Council of Foreign Relations Project on Innovation and Economic Performance

Industry Studies Section

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1. Introduction

The automobile industry is a classic among the prominent mature sectors of the industrialized economies. The industry has existed in most of those economies for roughly a century. Economies of scale in manufacturing mean that the total number of firms making final product is relatively small. That final product is complex, and so inevitably are the coordination burdens of assembling it in volume. These coordination problems are the more extreme because the industry's supply chains and the channels of distribution are deep and often broad as well. The scale of all these operations, when everything is added up, is generally very large: the industry typically accounts for a significant fraction of both GDP and national employment.

The adjective "mature" may suggest stagnancy. But the historical development of the industry exhibits dramatic change. This point is most simply defended with examples from the industry's earlier years, though we will argue below that innovations of first-order importance have taken place relatively recently and may still be emerging. So consider the following. The product was initially so expensive that only the wealthy could afford it; but its real price fell dramatically and a mass market emerged. The industry's histories of product and process innovation are long and relatively intricate. So too is the industry's organizational history. Furthermore, the industry represents an enabling technology that spurred change among its consumers. It is difficult to believe that the spatial distribution of work and residence in the United States—to choose an example that is large as well as vivid—would have evolved as it did in the absence of the automobile.

There have been notable bursts of productivity improvement in the industry's history as well as long periods of modest but relatively steady growth. Some of the productivity history was clearly affected by law and policy as well as the course of technology and managerial innovation. Other aspects of economic performance also changed in noteworthy ways. All things considered, this industry provides an interesting context in which to examine the themes of innovation and economic performance, and that both historically and in the context of recent technological developments.

The core of the chapter is organized according to three types of innovation: product innovation, process innovation, and organization innovation. We begin with the categories and a discussion of how one might measure performance in each and of the basic outlines of what one finds. We then describe the most significant innovations in each of the categories, also discussing the drivers of these innovations, the reasons the innovations occurred where they did, and the performance consequences. We conclude with forward-looking discussion.

In all of this, our range of reference is global. The text, however, generally focuses on developments in America. The reason behind this is simple. America is the largest home market. The earliest major innovations happened here because of this. America remains by far the most competitive market. Europe (as a region as well as nation-by-nation) and Japan are quite protected by comparison, American measures in the past thirty years notwithstanding. America is thus where the development of innovations counts most heavily and where firms with inefficient techniques face the most severe consequences. It is, ultimately, the market from which the analyst has the most to learn.

2. Innovation categorized and the question of quantity

The most obvious form innovation might take is product innovation, that is, the development of new and more desired or sophisticated (or both) features for the basic product. The automotive industry has seen tremendous innovation of this type, particularly in its early years. The most casual comparisons of product photographs of models from the beginning and end of the first forty years of the industry's commercial existence suffice to document radical changes in, for example, power sources, body shapes and functions, steering control mechanisms, wheels, and even tires.

It is certainly possible to chronicle these immensely heterogeneous changes systematically.[1] Measuring them quantitatively requires a common standard and is harder. Raff and Trajtenberg 1996 have made a start at this on data from the (well-documented) American marketplace 1906—1940. Their calculations suggest quite notable progress over the period. (Table 1 reproduces the key results.) Problems with the underlying hedonic estimation methods deployed are nontrivial and the fine quantitative detail should be interpreted with caution.[2] But the basic pattern is plain: The value placed upon new features in the market rose over these years an average of two percent per annum in real terms. This is substantial by any reasonable standard.

--Table 1 about here--

What happened to prices themselves? There are no long-term calculations for the industry for anywhere other than America. There, the hedonic estimates of Raff and Trajtenberg can be linked up with previous computations by Griliches (1961) and Gordon (1990) to create a much longer time series running from 1906 through 1982. (See Table

[1] See e.g. Newcomb and Spurr 1989.
[2] See the comment Triplett 1996.

2.) These estimates give equal weight to each model for sale (rather than weighting the significance of each model by its sales) and therefore underestimate the effects of scale economies in production. They are also corrected for changes in the general price level. The series shows real prices dropping very sharply, just as volumes were exploding, in the first several decades of the twentieth century. By the time of the Great Depression, even the Dustbowl farmers forced off their land could load their meager possessions into a car when giving up and leaving for California. The performance of the American industry in getting the product before an increasingly larger population of potential consumers was remarkable.

--Table 2 about here--

Process change is another important form innovation can take. We see three basic domains for process change in the industry's history: design, manufacturing, and quality assurance. Hard data on design performance is only of relatively recent vintage and is thin in its coverage. The regional differences it highlights are nonetheless very striking. We discuss the data in its context in Section 3 below. The second arena concerns the manufacturing process itself. Here one might measure productivity, either crudely with some measure of output per capita (or per employee hour) or with more sophistication by also capturing the utilization of inputs other than labor. This is an industry that has been transformed by capital investment from very early on—this is the message of the famous sequence in the film *Modern Times*—so leaving capital out seems a distortion. But aggregation problems in non-labor data series such as capital make leaving it in problematic in industry-level calculations, as do problems with series continuity over time and with including firms carrying out widely differing sets of activities.[3] The third aspect of process innovation is even more elusive, since none of the standard measurements of productivity in this industry for which long-term comparisons can be made incorporates any consideration of product quality or post-production longevity. Two rounds of international plant-level surveys designed in part to overcome all these problems were carried out in the mid-1980s and 1990s, however. These take the progress the initial development of mass production methods represents as a given and ask "And then what?" Their answers are illuminating, and we report them in Section 4 below. Overall, the basic facts are clear. Recent developments represent a substantial improvement over classic American mass production methods. Those were in themselves a radical transformation.[4] This is an industry that once made very small qualities of output essentially by hand and sold them to the fairly well-to-do clientele that represented the only potential customers who could afford them. It became an industry with tremendous scale economies and a mass market. Subsequent developments enabled far more productive manufacturing still. This is innovation on a grand scale, whatever the numbers.

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[3] The aggregation problems were the reason the Census Bureau stopped collecting capital data with the 1919 Census of Manufactures. They did not resume until well after World War II.

[4] Raff 1996 gives preliminary total factor productivity growth figures for Ford. The underlying data are not problematic in the way industry data are and they home in on the firm (indeed, the plant) in which the innovation was actually happening.

Organization innovations are even less easily measured quantitatively measured over a long time span than are product and process innovation. Nevertheless, we view these as key to understanding evolution of the automotive sector over the past century. We attempt to put the important developments in context in Section 5 below.

3. Product and design innovation

The basic elements of an automobile are an engine, a mechanical system to translate the actions of the engine to motive power, a steering system to guide the vehicle, and a system to carry the users and their belongings.[5] The engine is complex in itself, and the basic set of systems, none of which are simple mechanically, needs augmentation to make the experience of riding tolerable. All of these must, as a matter of design, work well and work well together. Each system works better when its own physical parts and components have tighter tolerances relative to specifications. Since the parts and components are very numerous even in the simplest and least sophisticated designs (a round figure of 10,000 basic parts is a reasonable baseline figure over the period discussed here), manufacturing and assembly in a timely, efficient, and reliable way inevitably represents a difficult coordination task.

None of this is simplified by the fact that designs will inevitably change over time as advances in materials and in engineering knowledge suggest better ways of carrying out old functions and sometimes even suggest new ones. In the early years, as described above, the pace of this change was rapid. The American industry, during a period in which it was unambiguously the world's most vibrant, also built some elements of rapid change in permanently: it developed the practice of frequent and at least superficial design changes as a marketing tool early on. [6] It has therefore had high-frequency changes (and the inventory problems associated with relatively long-lived products) to deal with for a very long time.

A long view of the industry's history suggests a striking observation about the evolution of the product.[7] Profound uncertainties attended the character of many mechanical systems in the earliest years of the industry, even concerning elements as fundamental as whether the source of power should be steam, electricity, or internal combustion.[8] But dominant designs generally emerged relatively quickly. With the development of deep draw presses in the early 1920s, the technology for making bodies with recognizably modern materials and contours was available as well.

From circa 1910 through the 1960's at least, the American firms Ford and, from the late 1920s, General Motors were the dominant automotive firms in the world. The

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[5] For finer detail on automotive engineering systems as systems, see Society of Automotive Engineers Historical Committee 1997.

[6] Sloan 1964 gives the traditional account of how the annual model change began. (See pp. 152, 165-168, and 240.) Perusal of the trade journals during the teens suggests that Sloan may have given himself excessive credit.

[7] Abernathy 1978 is an early and important source of this line of thought.

[8] See e.g. Flink 1970, chapter 8. These uncertainties soon resolved, though steam cars remained in production for many years thereafter.

bulk of this dominance owed to massive scale economies and widespread local assembly plants rather than to product innovation (Ford manufactured the Model T from 1908 through 1927!), though GM developed and maintained a formidable R&D capability that was responsible for a number of genuine if not radical innovations.[9] One consequence of the decimation of Japanese and German industrial plant during World War II was that large-scale foreign competition in autos did not develop immediately after the war. Ford and GM subsidiaries in Japan and Europe did continue to function.

European industry contributed important product innovations in the post-War period, however, including electronic fuel injection and anti-lock braking systems. These innovations reflect the European bias toward high-performance automobiles (designed to take full advantage of the unregulated speeds on Germany's autobahns, for example) in contrast to the American orientation to the mass market.[10]

Both Japanese and European firms devoted far more resources in the post-war period to small car design in general than American firms did. Space in urban areas was more constrained in both regions and income levels for the bulk of the population were lower. Fuel costs also had an effect on product innovation. Originally plentiful domestic sources accustomed Americans to cheap fuel, and the voters have ever since encouraged their political leaders to keep it that way. With fuel costs of secondary importance, the most profitable path to producing upscale vehicles in the United States was to make them large and heavy.[11] This required little innovative input. In Europe, by contrast, fuel was heavily taxed. For upscale cars to deliver superior performance and comfort with fuel expenses the customers would regard as tolerable, innovation in powertrain performance and the driving experience was an absolute requirement.

Regulation can have a more direct effect on product innovation as well, of course. Regulation of safety, exhaust emissions, and fuel economy in the United States has had a significant effect on the features and performance characteristics of cars offered for sale.

Even in the absence of fundamental product innovation, the design of an entirely new model (i.e. one not made from off-the-shelf components) always involved substantial fixed costs in terms of time and other resources. Given the level of complexity end-of-the-century products have attained, these now routinely come to billions of dollars. A careful survey conducted in the 1980s yielded the comparative data given in Table 3.

--Table 3 about here--

One striking feature of the data in this table is the large differences between Japanese product development efficiency and that of the Americans and Europeans. While the Japanese have not placed any sustained emphasis to date on product

[9] The most notable of these innovations was probably the automatic transmission of the late 1930s. On the local assembly plants both domestic and foreign, see Maxcy 1981, pp. 70 and 76.
[10] That mass market was surely the larger for the Federal government's road-building subsidies. See Flink 1988 e.g. 175-176 on "the most ambitious public-works program undertaken in American history".
[11] The famous unattributed slogan is "We make 'em by the piece and we sell 'em by the pound."

innovation, they have become strikingly good at developing relatively standard offerings with great efficiency. This is, in the context of other aspects of their capabilities discussed below, of particularly great value to them.

Very recently, however, the Japanese firms of Toyota and Honda have taken the worldwide lead in offering a distinctively new form of powertrain known as hybrid gasoline-electric. Such vehicles have two power plants and use the gasoline engine both to propel the vehicle as well as to generate electricity for use by a second, all-electric, drive train. The electric drive train can serve as the principle source of propulsion at low speeds and can augment power at high speeds when surges are needed. This allows the internal combustion engine to spend more of its time operating under the conditions that are optimal for its economy and cleanliness. Overall improvements to fuel economy relative to the standard technology are in the 50 percent to 100 percent range. The motivation for investing in these innovations seems to be getting the jump on a technology that will deliver fuel economy at a level that may ultimately be mandated by many governments around the world. Whether this investment represents investment in a new capability, as opposed to no more than a new set of features, remains to be seen.

4. Innovation in production systems

One cannot always draw a bright line distinguishing between innovations in production systems and organization. But because the automotive industry has been the source of two fundamentally paradigm-altering innovations in the domain of production systems, mass production at Ford and lean production at Toyota, we believe it useful to distinguish these, and others born on the factory floor, from other types of organizational innovations.

Industry production itself began in a fragmented fashion. Once adequately efficient internal combustion engines became reasonably widely available, the mechanically skilled and inventive began to dream and to tinker. The spirit of enterprise was widespread and companies formed in profusion. Their products were made in small numbers. Skilled mechanics—artisans—worked in a skill-intensive fashion. Unit costs were high. But entry barriers were low and those with the wherewithal to be customers in those early days were willing to buy what firms, especially local firms, were offering.

Henry Ford soon became the leading figure among the tinkerers. Ford tinkered with product but also with process. His vision of the relationship between the two was quite concrete, namely that

> "[t]he way to make automobiles is to make one automobile like another, to make them all alike, to make them come through the factory just alike, like one pin is like another when it comes from the pin factory and one match is like another when it comes from the match factory."[12]

[12] Ford 1922, p. 59.

He sought a simple product, undifferentiated and cheap, sturdy, and easy to repair. It was to be a car for the multitudes, a theretofore essentially unaddressed market segment. This so-called mass market rapidly became the most important one economically.

The implications of this approach were systemic and powerful. Implementation required, as a practical matter, interchangeable parts and thus the whole expensive panoply of American System measurement and (machine) manufacturing methods for parts and components.[13] Economies of scale became very important as a consequence. But the economies of scale were there to be seized. Prices were lowered. Volumes shot up. Unit costs sank. From 1911, Ford's profit as a percentage of sales price rose virtually monotonically for half a decade, from seventeen percent to thirty-one.[14]

The shift to truly interchangeable parts facilitated the wholesale departure from the factory floor of highly skilled mechanics in favor of semi-skilled machine-minders working with standalone machines or on the side of a moving assembly line. With this departure went the last traces of the artisanal coincidence of task definition and task execution.[15] With all the routinization came the challenges of coordination, which were very demanding at the output volumes in question even with what was essentially only a single model in production at any one time.[16] For the Ford company soon became by a very wide margin the largest producer in the industry. Its new mother plant became in its time the largest single manufacturing establishment in the Western world. Ford's interchangeable factory workers (with their fabulous pay levels of five dollars per day) became for a time the best-paid essentially unskilled laborers in the world.[17]

Ford's factory in the teens and twenties was the cynosure of the world of manufacturing. It was a triumph of scale, of coordination, and of management more broadly. Industrialists—as well as dignitaries, newspaper reporters, and even Charlie Chaplin—came from far and wide to observe and to marvel.[18] Many returned to their homes planning on imitation (though even with the benefit of trade barriers and the partiality of local consumers to domestic producers, few of the European mass producers were such great financial successes).

The post World War II era witnessed the development of automatic transfer machines.[19] These are machines which perform a sequence of operations on a given piece, mechanically moving the piece from one machine element to the next and automatically orienting the piece at each stage. They were first created specifically for

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[13] On the American System, see Hounshell 1984.
[14] K. Williams et al. 1994, p. 98, Table 7.1.
[15] Meyer 1981.
[16] The single model represents the famous philosophy that "the customer can have any color he wants so long as it is black". The facts that the basic mechanical elements could be fitted at the end with a (small) variety of basic body types and that there were, over the years, minor changes in some of the mechanical systems are of the most minor significance to the point being made in the text.
[17] See Raff 1987.
[18] On the industrialists, see Fridenson 1978 and Laux 1992, p. 54. For some specific examples with important consequences, see Schweitzer 1992, p. 36, on Citröen (see also Cohen 1991) and Lewchuk 1987, p. 171, on Austin. For the influence on Fiat, see Bigazzi 1987, p. 81.
[19] See Hounshell 2000.

engine plants in the interwar years but saw their most widespread implementation after the Second World War. As an innovation, they represent a sort of n^{th} degree development of the moving assembly line. The machines were expensive enough that they naturally were developed in the largest market. The machines that emerged were, however, highly dedicated to specific designs. This product inflexibility, as much as downtime, became a major problem that was not adequately addressed until the development of numerically controlled (i.e. programmable) machine tools and so-called robots in recent years.[20]

Aside only the reference to Ford's (transitory) wage policy, the account given thus far of the industry's development during the middle third of the century is in one important respect seriously incomplete. It all but leaves out labor; and labor was increasingly not the infinitely malleable factor of production of neoclassical economic theory.

The roots of labor's complex role begin in America in the inter-war years. The diffusion of mass production methods drove the skill requirements of typical industry jobs sharply downwards. Efforts by unions in the teens and twenties to organize in the industry were by turns quixotic and ambivalent. They were certainly never successful. By the time of the 1930s, management was generally fairly determined to resist. But the New Deal labor legislation made it relatively much easier to organize. When (in the eyes of General Motors) the judicial response to the bitter sit-down strike at its Flint plants in 1937 was to decline to enforce GM's rights to control its property, the companies could see that organization had become inevitable.[21] All the principal manufacturers soon signed contracts with the United Auto Workers. By the end of the war, the unions were clearly there to stay.

The first post-war contracts in America set a pattern that was reminiscent of military hierarchy but was perhaps less valuable in manufacturing. The union members were responsible for effort input, management for everything else.[22] Ford, and even the theorist Frederick Taylor, could hardly have wished for more.[23] This simplified the position of union officials and may have been helpful in maintaining solidarity among the rank-and-file; but it had its own longer-run costs. The people who carried out the tasks often had the opportunity to observe and invent in ways that would have considerably enhanced productivity. But drawing such a radical distinction between what management did and what the workers did in effect threw away these possibilities. It also made for more routine, and ultimately stultifying, jobs. It gave any management looking for ways to enhance productivity an incentive to find it simply by making the work more demanding. It gave any management looking for ways to enhance profits an incentive, at least at the margin, to find it through marketing or keeping a lid on product market competition rather than by inevitably disruptive and costly innovation in its operations.

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[20] See Noble 1984. Jaikumar 1986 exposes the fact that the most sophisticated and flexible of these more recent machines were at that time actually `deployed more flexibly in Japan than elsewhere. This observation is compatible with the argument about the Japanese approach to production developed below.

[21] On the strike, see S. Fine 1963.

[22] See Lichtenstein 1995, pp. 277-278, for management's perspective.

[23] The locus classicus is Taylor 1911.

The job characteristics and incentives identified above proved to be the dragon's teeth of worker discontent. By the early 1970's, on the eve of the oil price shock, the U.S. auto industry was in vulnerable shape. The blue-collar employees were alienated.[24] Production quality was low. Management itself had gone slack as well. An increasingly tight oligopoly had enjoyed long decades of a vast and steadily growing domestic market essentially free from foreign competition. The oligopolists competed among themselves more on the basis of advertising than of importantly different technology

All of these features were basically common to the principal European firms as well. Their product markets were largely national, with only a little intra-European trade and for the most part relatively little extra-European exporting. The European unions were organized primarily on a national basis, and they saw their interests as more closely aligned with management and the fate of the firm than the Americans did. But—perhaps because of the political culture, perhaps because of the social background of the labor force, perhaps because the production technology had for the most part changed jobs in the same way jobs had changed in the U.S.—an oppositional attitude was still common.[25]

There were alternatives to be contemplated. Most strikingly on the labor side, a small number of European firms, most notably Volvo, had begun to experiment with meliorative models of productive organization.[26] These initiatives could be interpreted as job design oriented towards engaged and satisfied employees. German workers had by statutory right from the post-war years a place on a so-called supervisory board involved in the overall governance of the enterprise.[27] The American firms were aware of these experiments but initially thought them responses to European firms' different competitive strategies, organizations, and legal environments. They seem to have felt no need to change themselves. Nor did the initiatives in fact diffuse much within Europe. In fact, the Europeans seemed to focus primarily on product innovation throughout this period

The relative neglect of process innovation by the American and European firms began to face its decisive challenge in the mid-1970s. The source of the challenge was less internal strains than consumers and international competition. The pressure began soon after oil prices went up and was, at first, most conspicuous in America. Flexibility the old-style system could not deliver became particularly important when consumers discovered that Japanese automobile manufacturers were able to offer American car buyers shocked by the new fuel prices attractively small and efficient cars. Worse, it rapidly became clear that the Japanese had levels of manufacturing quality far higher than Detroit could offer. The previously reliable consumers began to desert the Detroit firms in droves. Defensive trade policy did not thwart this as much as it might have since Japanese firms built plants (and eventually whole supply chains) in the U.S. and Europe in response to protectionist trade agreements. This was good for local labor but bad

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[24] See especially Bardou et al. 1982, pp. 263-264.
[25] Bardou et al. op. cit., especially pp. 258ff, and Laux op cit., chapters 9-11 passim.
[26] See inter alia Davis et al. 1975. Some of these experiments were joint company/union initiatives.
[27] On the German "co-determination" statutes and their consequences, see e.g. Hunnius et al. 1973, pp. 194-210

news for the local car manufacturers. These established producers had a new set of competitors who were doing something unanticipated and important right.

The most widely appreciated consequence of this was the intense attention devoted to the production system developed by Toyota, called sometimes the Toyota Production System (TPS) and sometimes more simply lean production.[28] The central focus of that system was not on specific models or features but rather on flexibility, efficiency, and quality in the production process. (This is to say that the fact that the models and features, initially just well adapted to the small spaces of Japanese cities and the small budgets of Japanese consumers, became attractive in the vast American market was a lucky coincidence. But the appeal of the system's performance characteristics was not.) The system represented a radical change from the Ford-style approach to mass production. Whereas it had previously seemed that efficiency and quality had to be traded off against each other, for example, TPS showed that quality improvement could actually drive improved efficiency.[29]

The system and its virtues evolved from Toyota's post-war drive to re-build an auto industry in an environment of low capital availability and very small market size. Before the war, the Toyota company's automotive operations were sustained by government assistance.[30] Taiichi Ohno, the engineer who eventually transformed the Toyota automotive operations, had studied Ford and GM factories in the inter-war period.[31] He was awed by the scale and capital intensity of the American production technology. He realized that Toyota could not set out by trying to replicate the American mass-production system and certainly could not make a success of it in the relatively modest Japanese market. He also saw vulnerabilities in the American approach. He therefore set about finding ways to carry out efficient small-batch production with consistent high-quality output. Toyota's lean production system was born from necessity and scarcity.[32]

This so-called lean system had at its center a taut supply chain ("just-in-time manufacturing"), which minimized working capital tied up in stocks, facilitated mistake-catching, and nurtured an ability, grounded in both human and institutional capital, to learn from mistakes and continuously improve operations.[33] The performance contrasts to classic mass production were in important respects quite noteworthy. The first clear measurement in the literature (see Table 4) dates from the mid-1980s but compares two plants that close observation confirmed to be good representatives of their system archetypes. The differences are large.

--Table 4 about here--

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[28] See Cusumano 1985, chapter 5, for an example of description and analysis and Womack, Jones, and Roos 1990 for an example of proslytization.
[29] This is modeled in C. Fine 1986, C. Fine 1988, and C. Fine and Porteus 1989 for models.
[30] Cusumano op. cit., p. 17
[31] On the factories, see Maxcy 1981, pp. 73-74.
[32] Cusumano op. cit., chapter 5, describes this process in detail.
[33] This was supported by the organization of labor into company, rather than industrial, unions.

These figures incorporate a careful, even if not completely robust, attempt to adjust measures so as to compare apples with apples. Even on such a basis, the Toyota plant requires only roughly half the production hours. It requires less than five-eights the assembly space per car. Its defect rate is less than one-third that of its American counterpart. And its parts inventories are a tiny fraction of those of the American plant. These are gaps to be reckoned with.

Both the supply chain organization and the within-the-plant activities represented complex and difficult-to-transfer sets of routines. The process of their diffusion to Detroit has at best been slow and incomplete. Some of this was under way by the mid-1980s and was bearing measurable fruit—Table 5, reporting results of a extensive survey, illustrates. Yet the basic pattern remained. The hours input measure of productivity for the American-owned plants remains half-again the level of the Japanese. The quality gap is much smaller, but the American level is still more than one-third higher than the Japanese. This broad survey gives more details of work organization than did the preceding two-plant comparison, and the contrasts are still very great. The same is true, albeit to a smaller extent, of automation. The role of the American union in this state of affairs is certainly substantial. (One can also see from the table that these differences were not primarily due to the use of the American workforce, since the Japanese plants sited in America did better than the American-owned ones.)

--Table 5 about here--

A second round of the survey, giving data from a 1994 follow-up survey, shows continued progress but a continued gap as well.[34] (See Table 6.) Productivity levels were slowly converging, but the American labor requirements were still in excess of one-third higher than those of the Japanese home plants. Absolute defect levels were down but the relative performance remained about the same. Revealingly, a new measure of the complexity of model mix within each factory—that is, a measure of how much model mix each factory can cope with—has the Japanese at twice the level of the Americans.

--Table 6 about here--

All these consequences for efficiency and quality represented deep changes. An equally profound consequence of the collision, however, concerned manufacturing flexibility in itself. In the (immediate) absence of the system and infrastructure of the Japanese and in the face of the Japanese cost advantages, the question of how else the Detroit manufacturers might economically make heterogeneous offerings available to American customers had to be confronted. The historic method had been oriented towards batchwork with a view towards very large markets and squeezing the maximum value available out of set-up costs. If an individual customer wanted something specific and out of sequence, and no inventory was available somewhere in the distribution channels, then he or she simply waited. The wait would certainly be weeks and could well be significantly longer. Shifts in market preferences across models were even harder to meet. Some of the roots of this lay in the planning and coordination functions and in supply chain organization (and ultimately in information technology), but part lay

[34] A third round is under way but still incomplete as of this writing.

in plant and equipment design. American automobile plants have not historically been particularly flexible in themselves. Throughout the postwar period to the late 1970s and early 80s, plants were generally dedicated to a single model. In the course of the 80s, there began to be plants dedicated to platforms but able to put together any of the models sharing that platform. It has only been since the late 80s and early 90s that American plants have been capable of manufacturing multiple platforms from a single facility. The Japanese were consistently a step ahead at each stage of this progression (as the bottom row of Table 6 clearly suggests).

5. Organization Innovation: Internal Operations and the Extended Enterprise

In the earliest years of a recognizable industry in America, firms were predominantly assemblers of bought-in parts and components. The entrepreneurs were often engineers as much as businessmen.[35] Even as the early firms grew relatively large, most remained assemblers. (Some high-end firms such as Packard backward integrated—and, indeed, claimed this as a virtue in their advertising—but the practice was not common.) Through circa 1908 there appear to be few examples of firms that produced their cars by any means other than batch production using relatively low tolerance parts, highly skilled mechanics fitting the parts together, and relatively modest production runs. Relatively customized orders seem to have been widely entertained and a non-trivial number of firms included among their priced offerings bodyless chassis to be completed by custom coachbuilders.[36]

There were a number of noteworthy consolidations of firms in the period through the first World War, but these appear to have been motivated more by financial distress than by any detailed vision of economies of scale or scope.[37] The early years saw tremendous rates of entry and exit, and the fact that there was not more consolidation than we observe suggests that both strategies and managerial capabilities generally were really not up to the demands of large-scale enterprise.[38]

Automotive industry supply initially came from firms principally in the business of supplying previously established downstream industries with commodities like metal stampings and castings. Downstream industries with relevant needs were plentiful in the upper Midwest, which encouraged the early automobile industry to congregate in that region.

The early auto firms bought from these firms either off-the-rack or on a job- basis. As industry demands grew, supply firms began to see profit in specializing in auto parts (and relationships). But initially there was a problem. The large firm, Ford, seemed a dangerous partner. Ford found some suppliers willing to dedicate equipment and time to

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[35] See Kimes and Clark 1996 passim for American examples.
[36] This is most easily reviewed through the price-and-specification tables in the annual statistical issues of e.g. *The Automobile* (the predecessor publication to *Automotive Industries*). For European parallels, see Laux op. cit., chapters 2-3.
[37] See e.g. Kennedy 1941 , pp. 48-58.
[38] On entry and exit, see Epstein 1928.

its growing needs but seems to have had real difficulties sustaining the old supply system. The most obvious explanation is the fear of ex post expropriation.[39] Ford's degree of backward integration grew to very substantial proportions quite apart from the famous iron mines and rubber plantation.[40] Many of the other producers of the day had idiosyncratic specifications for basic parts, and there were few really common specifications. This put all the small firms at a considerable cost disadvantage regarding intermediate inputs. The incentives to develop common standards were powerful but apparently less powerful than other, countervailing, forces: the standards movement was for some time not particularly successful.[41]

The tremendous expansion of the market in the decade after the First World War was a great boon to the supply firms. The largest manufacturers were still integrating backward; but as a mass market and second-hand market developed, a lucrative market for replacement parts that the manufacturers did not really want to address developed in tandem. The loss of business on the one front was more than offset by the gain on the other. To compete in this replacement parts market, the suppliers had to offer (to a discerning trade) a combination of quality, durability, and price superior to those of the manufacturers. This the suppliers learned to do.[42] They were then well placed, as time wore on and conditions evolved, to share in the activities and costs of actual innovation in the manufacturers' annual model changes.[43] Relationships, the most recent if somewhat sketchy research suggests, were long-term and cooperative, even between supply firms linked primarily to one final manufacturer but supplying others.[44]

Ford was to this point the paradigm case of the large firm, but it was not horizontally diversified. General Motors pushed largeness farther. In the early 1920s, General Motors was a holding company of a number of distinct automobile brands and a variety or parts suppliers and more or less related firms. Coordinated operating management began with the appointment, in chaotic circumstances, of Alfred Sloan as chief executive.[45] One of his first, and most famous, initiatives was to create an orderly product line in a way that minimized the degree of competition between divisions producing final goods. Sloan intended to offer a car "for every purse and purpose". He also imported financial controls concepts from Dupont (a major GM shareholder), and refined these tools for managerial control of his large and growing industrial empire. A less widely appreciated but quite important (and highly complementary) innovation involved getting the separate divisions to use common parts.[46] This exploited, to one extent or another, the collective scale of the divisions without depressing divisional profits. It should probably be understood as making the provision of variety economically attractive, since it seems to have been both quantitatively important and easily imitated given sufficient overall scale.[47]

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[39] See Helper 1991.
[40] See Nevins and Hill.
[41] Thompson 1954
[42] Schwartz 2000, p. 67.
[43] See Heldt 1933.
[44] Ibid.
[45] See Chandler and Salsbury 1971, chapter 18 (especially pp. 482-491).
[46] Sloan 1964, pp. 155-158.
[47] See Raff 1991 on the quantitative importance.

This organization innovation history demonstrates the successful development of the American industry's ability to mobilize resources to address a mass market—in particular, its own vast domestic market—and the slower and still incomplete development of its ability to respond comparably to address profitably the latent demands for quality and variety, both at any moment in time and as the tastes of that market develop over time.

The situation after the war was very different. The great bursts of product innovation were largely at an end. So was the long industry shakeout: most of the smaller firms were gone and the mid-sized firms were dying.[48] Only Ford, General Motors, American Motors, and Chrysler were left in remotely robust health. The focus of competition among them shifted to marketing. Concurrently, the focus of the procurement officials shifted to minimizing unit costs of supply.

This led to a very different sort of relationship between the suppliers and their immediate customers. Parts design returned from the suppliers to the big manufacturers. The manufacturers kept their suppliers on short-term contracts. There were multiple actual sources for each part, and all suppliers knew the manufacturers kept other possible sources in the wings. Differences were sorted out by changing contractors rather than by discussion and mutual accommodation. This is a reasonable approach if the production model, and indeed business model, is essentially Ford-like: the supply strategy was complementary to the idea of manufacturing organized around long production runs of a fixed and small number of basic designs in order to minimize unit costs.

This may indeed have kept costs low, but it did not encourage suppliers to invest in quality or indeed in anything beyond what was specified in the contract. Little information flowed. When Detroit sought, in the 1980s, to replicate Toyota's relations with its suppliers, there was little infrastructure and less trust upon which to build.

Chrysler initially developed its so-called Extended Enterprise system in crisis. Its financial condition was weak and weakening, and perennially standing third in the suppliers' queues behind the larger of the Big Three firms was not helping the situation. It needed somehow to offer a better deal. The deal it offered, based to a significant degree upon the model of Japan's Honda Motor Corporation, involved stepping back from this regime of pitting the suppliers against one another. Chrysler proposed committing to long-term relationships, devolving more responsibility to its suppliers, and sharing the rents and any incremental cost-savings. It also stepped up outsourcing. In essence, Chrysler increased the modularity of its product design while simultaneously modularizing its supply chain practices relative to most other companies in the industry.[49] This was appealing enough from the perspective of the suppliers—there was more business, it was more reliable, the margins were better, and it built up the capabilities of the firms—but it was even more appealing at the time from the perspective of Chrysler. Corporate overheads went down and Chrysler devoted its own attentions more to the stages of the value chain where it had distinctive expertise or really needed to operate and

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[48] On the shakeout, see Bresnahan and Raff 1991 and forthcoming and Vatter 1952.
[49] See C. Fine 1998 for a more extended discussion.

less to those where it did not. Its advantage in minivans and jeeps, referenced above, gave Chrysler just enough breathing room to refine its new business model and race ahead (in unit profit, return on assets, and product launch speed) of its larger American rivals, an outcome which was not widely anticipated as late as 1990, but was quite in evidence by 1995, as is illustrated vividly by the data in Table 7.

--Table 7 about here--

While Chrysler was building much more cooperative relationships with a stronger, more technologically capable supply base than the industry had previously known, General Motors moved in the opposite direction. In the early 1990s, GM's procurement function, under the leadership of the forceful and colorful Ignacio Lopez, pared its supply costs by attempting to squeeze every last penny from supplier profit margins and every last ounce of goodwill from supplier dispositions. GM reported over $4 billion in annual savings from this effort, but the data in Table 7 suggest that the Chrysler approach was far more fruitful.

More recently, General Motors has shown some appreciation of the merits of the Chrysler approach to supplier relations, in word and at least to some extent in deed. Ford began between the two and remains there. Daimler Benz allegedly acquired Chrysler in part to master its Extended Enterprise model, but has, ironically, largely dismantled the model as well as the team that built it, with little but red ink to show for its trouble.

Marketing and distribution in Europe and Japan largely resemble their counterparts in the U.S. but with less competition and stronger legal rights of the manufacturers over the dealers.[50] (Local differences persist, however. One seemingly quaint example is the tradition of door-to-door sales of cars in Japan, still widely practiced well into the 1990s.) The American market has seen have seen more radical change and generally seen it sooner.

The three most important innovations in marketing have been brand management, the institutionalization of the annual model change and the growth of the latter into a design strategy of planned obsolescence. Brand management has its roots in Sloan's reorganization of GM in the early 1920s: once divisional managers were held accountable for and evaluated on the basis of brand results, they developed a interest in brand identity far beyond keeping out of the way of other GM divisions. This certainly diffused into the culture of GM upper management, entry into which was typically from below rather than from outside. At GM, annual model changes seem to have been originally principally a species of coordination device; but they eventually became a key marketing tool, appealing to fashion impulses in the American buyer. Once the tapering off of product innovation was well under way and the model changes had relatively little real technical advance to offer, planned obsolescence was what seemed most obviously left, particularly given that the new car market began to seem saturated in the 20s (in the sense of the substantial end of the discovery of previously unserved automobile customers and also of the development of a secondhand market). To further stimulate sales, the manufacturers established consumer finance units to help potential customers

[50] Womack et al. 1990, pp. 175ff.. See also Altschuler et al. 1984, p. 168.

purchase their (increasingly expensive) products in the 1920s. These rapidly became big businesses in themselves.

The sales system has been oriented to legally independent (but generally exclusive) dealers from the start. The early manufacturers were not flush with capital and the prospect of finding others to invest in facilities and inventory for sale was attractive. The agency problems were less extreme as well. The financial risk-spreading was also welcome.

The contractual relations between the manufacturers and the dealers came to be complex and have a long and somewhat tangled history.[51] This history has important political as well as economic elements.[52] The most striking development in it from our perspective is the passage in 1956, at the end of a long campaign, of a federal statute known as the Dealer's Day In Court Act which essentially give the dealers legally enforceable rights in their territorial franchises and their ability to sell the manufacturer's cars in these. The Act in effect entrenched the dealers and made management of the distribution channel as a whole fairly difficult for the automakers.

This system has seemed to be changing in a way that gives even more power to the dealers in recent years. There have been increasing numbers of multiple-site and even multiple-nameplate dealers. Attempts by the manufacturers to establish sales channels owned by themselves have been resisted fiercely. It is as yet unclear as yet how the development of the Internet will ultimately affect this balance of power.

Yet it appears that the main significance of the Internet for automobile marketing will not ultimately concern this balance at all but rather relations between customer and dealer and their effect on operations. Historically, the manufacturers have made to stock rather than to order. A selection of alternative purchase options are available in dealer inventory and regionally; but, as remarked above, options outside of this set can only be supplied with a delay, potentially a substantial one. As the Internet makes information about alternatives and desires easily available to both buyer and seller, and Internet firms such as Amazon and Dell begin to accustom potential purchasers of increasingly diverse products to very wide selections and to rapid, sometimes even make-to-order, fulfillment, the question arises of how long the traditional (and costly) make-to-stock regime can survive[53]. The number of possible combinations of features on offer to automobile customers is extraordinarily large The coordination challenges of a rapid make-to-order system under such circumstances would be intimidating even with a technically stable product, the difficulties of transition entirely aside. But this is the challenge currently facing the manufacturers. Again, the complementarities all along the value chain are

[51] See e.g. White 1971, chapter 9. In Japan, in particular, relations between manufacturers and dealers have historically been somewhat closer. See Shimokawa1994, pp. 82ff.
[52] The foundations of the economic elements lie in what economists call the problem of double monopoly: the manufacturers would be better off if the dealers would sell more cars than the dealers, in their capacity as local monopolists, would otherwise wish to sell. The manufacturers naturally sought for ways to force cars on the dealers. The instigation of the massive Federal Trade Commission investigation of the industry in the late 1930s was only the first vivid example of the political clout of the dealers in fighting back.
[53] See Lapidus 2000

powerful; and the commercial appeal of being able to offer customers exactly what they want is potentially quite large.[54]

6. Conclusions

The automotive industry has a long and rich history from which to observe the processes and outcomes of innovation. Innovations sometimes come as radical shocks that trigger dramatic restructurings and sometimes as a long series of incremental changes. We discussed above a number of innovations, some radical and abrupt, others incremental and gradual, that have occurred in the automotive industry over the last century. Both basic types were present in abundance. In organizing further discussion of these, it is helpful to consider product innovations, production system process innovations, and organizational innovations one by one.

Aside from the basic initial idea of connecting an inanimate power source to the wagons once pulled by horses, product innovations in the industry have been primarily incremental. That is, the basic form of the automobile has not changed abruptly at any point in the past hundred years and the system forms have not changed abruptly since the dominant designs emerged. The changes that have occurred since then have been significant in the aggregate but have appeared quite gradually. These incremental product innovations have emerged from technical innovations in areas such as drive trains, suspensions, chassis, bodies, interiors, and, more recently, electronics as well as from responses to customer desires for greater speed, comfort, safety, etc. Some of the product innovations were stimulated by regional needs. Japan perfected small cars because the spaces available for cars were small. Germany developed high-performance cars and engines that could exploit fully the high-speed autobahns that were built for relatively rapid automotive transit.

Complementary innovations in infrastructure (e.g. paved roads and limited access highways) have played an important role in the development of these incremental innovations to satisfy automobile buyers' demands and uses. Here social investment supported consumer desires to exploit fully the personal transportation opportunities afforded by owning a car. Government regulation influenced product innovation as well. American regulation of noxious emissions, fuel economy, and safety, for example, enabled automobile usage to grow enormously without (yet) having its public health side effects and other negative environmental and congestion externalities overwhelm the collective transportation benefits.

In the domain of production system processes, we find first of all two radical process innovations. These have ultimately proved to be of the first order of importance for the whole of the industrialized economy: no manufacturing industry in the developed world has been left untouched by the examples of Ford's mass production system and Toyota's lean production system. The Ford system itself benefited greatly from the earlier development of manufacturing methods utilizing interchangeable parts in industries such as firearms and bicycles. The Toyota system emerged in part as a

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[54] Ibid.

reaction to the Ford approach. One can only conclude from this that inter- as well as intra-industry diffusion of process innovation can play a key role in industrial evolution as well.

These radical innovations came in one case from the entrepreneurial drive to exploit a market opportunity (Ford's mass production system) and in the other from the desire to overcome scarcity and adverse conditions (Toyota's lean production system). But they were not the only process innovations that mattered. The incremental process innovations that occurred in the half-century between these two shifts in production process paradigm, as well as the process innovations that have occurred since the initial implementations of lean production, are generally thought to have been collectively enormously important as well.[55] These incremental improvements generally arose from ongoing competitive pressures to reduce costs while improving quality and customer service. Thus the openness of markets to competition was of great importance in both cases.

Organizational innovations can have significant consequences for economic performance. But such innovations appear to be much more difficult to import from one company to another than product innovations. Ford and General Motors have labored long and hard to accomplish organizational change to replicate Toyota's performance with the lean production system. The resulting progress has most definitely been gradual and incremental when evident at all. Such organizations' ability to change their ways of working depend deeply upon their histories, their persistent institutional characteristics, and upon the complex interactions among their many actors.

Nevertheless, organizational innovations can be significant and can ultimately be copied by others (at least in part). A variety of forces can catalyze such change. Sloan's creation of the multi-divisional General Motors was stimulated primarily by a desire to exploit the enormous opportunities for market segmentation in the still-young industry. Roughly half a century later, Toyota, Honda, and Nissan each launched their first premium brand divisions to compete more directly with the luxury brands of other automakers. In contrast to Sloan's expansion motivations, Chrysler's Extended Enterprise system was an innovation dictated by stark challenges to the company's survival. That system was, in turn, conceived in part by an attempt to replicate some of the institutional characteristics observed in Honda's supply chain relationships.

What lies ahead? The automobile plays a central role in the lives of citizens of the industrialized world. Our landscape and our daily lives are organized around the availability and ubiquity of personal motorized transportation and the huge infrastructure we have developed to support our driving needs and desires. Our competitive system will continue to reward the efficient exploitation of resources for consumer satisfaction and will ultimately punish firms that stray too far from the frontier. In the automobile industry, however, market share adjustments have sometimes been surprisingly slow due to governmental protection of domestic automakers (on all continents), high entry

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[55] This does not seem to be an uncommon state of affairs. For example, Hollander 1965, in a detailed study of radical and incremental innovations in Dupont factories over several decades, found that the cumulative impact of incremental innovations was roughly equal to that of the radical innovations.

barriers resulting from the industry's huge economies of scale, and significant market clout within a tight oligopoly. We note, for example, that General Motors has been demonstrably quite far from the efficient frontier in the core activities of design, product development, and manufacturing for a quarter of a century, yet remains the world's largest automaker.

In each of the major industrialized regions, governments have on occasion found ways to blunt the effects of global competition on domestic producers. Reductions in trade barriers have begun to force adjustments, however. In the past half-decade, we have seen the acquisition of the weaker firms in Japan, Korea, Europe, and North America by a few of the remaining giants—Ford, General Motors, DaimlerChrysler, Renault, and Volkswagen. (Toyota alone among the giants has resisted any urges to merge with or acquire weakened companies.) Such consolidation may slow further the weeding out of inefficiencies among the remaining giants due to internal sources of resistance and the large firms' scale and marketing powers. But market shares do show clear evidence of shifting, however slowly, towards the more efficient producers.

In addition to competitive pressures, the undesirable externalities of foul air, global warming, and congestion will also drive innovation even as other product innovations make the automobile an ever more desirable product. Since humans seem unlikely ever to abandon their cars, innovation in aid of livable compromises will surely continue. Because of the industry's enormous economic and social impact, we expect that these issues will continue to be addressed through public policy as well as through private investment and competition.

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TABLE 1

Price and Quality Indices for American Automobiles
(in constant 1993 dollars)

Year	Mean price	Mean QA price	% change quality
1906	52,640	52,640	
1908	46,640	36,848	0.19
1910	39,860	27,583	0.10
1912	41,400	24,214	0.16
1914	44,242	20,424	0.23
1916	29,483	14,423	-0.03
1918	24,875	12,160	0.00
1920	24,566	12,528	-0.04
1922	27,146	13,634	0.02
1924	22,732	11,528	0.00
1926	22,082	10,002	0.10
1928	21,241	8,791	0.08
1930	20,702	7,896	0.07
1932	25,803	7,843	0.25
1934	23,236	7,370	-0.04
1936	17,842	7,264	-0.21
1938	19,036	8,422	-0.09
1940	16,565	8,107	-0.09
Annual:			0.02

Mean price is the mean price in the paper's database for the given year, stated in constant 1993 dollars. Mean quality-adjusted price is the mean hedonic price for the year as calculated in the paper. % change quality is calculated as the residual percentage change mean price less percentage change mean quality-adjusted price.

Source: Raff and Trajtenberg 1996, p. 87.

TABLE 2

Nominal and real hedonic prices for American Automobiles 1906—1983

Year	Index (nominal)	Index (real)
1906	100.0	100.0
1908	70.0	70.0
1910	54.0	52.1
1912	49.3	45.9
1914	43.3	38.8
1916	33.1	27.2
1918	38.4	22.8
1920	53.4	23.9
1922	47.9	25.6
1924	41.2	21.6
1926	37.3	18.9
1928	34.8	18.3
1930	33.4	17.9
1932	27.4	17.9
1934	25.3	16.9
1936	25.5	16.6
1938	30.2	19.2
1940	28.8	18.4
1948	39.9	14.8
1950	45.0	16.7
1952	49.7	16.8
1954	48.3	16.1
1956	49.7	16.4
1958	49.7	15.4
1960	50.3	15.2
1962	52.8	15.7
1964	51.3	14.8
1966	50.8	14.1
1968	53.4	13.8
1970	53.9	12.5
1972	55.6	11.9
1974	58.4	10.6
1976	72.0	11.3
1978	85.4	11.7
1980	99.2	10.8
1982	135.3	12.6

Source: Raff and Trajtenberg 1996, p. 90; U.S. Bureau of the Census 1997, Series E-135, “Avg.” column.

TABLE 3

Selected Data on Product Development Performance 1980--1987

	Japanese Volume Producer	U.S. Volume Producer	European Volume Producer	European High-End Specialist	Overall
Number of organizations	8	5	5	4	22
Number of projects	12	6	7	4	29
Years of introduction	1981-1985	1984-1987	1980-1987	1982-1986	1980-1987
Average engineering hours (millions)	1.2	3.5	3.4	3.4	2.5
Lead Time (months)	42.6	61.9	57.6	71.5	54.2
Total Product Quality Index	58	41	41	84	55

"Year of introduction" is the calendar year when the first version of the model was introduced to the market. "Engineering hours" are hours spent directly on the project excluding process engineering. "Lead time" is the time elapsed between the start of the project (concept study) and the start of sales. The Total Product Quality Index is constructed from quality and market share data; details are given in the source's Appendix.

Source: Clark and Fujimoto 1991, p. 73.

TABLE 4

Classic Mass Production compared to the Lean System:
A 1986 Snapshot

	Classic Mass Production: GM Framingham Assembly Plant	Lean Production: Toyota Takaoka Assembly Plant
Adjusted assembly hours per car	31	16
Assembly defects per 100 cars	130	45
Assembly space per car	8.1	4.8
Inventories of parts (average)	2 weeks	2 hours

"Adjusted assembly hours per car" is gross assembly hours adjusted to make the measurement comparable across the two plants and then divided by the total number of cars produced. The adjustments are described in the source, pp. 80-81. The assembly defects data were estimated from the J.D. Power Initial Quality Survey for 1987. "Assembly space per car" is square feet per vehicle per year, adjusted for vehicle size. The inventories figure is a rough average for major parts.

Source: Womack, Jones, and Roos 1990, p. 81

TABLE 5

Assembly Plant Characteristics for Volume Producers: 1989 IMVP Survey

	Japanese in Japan	Japanese in North America	American in North America
Performance			
Productivity	16.8	21.2	25.1
Quality	60.0	65.0	82.3
Layout			
Space	5.7	9.1	7.8
Size of repair area	4.1	4.9	12.9
Inventories	.2	1.6	2.9
Workforce			
Percent in teams	69.3	71.3	17.3
Degree of job rotation	3.0	2.7	0.9
Suggestions/employee	61.6	1.4	0.4
Number of job classes	11.9	8.7	67.1
Training of new . production employee	380.3	370.0	46.4
Absenteeism	5.0	4.8	11.7
Automation			
Welding (% direct steps)	86.2	85.0	76.2
Painting (% direct steps)	54.6	40.7	33.6
Assembly (% direct steps)	1.7	1.1	1.2

"Productivity" is hours per vehicle. "Quality" is defects per one hundred vehicles. "Space" is square feet per vehicle per year. "Size of repair area" is given as a percentage of assembly space. "Inventories" for eight sample parts and is measured in days. "Degree of job rotation is measured on a scale running from 0 (none) to 4 (frequent). "Training of new production employees" is measured in hours.

Source: Womack, Jones, and Roos 1990, p. 92.

TABLE 6

Assembly Plant Characteristics for Volume Producers: 1994 IMVP Survey

	Japanese in Japan	Japanese in North America	American in North America
Productivity	16.2	17.3	21.9
Quality	52	48	71
Model mix complexity index	39.5	24	20

"Productivity" is labor hours per vehicle. "Quality" is defects per one hundred vehicles. The "Model Mix Complexity Index" is scaled from 0 (simplest model mix) to 100 (most complex).

Source: MacDuffie and Pil 1999, p. 385.

TABLE 7

CHRYSLER PROFIT AND MARKET SHARE PERFORMANCE RELATIVE TO FORD AND GENERAL MOTORS (1988 – 1998)

Perf. Measure	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Return on Assets											
Chrysler	**3.5%**	**1.1%**	**0.3%**	**-1.9%**	**2.3%**	**8.8%**	**11.8%**	**9.8%**	**15.0%**	**9.5%**	**11.1%**
Ford	**5.8%**	**3.7%**	**0.8%**	**-0.1%**	**-1.4%**	**2.0%**	**8.5%**	**4.5%**	**3.2%**	**8.2%**	**7.5%**
GM	**5.4%**	**5.1%**	**-1.3%**	**-1.8%**	**-3.1%**	**1.3%**	**6.9%**	**6.7%**	**4.3%**	**0.0%**	**2.8%**
Profit per Unit											
Chrysler	**$649**	**$249**	**$209**	**($427)**	**$445**	**$1709**	**$2110**	**$1290**	**$2059**	**$1468**	**$2055**
Ford	**$1014**	**$663**	**$53**	**($700)**	**($307)**	**$240**	**$775**	**$479**	**$378**	**$1000**	**$1019**
GM	**$684**	**$645**	**($462)**	**($883)**	**($541)**	**$208**	**$270**	**$594**	**$542**	**$683**	**$312**
Market Share											
Chrysler	**13.9%**	**13.7%**	**13.2%**	**12.2%**	**12.2%**	**14.7%**	**14.6%**	**14.7%**	**16.2%**	**15.1%**	**16.1%**
Ford	**23.7%**	**24.6%**	**23.8%**	**22.8%**	**24.6%**	**25.6%**	**25.3%**	**25.8%**	**25.8%**	**25.2%**	**24.6%**
GM	**34.9%**	**35.0%**	**35.5%**	**35.1%**	**33.9%**	**33.4%**	**33.1%**	**32.6%**	**30.9%**	**31.0%**	**28.9%**

Return on Assets is pretax automotive operating income divided by total automotive assets as given in the companies' annual reports. Profit per unit is pretax profit per unit sold, with the data drawn from Chilton's Automotive Industries, Report Card Issues. Market Share is the percentage of the U.S. market by units, with the data drawn from Chilton's Automotive Industries, Report Card Issues.

Source: Dyer 2000.