All specifications use robust standard errors clustered at the 2-digit ISIC sector level (in parentheses).

*Labor controls include short-term and long-term labor payments reported by each firm.

*Capital controls include fixed-capital (property, plants, equipment).

*Input controls include short-term inventories, raw materials, and intermediate inputs.

*Interactions displayed here use aggregated sector groupings at the 1-Digit ISIC sector level. See Appendix 3 for

*Year Fixed Effects include annual year dummies from 1995 to 2009.

*Sector-by-Year Fixed Effects use 1-Digit ISIC sector level groupings to avoid colinearity problems.

*F-test tests joint significance of the minimum wage vector as IV. F-statistic listed.
<table>
<thead>
<tr>
<th>Dependent Variable = Colombian Firm Log Output (lnoutput_firm)</th>
<th>OLS with firm and year fixed effects</th>
<th>OLS with firm, year, and sector-by-year fixed effects</th>
<th>OLS including sector-by-Backward interactions</th>
<th>2SLS (IV: vector of FDI-sending-country average wages)</th>
<th>2SLS (IV: vector of FDI-sending-country average wages) with interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Share of Total Sector (Backward)$^a$</td>
<td>-0.0567** (0.0278)</td>
<td>-0.078988* (0.0401)</td>
<td>0.0364 (0.0508)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Log of labor (llabor)$^b$</td>
<td>0.0712*** (0.0037)</td>
<td>0.0724*** (0.0040)</td>
<td>0.0710*** (0.0037)</td>
<td>0.0720*** (0.0073)</td>
<td>0.052*** (0.0123)</td>
</tr>
<tr>
<td>Log of capital (lcapital)$^c$</td>
<td>0.1476*** (0.0153)</td>
<td>0.1443*** (0.0136)</td>
<td>0.1476*** (0.0152)</td>
<td>0.144*** (0.0145)</td>
<td>0.2511*** (0.0411)</td>
</tr>
<tr>
<td>Log of inputs (linputs)$^d$</td>
<td>0.2151*** (0.0206)</td>
<td>0.2115*** (0.0217)</td>
<td>0.2149*** (0.0205)</td>
<td>0.256*** (0.0246)</td>
<td>0.2514*** (0.0342)</td>
</tr>
<tr>
<td>Backward * agr-forestry$^e$</td>
<td>-0.1498***</td>
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<td>0.1169</td>
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<td></td>
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</tr>
<tr>
<td>Backward * petroleum</td>
<td>0.0366</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Backward * manufacturing</td>
<td>-0.0104</td>
<td></td>
<td></td>
<td>1.600487**</td>
<td>2.8774</td>
</tr>
<tr>
<td>Backward * construction</td>
<td>-0.1552***</td>
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<td>4.6428</td>
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<tr>
<td>Backward * elec-gas-water</td>
<td>-0.2586***</td>
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<td>33.7617</td>
</tr>
<tr>
<td>Backward * commerce-services</td>
<td>-0.0763***</td>
<td></td>
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<tr>
<td>Backward * transport-comms</td>
<td>-0.0532***</td>
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<tr>
<td>Backward * financial-services</td>
<td>-0.1202***</td>
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<td>0.8020</td>
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<td>Backward * public-services</td>
<td>-0.1808</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Year Fixed Effects$^f$</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Sector-by-Year Fixed Effects$^g$</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>Number of Domestic Firms</td>
<td>15,427</td>
<td>15,427</td>
<td>15,427</td>
<td>4,563</td>
<td>4,563</td>
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<tr>
<td>Number of Observations</td>
<td>86,048</td>
<td>86,048</td>
<td>86,048</td>
<td>30,505</td>
<td>30,505</td>
</tr>
<tr>
<td>R$^2$</td>
<td>0.4378</td>
<td>0.4486</td>
<td>0.4386</td>
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<td></td>
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<tr>
<td>F-test for IV strength$^h$</td>
<td>7.72</td>
<td>7.72</td>
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</table>
7. Inter-Industry Analysis Results

7.1. Backward and Forward Linkage Direct Requirement Classifications

While the econometric results presented above describe marginal impact effects of FDI on a number of local economic outcome variables, input-output analysis better captures the direct and indirect effects of MNC entry in terms of foreign firms' backward and forward linkages to the local economy, and is the most appropriate means to gauge FDI’s effect on economic diversification. The following section classifies the economy by such linkages using data from the 2007 Supply and Use tables as well as the 2007 SDS firm-level financial statements (combined into a single input-output table). The year 2007 is chosen representatively as to avoid picking up noise due to the international financial crisis that escalated in 2008 after the collapse of Lehman Brothers. 2007 was also a particularly high output year for the Colombian economy, which experienced an annualized 7.5% GDP growth rate.

In Table 7.1, I classify each of the 59 sectors of the Colombian economy (at the 2-digit ISIC level) by MNC-generated direct requirements in terms of backward and forward linkages according to the Chenery-Watanabe classifications presented in Chapter 5. The values listed under Backward Linkages and Forward Linkages represent the total supply requirements and inputs sold by the foreign sector listed on the left respectively, per one unit of total output of the sector listed. The coefficient associated with backward linkages represents the direct requirements for one unit of total output in the sector, and the coefficient associated with forward linkages represents total sales from that sector to all other sectors in the economy per one unit of total output.

Notably and contrary to the prevailing literature, the Petroleum, Natural Gas, and Uranium as well as the Petroleum Refining sectors (7 and 27) appear to exhibit relatively high backward and forward linkages to the local economy—which suggests that extractive foreign firms actually may have positive impact on local economic diversification. The implications of this result are profound if Colombian oil reserves continue to be discovered at record rates and the country designs its economic diversification policy around that sector’s growth, or bases its strategy on attracting foreign petroleum firms to exploit new resources. Agricultural goods produced by
MNCs in Colombia exhibit particularly low linkages to the rest of the economy, which may represent the fact that the majority of these goods are destined for exports or do not require heavy input shares relative to output, as “natural inputs” are used in their production. Another surprising outcome is that the Coal sector (6) also demonstrates total output multipliers on the high end of the distribution. As coal is a strong and growing commodity in Colombia and is part of the energy and mining boom discussed earlier, this further indicates that mineral and mining sectors in Colombia tend to have uncharacteristically strong linkages for such an extractive commodities. This could be due to the deliberate diversification efforts discussed in Chapter 1, however further discussed is required to understand this phenomenon.

Textile and leather mill sectors (20–23) as well as other foreign manufacturing industries also exhibit expectedly high backward linkages, whereas commerce sectors (43–45) show high backward and forward linkages even though such sectors are not traditionally known for producing products with substantial input requirements. This latter result suggests that foreign retail firms located in Colombia are not importing inputs, but rather buying locally. Foreign material producers of chemicals, plastics, minerals, and metals (28–31) also exhibit high forward linkages to domestic firms suggesting possible gains in value added production, and construction sectors have high backward linkages as well. This latter result could be partially likely due to local content requirements on government contracts, whereby foreign firms must partner with preferred vendors and therefore buy a disproportionate amount of supplies (whether through market mechanism or not) from local industries designated by the government. Lastly, as expected, the data suggest that investments in Commerce and Business Services have some of the largest values for forward linkages, as they provide goods and services for consumption to other sectors.

Overall, such analysis is useful for understanding the inter-sectoral relationships between industries, as the linkage between any two sectors can be uniquely identified (as will be applied in the next chapter). However in the context of this study, it is also useful to analyze these relationships compared with the same linkages that occur between domestic industries and domestic suppliers. The domestic table (in Appendix F) calculated by the same methods to isolate domestic from foreign technology, shows a much higher proportion of direct
requirements (particularly backward linkages) among manufacturing firms. This makes sense (and suggests that the input-output tables are divided correctly), as one would expect that foreign manufacturing firms buy less direct inputs from local industries whereas local manufacturing firms with both more familiarity (information) and access buy a larger share of direct manufacturing inputs relative to their foreign counterparts.

7.2. Backward and Forward Linkage Total Requirement Classifications

Symmetric analysis can also be applied to the total requirements generated by each sector—using the Hirschman-Rasmussen linkages discussed in Chapter 5. In Table 7.2 we observe the backward and forward linkages generated in response to one unit of final demand in each sector. We observe that Manufacturing and Construction sectors exhibit some of the largest total requirements with respect to backward and forward linkages when indirect effects are accounted for, implying that those sectors’ goods are used as intermediate inputs for other supplies, especially in cases where direct linkages were not previously classified so high. Again, we observe similar trends regarding textiles (including leather) and material manufactures (plastics and metallurgical products, etc.), with little relative variation from the direct input classifications, resulting in a scaling effect. Regarding forward linkages, again we observe that the total requirements generated are low across most agriculture and manufacturing industries, however the data again suggest that petroleum, metallic and non-metallic minerals, actually provide high forward linkages when indirect inputs are accounted for.

Comparing the MNC linkages listed in Table 7.2 with the domestic counterpart linkages from Appendix G, we note that again, there is a marked difference in that the domestic total linkages are highly weighted (highly connected) for domestic manufacturing firms versus multinationals. As discussed previously, this is further evidence that MNCs (hypothesized to be heavy importers) in manufacturing generate less total requirements than domestic manufacturers implying that they purchase a larger share of imported inputs from abroad.
<table>
<thead>
<tr>
<th>ISIC Code</th>
<th>Sector Description</th>
<th>Backward Linkage Classification</th>
<th>Forward Linkage Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coffe Beans</td>
<td>0.1002 Low</td>
<td>0.4120 High</td>
</tr>
<tr>
<td>2</td>
<td>Other Agricultural Goods</td>
<td>0.1567 Low</td>
<td>0.1719 Low</td>
</tr>
<tr>
<td>3</td>
<td>Live Animals and Animal Goods</td>
<td>0.3121 Low</td>
<td>0.3318 Low</td>
</tr>
<tr>
<td>4</td>
<td>Forestry and Wood</td>
<td>0.1985 Low</td>
<td>0.4787 High</td>
</tr>
<tr>
<td>5</td>
<td>Fishing Goods</td>
<td>0.1176 Low</td>
<td>0.1869 Low</td>
</tr>
<tr>
<td>6</td>
<td>Coal</td>
<td>0.3956 High</td>
<td>0.1127 Low</td>
</tr>
<tr>
<td>7</td>
<td>Petroleum, Natural Gas, Uranium</td>
<td>0.3101 Low</td>
<td>0.5172 High</td>
</tr>
<tr>
<td>8</td>
<td>Metallic Minerals</td>
<td>0.1510 Low</td>
<td>0.4285 High</td>
</tr>
<tr>
<td>9</td>
<td>Non-Metalic Minerals</td>
<td>0.1615 Low</td>
<td>0.8657 High</td>
</tr>
<tr>
<td>10</td>
<td>Meat and Fish Products</td>
<td>0.3440 Low</td>
<td>0.0624 Low</td>
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<tr>
<td>11</td>
<td>Oils, Animal and Vegetable Grease Products</td>
<td>0.2714 Low</td>
<td>0.2091 Low</td>
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<tr>
<td>12</td>
<td>Lactose Products</td>
<td>0.3194 Low</td>
<td>0.0479 Low</td>
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<tr>
<td>13</td>
<td>Milled Products and Starches</td>
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<td>0.2749 Low</td>
</tr>
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<td>14</td>
<td>Coffee Products</td>
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<td>0.0900 Low</td>
</tr>
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<td>15</td>
<td>Sugar and Cane Products</td>
<td>0.2657 Low</td>
<td>0.1613 Low</td>
</tr>
<tr>
<td>16</td>
<td>Cacao, Chocolate, and Jam Products</td>
<td>0.2809 Low</td>
<td>0.0450 Low</td>
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<tr>
<td>17</td>
<td>Food Products</td>
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<td>0.1017 Low</td>
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<td>18</td>
<td>Beverages</td>
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<td>0.0385 Low</td>
</tr>
<tr>
<td>19</td>
<td>Tobacco Products</td>
<td>0.2014 Low</td>
<td>0.0149 Low</td>
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<td>20</td>
<td>Fabrics and Fiber Textiles</td>
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<tr>
<td>21</td>
<td>Textile Articles</td>
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<td>22</td>
<td>Clothing Textiles</td>
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<tr>
<td>23</td>
<td>Leather Products</td>
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<tr>
<td>24</td>
<td>Wood Products</td>
<td>0.2277 Low</td>
<td>0.9037 High</td>
</tr>
<tr>
<td>25</td>
<td>Paper and Cardboard Products</td>
<td>0.5040 High</td>
<td>0.7280 High</td>
</tr>
<tr>
<td>26</td>
<td>Printing and Editing Machines</td>
<td>0.5676 High</td>
<td>0.6355 High</td>
</tr>
<tr>
<td>27</td>
<td>Petroleum, Refining, Nuclear Combustion</td>
<td>0.5580 High</td>
<td>0.6964 High</td>
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<tr>
<td>28</td>
<td>Chemical Products</td>
<td>0.3288 High</td>
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<tr>
<td>29</td>
<td>Plastic and Rubber Products</td>
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<td>30</td>
<td>Non-Metalic Mineral Products</td>
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<td>31</td>
<td>Metallurgical Products</td>
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<td>32</td>
<td>Machinery and Equipment</td>
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<td>33</td>
<td>Other Machinery and Electronic Appliances</td>
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<td>0.3064 Low</td>
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<td>34</td>
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<tr>
<td>35</td>
<td>Finance</td>
<td>0.2111 Low</td>
<td>0.1336 Low</td>
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<td>36</td>
<td>Other Manufactured Goods</td>
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<td>37</td>
<td>Waste and Recycling</td>
<td>0.0171 Low</td>
<td>0.3907 High</td>
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<tr>
<td>38</td>
<td>Electric Energy</td>
<td>0.4695 High</td>
<td>0.4370 High</td>
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<tr>
<td>39</td>
<td>Gas</td>
<td>0.4557 High</td>
<td>0.3178 Low</td>
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<tr>
<td>40</td>
<td>Water</td>
<td>0.2395 Low</td>
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<tr>
<td>41</td>
<td>Private Construction</td>
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<td>0.0649 Low</td>
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<td>42</td>
<td>Public Construction</td>
<td>0.4129 High</td>
<td>0.2779 High</td>
</tr>
<tr>
<td>43</td>
<td>Commerce Services</td>
<td>0.3836 High</td>
<td>0.8330 High</td>
</tr>
<tr>
<td>44</td>
<td>Repair Services</td>
<td>0.8727 High</td>
<td>0.2837 High</td>
</tr>
<tr>
<td>45</td>
<td>Tourism, Hotels, Restaurants</td>
<td>0.4675 High</td>
<td>0.2447 Low</td>
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<td>46</td>
<td>Land Transport Services</td>
<td>0.4043 High</td>
<td>0.5255 High</td>
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<td>Water Transport Services</td>
<td>0.4939 High</td>
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<td>Air Transport Services</td>
<td>0.4941 High</td>
<td>0.4036 High</td>
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<td>49</td>
<td>Other Transport Services</td>
<td>0.5075 High</td>
<td>0.6606 High</td>
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<td>50</td>
<td>Mail and Telecommunication Services</td>
<td>0.4878 High</td>
<td>0.3827 High</td>
</tr>
<tr>
<td>51</td>
<td>Financial Intermediary Services</td>
<td>0.3401 Low</td>
<td>0.7305 High</td>
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<td>52</td>
<td>Rental Services</td>
<td>0.1206 Low</td>
<td>0.2654 Low</td>
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<td>53</td>
<td>Business Services</td>
<td>0.2905 Low</td>
<td>0.8514 High</td>
</tr>
<tr>
<td>54</td>
<td>Public Administration and Defense</td>
<td>0.4989 High</td>
<td>0.0595 Low</td>
</tr>
<tr>
<td>55</td>
<td>Educational Services</td>
<td>0.1604 Low</td>
<td>0.0458 Low</td>
</tr>
<tr>
<td>56</td>
<td>Social and Health Services</td>
<td>0.3551 Low</td>
<td>0.0187 Low</td>
</tr>
<tr>
<td>57</td>
<td>Sewage Services</td>
<td>0.5143 High</td>
<td>0.3895 Low</td>
</tr>
<tr>
<td>58</td>
<td>Cultural Services</td>
<td>0.7098 High</td>
<td>0.5318 High</td>
</tr>
<tr>
<td>MEAN</td>
<td></td>
<td>0.3642 Low</td>
<td>0.3685 High</td>
</tr>
<tr>
<td>STANDARD DEVIATION</td>
<td></td>
<td>0.1668 Low</td>
<td>0.2585 High</td>
</tr>
</tbody>
</table>
Table 7.2 Hirschman-Rasmussen Classifications of Multinational Firm Total Requirements from Domestic Suppliers: Backward and Forward Linkages to Colombian Firms (2007)

<table>
<thead>
<tr>
<th>ISIC Code</th>
<th>Sector Description</th>
<th>Backward Linkage Classification</th>
<th>Forward Linkage Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coffe Beans</td>
<td>1.1663 Low</td>
<td>1.4589 Low</td>
</tr>
<tr>
<td>2</td>
<td>Other Agricultural Goods</td>
<td>1.2422 Low</td>
<td>1.2264 Low</td>
</tr>
<tr>
<td>3</td>
<td>Live Animals and Animal Goods</td>
<td>1.4658 Low</td>
<td>1.3790 Low</td>
</tr>
<tr>
<td>4</td>
<td>Forestry and Wood</td>
<td>1.3416 Low</td>
<td>1.9483 High</td>
</tr>
<tr>
<td>5</td>
<td>Fishing Goods</td>
<td>1.1985 Low</td>
<td>1.2028 Low</td>
</tr>
<tr>
<td>6</td>
<td>Coal</td>
<td>1.562 High</td>
<td>1.831 Low</td>
</tr>
<tr>
<td>7</td>
<td>Petroleum, Natural Gas, Uranium</td>
<td>1.5003 Low</td>
<td>2.1483 High</td>
</tr>
<tr>
<td>8</td>
<td>Metallic Minerals</td>
<td>1.2619 Low</td>
<td>1.9589 High</td>
</tr>
<tr>
<td>9</td>
<td>Non-Metallic Minerals</td>
<td>1.2657 Low</td>
<td>2.4119 High</td>
</tr>
<tr>
<td>10</td>
<td>Meat and Fish Products</td>
<td>1.5127 Low</td>
<td>1.0787 Low</td>
</tr>
<tr>
<td>11</td>
<td>Oils, Animal and Vegetable Grease Products</td>
<td>1.4079 Low</td>
<td>1.3044 Low</td>
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<tr>
<td>12</td>
<td>Lactose Products</td>
<td>1.4910 Low</td>
<td>1.0599 Low</td>
</tr>
<tr>
<td>13</td>
<td>Milled Products and Starches</td>
<td>1.3779 Low</td>
<td>1.4083 Low</td>
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<tr>
<td>14</td>
<td>Coffee Products</td>
<td>1.5338 Low</td>
<td>1.1088 Low</td>
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<tr>
<td>15</td>
<td>Sugar and Cane Products</td>
<td>1.3885 Low</td>
<td>1.1940 Low</td>
</tr>
<tr>
<td>16</td>
<td>Cacao, Chocolate, and Jam Products</td>
<td>1.4317 Low</td>
<td>1.0644 Low</td>
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<tr>
<td>17</td>
<td>Food Products</td>
<td>1.4333 Low</td>
<td>1.1364 Low</td>
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<tr>
<td>18</td>
<td>Beverages</td>
<td>1.3468 Low</td>
<td>1.0574 Low</td>
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<tr>
<td>19</td>
<td>Tobacco Products</td>
<td>1.3196 Low</td>
<td>1.0157 Low</td>
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<tr>
<td>20</td>
<td>Fabrics and Fiber Textiles</td>
<td>1.8742 High</td>
<td>1.9053 High</td>
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<td>21</td>
<td>Textile Articles</td>
<td>1.8699 High</td>
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<tr>
<td>22</td>
<td>Clothing Textiles</td>
<td>1.7287 High</td>
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<td>23</td>
<td>Leather Products</td>
<td>1.8641 High</td>
<td>1.2141 Low</td>
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<tr>
<td>24</td>
<td>Wood Products</td>
<td>1.3361 Low</td>
<td>2.3207 High</td>
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<tr>
<td>25</td>
<td>Paper and Cardboard Products</td>
<td>1.8333 High</td>
<td>2.5614 High</td>
</tr>
<tr>
<td>26</td>
<td>Printing and Editing Machines</td>
<td>1.9859 High</td>
<td>2.2827 High</td>
</tr>
<tr>
<td>27</td>
<td>Petroleum, Refining, Nuclear Combustion</td>
<td>1.8565 High</td>
<td>2.2504 High</td>
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<tr>
<td>28</td>
<td>Chemical Products</td>
<td>1.5813 Low</td>
<td>1.9088 High</td>
</tr>
<tr>
<td>29</td>
<td>Plastic and Rubber Products</td>
<td>1.6902 High</td>
<td>2.2732 High</td>
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<tr>
<td>30</td>
<td>Non-Metallic Mineral Products</td>
<td>2.2274 High</td>
<td>2.0566 High</td>
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<tr>
<td>31</td>
<td>Metallurgical Products</td>
<td>1.8813 High</td>
<td>2.2459 High</td>
</tr>
<tr>
<td>32</td>
<td>Machinery and Equipment</td>
<td>1.5852 Low</td>
<td>1.6439 High</td>
</tr>
<tr>
<td>33</td>
<td>Other Machinery and Electronic Appliances</td>
<td>1.5358 Low</td>
<td>1.4906 Low</td>
</tr>
<tr>
<td>34</td>
<td>Transportation Equipment</td>
<td>1.6303 Low</td>
<td>1.7762 High</td>
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<tr>
<td>35</td>
<td>Furniture</td>
<td>1.3388 Low</td>
<td>1.1806 Low</td>
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<tr>
<td>36</td>
<td>Other Manufactured Goods</td>
<td>1.2808 Low</td>
<td>1.2787 Low</td>
</tr>
<tr>
<td>37</td>
<td>Waste and Recycling</td>
<td>1.0308 Low</td>
<td>1.8478 High</td>
</tr>
<tr>
<td>38</td>
<td>Electric Energy</td>
<td>1.8213 High</td>
<td>1.8616 Low</td>
</tr>
<tr>
<td>39</td>
<td>Gas</td>
<td>1.7335 High</td>
<td>1.5318 Low</td>
</tr>
<tr>
<td>40</td>
<td>Water</td>
<td>1.3837 Low</td>
<td>1.3671 Low</td>
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<tr>
<td>41</td>
<td>Private Construction</td>
<td>1.8739 High</td>
<td>1.1099 Low</td>
</tr>
<tr>
<td>42</td>
<td>Public Construction</td>
<td>1.7543 High</td>
<td>1.4049 Low</td>
</tr>
<tr>
<td>43</td>
<td>Commerce Services</td>
<td>1.6460 High</td>
<td>2.5580 High</td>
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<tr>
<td>44</td>
<td>Repair Services</td>
<td>2.5024 High</td>
<td>1.5684 Low</td>
</tr>
<tr>
<td>45</td>
<td>Tourism, Hotels, Restaurants</td>
<td>1.7197 High</td>
<td>1.4920 Low</td>
</tr>
<tr>
<td>46</td>
<td>Land Transport Services</td>
<td>1.7851 High</td>
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<tr>
<td>47</td>
<td>Water Transport Services</td>
<td>1.8405 High</td>
<td>2.0199 High</td>
</tr>
<tr>
<td>48</td>
<td>Air Transport Services</td>
<td>1.8821 High</td>
<td>1.8308 High</td>
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<td>49</td>
<td>Other Transport Services</td>
<td>1.8315 High</td>
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<td>Mail and Telecommunication Services</td>
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<td>51</td>
<td>Financial Intermediary Services</td>
<td>1.5428 Low</td>
<td>2.1349 High</td>
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<td>52</td>
<td>Rental Services</td>
<td>1.1555 Low</td>
<td>1.5779 Low</td>
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<td>53</td>
<td>Business Services</td>
<td>1.4782 Low</td>
<td>2.6680 High</td>
</tr>
<tr>
<td>54</td>
<td>Public Administration and Defense</td>
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<td>55</td>
<td>Educational Services</td>
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<td>56</td>
<td>Social and Health Services</td>
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<td>1.0211 Low</td>
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<td>57</td>
<td>Sewage Services</td>
<td>1.8357 High</td>
<td>1.7226 High</td>
</tr>
<tr>
<td>58</td>
<td>Cultural Services</td>
<td>2.3467 High</td>
<td>2.0917 High</td>
</tr>
</tbody>
</table>

**MEAN** 1.6045 1.6391

**STANDARD DEVIATION** 0.2955 0.4734
8. Sectoral Analysis By Ten Broad Sectors: Impact Summaries

8.1 The Impact of FDI on the Colombian Agriculture, Forestry, Fishing Sector

WEIGHING THE COSTS AND BENEFITS OF FDI TO AGRICULTURE, FORESTRY, FISHING

| Direct Labor Payments (Wages) Paid in 2007: | 4,783,751 Thousands of $COP |
| Backward Linkages (2007): | Low |
| Forward Linkages (2007): | Mixed |
| Horizontal Productivity Spillovers to Local Firms: | Not Statistically Different from Zero |
| Backward Productivity Spillovers to Local Firms: | Not Available |
| Competition Effect on Local Firms: | -1.87% Output Loss / 1% MNC Share Increase |
| Competition Effect on Local Labor Payments: | Not Statistically Different from Zero |
| Impact on Probability of Domestic Firm Exit: | Not Statistically Different from Zero |

FDI Impact Summary: MNC investments in Agriculture, Forestry, and Fishing tend to exhibit low linkages to the rest of the economy and place competitive pressure on local firms, however they also provide a relatively large number of direct labor payments to Colombian laborers. MNC investments in this sector are also concentrated largely on the Pacific coast, which might have implications for local economic development if the Valle del Cauca region is specially targeted for growth. However it is important to note that this high concentration is likely the result of coffee industry investors who registered in the largest city near the region, Cali, Colombia.
8.2 The Impact of FDI on the Colombian *Mining and Minerals* Sector

**WEIGHING THE COSTS AND BENEFITS OF FDI TO MINING AND MINERALS**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Labor Payments (Wages) Paid in 2007:</td>
<td>537,606 Thousands of SCOP</td>
</tr>
<tr>
<td>Forward Linkages (2007):</td>
<td>Mixed</td>
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<tr>
<td>Horizontal Productivity Spillovers to Local Firms:</td>
<td>2.2% Output Gain from Productivity Spillovers</td>
</tr>
<tr>
<td>Backward Productivity Spillovers to Local Firms:</td>
<td>Not Available</td>
</tr>
<tr>
<td>Competition Effect on Local Firms:</td>
<td>2.74% Output Gain / 1% MNC Share Increase</td>
</tr>
<tr>
<td>Competition Effect on Local Labor Payments:</td>
<td>Not Statistically Different from Zero</td>
</tr>
<tr>
<td>Impact on Probability of Domestic Firm Exit:</td>
<td>Not Statistically Different from Zero</td>
</tr>
</tbody>
</table>

**FDI Impact Summary:** FDI to the *Mining and Minerals* sector also exhibits low linkages to the rest of the economy, however MNC investments in *Coal* tend to have very large backward linkages to local suppliers. This could be due to new mine investments which require machinery purchases or other investments in local manufacturing tools, construction, and drilling or boring. Despite modest overall linkages, foreign investments in this sector generate positive productivity spillovers to other mineral and mining sectors and tend to increase the output of their counterpart domestic firms rather than outcompete them. It is important to note that the regression specifications controlled for the current mining boom, suggesting that this result that can be attributed to technology sharing and possible joint operations that simultaneously boost both domestic and foreign firm output.
8.3 The Impact of FDI on the Colombian Petroleum and Derivatives Sector

WEIGHING THE COSTS AND BENEFITS OF FDI TO PETROLEUM AND DERIVATIVES

| Direct Labor Payments (Wages) Paid in 2007: | 12,700,000 Thousands of SCOP |
| Forward Linkages (2007): | High |
| Horizontal Productivity Spillovers to Local Firms: | Not Statistically Different from Zero |
| Backward Productivity Spillovers to Local Firms: | Not Available |
| Competition Effect on Local Firms: | Not Statistically Different from Zero |
| Competition Effect on Local Labor Payments: | -1.75% Wage Loss / 1% MNC Share Increase |
| Impact on Probability of Domestic Firm Exit: | Not Statistically Different from Zero |

FDI Impact Summary: The data suggest that FDI to the Petroleum and Petroleum Derivatives sector generates substantial linkages to the domestic economy, with profound implications for economic diversification from the ensuing oil discoveries. There are expected losses in labor payments to Colombian petroleum firms in the same sector, and the direct wage payments from MNCs operating in the petroleum sector in Colombia are also relatively low. Depending on local policy priorities, the sector’s high local linkages might be enough to encourage policies to attract foreign firms toward the end of diversification. According to the map, such investments are also disproportionately registered in the capital Bogotá as well as the coastal regions that traditionally act as downstream refinement centers and petrochemical production hubs.
WEIGHING THE COSTS AND BENEFITS OF FDI TO MANUFACTURING

| Direct Labor Payments (Wages) Paid in 2007: | 40,700,000 Thousands of SCOP |
| Forward Linkages (2007): | Mixed |
| Horizontal Productivity Spillovers to Local Firms: | Not Statistically Different from Zero |
| Backward Productivity Spillovers to Local Firms: | 160% Output Gain from Productivity Spillover |
| Competition Effect on Local Firms: | -1.53% Output Loss / 1% MNC Share Increase |
| Competition Effect on Local Labor Payments: | -2.6% Wage Loss per 1% MNC Share Increase |
| Impact on Probability of Domestic Firm Exit: | MNC Entry Decreases Probability of Firm Exit |

**FDI Impact Summary:** FDI to the Manufacturing sector generates the majority of direct labor payments when the economy is divided into the ten aggregate classifications studied. While the backward and forward linkages generated by foreign manufacturers are moderate at best, domestic manufacturers exhibit overwhelmingly positive total factor productivity (TFP) spillovers from foreign purchasers who like pressure them to increase productivity along the entire value chain. While MNCs tend to place competitive pressure on local manufactures within the same sector, evidence suggests that FDI entry also decreases the probability that the same firms go out of business—which may be due to the demonstration effect—resulting in losses among domestic firms without full crowd out.
8.5 The Impact of FDI on the Colombian Electricity, Gas, and Water Sector

WEIGHING THE COSTS AND BENEFITS OF FDI TO ELECTRICITY, GAS, AND WATER

<table>
<thead>
<tr>
<th>Description</th>
<th>Metric</th>
</tr>
</thead>
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<tr>
<td>Direct Labor Payments (Wages) Paid in 2007</td>
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</tr>
<tr>
<td>Backward Linkages (2007):</td>
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</tr>
<tr>
<td>Forward Linkages (2007):</td>
<td>Low</td>
</tr>
<tr>
<td>Horizontal Productivity Spillovers to Local Firms:</td>
<td>Not Statistically Different from Zero</td>
</tr>
<tr>
<td>Backward Productivity Spillovers to Local Firms:</td>
<td>Not Statistically Different from Zero</td>
</tr>
<tr>
<td>Competition Effect on Local Firms:</td>
<td>-2.09% Output Loss / 1% MNC Share Increase</td>
</tr>
<tr>
<td>Competition Effect on Local Labor Payments:</td>
<td>-2.79% Wage Loss / 1% MNC Share Increase</td>
</tr>
<tr>
<td>Impact on Probability of Domestic Firm Exit:</td>
<td>Not Statistically Different from Zero</td>
</tr>
</tbody>
</table>

FDI Impact Summary: Foreign investment in the Colombian Utilities sectors tend to place downward pressure on local firms, however this result could be biased by a small sample size and the fact that all foreign investment in this sector takes place in the capital city of Bogotá. Overall however, if policymakers view competing foreign utilities companies as providing cheaper or more efficient inputs, the losses incurred may be offset by other gains in service provision and long run cost savings.
8.6 The Impact of FDI on the Colombian Construction Sector

WEIGHING THE COSTS AND BENEFITS OF FDI TO CONSTRUCTION

| Direct Labor Payments (Wages) Paid in 2007: | 3,382,020 Thousands of SCOP |
| Backward Linkages (2007): | High |
| Forward Linkages (2007): | High |
| Horizontal Productivity Spillovers to Local Firms: | Not Statistically Different from Zero |
| Backward Productivity Spillovers to Local Firms: | Not Statistically Different from Zero |
| Competition Effect on Local Firms: | -4.53% Output Loss / 1% MNC Share Increase |
| Competition Effect on Local Labor Payments: | Not Statistically Different from Zero |
| Impact on Probability of Domestic Firm Exit: | MNC Entry Increases Probability of Firm Exit |

**FDI Impact Summary:** FDI to the Colombian Construction sector exhibits some of the highest backward and forward linkages observed, which may be the result of government mandating foreign construction firms to contract specific vendors for public works projects. Even so, foreign construction firms tend to place very large downward pressure on local firms, and increase the probability that domestic construction firms go out of business. If this is the case, public works and government contracts for construction may be some of the few sectors through which government could legally advocate for protectionist subsidies under the premise that they require construction be done by preferred vendors.
8.7 The Impact of FDI on the Colombian *Commerce and Services* Sector

**WEIGHING THE COSTS AND BENEFITS OF FDI TO *COMMERCE AND SERVICES***

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
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<td>Direct Labor Payments (Wages) Paid in 2007</td>
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<tr>
<td>Backward Linkages (2007):</td>
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<td>Forward Linkages (2007):</td>
<td>High</td>
</tr>
<tr>
<td>Horizontal Productivity Spillovers to Local Firms:</td>
<td>1.1% Output Gain from Productivity Spillover</td>
</tr>
<tr>
<td>Backward Productivity Spillovers to Local Firms:</td>
<td>Not Statistically Different from Zero</td>
</tr>
<tr>
<td>Competition Effect on Local Firms:</td>
<td>Not Statistically Different from Zero</td>
</tr>
<tr>
<td>Competition Effect on Local Labor Payments:</td>
<td>Not Statistically Different from Zero</td>
</tr>
<tr>
<td>Impact on Probability of Domestic Firm Exit:</td>
<td>Not Statistically Different from Zero</td>
</tr>
</tbody>
</table>

**FDI Impact Summary:** Local gains from FDI in the Colombian *Commerce and Services* sector tends to be concentrated among direct labor payments, linkages (particularly forward linkages) as well as small within sector productivity gains. While the statistical analysis did not have enough power to pick up whether there was a small competition effect on local retailers, it is indeed plausible that there are positive productivity spillovers in commerce as marketing and tacit knowledge are more readily leaked in such industries (as demonstrated by the disaggregated TFP spillover results in Appendix E). Like domestic commerce, FDI in this sector is also very widely distributed regionally.
8.8 The Impact of FDI on the Colombian Transportation, Communications, and Storage Sector

WEIGHING THE COSTS AND BENEFITS OF FDI TO TRANSPORTATION, COMMS., STORAGE

| Direct Labor Payments (Wages) Paid in 2007: | 2,150,710 Thousands of SCOP  |
| Backward Linkages (2007):                   | High                         |
| Forward Linkages (2007):                    | High                         |
| Horizontal Productivity Spillovers to Local Firms: | Not Statistically Different from Zero |
| Backward Productivity Spillovers to Local Firms: | Not Available                |
| Competition Effect on Local Firms:          | -15.5% Output Loss / 1% MNC Share Increase |
| Impact on Probability of Domestic Firm Exit: | Not Statistically Different from Zero |

FDI Impact Summary: FDI entry into the Transportation, Communications, and Storage sector tends to place particularly strong pressure on domestic firms in the same sectors, who experience on average a 15.5% output loss per every 1% gain in market share on behalf of MNCs. While such consequences would suggest that FDI in transportation sectors is detrimental to local firm growth, if such investments facilitate lower transaction costs by way of more efficient transportation and movement of freight, then policymakers may want to consider retaining and enhancing such investments. However as the statistics indicate that there is no statistically significant productivity spillover, such targeting strategies may or may not be prudent.
8.9 The Impact of FDI on the Colombian Financial Services Sector

<table>
<thead>
<tr>
<th>WEIGHING THE COSTS AND BENEFITS OF FDI TO FINANCIAL SERVICES</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direct Labor Payments (Wages) Paid in 2007:</strong> 688,951 Thousands of COP</td>
</tr>
<tr>
<td><strong>Backward Linkages (2007):</strong> Low</td>
</tr>
<tr>
<td><strong>Forward Linkages (2007):</strong> Mixed</td>
</tr>
<tr>
<td><strong>Horizontal Productivity Spillovers to Local Firms:</strong> Not Statistically Different from Zero</td>
</tr>
<tr>
<td><strong>Backward Productivity Spillovers to Local Firms:</strong> Not Statistically Different from Zero</td>
</tr>
<tr>
<td><strong>Competition Effect on Local Firms:</strong> -11.1% Output Loss / 1% MNC Share Increase</td>
</tr>
<tr>
<td><strong>Competition Effect on Local Labor:</strong> -36.9% Wage Loss / 1% MNC Share Increase</td>
</tr>
<tr>
<td><strong>Impact on Probability of Domestic Firm Exit:</strong> MNC Entry Increases Probability of Firm Exit</td>
</tr>
</tbody>
</table>

FDI Impact Summary: One of the most clear “losing” sectors as a result of FDI entry, as suggested by the data, is the Colombian Financial Services sector. Data indicates that local firms lose on average 11.1% of revenue for every 1% increase in MNC market share, while local wages experience even more substantial losses, which is likely a result of local firms competing with the more efficient foreign financial firms—placing pressure on local labor costs. In this case it is also important to take a nuanced approach, and recognize that while the negative impact is evident, access to finance is often a large barrier to entrepreneurial activity in developing countries. If Colombia sees access to finance as a large barrier to growth, policymakers may decide to attract foreign means of financing despite such obvious losses for domestic firms in the same industry.
8.10 The Impact of FDI on the Colombian *Public Services* Sector

**Legend**
- Public Services, Domestic Firm Revenue (SCOP)
- Public Services, Foreign Firm Revenue (SCOP)

**WEIGHING THE COSTS AND BENEFITS OF FDI TO PUBLIC SERVICES**

| Direct Labor Payments (Wages) Paid in 2007: | 472,261 Thousands of SCOP |
| Backward Linkages: | Mixed |
| Forward Linkages: | Low |
| Horizontal Productivity Spillovers to Local Firms: | 1.9% Output Gain From Productivity Spillover |
| Backward Productivity Spillovers to Local Firms: | Not Available |
| Competition Effect on Local Firms: | Not Statistically Different from Zero |
| Competition Effect on Local Labor Payments: | Not Statistically Different from Zero |
| Impact on Probability of Domestic Firm Exit: | MNC Entry Increases Probability of Firm Exit |

**FDI Impact Summary:** FDI to the *Public Services* sector has a very clear horizontal productivity spillover effect on local public agencies. This is likely due to joint ventures since foreign firms cannot legally own public entities, however as demonstrated by the direct labor payments, this proportion of foreign investment is very low relative to other sectors.
9. Conclusion: Structural Preconditions and Policy Implications

In this paper I identify and analyze three potential channels through which FDI impacts domestic firms directly—industry revenue, industry wages, and firm productivity—and conclude that the net impact of MNC entry on domestic firms varies by sector. I find a negative and statistically significant correlation between foreign share of sector output and domestic sector revenue—a 1.8% average decrease in domestic revenue for a given 1% increase in MNC sector output share. The impact on wages at the industry level yields a similar result—a 1% increase in foreign share of output is associated with a 2.3% decrease in average domestic labor payments. The results also suggest countervailing positive and statistically significant (causal) TFP spillovers—a 1% increase in MNC sector output share causes a 2.2% increase in average domestic firm revenue through horizontal TFP spillovers, and a 160% increase in firm revenue through backward TFP spillovers to the manufacturing sector.

It is important to highlight that this paper captures a limited set of the dynamic effects of FDI and MNC entry on economic growth and employment generation, and its policy recommendations only implicate strategies insofar as they relate to the stated goals of FDI attraction (by policymakers)—whether those be economic diversification, access to financing, productivity spillovers, backward linkages, or employment generation. While the econometric specifications identify competition and productivity spillover effects within each sector according to their impact on domestic sector revenue and wages, there are other direct and indirect benefits from MNC entry that are better captured by inter-industry linkage analysis. When combined with the regression results, the results from the inter-industry linkage analysis makes clear that the impact of FDI is both dynamic and varied. Policymakers considering targeting FDI from specific sectors must keep in mind that some industries incur losses due to competition, while others exhibit high productivity gains, low or high backward and forward linkages, and any combination of these outcomes depending on the sector under consideration.

There are however, some direct results that are worth noting explicitly. Regarding the stated policy goal of economic diversification, industrial and competitiveness policies designed around booming sectors such as petroleum, may in fact prove useful in diversifying production and
avoiding volatile dependency on high-yield cash crops. Contrary to the prevailing literature, the evidence in the case of Colombia suggests that local sectors have a lot to gain from the presence of extractive mineral and mining, as well as petroleum sectors—output and productivity gains in the case of the former and linkage gains in the case of the latter (as defined by the cost and benefit outcome variables described in this paper and not any other potential externalities.) This stands in direct contrast to Kugler (2006) who found no overall intra-sector TFP spillovers in the Colombian case. As the Colombian mining sectors continue to experience an ongoing energy-mining boom due to new oil and minerals discoveries coupled with rising global commodity demand driven largely by Asia, MNCs may play an important role in encouraging Colombian (public and private sector) capture of the benefits from the boom. It is also worth noting that positive TFP spillovers to public service sectors may also indicate more effective governance, which, if considered a substantial barrier to growth, may also deserve special weighting in the FDI policymaking process (through the investment promotion agencies described in Chapter 1). In all analyses, the models suggest that domestic financial service sectors perform poorly in the presence of FDI—there is both a higher probability of domestic firm exit associated with increasing MNC share in financial services, as well as lower industry-wide domestic output and labor payments associated with MNC entry. However if financial services are delivered either more cheaply or more effectively to local entrepreneurs and households, policymakers may choose to attract such firms regardless of their negative consequences for local financial firms.

Overall, the associational and causal effects of MNC entry on domestic firm output, wages, and productivity, suggest that the net gains from FDI openness are limited, but vary largely by sector. Contrary to the prevailing literature, extractive sectors in Colombia share high structural linkages to the local economy that may facilitate growth. Consistent with my hypothesis, the data suggest that economic structure plays an important role in capturing gains from MNCs. To maximize spillovers from FDI, policymakers can prioritize which of the slate of metrics analyzed is their greatest priority, and then plan accordingly. Industrial policies that correct coordination failures can place petroleum and mining sectors at the center of diversification strategies, while policies that encourage FDI in transportation and public services may be better suited to overall improvements in the investment climate, logistics, governance, and activities whose efficiency gains affect large-scale coordination costs.
At the very least, this paper suggests that a dynamic framework capable of capturing both horizontal and backward spillover effects from FDI is required for policymakers to effectively weigh the costs and benefits associated with MNC entry in each sector. The degree to which the resulting effects implicate policy however, is determined by how Colombian policymakers frame the priorities for economic growth. This suggests that the role of foreign investment in any given sector can be tailored to local economic growth strategies according to policy objectives.
Appendix A. Normality Check After Initial Cleaning of *output* Variable

Appendix B. Normality Check After Initial Cleaning of *inputs* Variable
**APPENDIX C—DISAGGREGATED VERSION OF TABLE 6.2, MODEL 3 - IMPACT ON INDUSTRY REVENUE:**

<table>
<thead>
<tr>
<th>Sector Groupings</th>
<th>1-Digit ISIC Sector Groupings</th>
<th>Coefficient</th>
<th>P</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Export-Oriented Agriculture</td>
<td>Agriculture, Fishing, Forestry</td>
<td>(0.0208) *</td>
<td>0.0110</td>
<td></td>
</tr>
<tr>
<td>Coal and Derivatives</td>
<td>Mining &amp; Minerals</td>
<td>0.1121 ***</td>
<td>0.0202</td>
<td></td>
</tr>
<tr>
<td>Petroleum and Natural Gas Extraction</td>
<td>Petroleum &amp; Derivatives</td>
<td>0.0053</td>
<td>0.0048</td>
<td></td>
</tr>
<tr>
<td>Extraction of Other Minerals</td>
<td>Mining &amp; Minerals</td>
<td>0.0183 *</td>
<td>0.0187</td>
<td></td>
</tr>
<tr>
<td>Food Products</td>
<td>Manufacturing</td>
<td>(0.9821)</td>
<td>0.7701</td>
<td></td>
</tr>
<tr>
<td>Beverages</td>
<td>Manufacturing</td>
<td>(0.0140) ***</td>
<td>0.0019</td>
<td></td>
</tr>
<tr>
<td>Fabric Production (Textiles)</td>
<td>Manufacturing</td>
<td>(0.1801) ***</td>
<td>0.0448</td>
<td></td>
</tr>
<tr>
<td>Clothing</td>
<td>Manufacturing</td>
<td>0.0074</td>
<td>0.0999</td>
<td></td>
</tr>
<tr>
<td>Footwear</td>
<td>Manufacturing</td>
<td>(0.1507) ***</td>
<td>0.0384</td>
<td></td>
</tr>
<tr>
<td>Paper, Cardboard, Derivatives</td>
<td>Manufacturing</td>
<td>0.1505 ***</td>
<td>0.0263</td>
<td></td>
</tr>
<tr>
<td>Stationary and Printing</td>
<td>Manufacturing</td>
<td>(0.3504) ***</td>
<td>0.1259</td>
<td></td>
</tr>
<tr>
<td>Chemical Products</td>
<td>Manufacturing</td>
<td>(0.1095) *</td>
<td>0.0598</td>
<td></td>
</tr>
<tr>
<td>Rubber Products</td>
<td>Manufacturing</td>
<td>(0.0136) ***</td>
<td>0.0015</td>
<td></td>
</tr>
<tr>
<td>Plastics</td>
<td>Manufacturing</td>
<td>(0.0273)</td>
<td>0.0447</td>
<td></td>
</tr>
<tr>
<td>Non-Metallic Mineral Products</td>
<td>Manufacturing</td>
<td>0.6420 ***</td>
<td>0.1926</td>
<td></td>
</tr>
<tr>
<td>Cement Products</td>
<td>Manufacturing</td>
<td>0.5439</td>
<td>0.8424</td>
<td></td>
</tr>
<tr>
<td>Basic Metals</td>
<td>Manufacturing</td>
<td>16.1307 ***</td>
<td>4.4443</td>
<td></td>
</tr>
<tr>
<td>Metalmechanic Products</td>
<td>Manufacturing</td>
<td>(0.0540)</td>
<td>0.0525</td>
<td></td>
</tr>
<tr>
<td>Automobile Motors</td>
<td>Manufacturing</td>
<td>(0.2913) ***</td>
<td>0.0766</td>
<td></td>
</tr>
<tr>
<td>Other Manufactures</td>
<td>Manufacturing</td>
<td>(0.1336) **</td>
<td>0.0512</td>
<td></td>
</tr>
<tr>
<td>Electricity, Gas, Water</td>
<td>Electricity, Gas, Water</td>
<td>(0.0223) ***</td>
<td>0.0016</td>
<td></td>
</tr>
<tr>
<td>Residential Construction</td>
<td>Construction</td>
<td>(0.0106)</td>
<td>0.0095</td>
<td></td>
</tr>
<tr>
<td>Local Transportation Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>0.0324</td>
<td>0.0269</td>
<td></td>
</tr>
<tr>
<td>Wholesale Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>(0.1306) ***</td>
<td>0.0208</td>
<td></td>
</tr>
<tr>
<td>Retail Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>(0.4249) ***</td>
<td>0.1141</td>
<td></td>
</tr>
<tr>
<td>Housing, Lodging</td>
<td>Commerce, Services, Tourism</td>
<td>(0.0183)</td>
<td>0.0168</td>
<td></td>
</tr>
<tr>
<td>Freight Transportation by Land</td>
<td>Transportation, Communications, Storage</td>
<td>0.1384 ***</td>
<td>0.0636</td>
<td></td>
</tr>
<tr>
<td>Investment in Services</td>
<td>Financial Services</td>
<td>(0.1393) *</td>
<td>0.0762</td>
<td></td>
</tr>
<tr>
<td>Land Development</td>
<td>Financial Services</td>
<td>(0.1065) ***</td>
<td>0.0165</td>
<td></td>
</tr>
<tr>
<td>Education</td>
<td>Public Services</td>
<td>0.7707 ***</td>
<td>0.0386</td>
<td></td>
</tr>
<tr>
<td>Social Services and Health</td>
<td>Public Services</td>
<td>5.3766 ***</td>
<td>0.4173</td>
<td></td>
</tr>
<tr>
<td>Other Community Services</td>
<td>Public Services</td>
<td>0.0614</td>
<td>0.0351</td>
<td></td>
</tr>
<tr>
<td>Combustibles Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>0.2241 ***</td>
<td>0.0223</td>
<td></td>
</tr>
<tr>
<td>Other Agricultural Sectors</td>
<td>Agriculture, Fishing, Forestry</td>
<td>(0.6693) **</td>
<td>0.3143</td>
<td></td>
</tr>
<tr>
<td>Cattle and Hunting</td>
<td>Agriculture, Fishing, Forestry</td>
<td>0.0602</td>
<td>0.2536</td>
<td></td>
</tr>
<tr>
<td>Other Textile Manufacturers</td>
<td>Manufacturing</td>
<td>0.0016</td>
<td>0.0433</td>
<td></td>
</tr>
<tr>
<td>Newspaper Publications</td>
<td>Manufacturing</td>
<td>(1.0613)</td>
<td>0.9975</td>
<td></td>
</tr>
<tr>
<td>Equipment and Machinery Production</td>
<td>Manufacturing</td>
<td>(0.4235) ***</td>
<td>0.0332</td>
<td></td>
</tr>
<tr>
<td>Other Transportation</td>
<td>Transportation, Communications, Storage</td>
<td>20.0318 **</td>
<td>1.4076</td>
<td></td>
</tr>
<tr>
<td>Storage, Cargo, Containers</td>
<td>Transportation, Communications, Storage</td>
<td>(0.3954) ***</td>
<td>0.0363</td>
<td></td>
</tr>
<tr>
<td>Telephones and Communication</td>
<td>Transportation, Communications, Storage</td>
<td>(0.1349) ***</td>
<td>0.0142</td>
<td></td>
</tr>
<tr>
<td>Radio and Television</td>
<td>Transportation, Communications, Storage</td>
<td>(3.2665) ***</td>
<td>1.1188</td>
<td></td>
</tr>
<tr>
<td>Fishing</td>
<td>Agriculture, Fishing, Forestry</td>
<td>(0.0177) ***</td>
<td>0.0042</td>
<td></td>
</tr>
<tr>
<td>Information Services</td>
<td>Commerce, Services, Tourism</td>
<td>0.0642 ***</td>
<td>0.0127</td>
<td></td>
</tr>
<tr>
<td>Other Entrepreneurial Activities</td>
<td>Commerce, Services, Tourism</td>
<td>(0.0749) ***</td>
<td>0.0272</td>
<td></td>
</tr>
<tr>
<td>Civil Construction</td>
<td>Construction</td>
<td>(0.0606) ***</td>
<td>0.0068</td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td>Construction</td>
<td>(0.0262) ***</td>
<td>0.0068</td>
<td></td>
</tr>
<tr>
<td>Petroleum and Gas Derivatives</td>
<td>Petroleum &amp; Derivatives</td>
<td>(0.0396) ***</td>
<td>0.0037</td>
<td></td>
</tr>
<tr>
<td>Restaurants, Food, Beverage</td>
<td>Commerce, Services, Tourism</td>
<td>0.3186 ***</td>
<td>0.0620</td>
<td></td>
</tr>
<tr>
<td>Tourism</td>
<td>Commerce, Services, Tourism</td>
<td>1.4391 ***</td>
<td>0.1749</td>
<td></td>
</tr>
</tbody>
</table>

Sector Fixed Effects: Yes
Year Fixed Effects: Yes
Sector-by-Year Fixed Effects: No
Number of Domestic Sectors: 50
Number of Observations: 750
R² (within): 0.734

*** p<0.01, ** p<0.05, * p<0.10
All specifications use robust standard errors clustered at the 2-digit ISIC sector level.
Negative estimates are listed in parentheses.
P = p-value, S.E. = Standard Error
Note: Horizontal estimates and standard errors are devided by 100 for a 1% marginal effect interpretation.
**APPENDIX D—DISAGGREGATED VERSION OF TABLE 6.3, MODEL 3 - IMPACT ON INDUSTRY WAGES:**

<table>
<thead>
<tr>
<th>#</th>
<th>2-DIGIT ISIC SECTOR GROUPINGS</th>
<th>1-DIGIT ISIC SECTOR GROUPINGS</th>
<th>Coefficient</th>
<th>P</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Export-Oriented Agriculture</td>
<td>Agriculture, Fishing, Forestry</td>
<td>(0.0304) **</td>
<td>0.0136</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Coal and Derivatives</td>
<td>Mining &amp; Minerals</td>
<td>(0.0795) **</td>
<td>0.0337</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Petroleum and Natural Gas Extraction</td>
<td>Petroleum &amp; Derivatives</td>
<td>(0.0167) **</td>
<td>0.0063</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Extraction of Other Minerals</td>
<td>Mining &amp; Minerals</td>
<td>0.0222 *</td>
<td>0.0130</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Food Products</td>
<td>Manufacturing</td>
<td>1.0342</td>
<td>1.1533</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Beverages</td>
<td>Manufacturing</td>
<td>(0.0300) ***</td>
<td>0.0024</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Fabric Production (Textiles)</td>
<td>Manufacturing</td>
<td>0.0602</td>
<td>0.0702</td>
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<td>8</td>
<td>Clothing</td>
<td>Manufacturing</td>
<td>(0.3453) **</td>
<td>0.1669</td>
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<tr>
<td>9</td>
<td>Footwear</td>
<td>Manufacturing</td>
<td>(0.0428) **</td>
<td>0.0510</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Paper, Cardboard, Derivatives</td>
<td>Manufacturing</td>
<td>0.0269</td>
<td>0.0355</td>
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</tr>
<tr>
<td>11</td>
<td>Stationary and Printing</td>
<td>Manufacturing</td>
<td>(0.0697)</td>
<td>0.1330</td>
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<td>12</td>
<td>Chemical Products</td>
<td>Manufacturing</td>
<td>(0.0380)</td>
<td>0.0584</td>
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<tr>
<td>13</td>
<td>Rubber Products</td>
<td>Manufacturing</td>
<td>(0.0168) ***</td>
<td>0.0017</td>
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<td>14</td>
<td>Plastics</td>
<td>Manufacturing</td>
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<td>15</td>
<td>Non-Metalic Mineral Products</td>
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<td>0.1412</td>
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<tr>
<td>16</td>
<td>Cement Products</td>
<td>Manufacturing</td>
<td>(9.6136) ***</td>
<td>1.3173</td>
<td></td>
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<tr>
<td>17</td>
<td>Basic Metals</td>
<td>Manufacturing</td>
<td>30.9079 ***</td>
<td>6.9523</td>
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</tr>
<tr>
<td>18</td>
<td>Metalmechanic Products</td>
<td>Manufacturing</td>
<td>(0.1027)</td>
<td>0.0538</td>
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</tr>
<tr>
<td>19</td>
<td>Automobile Motors</td>
<td>Manufacturing</td>
<td>(0.1316)</td>
<td>0.0757</td>
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<tr>
<td>20</td>
<td>Other Manufactures</td>
<td>Manufacturing</td>
<td>0.2477 ***</td>
<td>0.0665</td>
<td></td>
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<tr>
<td>21</td>
<td>Electricity, Gas, Water</td>
<td>Electricity, Gas, Water</td>
<td>(0.0264) ***</td>
<td>0.0022</td>
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<tr>
<td>22</td>
<td>Residential Construction</td>
<td>Construction</td>
<td>0.0414</td>
<td>0.0104</td>
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<tr>
<td>23</td>
<td>Local Transportation Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>0.1188</td>
<td>0.0316</td>
<td></td>
</tr>
<tr>
<td>24</td>
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<td>Commerce, Services, Tourism</td>
<td>0.0301</td>
<td>0.0228</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Retail Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>1.1596 ***</td>
<td>0.1593</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Housing, Lodging</td>
<td>Commerce, Services, Tourism</td>
<td>(0.0267)</td>
<td>0.0262</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Retail Transportation by Land</td>
<td>Transportation, Communications, Storage</td>
<td>0.4716 ***</td>
<td>0.0851</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Freight Transportation by Land</td>
<td>Transportation, Communications, Storage</td>
<td>(3.2807) ***</td>
<td>0.1262</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Land Development</td>
<td>Financial Services</td>
<td>(0.2602) ***</td>
<td>0.0244</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>Education</td>
<td>Public Services</td>
<td>0.4713 ***</td>
<td>0.0537</td>
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</tr>
<tr>
<td>31</td>
<td>Social Services and Health</td>
<td>Public Services</td>
<td>3.7932 ***</td>
<td>0.6698</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Other Community Services</td>
<td>Public Services</td>
<td>0.0550 ***</td>
<td>0.0153</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Comulates Commerce</td>
<td>Commerce, Services, Tourism</td>
<td>0.2528 ***</td>
<td>0.0332</td>
<td></td>
</tr>
<tr>
<td>34</td>
<td>Other Agricultural Sectors</td>
<td>Agriculture, Fishing, Forestry</td>
<td>(0.4534)</td>
<td>0.5198</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Cattle and Hunting</td>
<td>Agriculture, Fishing, Forestry</td>
<td>1.0019 ***</td>
<td>0.2458</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>Other Textile Manufactures</td>
<td>Manufacturing</td>
<td>(0.2726) ***</td>
<td>0.0492</td>
<td></td>
</tr>
<tr>
<td>37</td>
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<td>Manufacturing</td>
<td>1.0697</td>
<td>1.0496</td>
<td></td>
</tr>
<tr>
<td>38</td>
<td>Equipment and Machinery Production</td>
<td>Manufacturing</td>
<td>(0.1088) ***</td>
<td>0.0361</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>Other Transportation</td>
<td>Transportation, Communications, Storage</td>
<td>25.1110 ***</td>
<td>1.6236</td>
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<td>40</td>
<td>Storage, Cargo, Containers</td>
<td>Transportation, Communications, Storage</td>
<td>0.2157 ***</td>
<td>0.0368</td>
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<tr>
<td>41</td>
<td>Telephones and Communication</td>
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<td>(0.2424)</td>
<td>0.0153</td>
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</tr>
<tr>
<td>42</td>
<td>Radio and Television</td>
<td>Transportation, Communications, Storage</td>
<td>(8.0663) ***</td>
<td>1.3790</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Fishing</td>
<td>Agriculture, Fishing, Forestry</td>
<td>(0.0058)</td>
<td>0.0044</td>
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<td>44</td>
<td>Information Services</td>
<td>Commerce, Services, Tourism</td>
<td>0.1537 ***</td>
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<td>45</td>
<td>Other Entrepreneurial Activities</td>
<td>Commerce, Services, Tourism</td>
<td>0.0556 **</td>
<td>0.0276</td>
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<tr>
<td>46</td>
<td>Civil Construction</td>
<td>Construction</td>
<td>(0.0004)</td>
<td>0.0071</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>Maintenance</td>
<td>Construction</td>
<td>(0.0142) *</td>
<td>0.0083</td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>Petroleum and Gas Derivatives</td>
<td>Petroleum &amp; Derivatives</td>
<td>(0.0171) ***</td>
<td>0.0033</td>
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<tr>
<td>49</td>
<td>Restaurants, Food, Beverage</td>
<td>Commerce, Services, Tourism</td>
<td>0.7395 ***</td>
<td>0.0801</td>
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<tr>
<td>50</td>
<td>Tourism</td>
<td>Commerce, Services, Tourism</td>
<td>2.7973 ***</td>
<td>0.2759</td>
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</tbody>
</table>

Sector Fixed Effects: Yes
Year Fixed Effects: Yes
Sector-by-Year Fixed Effects: No

Number of Domestic Sectors: 50
Number of Observations: 750
R² (within): 0.7111

*** p<0.01, ** p<0.05, * p<0.10

\*All specifications use robust standard errors clustered at the 2-digit ISIC sector level.
\*Negative estimates are listed in parantheses.
P = p-value; S.E. = Standard Error

Note: Horizontal R² is calculated in terms of within sector labor payments.
### APPENDIX E—DISAGGREGATED VERSION OF TABLE 6.4, MODEL 3

**Firm Revenue Impact from TFP:**

<table>
<thead>
<tr>
<th>#</th>
<th>2-DIGIT ISIC SECTOR GROUPINGS</th>
<th>1-DIGIT ISIC SECTOR GROUPINGS</th>
<th>Coefficient</th>
<th>P</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Export-Oriented Agriculture</td>
<td>Agriculture, Fishing, Forestry</td>
<td>0.0073</td>
<td>0.0031</td>
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<tr>
<td>2</td>
<td>Coal and Derivatives</td>
<td>Mining &amp; Minerals</td>
<td>0.0403</td>
<td><strong>0.0071</strong></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Petroleum and Natural Gas Extraction</td>
<td>Petroleum &amp; Derivatives</td>
<td>0.0344</td>
<td><strong>0.0013</strong></td>
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<tr>
<td>4</td>
<td>Extraction of Other Minerals</td>
<td>Mining &amp; Minerals</td>
<td>0.0178</td>
<td><strong>0.0027</strong></td>
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</tr>
<tr>
<td>5</td>
<td>Food Products</td>
<td>Manufacturing</td>
<td>(0.0621)</td>
<td><strong>0.2274</strong></td>
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<tr>
<td>6</td>
<td>Beverages</td>
<td>Manufacturing</td>
<td>(0.0061)</td>
<td>0.0007</td>
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<tr>
<td>7</td>
<td>Fabric Production (Textiles)</td>
<td>Manufacturing</td>
<td>(0.1668)</td>
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<td>8</td>
<td>Clothing</td>
<td>Manufacturing</td>
<td>(0.1853)</td>
<td><strong>0.0349</strong></td>
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<td>9</td>
<td>Footwear</td>
<td>Manufactured</td>
<td>(0.0297)</td>
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<td>10</td>
<td>Paper, Cardboard, Derivatives</td>
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<td>0.0091</td>
<td>0.0186</td>
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<tr>
<td>11</td>
<td>Stationary and Printing</td>
<td>Manufacturing</td>
<td>(0.0693)</td>
<td>0.0435</td>
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<td>12</td>
<td>Chemical Products</td>
<td>Manufacturing</td>
<td>0.0778</td>
<td><strong>0.0135</strong></td>
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</tr>
<tr>
<td>13</td>
<td>Rubber Products</td>
<td>Manufacturing</td>
<td>0.0036</td>
<td><strong>0.0005</strong></td>
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<tr>
<td>14</td>
<td>Plastics</td>
<td>Manufacturing</td>
<td>(0.0160)</td>
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<tr>
<td>15</td>
<td>Non-Metallic Mineral Products</td>
<td>Manufacturing</td>
<td>(0.0039)</td>
<td><strong>0.063</strong></td>
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<tr>
<td>16</td>
<td>Cement Products</td>
<td>Manufacturing</td>
<td>0.7139</td>
<td><strong>0.2283</strong></td>
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<tr>
<td>17</td>
<td>Basic Metals</td>
<td>Manufacturing</td>
<td>20.5124</td>
<td><strong>1.6663</strong></td>
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<tr>
<td>18</td>
<td>Metalmechanic Products</td>
<td>Manufacturing</td>
<td>(0.1189)</td>
<td><strong>0.0113</strong></td>
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<tr>
<td>19</td>
<td>Automobile Motors</td>
<td>Manufacturing</td>
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<tr>
<td>20</td>
<td>Other Manufacturers</td>
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<td>Residential Construction</td>
<td>Construction</td>
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<td>Local Transportation Commerce</td>
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<td>Wholesale Commerce</td>
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<tr>
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<td>Retail Commerce</td>
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<td>(0.1522)</td>
<td><strong>0.0566</strong></td>
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<td>26</td>
<td>Housing, Lodging</td>
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<td>0.0199</td>
<td><strong>0.0071</strong></td>
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<td>27</td>
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<td><strong>0.0136</strong></td>
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<td>Investment in Services</td>
<td>Financial Services</td>
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<td>Land Development</td>
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<td>0.0054</td>
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<td>Education</td>
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<td>Social Services and Health</td>
<td>Public Services</td>
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<td>Newspaper Publications</td>
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<td>0.3065</td>
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<tr>
<td>46</td>
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<td>Construction</td>
<td>0.0062</td>
<td><strong>0.0014</strong></td>
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<td>47</td>
<td>Maintenance</td>
<td>Construction</td>
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<td><strong>0.0017</strong></td>
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<td>Log of capital (K-capital)</td>
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<td>Log of inputs (inputs)</td>
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<td>Firm Fixed Effects</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Year Fixed Effects</td>
<td>Yes</td>
<td></td>
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<td></td>
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<tr>
<td></td>
<td>Sector-by-Year Fixed Effects</td>
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<td>Number of Domestic Firms</td>
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<td>Number of Observations</td>
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<td></td>
<td>R² (within)</td>
<td>0.44</td>
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</tbody>
</table>

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**Notes:**
- All specifications use robust standard errors clustered at the 2-digit ISIC sector level.
- Negative estimates are listed in parentheses.
- FDI_share estimates and standard errors are divided by 100 for a 1% marginal effect interpretation.

---
## Appendix F. Chenery-Watanabe Classifications of Domestic Firm Direct Requirements from Domestic Suppliers: Backward and Forward Linkages to Colombian Firms (2007)

<table>
<thead>
<tr>
<th>ISIC Code</th>
<th>Sector Description</th>
<th>Backward Linkage</th>
<th>Classification</th>
<th>Forward Linkage</th>
<th>Classification</th>
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<tr>
<td>1</td>
<td>Coffe Beans</td>
<td>0.1312</td>
<td>Low</td>
<td>0.8530</td>
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<td>2</td>
<td>Other Agricultural Goods</td>
<td>0.2052</td>
<td>Low</td>
<td>0.3204</td>
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<td>3</td>
<td>Live Animals and Animal Goods</td>
<td>0.2476</td>
<td>Low</td>
<td>0.6104</td>
<td>High</td>
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<td>4</td>
<td>Forestry and Wood</td>
<td>0.1986</td>
<td>Low</td>
<td>0.7076</td>
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<td>5</td>
<td>Fishing Goods</td>
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<td>Coal</td>
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<td>0.1006</td>
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<td>7</td>
<td>Petroleum, Natural Gas, Uranium</td>
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<td>Low</td>
<td>0.3994</td>
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<td>8</td>
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<td>0.3942</td>
<td>High</td>
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<td>High</td>
<td>0.1206</td>
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<td>Milled Products and Starches</td>
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<td>15</td>
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<td>18</td>
<td>Beverages</td>
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<td>Low</td>
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<td>0.4262</td>
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<td>21</td>
<td>Textile Articles</td>
<td>0.4001</td>
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<td>0.3131</td>
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<td>22</td>
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<td>High</td>
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<td>0.1447</td>
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<td>0.4998</td>
<td>High</td>
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<td>Paper and Cardboard Products</td>
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<td>Printing and Editing Machines</td>
<td>0.4541</td>
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<td>27</td>
<td>Petroleum, Refining, Nuclear Combustion</td>
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<td>Chemical Products</td>
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**Standard Deviation**

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## Appendix G. Hirschman-Rasmussen Classifications of Domestic Firm Total Requirements from Domestic Suppliers: Backward and Forward Linkages to Colombian Firms (2007)

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