# Design Rules, Volume 2: How Technology Shapes Organizations

## Chapter 10 Variations on the Theme of Flow Production

Carliss Y. Baldwin

Working Paper 20-034

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**Chapter 10 Variations on the Theme of Flow Production**

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## Abstract

The purpose of this chapter is to explore how technologies and organizations engaged in flow production evolve over time. To allow for an apples-to-apples comparison, I examine organizations using essentially the same physical technologies, making similar products, and competing in the same markets. Specifically, I look at the organizational differences among the largest automakers in the U.S. and Japan. I focus first on Ford between 1910 and 1930, then on General Motors from the 1920s through the 1960s, then Toyota (and other Japanese automakers) from the 1960s through 2000. The differences among these organizations show that while technology shapes organizations within broad limits, it does not determine an organization's complete design nor its long-term competitive success.

## Introduction

In the previous chapter, I argued that the value structure of multi-step flow production processes rewards organizations characterized by unified governance, direct authority, and managerial hierarchies. Furthermore, the rewards to this form of organization are greater in large and growing markets and when there were opportunities to invest in high-volume automated equipment. However, in practice, technological forces do not determine all facets of organizational structure. In addition to technology, organizations are affected by their history, the surrounding culture, internal fissures and contradictions, and leadership. In this chapter, I explore the extent of variability among organizations engaged in flow production and the long-run success of various organizational "prototypes."

To allow for an apples-to-apples comparison, I examine organizations using essentially the same physical technologies, making similar products, and competing in the same markets. Specifically, I look at the organizational differences among the largest automakers in the U.S. and Japan. I focus first on Ford between 1910 and 1930, then on

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The three organizations considered in this chapter did not violate the theoretical principles derived in the previous chapter. All three established vertically integrated, synchronized flow production processes spanning essentially all potential bottlenecks, including new product design, marketing, and distribution.[1] Their processes were subject to unified governance. (Toyota used relational contracts but demanded very high levels of transparency and cooperation from its suppliers.[2]) All used direct authority, although Toyota emphasized coaching over coercion. Finally all created managerial hierarchies to channel information, assign responsibility, and evaluate performance.

Their differences arose within this common framework, thus can be seen as variations on the common theme of flow production. One possible path, exemplified by Ford Motor Company in the 1920s, was the movement of both the technology and organization towards increasing complexity and eventual stasis. The technical system proved incapable of changing even as market demands continue to evolve. To make a new car (the Model A), Ford was forced to create a wholly new flow production process. The expense of the changeover and the interruption of sales was staggering, costing the company around $250 million (about $3.7 billion in 2019 dollars).[3]

Another possibility, illustrated by General Motors in the 1930s, was to create multiple divisions, with separate task networks, within a single corporation. Multidivisional organizations could respond to changing technologies and market opportunities by reallocating resources across divisions, and by adding and divesting business units. However, in many of these companies in the United States, there was a sharp division between managers and unionized workers, which led to disaffection, mutual antagonism and distrust. The end result was lower labor productivity than was technically feasible.

A third possibility, first demonstrated by Toyota Motors and other Japanese manufacturing companies, was to bring workers (and suppliers) into a long-term relational contract with the corporation and engage all members of the extended organization in the effort to continuously improve process flows within the entire technical system.

I end the chapter by reviewing recent evidence on the long-term viability in the

[1] Vertical integration did not extend to car sales and service, however. All three companies maintained dealer networks made up of both company-owned and franchised establishments. On the benefits and costs of franchising, see Lafontaine and Slade (2007) and citations therein.

[2] Sako (2004).

[3] Hounshell (1984) p. 298.

auto industry of these different evolutionary paths.

## 10.1 Ford—Evolution towards Complexity and Stasis

Flow rationalization has its own logic. The identification and elimination of bottlenecks generally takes place as a series of local adaptations and interventions. Bit by bit, the process is refined by tweaking it here and there. This localized, path-dependent, evolutionary approach to improvement has several consequences. First, the technologies are likely to become more complex through the dynamic of "structural deepening" (described below). In addition, after a series of local adaptations, steps within the process are likely to become tightly coupled, interdependent, and difficult to separate. I discuss these evolutionary trends in subsections below.

*Increasing Complexity*

Brian Arthur has argued that a tendency to become more complex over time is a fundamental property of technologies.[4] He calls this process "structural deepening." Structural deepening is a response to the existence of deficiencies and limitations in a pre-existing technical system. "To overcome these limits, [the designers of] a technology will add subsystems or assemblies that (a) enhance its basic performance, (b) allow it to monitor and react to changed or exceptional circumstances, (c) adapt to a wider range of tasks, and (d) enhance its safety and reliability." [5]

Arthur used the evolution of jet engines to illustrate the process of structural deepening. The original jet engine had a single compressor to supply pressurized air for fuel combustion. Over time, designers added more compressors, a guide vane system, a control system for the guide vane, plus an anti-surge system with its own sensors and controls. The original turbojet engine of 1936 had "one moving compressor and a few hundred parts; its modern equivalent has 22,000 parts," but is "30 to 50 times more powerful." [6]

*Increasing Interdependence*

Structural deepening is a way for technologies to improve, but "over time it encrusts the technology with assemblies and subassemblies needed for superior performance." [7] More often than not, the assemblies and subassemblies are co-specialized to one another. No part can be redesigned without redesigning many others, and eventually no changes can be made at all except at an exhorbitant cost. Thus components of the system become ever more interdependent.

Growing interdependence caused by structural deepening is amplified by the need

[4] Arthur (2009) p. 132.

[5] *Ibid.* p. 135.

[6] *Ibid.* p. 137.

[7] *Ibid.* p. 137.

to synchronize flows and balance capacities throughout the process. Thus in the limit, there will be no natural breakpoints in the system: the flow will be seamless. Such tight coupling is conducive to efficiency, but not to adaptability. Changes in any one part will ripple through the system and disrupt the functioning of the whole. The process will deliver high levels of output at low cost, but it cannot be interrupted and cannot be changed piecemeal.

*Structural Deepening at Ford Motor Company*

The process developed at the Ford Motor Company for production of the Model T illustrates how a complex technical system can evolve into complexity and eventual stasis. The original Ford factory was a model of systematic management, characterized by a well-defined sequence of finely divided steps (most of which could be performed by unskilled workers), interchangeable parts, single-purpose machine tools, centralized purchasing and inventory management, and a factory-wide scheduling system supported by specialized time-keepers and cost accountants.[8]

Then, early in 1913, Ford's managers tried out a new design in one of their subassembly lines. As described by David Hounshell, "No longer did the men stand at individual workbenches, putting together an entire flywheel magneto assembly … . [Instead they were] instructed by the foreman to place one particular part in the assembly or perhaps start a few nuts or even just tighten them and then push the flywheel down the row to the next worker."[9]

Even on the first day of operation, the productivity gains from the moving line were impressive. During the next year, moving assembly lines were installed throughout the factory—in engines, transmissions, the chassis, and a host of subassemblies. Wherever the lines appeared, the gains in productivity were substantial. Ford engineers then added automatic conveyor systems and gravity slides to automate the flow of parts to the different points of assembly.[10]

Productivity went up and costs went down, but serious labor problems emerged almost immediately. Turnover at the factory was 380% in 1913. On January 5, 1914, Ford adopted a $5.00 a day basic wage, and its labor problems were solved. "[N]ow the company could ask its workers to become for eight hours a day a part of the production machine that the Ford engineers had designed."[11]

In retrospect, the Ford moving assembly line was the logical end result of systematic flow rationalization. Once the lines and supporting conveyors were installed, *the entire factory moved in synchrony with no gaps or interruptions*.

[8] Hounshell (1984) pp. 220-240; 271-273.

[9] Ibid. p. 247.

[10] *Ibid.*

[11] *Ibid.* p. 259; Raff (1988).

In the years that followed, under the single-minded leadership of the first Henry Ford, the company continued to adhere to the principles of high throughput and efficiency. The factory made one product—the Model T—with very few optional features. ("Any color as long as it is black.") Production increased from 10,000 vehicles in 1908-09 to approximately 2,000,000 per year in 1923-1925. Over the same time period, the price of a touring car fell from $950 to $290.[12]

The production lines accommodated many small changes as the process of rationalization continued. Between 1920 and 1925, the production cycle was cut from 21 days to 52 hours.[13] An all-metal body was introduced in 1925. (The all-metal body contributed substantially to shortening the production cycle, because painted wooden bodies would take more than a week to dry, while metal bodies could be baked in large ovens and would dry in 24 hours.[14])

However, the Model T failed to incorporate many innovations, which other manufacturers introduced during the 1910s and 1920s. Consistent with Kim Clark's model of feature evolution (see Chapter 6), consumers had come to value electric starters, more powerful engines, comfortable seats, three- and four-gear transmissions, shock absorbers, and even *color.* By the mid-1920s, the ignition, carburetor, transmission, brakes, suspension systems and appearance of the Model T were all out-moded.

The steps in the Model T's production process were so intertwined that it was impossible to build these desirable features into the vehicle. Both the car and the production system had been "structurally deepened" becoming more complex and indecomposable in the process. The old plant worked efficiently, but it was not set up to accommodate change.

For example, in accordance with the principles of flow rationalization, Ford's Highland Park factory was laid out as a sequence of machining steps with short distances between successive operations.[15] The chief of the tool department, explained, "Mr. Ford's idea … was to get the machines as close together as possible to save floor space. … [But] the machines were in so tight that sometimes if we had to move a machine, we'd have to move four or five different machines to get that one out." [16] Over almost two decades, the layout of the plant had evolved to the point where nothing in it could be moved.

In addition, the majority of machine tools in the plant were specifically designed to make a single component that fit into the vehicle in a particular way. Little thought was given to the fact that the dimensions of the part might change or the part itself might not be needed.

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[12] Ford Motor Company (1927) p. 8.

[13] *Ibid.* pp. 18-19.

[14] Neuwenhuis and Wells (2007).

[15] Hounshell (1984) p. 224.

[16] William Pioch, quoted by *ibid.* p. 287.

Because of this high degree of specialization, the changeover from Model T to Model A in 1927 required rebuilding half the machine tools used in production (approximately16,000 out of 32,000) and scrapping another quarter.[17] Again single-minded dedication to incremental increases in efficiency caused the system as a whole to evolve towards complexity and eventual stasis.

In contrast, as described in the next section, during the 1920s, GM introduced new features and styling changes in all its models every year. [18] In 1928, under the direction of William Knudsen, a former Ford production manager, a major model change in the Chevrolet division, was completed in just three weeks. The subsequent ramp up to full production took only two months. In contrast at Ford, the changeover from Model T to Model A resulted in a six-month shutdown, and the plant did not reach full production for another two years.[19]

Switching to the Model A did not save Ford Motors. In the 1930s, Henry Ford continued to offer a narrow product line and to manage production for efficiency alone. The company left most advertising to dealers who conducted independent, often inconsistent campaigns. It provided almost no credit to dealers or consumers.[20] By 1944, the company was almost bankrupt. It recovered only after Henry Ford II took over the company and reorganized it along the lines of General Motors, the subject of the next section.[21]

## 10.2 General Motors—Organizing for Product Variety and Customer Migration

General Motors had very different origins from Ford. It started out in 1908 as a the brainchild of William Durant, who managed to fold ten automobile companies, three truck-makers and ten parts and accessory makers into one holding company. No attempt was made to increase efficiency or to coordinate across the separate companies. Durant ran short of cash in 1910, and was forced to turn over control of the company to a group of bankers.[22]

Never deterred, Durant built up *another* holding company with the financial backing of Pierre S. Du Pont. Durant regained control of General Motors in 1915 and merged the two holding companies. He continued his acquisition spree and also began a major drive to add new capacity. The new company was profitable from 1918 through the middle of 1920, when the market for automobiles and GM's stock price collapsed. A bailout by the Du Ponts and J.P. Morgan & Co. was hurriedly arranged, and Durant was

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[17] *Ibid.* p. 288.

[18] Chandler (1964), p. 146; Tedlow (1988).

[19] Hounshell (1984) pp. 264-267

[20] Tedlow (1988).

[21] Hounshell (1995); Drucker (1946; 1993) p. 291.

[22] Chandler (1964) pp. 49-53.

forced to resign.[23]

Pierre S. Du Pont, already Chairman of the Board, became President. He hired Alfred P. Sloan as Vice President, in charge of planning the reorganization and rationalization of the company. In 1923, Sloan was appointed President of the company subject to the control of the Executive and Finance Commitees of the Board.[24]

At this time, the situation in the operating units of the company was dire. Many years later, Sloan admitted that in 1920 GM had only two acceptable product lines, Cadillac and Buick. For the rest:

> The other cars were very bad. … There was practically no coordination or planning of the products in relation to the then-existing market. The cars were brought into existence in … a very haphazard way. … There was no concept at all in our engineering departments as to … what should be done to make a quality product. … Mr. Durant did not think in terms of those kinds of things.[25]

In other words, the principles of systematic and scientific management which had been worked out by mechanical and industrial engineers in the last decades of the 19th Century and the principles of efficient mass production developed at Ford in the early 20th Century were not used at GM before 1920. Nevertheless, in its "haphazard" way, in 1919, the company produced almost 400,000 vehicles, had assets of $452,000,000, and employed 85,000 people.[26]

*A Broad Product Line and Flexible Manufacturing*

The new management team, led by Pierre Du Pont and Alfred Sloan adopted a very different strategy and a much more formal organization design than Henry Ford used to manage his company.[27] First, making a virtue of necessity, in 1921, the company adopted the policy of offering "a car for every purse and purpose."[28] Its aim was to "establish a complete line of motor cars from the lowest to the highest price that would justify quantity production."[29] The product line itself was rationalized so that (1) there would be an offering in each price class able to support large-volume production; and (2)

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[23] Ibid. pp. 71-73.

[24] Ibid. pp. 111-113; Mott (1924) excerpted in Chandler (1964) p. 118-119.

[25] Sloan (1952), excerpted in Chandler (1964) p. 149.

[26] General Motors Annual Report 1919.

[27] Ford's organizational philosophy was not to have an organization with formal roles and specified responsibilities. Instead, he ruled the company through his favorites, especially Charles Sorensen and Harry Bennett. Ford (1922) *My Life and Work*, excerpted in Chandler (1964) pp. 141-144. Hounshell (1984) pp. 289-293.

[28] General Motors Annual Report 1925, excerpted in Chandler (1964) p. 151.

[29] General Motors Annual Report 1923, excerpted in Chandler (1964) p. 150.

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the divisions making different models would not compete with one another.

Sloan likened this strategy to that of a "commanding general [who would] have an army in every point of the front line, so that he could not be attacked." [30] In other words, Sloan aimed to secure all the emerging strategic bottlenecks across the entire auto industry.

In early 1922, Pierre Du Pont recruited William Knudsen, a high-level production manager at Ford, to be vice president of operations at the Chevrolet division reporting directly to Du Pont. Knudsen became general manager of Chevrolet in 1924, and remained in that position until 1937, when he became president of GM itself.

Knudsen introduced many Ford practices at Chevrolet, but he did not seek to slavishly imitate the Ford system. Instead, within the constraints of a large-volume, synchronized flow production process, he introduced degrees of flexibility. Most notably, instead of building specialized machine tools for each production step, Knudsen installed only heavy-duty general-purpose machine tools, which could be adapted to making different parts by changing their jigs and fixtures.[31]

With this added flexibility, from 1924 onward, all GM divisions introduced (mostly minor) styling changes every year, and made them the focus of lavish advertising and sales campaigns designed to excite dealers and bring customers into the dealers' showrooms.[32] More expensive body changes were made every other year, while changes in the entire design took place in 1929 and 1937. The entire GM organization accepted as a fact that changes in the product design and related processes would take place on a planned basis every year. The changes in turn stimulated new car sales.[33]

In choosing to offer a line of differentiated products at different price points and to commit the organization to annual model changes, Du Pont, Sloan and Knudsen may have glimpsed the fact that, in the late 1920s, the market for the basic Model T was about to implode. Writing in early 1926, journalist James Dalton estimated that of the 23 million families in the United States, 19 million already owned a car. He concluded that, during the next four years (1926-1929), any sales of automobiles above 500,000 per year would have to be to families that already owned a car. [34]

The problem was that in 1925, *Ford was producing 1.6 million cars per year, and relied on that volume to achieve its low unit cost and prices*.[35] Any decline in this

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[31] A "fixture" is a device added to a basic machine tool that holds and locates the workpiece, but does not guide the cutting tool. A "jig" holds and locates the workpiece and also guides the cutting tool. The same machine tool can be used to make parts of different shapes by changing its jigs or its fixtures.

[32] "How to Sell Automobiles," *Fortune* (February 1939), excerpted in Chandler (1964) pp. 157-163.

[33] Tedlow (1988) p. 56.

[34] Dalton (1926) republished in Chandler (1964) pp. 104-111.

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volume would be fatal to the company's prices and profits. However, the unchanging, no-frills Model T offered buyers few incentives to buy a brand-new vehicle. Thus, to maintain current levels of production, Ford would have "to produce something different, distinctive and attractive."[36]

Unfortunately, such a product was beyond the reach of Ford's existing production system. Ford's business model, which had served it well for twenty years, was about to hit a wall. In contrast, GM was explicitly set up to offer "something different, distinctive and attractive" at six different price points and to change the offerings in each division every year. The question was, how could it do so efficiently?

*Common Parts*

Commitments to high variety and regular product innovation begged the question of how to achieve the volumes needed to support capital-intensive, low-cost, high-volume production. In 1923, after Knudsen redesigned and ramped up Chevrolet's production, the division's sales still amounted to less than one-quarter of Ford's.[37] The other divisions, which offered more expensive cars, were much smaller.

As a means of achieving volume production, Sloan preached the gospel of common parts. The boldest move in this direction was the Pontiac six-cylinder vehicle designed to fill a perceived gap in the line between Chevrolet and Oldsmobile. The car was conceived to be an Oldsmobile six-cylinder engine mounted on a Chevrolet chassis. It aimed to be the lowest-price six-cylinder car on the market. Crucially, except for the engine, the new car would be made in Chevrolet plants.

Daniel Raff has made a convincing argument that Pontiac's projected volume of production, when added to Chevrolet's, would bring the latter's volume up to essentially the same level as Ford's. The impact of this extra volume on Chevrolet's unit cost would allow Chevrolets to be priced at close to parity with a Ford Model T while still being profitable.

GM increased its commitment to shared parts across all divisions during the 1930s. A Fortune article written in 1938 noted that parts sharing with other divisions was "a major reason why the Cadillac Division … can earn a profit at all."[38]

GM thus adopted the technical architecture of what later came to be known as a "product platform."[39] As noted in Chapter 6, a platform architecture divides the components of a system (in this case the parts of a car) into a set of "core" elements common to all members of the system and a set of variable elements that can be mixed

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[36] Dalton (1926) in Chandler (1964) p. 111.

[37] Raff (1991) p. 734.

[38] Ibid. p. 744. Cadillac was GM highest-priced luxury car, with the smallest unit sales of any division.

[39] The term "product platform" did not come into common use until the 1980s.

and matched with the core to create purchase options for consumers.[40] This technical architecture requires breaking apart the steps in the total flow production process into a set of modular components and corresponding modular processes. The modular components are connected via standard interfaces, while the process modules are insulated from one another using time lags and inventory buffers.

Designing a product platform for a flow production process involves striking a balance between unit costs of production and consumers' willingness to pay for optional features and upgrades. Product platforms necessarily fall short of the mass production ideal of wholly synchronized, efficient flow. However, a platform architecture allows a manufacturer to sell to a larger group of consumers and to reduce the cost of innovation. Ideally, the core elements in a product platform are invisible to consumers and change very slowly, while the optional peripheral elements are highly visible and can change very rapidly.[41]

*Multidivisional Organization*

A remarkable aspect of the organization envisioned by Sloan and implemented in 1924 is that it contained over thirty separate divisions charged with making parts, assembling cars, and managing distribution. Charles Mott, a member of the Board of Directors and GM's largest individual shareholder, described the organization in 1924:

> Each division operates as an independent unit, the head of which is practically as independent as if he were the president of a separate company, but at the same time his work is co-ordinated by the functioning of certain committees and advisory staff … . Under this arrangement, each division enjoys advantages that would be beyond the reach of individual organizations.[42]

Two decades later, in *The Concept of the Corporation*, the management scholar Peter Drucker echoed the mantra of decentralized decision-making:

> [The divisional manager] acts as the boss of his outfit. He is in complete charge of production and sales; he hires, fires, and promotes … . [He] decides the factory layout, the technical methods and equiment used. He … plans for expansion and for new plants … . [He] is in charge of advertising and public relations for his division. He buys his supplies independently from suppliers of his own choice. … He makes contracts with dealers and gives or cancels their franchises.[43]

Divisional managers received bonuses in the form of cash and stock. The bonuses were based on both divisional performance and that of the corporation as a whole. They

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[40] Hayes, Wheelwright and Clark (1988); Wheelwright and Clark (1992); Pine (1993); Sanderson and Uzumeri (1995); Baldwin and Woodard (2009); Meyer and Lehnerd (2011).

[41] Baldwin and Woodard (2009).

[42] C.S. Mott (1924) excerpted in Chandler (1964), p. 119.

[43] Drucker (1946; 1993) p. 56.

were an important part of a divisional manager's total compensation: the manager of even a small division would in a few years become a "moderately wealthy" man.[44]

Despite talk of their independence, divisional managers did not have entirely free rein. Instead they operated under a set of formal and informal controls:[45]

- Central management approved the manufacturing program of each division and the price range of products sold to end users. (Inter-divisional transfer prices were reportedly set via negotiation between the divisions.)
- Central management had "absolute power" to remove a divisional manager and appoint a new one in his stead. Thus, in the words of Baker, Gibbons and Murphy, the mangers' decision rights were "loaned but not owned." [46]
- Central managers were in constant contact with division managers and expected to be consulted on every major policy decision. Central management also had formal veto power on capital investments and the hiring of executives above certain spending limits.
- Central management supplied all capital needed for approved initiatives; managed all legal matters; imposed a uniform accounting system; and handled all labor negotiations.
- Divisional managers were advised by the "service staffs" of the parent company. Service staffs acted as liaisons between different divisions and as a conduit for transmitting innovations developed outside GM. They also "informed central management of all important developments within the divisions."

Thus GM (as well as other companies adopting a multidivisional structure) maintained unified governance of their holdings both by virtue of their legal status as corporations and by virtue of the information and control systems set up by central management.

The success of this form of organization in implementing multi-product flow production systems was impressive. According to Alfred Chandler, by 1959, essentially all of the largest firms[47] in the automobile, chemical, electrical and electronic industries had adopted this form of organization. The "M-form" of organization was also widely used in the food processing, oil, rubber, and mass merchandising industries. Only firms in the metals processing industries failed to adopt it.[48]

In a study published in 1974, Richard Rumelt found that, between 1950 and 1970,

[44] Ibid. p. 59.

[45] Ibid. pp. 50-55.

[46] Baker, Gibbons and Murphy (1999).

[47] Largest is defined as one of the Top 70 U.S. firms in 1948 or 1959 ranked by assets.

[48] Chandler (1962) p. 6.

the percentage of firms in the Fortune 500 with a multi-divisional structure grew from just over 25% to over 75%.[49] By 1970, multi-product companies with multi-divisional organizational structures dominated the U.S. economy.[50]

A subtle aspect of the model, which Peter Drucker emphasized, lay in way it provided for management training and orderly succession. At GM, the smaller divisions served as training and proving grounds for managers who would go on to become leaders of the corporation as a whole. Many managers at GM believed that senior positions in the smaller divisions allowed talented individuals see a business in its entirety and become accustomed to making decisions on behalf of the enterprise as a whole. One went so far as to say that the efficiency of GM lay "in its having a small number of big businesses to make the money, and large number of small businesses to supply the leadership."[51]

Proof of the quality of this "deep bench" arose when the United States entered World War II, and GM converted from peacetime to war production. In the space of eighteen months (starting before war was declared in the U.S.), GM switched from being a company making around 250 closely related products to making 3000 largely unrelated products needed for the war effort.[52]

Because of decentralized operational decision-making, hundreds of efficient flow production lines using interchangeable parts and staffed by unskilled or semi-skilled workers were brought to full production in a period of a few months. GM's total production approximately doubled and it trained thousands of new workers and supervisors who had no prior experience in factories. High wartime morale certainly helped bolster production: however, a cadre of competent and knowledgeable managers—from GM and other private companies— who were able to build factories and to run them efficiently contributed equally to the success of the war production effort.[53]

*Vulnerabilities and Fissures*

It is easy to see how product platforms (a technical architecture) and multi-divisional corporations (the corresponding organizational architecture) might seem to offer the best of both worlds for multi-step flow production processes. One gets the efficiency and low-cost of automated, synchronized flow together with a broad product line—a product "for every purse and person." One gets the consistency of central planning and the discipline of central control, while allowing for decentralized innovation and product and process evolution. The corporation can offer prospective managers both financial security and opportunities for advancement. There is room for both specialists

[49] Rumelt (1974) Table 2-14. See also Chandler and Tedlow (1985) p. 698.

[50] Williamson (1975) pp. 136-151; Williamson (1985) pp. 279-284.

[51] Drucker (1946; 1993) pp. 125-129.

[52] Ibid. p. 82.

[53] Herman (2012).

and generalists in the organization: a manager can move forward on either path.

Notwithstanding these apparent benefits, with 20-20 hindsight, we can see problems in the way these technologies and organizations evolved in the United States in the decades after World War II. Peter Drucker saw two vulnerabilities quite clearly as early as 1946. The first was a flawed understanding on the part of corporate managers and engineers of how front-line workers and foremen influenced the productivity and efficiency of flow processes. This misunderstanding was reinforced by the teachings of Frederick W. Taylor as well as the political balance struck between managers and labor unions in the U.S. after World War II.[54] This suboptimal balance of power affected all U.S. automakers and many U.S. firms in other industries, and is discussed in the next section.

The second vulnerability Drucker saw was the tendency of senior managers to become isolated from the rest of society, thus parochial, and complacent. This mindset left GM, other U.S. automakers and the United Autoworkers unprepared for the competitive success of the Japanese auto companies in the 1970s and 1980s.[55]

In 1986, Toyota surpassed GM as the largest automaker by market value.[56] In June 2009, after losing $85 billion over ten years, GM filed for bankruptcy. Its shareholders were wiped out, and control of the company passed to its creditors, unions, and the U.S. and Canadian governments. The reorganized company has refocused its strategy on electric vehicles.[57]

## 10.3 Unionized Mass Production in the U.S. after World War II

The U.S. auto industry, like many others, became unionized in the latter part of the 1930s under the auspices of the New Deal. The process of unionization was long, bitter, and violent, ending with animosity and distrust on both sides.[58] After a hiatus caused by World War II, policies and practices at unionized plants were codified during the 1950s and 1960s.

In defining shop floor practice, management's inclination—reinforced by the union—was to create a strong divide between the design of the production system and the work itself. There was preliminary evidence from wartime production and a survey of 300,000 GM employees that front-line workers and foremen had skills and knowledge relevant to workflow design *and* were eager to take on meaningful responsibilities.[59]

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[54] Braverman (1974; 1998) pp. 59-95; Piore and Sabel (1984).

[55] Halberstam(1986); Womack et al. (1990).

[56] Author's calculations from data in Compustat.

[57] De Bord (2018).

[58] Drucker (1946; 1993) pp. 207; Chandler (1964) pp. 194-198; Halberstam (1986) Chapter 19; Piore and Sabel (1984) pp. 97-103.

[59] Drucker (1946; 1993) p. 300; Winning entries from "My Job and Why I Like It," https://archive.org/stream/myjobandwhyilike00generich/myjobandwhyilike00generich_djvu.txt (viewed

However, managers and engineers, trained in the precepts of Frederick W. Taylor, were jealous of their own prerogatives and saw the division of knowledge work from physical work as an intrinsic part of efficient mass production.[60]

Union leaders too were opposed to having workers involved in improving production processes. Any degree of cooperation between company and workers was a threat to the union's control hence anathema to union leaders. Writing in the 1990s, Peter Drucker described an interview with Walter Reuther, head of the UAW, in the late 1940s in which the union leader laid out his position "Managers manage and workers work." Any other arrangement would place "an intolerable burden on the working man."[61]

From these inauspicious beginnings, there emerged a system of shop floor governance in the U.S. that was inflexible, adversarial, burdened by rules and regulations, and in the long run, very inefficient. Bored and disaffected workers, feeling no sense of responsibility for the products coming out of the long production lines, introduced random variation into the flow processes in the form of defective parts.[62] Control over job design and task assignment no longer rested with management alone: instead governance was split between managers and union officials and was frequently the focus of disputes and grievances. Resolution of grievances took place via a formal, quasi-judicial process in which precedent, not efficiency, was the guiding principle.[63]

This system of distributed governance was virtually guaranteed to undermine any effort to reduce cost or improve efficiency of a flow production process. However, the system evolved at a time of great prosperity and growth in the U.S. auto industry when no company wanted to lose sales or market share. The UAW's leader, Walter Reuther, was adept at playing one company off against another in attempts to gain concessions from all of them.[64] As long as the companies did not face significant external competition, the system seemed to work. Pay and profits went up every year.

Beginning in the 1970s, large, unionized companies in the U.S. increasingly faced competition from foreign manufacturers as well as domestic non-union plants. In the auto industry, the greatest challenge came from Japanese automakers. Led by Toyota, these companies had discovered and refined a new way of organizing multi-step flow production processes, centered on the concepts of "no waste" and "continuous improvement." The next section describes the Toyota Production System, the third organizational variant consistent with large-scale flow production technologies.

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8/20/19).

[60] Drucker (1946; 1993) p. 301.

[61] Ibid. pp. 302-303.

[62] Rothschild (1974).

[63] Piore and Sabel (1984) pp. 113-115.

[64] Halberstam (1986) p. 347.

## 10.41 Toyota — "No Waste" and Continuous Improvement

Even as U.S. automakers were becoming ensnared "in a net of rules with an ever finer mesh,"[65] Japanese auto manufacturers were developing a new way of organizing multi-step processes to better exploit the technological potential of flow production. By the 1950s, all automakers made similar products, although there were differences among them in styling, features, fuel efficiency and reliability. They also used similar production technologies: generalized machine tools for molding and stamping, a paint-and-dry operation; mechanized materials handling; and moving assembly lines. Producers mainly differed in terms of their production volume. In general, the highest volume plants achieved the lowest unit cost.[66]

Despite technological similarities, the context in which the so-called Toyota Production System (TPS) emerged in the 1950s and 1960s was very different from that of American companies at the time. The Japanese market for automobiles was small and spread out across many products and companies. Long production runs of identical parts and almost-identical vehicles were impossible.[67] Also, because of foreign exchange controls, capital to finance equipment and growth was very scarce.

To reduce cost and conserve capital, Eiji Toyoda, cousin of the founder of Toyota Motor Corporation, and Taichi Ohno, a machine shop manager, concentrated on reducing the switchover times for cutting tools and stamping machines in the production line.[68] For stamping machines, a switchover requires removing one die and replacing it with another. In U.S. factories changing a die took from two to eight hours and the changeover was performed by specialists.[69]

Between 1950 and 1962, through small cumulative modifications in the work flow of a die change, Toyota reduced the switching time from two to three hours to around 15 minutes. The introduction of Quick Die Change presses produced by Danly Corporation in the 1960s further reduced the time to 2-3 minutes by 1973.[70]

To reduce the disruption in workflow caused by switchovers, Ohno gave responsibility for executing the changes to workers in the line itself, instead of to specialists. He also organized front-line workers into teams charged with assigning tasks to members and responding to short-run fluctuations in orders in a particular part of the flow process.[71]

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[65] Piore and Sabel (1984) p. 114.

[66] Rhys (1972; 1977); Raff (1991); Fujimoto (1999).

[67] Fujimoto (1999).

[68] Smalley, A. (undated).

[69] Womack et al (1990) pp. 50-52.

[70] Smalley, A. (undated); Roser (2014).

[71] Womack et al (1990) p. 55.

Switchovers were only one source of "waste" (*muda*) in the production system. Ohno and other Toyota managers looked to eliminate waste wherever it occurred. In 2012, Takahiro Fujimoto estimated that the Toyota Production System then consisted of "400 organizational routines, all of which are dedicated to one functional objective — delivering a fast, efficient, and accurate flow" to each station in the plant.[72]

Faster, more frequent switchovers and other waste-eliminating practices reduced the need for large inventories and buffers in the flow process. Using inventory levels as a signal, Ohno developed a system of *lateral* communication (the *kanban* system) in which downstream stations ordered very small batches of parts from upstream stations on an as-needed basis.[73] The flow-lines of information and material were precisely specified, with the ideal transfer from supplier to requestor defined as a batch size of one, defect-free, delivered immediately.[74] Ultimately the series of requests flowing up the lines would reach Toyota's external suppliers who were held to a similar standard: small batches delivered immediately on request. The resulting system of *synchronized flows* became known as "just-in-time" (J-I-T) production.

The first effect of this system was to practically eliminate work-in-process inventory in the factory. James Womack, Daniel Jones and Daniel Roos recalled that the 1989 International Motor Vehicle Program (IMVP) survey asked how many *days* of inventory were in each factory. A Toyota manager asked if there was an error in translation: "Surely [they] meant *minutes* of inventory." [75] (See Table 9-1 below.)

A second effect was that small disruptions in the form of delays or defects would reverberate through the system, bringing the entire line to a standstill. In other words, the system as a whole was fragile.[76] Such fragility would not normally be considered a desirable feature in a production system. However, Ohno's genius was to see that making problems evident when they arose, rather than burying them in buffers and large batches, would allow even small bottlenecks to be identified and quickly addressed. Problem-solving on the line also did away with the need for indirect workers—die changers, machine repairers, housekeepers, inventory runners, substitutes—who were a ubiquitous feature in U.S. automakers' factories.[77] (Indirect workers were in part the consequence of the American companies' and unions' insistence on narrow job descriptions and formal job ladders.[78])

[72] Fujimoto (1999; 2012).

[73] Aoki (1988) Chapter 2.

[74] Spear and Bowen (1999).

[75] Womack et al (1990) p. 80.

[76] Ibid. p. 103.

[77] Ibid. p. 78.

[78] Piore and Sabel (1984) p. 113.

*Comparison of Performance*

The system of charging (and trusting) front-line workers organized in teams with (1) identifying defects in real time; (2) solving problems where and when they arose; (3) reconfiguring task assignments to respond to variation in orders; and (4) recommending process design improvements over time led to consistent, cumulative improvements in both labor productivity and quality for Japanese automakers vis a vis their U.S. and European counterparts.

Table 9-1 summarizes key differences across producers. The data were taken from a worldwide survey conducted by the International Motor Vehicle Program (IMVP) in 1989. The survey revealed that Japanese-owned plants in both Japan and North America were superior in productivity and quality to U.S.-owned plants in North America and all plants in Europe. The difference was not simply in average performance: *virtually every Japanese-owned plant had higher productivity and quality (fewer defects) than any U.S. or European-owned plant*.[79] Japanese-owned plants also operated with much lower levels of inventory than their U.S. and European counterparts.

Instead of looking to higher levels of automation to reduce cost and increase productivity (as was typical in U.S. companies[80]), Japanese automakers focused on improved work process flows, synchronization and defect elimination. In this respect, they were like advocates of systematic management in the U.S. at the beginning of the 20th Century (see the quotes from Kendall in Chapter 8 and Knudsen in Chapter 9).

However, in stark contrast to Taylorist doctrines about the need to separate mental and manual labor,[81] process improvements in Japanese companies were achieved by:

- Recruiting and training front-line operators and their supervisors to analyze process flow with the goal of continuous improvement;
- Emphasizing on-the-spot diagnosis of points of inefficiency (bottlenecks) followed by a disciplined search for root causes;
- Implementing changes rapidly with active cooperation instead of resistance from the workforce.

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[79] Womack et al (1990) Figure 4.8, p. 93.

[80] Hounshell (1995).

[81] For example, Frederick Taylor described the division of knowledge between workers and managers as follows: "It is only through enforced standardization of methods, enforced adoption of the best implements and working conditions, and enforced cooperation that this faster work can be assured. *And the duty of enforcing the adoption of standards and enforcing this cooperation rests with management alone.*" Taylor (1911) p. 64. [Emphasis added.]

**Table 9-1 Characteristics of Auto Assembly Plants by Ownership and Location (Averages by Region)**

| Ownership/ Location | Japan/ Japan | Japan/ North America | US/ North America | All Europe |
|---|---|---|---|---|
| Productivity (1) | 16.8 | 21.2 | 25.1 | 36.2 |
| Quality (2) | 60.0 | 65.0 | 82.3 | 97.0 |
| Inventory (3) | 0.2 | 1.6 | 2.9 | 2.0 |
| Size of Repair Area (4) | 4.1 | 4.9 | 12.9 | 14.4 |
| % Workforce in Teams | 69.3 | 71.3 | 17.3 | 6.0 |
| Training of New Employees (hours) | 380.3 | 370.0 | 46.4 | 173.3 |
| Number of Job Classes | 11.9 | 8.7 | 67.1 | 14.8 |
| Suggestions per Employee | 61.6 | 1.4 | 0.4 | 0.4 |

(1) Hours per vehicle. This is an inverse measure: lower is better.
(2) Assembly defects per 100 vehicles. Lower is better.
This number reflects defects found by consumers.
(3) Days for 8 sample parts. Lower is better.
(4) % of assembly space in plant. Lower is better. Repair areas are spaces where vehicles that do not pass the final quality assurance test are repaired by specialists.
This number reflects the number of defects found and fixed within the factory.

**Source:** Adapted from Womack, Jones and Roos (1990) p. 92. Data from IMVP Assembly Plant Survey (1989) and J.D. Power.

*Thus in Japanese companies, systematic management principles were translated into a set of cognitive skills taught to front-line workers by supervisors acting as their coaches.*[82] Workers employed those skills in the ordinary performance of their jobs. Continuous improvement (kaizen) was a byproduct of normal work, not a series of externally imposed interventions that disrupted the work.

*Engaging Workers in the Productive System*

Obviously successful implementation of Japanese practices requires not simply a workforce with appropriate training, but one that is engaged and committed to the twin goals of waste reduction and continuous improvement. How can a company recruit and retain an engaged, skilled and committed workforce? Japanese manufacturers achieved this goal by entering into long-run relational contracts with their workers, giving them job security with substantial protection from downturns. In addition, through bonus systems, workers' pay fluctuated with the profits of the company: there was both gain-sharing and loss-sharing.[83]

Furthermore, in contrast to the U.S. unions, which represented all workers in a given industry, Japanese workers were generally represented by company unions. Union leaders in Japan knew that the welfare and security of their members depended on their company's competitive success.[84]

Finally, shop floor practice in Japan differed from the U.S. in ways that indicated a higher level of respect for workers and their skills. First, in the exercise of direct authority, Japanese companies emphasized teaching over coercion. This meant selecting first-line supervisors for teaching skills and training them to be coaches, not drivers.[85] Second, front-line workers were given critical decision rights affecting the entire production system. The *andon cord* running along the production line meant that anyone in the entire synchronized step process could "stop the line" and would be praised, not punished for doing so.[86]

*Management of Suppliers*

Because of their market's fragmentation, Japanese assemblers could not afford to be as vertically integrated as their U.S. counterparts.[87] In 1989, GM accounted for 70% of the value added in production to its vehicles, while Toyota Motor Company accounted

[82] Spear and Bowen (1999); Spear (2003). As Table 9-1 shows, new workers at Japanese-owned plants received eight times as many hours of training on average as new workers at U.S.-owned plants.

[83] Aoki (1988) Chapter 3; Milgrom and Roberts (1994); Fujimoto (2012).

[84] Halberstam (1986) Chapter 8; Milgrom and Roberts (1994).

[85] For a description of the training of a North American manager in the principles of the Toyota Production System, see Spear (2004).

[86] Mishina and Takeda (1992). Andon cords were replaced by wireless call buttons at most Toyota factories in the mid-2010s.

[87] Helper and Sako (2010) p. 411.

for only 27%.[88] Nevertheless, Toyota and other Japanese automakers demanded of their suppliers the same low-inventory, just-in-time replenishment as they required in the assembly process.

Rather than forcing suppliers to bid competitively for one-year contracts to supply parts (as was standard practice in the U.S.), Japanese companies entered into four-year formal contracts and longer-term relational contracts with a small number of "first-tier" suppliers. Typically they selected two suppliers for a given part or subassembly in order to foster competition between them.[89] However the suppliers were generally members of a longstanding group (*keiretsu*), and these long-term relationships were almost never broken.[90]

The lead firm of the group demanded full transparency of its suppliers: its representatives could inspect any aspect of suppliers' business including factory operations and cost data. Suppliers in turn could observe their customers' facilities and practices. Indeed suppliers were expected to assign "engineers-in-residence" to their customers' factories to assist in trouble-shooting and parts redesign.

Toyota and other Japanese automakers also expected their suppliers to demonstrate continuous improvement. Annual price declines were written into the four-year supply contracts for each part. If cost reductions exceeded the price decline, suppliers were allowed to retain the balance.[91]

To differing degrees, the top Japanese automakers also assisted their suppliers in developing the capabilities needed to consistently cut costs. By the early 2000s, Toyota, Nissan and Honda each sponsored formal supplier development programs. At each company, 50 to 80 experienced engineers were assigned to initiatives aimed at teaching suppliers how to improve their internal practices both on the shop floor and in the supplier's business as a whole. Each had also developed clear rules for sharing gains and honored these implicit commitments in good times and bad.[92] In contrast, U.S. automakers that attempted to mimic the Japanese model in the 1990s continued to treat their suppliers as adversaries.[93]

The result of the Japanese firms' sustained practices was a high level of trust between the automakers and their suppliers. Mari Sako reports that the automakers "generally encountered no barriers to the suppliers opening their books for advice."[94] Because of trust between the parties, it was cost-effective to locate transactions at thick

[88] Womack et al (1990) p. 159.

[89] Ro, Liker, Fixson (2008) p. 362.

[90] Aoki (1988) p. 205.

[91] Womack et al. (1990) p. 153.

[92] Sako (2004).

[93] Ro, Liker and Fixson (2008).

[94] Sako (2004) p. 301.

crossing points in the task network. In effect, through long-term relational contracts and ongoing face-to-face communication, the parts suppliers and assembly firms created a shared transaction free zone where valuable information and knowledge could be exchanged without triggering demands for payment or opportunistic behavior on either side.[95]

## 10.5 Conclusion—How Technology Shapes Organizations

The auto industry cases discussed in this chapter are meant to provide evidence supporting two related points. First, there are broad similarities in the organizational structures and practices of companies making similar products using similar technology. Second, a common underlying technology does not wholly determine a company's organizational structure, policies and practices. Within the same technological envelope, companies may choose different organizational architectures, which then develop along different trajectories.[96]

The existence of different organizational forms in the auto and other industries engaged in flow production raises the question of dominance vs. equifinality. In direct competition will one form of organization deliver consistently superior economic performance? If so, then absent government intervention (such as tariffs or subsidies), the higher performing form of organization should eventually be the only one to survive. One organizational form will dominate.

Alternatively, over the long term, different organizational forms might deliver comparable levels of economic performance. In that case, the industry will contain companies implementing similar technologies using different organizational structures, practices and policies. The system as a whole will exhibit equifinality.

In the conclusion to this chapter, I consider whether today the global auto industry is characterized by dominance or equifinality.

*Commonalities*

Today the three automakers have in common unified governance, the exercise of direct authority, and the use of hierarchies to manage information and delegate responsibilities. Ford, GM and Toyota are all vertically integrated. Through their entire history, each has included a large number of consecutive steps within the boundaries of a single corporation under unified governance. Toyota is the least vertically integrated, but is able to achieve something close to unified governance of its supply network through mandated transparency combined with long-term relational contracts.[97]

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[95] See Chapter 2.

[96] Dosi (1982; 1988).

[97] In Chapter 18, we will see how Dell Computer used transparency plus digital technology to achieve close-to-unified governance of a large supply network.

All three automakers also exercise direct authority over employees. They define steps and tasks in the production process and assign workers to jobs. However, in the U.S., the relationship between workers and managers has traditionally been adversarial. In contrast, Toyota downplays the use of direct authority in the workplace, relies on self-managed teams, and trains its managers to be teachers and coaches.

Finally, all three companies have created extensive hierarchies for managing information flows and allocating decision rights and responsibilities. Toyota, however, also relies on lateral information flows (the *kanban* system) to achieve synchronized flow with low inventory and just-in-time deliveries.

*Differences*

Notwithstanding these commonalities, the three companies originated at different times and faced different early challenges in both production and marketing. Their founders and early managers had dramatically different visions of the possibilities inherent in the technology and marketplace. Finally the companies competed with one another and learned from their own and their rivals' successes and failures.

Ford initially opted for very low levels of product variety and achieved low unit costs by driving flexibility out of its production system. This strategy proved unsustainable, however, as its market approached saturation. Thus, in the U.S. auto industry, evolution towards complexity and stasis proved to be a competitive failure and a technological and organizational dead end.

Starting out as an amalgam of separate companies, GM under the leadership of Du Pont and Sloan chose to offer a broad product line based on a platform of common parts. The company created a multi-divisional organization, made up of many separate product divisions answerable to a central group of senior executives and subject to centralized strategic planning, information gathering, and human resource and accounting systems. This hybrid organizational architecture succeeded where Ford failed.

GM and companies like it also trained a cadre of general managers in the tenets of efficient mass production. During World War II their managerial skills proved highly portable and valuable in implementing other flow production technologies, notably in aviation, armaments, ammunition, logistics, and many consumer goods.[98]

However, the U.S. auto industry's social contract did not extend to its front-line workers and foremen. After the war, the U.A.W. commanded the loyalty of the workforce. With industry-wide collective bargaining, it was able to obtain consistently high wage settlements from all companies in the industry. The union also promoted work rules and grievance procedures without regard to their effect on efficiency or ease of technological change. By the 1970s, GM and the rest of the U.S. auto industry faced an impasse between the labor and management that made technological progress virtually impossible. In effect, the whole industry became enmired in a system of inflexible

[98] Herman (2012).

practices that led in the end to complexity and stasis.[99]

Japanese automakers utilizing variants of the Toyota Production System began to compete head-to-head with American and European companies in the mid-1970s. They first made inroads by offering small, fuel-efficient vehicles, a category U.S. manufacturers had ignored. However, the Japanese firms' advantages in terms of productivity and quality were real. As Table 9-1 shows, in 1989, the Japanese organizational model dominated the classic American model of mass production just as as GM's model had dominated Ford's in the 1930s and 1940s.

*Complementarity within Forms of Organization*

In path-breaking articles published in 1990 and 1995, Paul Milgrom and John Roberts argued that production systems consist of distinct sets of individual practices and policies that are supermodular complements. If the degree of complementarity among elements is high, they argued, then changing one element by itself will have little or no effect on the performance of the whole. Indeed, in some cases, changing one practice or policy in isolation may cause overall performance to decline.[100]

However, under the stimulus of competition, it may be possible to stay within a given organizational architecture (maintaining most complementarities), while improving some elements incrementally. For example, in a classic mass production establishment, modifying work rules and combining job categories may reduce the number of indirect workers. Work-in-process inventory can be cut via computerized tracking and better scheduling. Computerized numerical control (CNC) can increase the precision (hence quality) of machined parts. Algorithmically controlled robots can speed up processing time and increase the flexibility of assembly lines.

In a working paper published in 2013, John MacDuffie, Bruce Kogut, Frits Pil and Charles Ragin presented evidence of improvement in automakers using classic mass production methods in the decade following the 1989 IMVP survey. Using results from a second IMVP survey in 2000, the authors looked at the before-and-after productivity, quality, and organizational practices of 24 plants at two points in time a decade apart.[101]

They found that *nine U.S. and European plants, which were not highly productive in 1989, had become highly productive by 2000*. Notably, these plants did not adopt Japanese practices, but combined low product variety (hence long production runs) with high levels of automation. These so-called efficient mass production plants achieved productivity on a par with the most productive plants using Toyota methods. (Their quality also improved, but fell short of the Japanese standard by 25%.)

Interestingly, *two highly productive plants in Japan switched from Toyota-style*

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[99] Halberstam (1986); Womack et al (1990).

[100] Milgrom and Roberts (1994).

[101] MacDuffie et al (2013).

*production to efficient mass production and continued to be highly productive afterward*. It is not clear from the study, which specific practices these plants changed, but in 2000 they ressembled U.S. and European factories more than other Japanese factories. In contrast, no plant switched from mass production to Toyota-style production. This is consistent with the contention that Toyota-style production is difficult to implement incrementally: to succeed, the system must be adopted wholesale at a green-field site.

I must emphasize that the sample size of this study is very small. Nevertheless, the findings support Milgrom and Roberts' contention that the elements of an organizational architecture are complementary, not independent. In the most successful organizations in the sample, complementary practices with respect to inventory levels, in-process buffering, scheduling, training, and task allocation tended to be clustered into two organizational prototypes—Toyota-style production and efficient mass production. In the 2000 survey, all highly productive plants conformed to one of these two prototypes: plants not conforming to either one did not achieve high productivity.

The findings also support the hypothesis of equifinality—that within a given technology (broadly defined), there may be different organizational routes to the similar levels of economic success. The technology itself creates constraints: for example, in a flow process with interdependent steps, production bottlenecks must be identified and addressed. The technology may also reward certain organizational features: for example, unified governance of adjacent steps; the exercise of direct authority in real time; and hierarchical systems of information flow and task delegation.

However, within the relatively broad parameters set by technology, organizations can modify their practices and policies to suit their resources, legacies and the surrounding culture, and still achieve high levels of technical and competitive performance. Technology thus sets the stage, but does not determine the ultimate design of a successful organization.

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