AUTOMOBILE INDUSTRY

1. From Craft Production to Mass Production and Lean Production
2. Industry Structure Dynamics
3. Future Projections

Overview

Peter Drucker christened the automobile industry 'the industry of industries' in 1946, and there are good enduring reasons for this label. In short, it has been at the forefront of thinking about how things are made and how we work.

Automobile manufacturing is the world's largest manufacturing activity, with just over 50 million new vehicles produced each year. One in every seven people is employed through the industry, either directly or indirectly. The indirect part is due to the need for a retail distribution network and the generation of demand for intermediate inputs (in the form of components and raw materials like steel and rubber). Governments have therefore looked to the industry as a major opportunity for national economic development, international trade and foreign direct investment.

The automobile is also the second largest expenditure item for households after housing. Many own a car, visit dealers, and are aware of the variety that exist in car models and options that reflect consumer preferences and lifestyles. The technological advances associated with the automobile transformed our idea about mobility, and will continue to do so with the advent of telematics and the Internet.

Throughout the twentieth century, the automobile industry has also been a significant source of innovative management thinking, transforming ideas about how best to make things. In the 1910s, Ford Motor Company's moving assembly line and standardised work replaced craft production. In the 1970s, Taiichi Ohno's Toyota Production System, and later, lean production techniques, were important managerial innovations with significance well beyond the automobile sector.

This entry will start by tracking the fundamental changes in manufacturing methods that enabled the automobile industry to become a massive generator of economic wealth. It will then provide explanations of changes in industry structure over time. Lastly, the future shape of the industry will be discussed with reference to telematics, e-business, and other technological developments.

1. From Craft Production to Mass Production and Lean Production

In the 1890s, in the United States and Europe, 'horseless carriages', as automobiles were better known then, were made one by one by craftsmen in metal and machine tool industries. Wealthy customers, employing chauffeurs and mechanics, placed orders to build a car to suit their precise desires. For them, customisation was more important than economical cost or ease of maintenance. And this was no problem because each part was made one at a time, and craftsmen, who thoroughly understood mechanical design principles and the materials with which they worked, filed parts together until they fitted together perfectly. Consequently, no two cars were, and needed to be, identical. The use of highly skilled workers and general-purpose machine tools resulted in a very low production volume. It is interesting to note that particularly in England, a small number of craft-based firms have survived into the twenty-first century to serve small market niches populated with buyers willing to pay a lot and wait a long time for the privilege of dealing directly with the factory to order their unique vehicles.

Craft-based production was largely superseded by mass production techniques in the first two decades of the twentieth century. A popular image of mass production is Ford's Model T rolling out of a moving assembly line. In contrast to craft production, mass production was characterised by (a) complete inter-changeability of standardised parts and the simplicity of attaching them to each other; (b) a standardized product design that can be produced in large batches to achieve economies of scale, coupled with large buffers of inventory stock to prevent any interruptions in production; and (c) a centralised hierarchy that controls and coordinates specialised and narrowly defined tasks. Consequently, a Ford assembler's average task cycle – the amount of time he worked before repeating the same operations – declined from 514 minutes (i.e. 8.56 hours) in 1908 to 1.19 minutes with the introduction of the moving assembly line at the Highland Park plant in 1913. A reduction in human effort to build cars was associated with the reduction of skilled craftsmen and an increase in semi-skilled and unskilled assembly operators.

The enormous growth in labour productivity that was enabled by mass production led to a world car industry dominated by American producers. In the heyday of mass production in 1955, the Big Three (Ford, General Motors and Chrysler) accounted for 95 percent of all American car sales, and North American production accounted for three-quarters of world motor vehicle production. But thereafter, the American market share declined, first with imports of European cars, then of Japanese and Korean cars, to the extent that by 1999, North American produced units were only 30% of the global production level. In 1999, 56.3 million cars were produced, of which 17.6m were in North America, 16.5m in Europe and 16.6 in Asia-Pacific (Japanese producers accounting for 8m within the Asia-Pacific region).

The European car industry was more fragmented than in the United States. Mass production principles were avidly studied by certain European manufacturers before the Second World War. But it was not until the 1950s that a return to civilian production enabled plants at Wolfsburg (Volkswagen), Flins (Renault) and Mirafiori (Fiat) to manufacture at a scale comparable to Detroit's major facilities. However, European manufacturers' competitive strength was never in production efficiency but lay in product differentiation and technical innovation. In particular, they made compact cars (e.g. VW Beetle), fun-to-drive sporty cars (e.g. MG), and later redefined the luxury car as a smaller vehicle with new technology. They introduced new product features such as front-wheel drive, fuel injection, unitised bodies, and five-speed transmissions. The success of this product strategy is reflected in the European share in world car production being on a par with, or greater than, the US share during much of the 1960s and early 1970s.

The quadrupling of oil prices in 1973, and subsequent price increases in 1979, swung American consumers' demand away from the gas-guzzling American vehicles to energy-efficient import cars, especially from Japan. Competition from overseas led to a contraction of the US auto industry, and the workforce employed in vehicle assembly by the Big Three contracted. In the 1980s, Japanese manufacturers overcame the yen appreciation and the voluntary export restraints by setting up assembly plants – known as 'transplants' – within North America, and by designing bigger luxury cars. By 1999, imported car sales and sales from Japanese transplants in North America put together accounted for 40% of total North American sales.

The visible 'flooding' of US and European markets by Japanese imports led to different interpretations of the Japanese success. Smaller car sizes, cheap labour and a more meticulous application of the American mass production principles were offered by some as explanations of their low costs. But more important than any of these factors was that Japanese manufacturers, and in particular Toyota, applied quite different principles of making things from mass production principles. The Toyota Production System, developed by Taiichi Ohno in the 1960s and 1970s, and lean production that was discovered in the 1980s,

inverted some of the dimensions of mass production. In particular, standardized product design, interchangeability of parts and the moving assembly line were common features. But lean production relied on (a) more general resources (e.g. multi-skilled workers and general-purpose machines) for flexible production, (b) small buffers and lot sizes to facilitate a market strategy of responding quickly to demand fluctuations with a greater variety of product designs, and (c) more decentralised authority with greater lateral communication across functional boundaries, team work, and operators' participation in quality circles and continuous improvement activities. The 'pull' system, rather than the 'push' system under mass production, led to greater production efficiency and quality improvements.

In 1989, according to an influential benchmarking study by the International Motor Vehicle Program (IMVP), North American and European assembly plants were found to be taking on average 50% and 100% longer respectively to assemble a car than their Japanese counterparts. Quality was also found to be considerably worse for American and European plants than in Japanese plants (Womack et al. 1990). The same study, repeated in 1993, shows a narrowing of performance gaps between plants in different regions, indicating the diffusion of lean production techniques throughout the world.

The superior efficiency of lean production over mass production is also reflected in product development performance. Clark and Fujimoto (1991) studied twenty-nine product development projects during 1983-87 from auto manufacturers in Japan, the US and Europe, and found that Japanese producers took forty-seven months worth of engineering time to design a new vehicle, compared with sixty months in the US and Europe. A major reason for this difference lay in over-lapping product development phases and the effective use of suppliers as part of the development team.

To summarise, the world automobile industry faced at least two distinct transformations in the twentieth century, first from craft production to mass production originating in the US, and second from mass production to lean production originating in Japan. These transformations have had an enormous impact on production efficiency and work organisation. Benchmarking and learning between plants have led to similar production principles being adopted in different parts of the world. But the studies by an international research group, GERPISA, show that instead of a universal 'best practice', automotive companies continue to follow their own forms of work organisation and production system that are shaped by different national environments and business histories.

2. Industry Structure Dynamics

In traditional economic analysis, economies of scale and barriers to entry explain industry structure. In the automobile industry, horizontal and vertical integration and de-integration may be explained by these factors, transaction cost economics, and technology shifts.

In the 1890s approximately a hundred 'coach makers' emerged in the Detroit area of the United States, each involved in some aspects of manufacturing 'horseless carriages.' But by the middle of the twentieth century this horizontally fractured industry was consolidated into a few massive, vertically integrated corporations such as Ford and General Motors. To some extent, horizontal integration may be explained by the economies of scale introduced by mass production. But as White points out, the minimum efficient scale of an assembly plant was estimated to be 100,000-400,000 units per annum, and would have allowed theoretically for seven more independent manufacturers besides the Big Three in the 1960s US. The high barriers to entry – especially large economies of scale in stamping, strong product differentiation, and high capital requirements for new models – have prevented new entrants

into the US industry. Oligopoly avoided price competition and relied on price leadership by General Motors.

Explanations of vertical integration were initially straightforward. The 1920s were time for consolidating the assembly line techniques that had been developed by Ford a decade earlier. The Rouge complex in Detroit that opened in 1931 represented an extreme case of vertical integration with its own steel mill and forging factory. At this time, vertical integration took place mainly because Ford perfected mass production techniques before his suppliers had and could achieve substantial cost savings by doing everything himself. Also purchases in the open marketplace would not deliver the needed parts with close tolerances and regular delivery schedule.

Subsequent analysis using transaction cost economics focuses on the non-production cost advantage of vertical integration. In this framework, the integration of Fisher Body by General Motors is often cited as an example of automobile manufacturers' wish to pre-empt being 'held up' by opportunistic suppliers when the latter use tools and dies specific to a customer company. But a re-examination of primary historical sources suggests that the transaction cost focus on opportunism as a given predisposition is mistaken, and that more importantly the acquisition of independent proprietors, such as the Fisher Brothers, opened up careers for them within larger organisations. Vertical integration occurred, in this perspective, as part of a managerial revolution.

As an alternative to vertical integration, intermediate forms of organisation, such as long-term supplier relationships based on trust, give the best of both market flexibility and organisational control. In Japan, 'relational contracting' between assemblers and suppliers is considered an essential complement to lean production, accounting for just-in-time delivery, low inter-firm buffer stocks, short product development lead-time, and joint problem solving for cost reduction and quality improvements.

In the 1980s, the global automobile industry has started to move back towards vertical disintegration. In the United States, Chrysler, the smallest of the Big Three, set an example by committing to long-term relationships for developing entire subsystems and to share the benefits of any cost-saving ideas with suppliers. Chrysler focused on designing, assembling and marketing vehicles while relying heavily on suppliers for component and technology development. By the late 1980s, the company emerged out of near bankruptcy to achieve the lowest cost structure and the highest average profit per vehicle amongst the Big Three. Ford and General Motors proceeded to compete by selling off their component divisions, Visteon and Delphi respectively. This vertical disintegration trend may be in part explained by an attempt to reverse the bureaucratic and organizational rigidities that possessed large established companies. But a technological factor is just as significant: the challenge of keeping ahead of competition across multiple technologies for the entire car has led major automobile manufacturers to focus on their core business, i.e. assembly, and to withdraw from component design and manufacturing.

But just as IBM lost its market power to Microsoft and Intel, the disintegration strategy of automobile manufacturers gives rise to potentially powerful independent suppliers of systems and modules, that in turn might lead manufacturers to vertically integrate at some future date. For the foreseeable future, however, large manufacturers of dashboards are forming alliances with electronics suppliers to become cockpit module suppliers. Similarly, large seats suppliers are acquiring smaller suppliers to increase their global presence, and to grow into interiors companies. There is talk of some interior suppliers taking one further step to assemble entire cars. If the outsourcing of entire automobile assembly happens not only for specialty cars but for mainline passenger cars, automobile manufacturers may find themselves withdrawing from assembly and focusing on design and marketing.

Globalisation (in the sense of access to global markets) and excess capacity in the industry have led to rapid horizontal concentration of automobile manufacturers. Many of the alliances are international. For instance, DaimlerChrysler, a German-US merger, with a link-up with Mitsubishi, cover the three continents. Ford's purchase of Jaguar, Volvo and Mazda, and Renault's equity stake in Nissan and Samsung, may be regarded in the same light.

To summarise, the global automobile industry consists of a handful of major international blocs of manufacturers. Suppliers are becoming increasingly concentrated with highly oligopolistic structures in the global markets for key parts such as seats. Globalisation of markets and component sourcing has led to greater consolidation of both assembler and supplier segments of the industry.

3. Future Projections

On one level, the global automobile industry may be characterised as mature, suffering from over-capacity and slow growth. But it is also an industry with much future potential as the definition of the scope of the industry changes. The main forces behind the next stage of evolution of the automobile industry are the Internet, telematics, and other technological developments.

The Internet is an enabler of a number of potentially fundamental changes in the way the automobile is designed, produced and sold. First, the Internet will enable consumers to configure the precise vehicle they want on-line, and receive delivery of such a 'built to order' car, just as in the case of Dell computers. Second, 'built-to-order' may promote the mixing and matching of physically independent 'modules' joined along a common interface in order to effect customisation. Thus the product architecture of the automobile may shift from being integral to more modular. Third, a true 'build-to-order' production system differs from either mass production or lean production in introducing a high level of volatility in production scheduling that would require even more flexible working arrangements. Fourth, if automobile manufacturers outsource the production of modules, powerful suppliers would become the engine of new technological development for the automobile industry. In the extreme, the brand holders would emerge as 'consumer services' companies with little in-house final assembly that had been considered essential to a company's identity as an automobile manufacturer. Lastly, the Big Three are the first movers among major companies in announcing a full-scale business-to-business, industry-wide electronic market for components. This practice will certainly transform procurement practices and supplier relations, although it is unclear whether it will be used primarily for auctions to squeeze supplier margins or for information sharing to promote loyal business relationships.

Telematics is largely about bringing information technologies inside the vehicle. Specifically, in-car services range from personal communication (phone/fax, email), convenience (travel and restaurant reservations, interactive shopping), safety (sensors to insure safe distances between cars), security (stolen vehicle tracking) to navigation (GPS locators with directions to destination). When the information-intensive vehicle is linked to a 'smart highway' or Intelligent Transportation System (ITS), even more services become possible, such as toll collection to congestion avoidance. Cars then become networked, that raises the question of whether and how the operating system of an on-line car will develop an industry standard. Other major technological changes on the horizon include alternative fuels to gasoline, such as fuel cells and electric cars; and new body materials such as aluminium and polymer composites that could be moulded in colours to eliminate painting. Any one of these developments has the potential to fundamentally alter the industry structure and the scope of what we continue to call 'the industry of industries.'

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