PARADIGM SHIFT:
FROM MASS PRODUCTION TO MASS CUSTOMIZATION

by

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ABSTRACT

Over the last twenty years serious problems in America's economic system have become apparent. This thesis contends that a major problem with American competitiveness can be traced to large manufacturing concerns and others who have adopted and advanced the system of Mass Production.

This system of production became a paradigm: a well-accepted model or pattern that establishes an informational framework and set of rules by which its practioners view the world. As a paradigm of manufacturing, the system of Mass Production has blinded its practitioners to the fundamental limits within the system itself that are the root causes of their difficulties.

This thesis further proposes that a new paradigm of increased variety and customization -- called "Mass Customization" -- is unfolding for many industries. Managers today need a new set of tools to analyze their industries to determine if they, too, need to shift from the old paradigm of Mass Production to the new paradigm of Mass Customization.

The degree of turbulence in a firm's market environment is proposed as the predictor of the degree of paradigm shift in any industry, and is validated through a survey of over 250 managers in various industries. A set of tools that managers can use to measure their firm's market turbulence and understand the profile of variety and customization present in their firm and industry is also provided.

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Chapter 1

Introduction

By now, everyone even remotely aware of what has been going on in the United States over the last twenty years knows that there are serious problems with our economic performance -- if not our entire economic system -- particularly when compared to the tremendous advances countries like Japan and Germany have made. There has been no shortage of explanations. Numerous books and studies have investigated these difficulties and nearly all attest that they are not the result of any short-term phenomenon: something very fundamental is happening. For example, The MIT Commission on Industrial Productivity concluded:

> [R]elative to other nations and relative to its own history, America does indeed have a serious productivity problem. This problem in productive performance, as we call it, is the result of major changes within and outside the United States in the past four decades. It is manifested by sluggish productivity growth and by shortcomings in the quality and innovativeness of the nation's products. Left unattended, the problem will impoverish America relative to other nations that have adapted more quickly and effectively to pervasive changes in technology and markets.[1]

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[1]Michael L. Dertouzos, Richard K. Lester, Robert M. Solow, and The MIT Commission on Industrial Productivity, **Made in America: Regaining the Productive Edge** (Cambridge, Massachusetts: The MIT Press, 1990), p. 166.

Likewise, there has been no shortage of recommendations on what America, and individual companies, can do to regain lost competitiveness. Too many times, however, there is no recognition that the fundamental changes are not hitting all industries equally and therefore there is little recognition that not all companies are facing the same circumstances and should not implement the same solutions in the same way.

For example, in an otherwise excellent study of the automobile industry that recommends Japan's "lean" system of production, the International Motor Vehicle Program at MIT claims that

> the principles of lean production can be applied *equally in every industry across the globe* and that the conversion to lean production will have a profound effect on human society -- it will truly change the world.[2] (emphasis added)

Rather than such blanket statements about all companies in all industries, what is really needed is an understanding of what fundamental changes are in fact occurring in America's economic system, where these changes apply and to what extent, and in particular how managers in individual companies can recognize these changes and act accordingly.

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[2]James P. Womack, Daniel T. Jones, and Daniel Roos, **The Machine that Changed the World** (New York: Rawson Associates, 1990), pp. 7-8.

Therefore, it is the contention of this thesis

- that a major problem with American competitiveness can be traced to large manufacturing concerns and others who have adopted and advanced the system of Mass Production;

- that the adoption of Mass Production as a paradigm of manufacturing has blinded its practitioners to the fundamental limits within the system itself that are the root causes of their difficulties;

- that a new paradigm of increased variety and customization -- called "Mass Customization" -- is unfolding for many industries;

- and that new tools are needed -- and provided -- for managers to able to determine whether and to what degree their industry and company are subject to this paradigm shift.

The following is a brief overview of the structure of this thesis. Chapter 2 provides historical background on the systems of production in America. Craft Production is discussed briefly, then full descriptions are given of Mass Production and the American System of Manufactures, its

nineteenth-century precursor. With this historical background, the systems of Craft and Mass Production are contrasted and compared to determine if Mass Production was indeed the winner, as it has been declared to be. Finally, the economic challenges to America are shown to largely be challenges to Mass Production.

Chapter 3 provides the reason that Mass Production is not winning these challenges: it is a paradigm -- a mental model -- whose central tenet of "efficiency through stability and control" is no longer a valid model of how firms in many industries should operate in today's world. Paradigms can be powerful mechanisms for ordering information and organizing research, but they also filter out information contradictory to their tenets. In this case, the paradigm of Mass Production filters out information about the limits to the system, limits that are increasingly being encountered in the market environments of many industries. The new paradigm of Mass Customization -- "variety and customization through flexibility and quick responsiveness" -- is proposed as representing the new model of how companies within these industries are reacting to their current market environments.

Chapter 4 gives examples of firms that are mass customizing products and services today. Examples are given for mass

customization through technology, people, and people with technology. Tools are provided to allow managers to examine their product set and organizations for customization possibilities, and some guidelines and principles are put forward for how companies can begin mass customizing.

Chapter 5 provides a means for managers to be able to predict whether their company and industry will have to make the paradigm shift from Mass Production to Mass Customization. The predictor of this shift is claimed to be *market turbulence*: the amount of instability, uncertainty, and lack of control present in a firm's marketplace. Market turbulence is described in terms of 17 market environment factors, and a Market Turbulence Map is developed to provide a diagnostic tool for managers to ascertain their level of turbulence and how much it is changing over time.

Chapter 6 validates market turbulence as the predictor of the paradigm shift through a survey of over 250 managers in various industries across the country. Increased variety and customization of products are found to be correlated with -- and apparently caused by -- increased market turbulence. Further analysis of five different industry groups reveals that the Market Turbulence Map accurately predicts the degree of change in variety and customization, including the

lack of change in industries that have no need (at this time) to undergo the paradigm shift.

Chapter 7 concludes by pointing the way towards making the future of America a success through Mass Customization.

It is the author's fervent hope that this thesis was not written to just sit on a shelf, but will actually be used by managers to better understand their market environments, and for those managers whose firms are experiencing high degrees of market turbulence, to help them make the paradigm shift from Mass Production to Mass Customization.

Chapter 2

Mass Production in Historical Perspective

Craft Production and Mechanization

In the history of economic affairs, the system of Mass Production is a relatively new invention. For centuries economic production was based on the notion of *craftsmen*. Everything produced was by the hands of someone possessing the requisite materials, tools, and, most importantly, skills. Craftsmen were also called *artisans* and their skill (or "know-how") to turn raw materials into finished goods was a source of pride.

With the Industrial Revolution came the general replacement of hand tools with machinery and mechanization as the primary instruments of production. Over time the use of machinery led down two distinct paths. The first path was a continuation of the basic idea of Craft Production: "Its foundation was the idea that machines and processes could augment the craftsman's skill, allowing the worker to embody his or her knowledge in ever more varied products: the more flexible the machine, the more widely applicable the

process, the more it expanded the craftsman's capacity for productive expression."[3] The second path, one that would eventually be named Mass Production,[4] had a very different idea: "Its guiding principle was that the cost of making any particular good could be dramatically reduced if only machinery could be substituted for the human skill needed to produce it."[5] Before more fully contrasting these two systems of production, it is necessary to better understand the principles of Mass Production as they were developed in the early twentieth century.

The American System of Manufactures

The principles of Mass Production did not spring full-blown from the craft tradition, but grew out of the mechanistic "factory system" that was common to the United States, Great Britain, and the other industrialized countries of Europe in the nineteenth century. In the middle of that century, however, the factory system in the United States took on a

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[3]Michael J. Piore and Charles F. Sabel, **The Second Industrial Divide: Possibilities for Prosperity** (Basic Books, Inc., Publishers, 1984), p. 19.

[4]No real distinction is made here between mass production processes as used in the automobile industry, continuous process methods as used in the aluminum industry, and machine-tending processes as used in the textile industry. Each share most of the common traits of Mass Production discussed in this and the next chapter.

[5]Piore and Sabel, *op cit.*

nature so distinctive that it became known as the *American System of Manufactures*, or just the *American System*.[6] It was this system of production that fueled the growth of the United States as an economic power. Between 1875 and 1899, just as the American System became the dominant sector of the American economy, commodity output per capita grew at an annual rate of 2.0 percent versus just 0.3 percent for the first three-quarters of the century.[7] As Table 2-1 shows, the manufacturing share of commodity output grew from 17 to 53 percent between 1839 and the end of the century. This growth was at the expense of agriculture -- but agriculture itself was undergoing tremendous increases in productivity at the very same time,[8] demonstrating the truly explosive nature of the change caused by the American System.

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[6]For a full discussion of the American System and the rise of Mass Production, see David A. Hounshell, **From the American System to Mass Production 1800-1932: The Development of Manufacturing Technology in the United States** (Baltimore: The Johns Hopkins University Press, 1984). For a description of the American System from the standpoint of Englishmen sent to the United States to uncover its nature, see Nathan Rosenberg, editor, **The American System of Manufactures: The Report of the Committee on the Machinery of the United States 1855 and the Special Reports of George Wallis and Joseph Whitworth 1854** (Edinburgh: Edinburgh University Press, 1969).

[7]Michael H. Best, **The New Competition: Institutions of Industrial Restructuring** (Cambridge, Massachusetts: Harvard University Press, 1990), p. 29.

[8]Nathan Rosenberg, **Technology and American Economic Growth** (Armonk, New York: M. E. Sharpe, Inc., 1972), pp. 25-27.

Table 2-1. Sector Shares in Commodity Output, 1839-1899
(percent of total output)

Year	Agriculture	Mining	Manufacturing	Construction
1839	72	1	17	10
1849	60	1	30	10
1859	56	1	32	11
1869	53	2	33	12
1879	49	3	37	11
1889	37	4	48	11
1899	33	5	53	9

Source: Adapted from Robert E. Gallman, "Commodity Output, 1839-1899," in William Parker, editor, **Trends in the American Economy in the Nineteenth Century** (Princeton, New Jersey: Princeton University Press, 1960), p. 26.

What was at the heart of the American System of Manufactures that caused it to be the driver of the United States economy? Table 2-2 lists the key characteristics of the American System that differentiated it from both craft production methods and the factory systems of Europe that had become increasingly mechanized in the seventeenth and eighteenth centuries.

The first characteristic was the defining principle upon which the system rested: *interchangeable parts*. Prior to the American System, individual parts had to be individually fitted to each other in the manufacturing of a product. This involved time-consuming effort throughout the entire production system filing down edges, testing, and filing again until sufficient fit was achieved. Interchangeable

parts, an "intellectual leap" in manufacturing,[9] greatly simplified the production process and saved a significant amount of labor. Perhaps even more importantly, "in the absence of the high degree of standardization and precision manufacture of component parts, upon which interchangeability is based, the repair and maintenance of complex products such as automobiles, bicycles, television sets, typewriters, etc., would assume truly nightmarish proportions."[10] Even in the nineteenth century repairing the relatively more simple products of the time required more skill than did their original manufacture.[11] The American System was in fact first developed in the firearms industry, heavily supported by the

Table 2-2. Characteristics of the American System of Manufactures

- Interchangeable parts
- Specialized machines
- Reliance on suppliers
- Process-focused
- Division of labor
- Based on worker skills
- Continuous technological improvement

[9]Hounshell, *op cit*, p. 29.

[10]Rosenberg, **Technology and American Economic Growth**, p. 92.

[11]H. J. Habakkuk, **American and British Technology in the Nineteenth Century: The Search for Labour-saving Inventions** (Cambridge, England: Cambridge University Press, 1962), p. 60, footnote 1.

US government, because the ability to repair firearms in the field was so very important.[12]

Along with interchangeable parts came the *specialized machines* necessary to produce the parts to the tight tolerances required to eliminate hand-fitting. Formerly general-purpose machines were adapted to all sorts of specialized functions throughout the production process:

> Americans had developed and applied the milling machine, a device of extraordinary versatility, to a wide range of purposes in shaping the metal parts of the musket. In so doing the machine had, in the United States, progressively displaced the highly expensive operations of hand filing and chiseling of parts. In fact, the development of specialized forms of the milling machine may be considered one of the really distinctive contributions of America to the system of interchangeable manufacture. For it was through the use of these machines that a high degree of uniformity of metal parts was achieved, far beyond what was possible by hand filing.[13]

To ensure exact interchangeability, systems of gauges and fixtures were developed as key components of the new machinery. The gauges allowed monitoring of the machines by both operators and supervisors so that any discrepancies

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[12]Rosenberg, **Technology and American Economic Growth**, pp. 90-92. Rosenberg notes the significance of the fact that "at one point in the Napoleonic Wars (1811) the British government had in its possession some 200,000 musket barrels which were useless because of the absence of a sufficient supply of skilled armorers to make or repair the locks" (p. 92).

[13]Rosenberg, **The American System of Manufactures**, pp. 59-60.

could be immediately detected.[14] To prevent small differences in how parts were fixed to the machines from multiplying across each operation, a reference point was designed into each part and the fixtures specially designed for the reference point.[15] All together, the innovations underlying these first two characteristics of the American System greatly increased quality, uniformity, and productivity.

The third characteristic, flowing from the second, was the *reliance on suppliers* that the use of specialized machinery entailed. As the economic historian Nathan Rosenberg notes, the entire machine tool industry, beginning in about 1820, was created in response to the needs of the practitioners of the American System.[16] While the first practitioners built their own machines in-house, they soon relinquished this to the burgeoning machine tool industry as it enabled them to focus more fully on their own production problems, avoid the costs of machine development, and share the technological advancements made by machine tool suppliers. These same advantages construed to suppliers of raw materials and non-critical components. As Rosenberg states, "American firms

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[14]Best, *op cit*, pp. 33-34.

[15]Hounshell, *op cit*, pp. 41-2.

[16]See Rosenberg, **Technology and American Economic Growth**, pp. 97-107.

showed a much greater talent than British firms for coordinating successfully their relationships with other firms upon whom they were dependent for the supply of essential inputs."[17]

The fourth characteristic of the American System, mentioned above, was this *focus on the process of production* that the previous advancements afforded company owners. Rather than simply providing isolated craftsmen with all the materials they needed to produce a product one at a time, naturally resulting in differences in quality and workmanship depending on who made the product, company owners could now focus on the entire organization and how the production process could be managed to greater effect.[18] What they developed was a functional organization of the factory, where materials and semi-finished products were moved from one station to another in batches.[19] Along with this transformation "from a craft pursuit into an industrial

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[17]Nathan Rosenberg, **Perspectives on Technology** (Cambridge, England: Cambridge University Press, 1976), p. 162.

[18]William J. Abernathy, Kim B. Clark, and Alan M. Kantrow, **Industrial Renaissance: Producing a Competitive Future for America** (New York: Basic Books, Inc., Publishers, 1983), pp. 32-3. See also Hounshell, *op cit*, for descriptions of how the entrepreneurs of the period focused on the production process involved in the American System.

[19]Best, *op cit*, p. 52.

discipline"[20] came increased supervision and worker accountability for schedules, quality, and materials usage.[21]

A further result from this process focus, one whose significance rates its separation as a characteristic of the System itself, was the *division of labor*. As the production process was standardized and routinized, it was argued that focusing workers on only a piece of it "naturally and almost inevitably would lead to improvements by the workers in the various techniques of the subdivided processes."[22] While craftsmen were not pleased with the loss of responsibility and eventual loss of skill, the division of labor did indeed increase efficiency and productivity.

Despite the loss of some abilities, the American System was still *fundamentally based on the skills of American workers*. This was attested to by a British Parliamentary report of 1868 that examined American industry and reported that the American worker

> understands everything you say to him as well as a man from a college in England would; he helps the employer by his own acuteness and intelligence; and, in consequence, he readily attains to any new knowledge, greatly assisting his employer by thoroughly

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[20]Hounshell, *op cit*, p. 33.

[21]Best, *op cit*, pp. 35-6.

[22]Hounshell, *op cit*, p. 33.

understanding what is the change that is needed, and helping him on the road towards it.[23]

Even as machines were being made to automate work, companies found that many machines were most useful when used by skilled craftsman, when used "to augment skill rather than to replace it."[24] As gains in agriculture productivity accelerated in the mid- to late-1800s, many of the new industrial workers came off the farm, where they were used to devising ways of making their own tasks easier and quicker to perform.[25]

The importance of the American worker to the entire production process resulted in "the absence in American factories of the organizational rigidities so familiar in the European [factories], by the concern of workers for personal advancement and material welfare, and by the belief of workers and managers alike in the boundless adaptability of American labor."[26] The dependence on worker skill and know-how extended to industrial suppliers and, in particular, the machine tool industry. As Rosenberg noted,

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[23]*Report from the Select Committee on Scientific Instruction*, Parliamentary Papers, 15 (1867-8) Question 6722, quoted in Rosenberg, **The American System of Manufactures**, p. 15. This is not an isolated quote; the Reports published in this volume frequently praise the American worker, especially in relation to those in England.

[24]Piore and Sabel, *op cit*, p. 46.

[25]Habakkuk, *op cit*, p. 51.

[26]Abernathy, Clark, and Kantrow, *op cit*, pp. 33-4.

this industry was so important to the American System because

> it came to constitute a pool or reservoir of the skills and technical knowledge which were essential to the generation of technical change throughout the machine-using sectors of the economy. Precisely because it came to deal with processes and problems which were common to an increasing number of industries, it played the role of a transmission center in the diffusion of the new technology. The pool of skill and technical knowledge was added to as a result of problems which arose in particular industries. Once the particular problem was solved and added to the pool, the solution became available, with perhaps minor modifications and redesigning, for employment in the growing number of technologically related industries.[27]

Thus, not only were the successes of individual companies due in large measure to the skills of workers trained in the craft tradition, but the diffusion of the American System throughout large sectors of the economy was itself due to their skills, techniques, and abilities to apply what they learned to a far-ranging set of problems. American entrepreneurs of the nineteenth century were great inventors, innovators, and imitators.[28] Combined with a

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[27]Rosenberg, **Technology and American Economic Growth**, p. 102.

[28]This was in large measure due to the scarcity of labor. In order to survive, entrepreneurs *had* to create labor-saving machinery, as they could not find sufficient labor to produce in the quantities desired. See Habakkuk, *op cit* for a complete development of this theme. Rosenberg, in **The American System of Manufactures** (pp.75-79), points out that machinery in the American System was not only labor-saving but also "resource-extravagant", owing to the tremendous availability of natural resources. This helps explain why the English were slow to adopt many of the machines, as natural resources in England were even more scarce than labor at the time.

newfound emphasis on product development and improvement that was introduced by the armsmaker Colonel Samuel Colt[29] and the establishment of several industrial research laboratories in the last two decades of the nineteenth century,[30] this demonstrates the final defining characteristic: how important *continuous technological improvement* -- in both product and process -- was to the American System of Manufactures. As an American observed in 1832,

> there is a feeling among us about everything which prevents us aiming at permanence; there reigns in America a popular and universal belief in the progress of the human spirit. We are always expecting an improvement to be found in everything.[31]

As noted at the beginning of this section, the American System was an extremely successful method of production in the middle to late nineteenth century. While no single company was a perfect model for all of the characteristics, these seven factors -- interchangeable parts, specialized machines, a reliance on suppliers, focus on the production process, the division of labor, the skills of its workers, and continuous technological improvement -- describe the

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[29]Abernathy, Clark, and Kantrow, *op cit*, pp. 35-36.

[30]Robert U. Ayres, **The Next Industrial Revolution: Reviving Industry through Innovation** (Cambridge, Massachusetts: Ballinger Publishing Company, 1984), p. 119.

[31]Quoted in de Tocqueville, **Journeys to England and Ireland**, J. P. Mayer, editor, (1958), p. 111, cited in Habakkuk, *op cit*, p. 57.

American System of Manufactures and were responsible for its success.

Mass Production

As the American System moved into the twentieth century, these factors were not enough to continue the growth of large enterprises in meeting the demands of an increasingly geographically-dispersed economy. A related but distinct system of manufacturing formed that, while it owed much to its predecessor and in fact overlapped it in time,[32] went far beyond it in organizing production for efficiency and low costs. This system became known as *Mass Production*, or as *Fordism* (after Henry Ford, under whose leadership the system was most purely implemented in the 1920s).

Mass Production was certainly the direct descendent of the American System. Interchangeable parts, specialized machines, process focus, and the division of labor were particularly important to Mass Production and were taken to new heights in the system, so much so that rather than mere characteristics of the system they could be called *principles* of Mass Production. Along with these, the

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[32]See Best, *op cit*, p. 52, footnote 3.

additional principles of Mass Production that differentiated it from its predecessor are listed in Table 2-3.

Table 2-3. Principles of Mass Production

From The American System
• Interchangeable parts • Specialized machines • Process-focused • Division of labor
Additional principles
• Flow • Focus on low-cost, low-priced products • Economies of scale • Product standardization • Degree of specialization • Focus on operational efficiency • Hierarchical organization and professional management • Vertical integration

Just as the defining principle of the American System was interchangeable parts, the *principle of flow* was defining to Mass Production. This principle was first used in continuous process industries such as the refining of petroleum and distilling of alcohol,[33] but could also be seen in cigarette manufacturing,[34] flour milling, and the "disassembly lines" of slaughterhouses.[35]

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[33]Alfred D. Chandler, Jr., **The Visible Hand: The Managerial Revolution in American Business** (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1977), pp. 253-8.

[34]*Ibid*, pp. 249-50.

[35]Hounshell, *op cit*, pp. 10-11. See also Rosenberg, **Technology and American Growth**, pp. 107-111, and, for a more detailed history of the development of the assembly line, Siegfried Giedion, **Mechanization Takes Command: a contribution of anonymous history** (New York: Oxford University Press, 1948), pp. 77-127.

It was Henry Ford and his production engineers who put the principle of flow to full use in the Model T assembly line, rearranging the functional organization of their factory into a moving line where each worker assembled a piece of a car, which moved on to the next worker for the next assembly step, and so on. This innovation became synonymous with Mass Production:

> In "moving the work to the men," the fundamental tenet of the assembly line, the Ford engineers found a method to speed up the slow men and slow down the fast men. The assembly line would bring regularity to the Ford factory, a regularity almost as dependable as the rising of the sun. With the installation of the assembly line and the extension of its dynamism to all phases of factory operations, the Ford production engineers wrought true mass production.[36]

When Ford's engineers introduced the assembly line to Model T production in October, 1913, the amount of labor time spent making a single car dropped from 12 hours and 8 minutes to 2 hours and 35 minutes. Six months later Model T's could roll off the assembly line at the rate of 1,000 a day, with the average labor time dropping to just over an hour and a half.[37]

One of the reasons that the principle of flow was never fully developed in the American System was that its practitioners never focused on lowering costs; their aims were primarily better quality and higher output, and in fact

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[36]*Ibid*, p. 237.

[37]Chandler, *op cit*, p. 280.

typically charged more for their products.[38] But the second principle of Mass Production, again put into effect by Ford,[39] was to *focus on low costs and low prices*, in order to truly create products for the "masses."

It was this cost focus that created the need for assembly-line flow. Out of these two concepts came the third principle of Mass Production, the notion of *economies of scale*, or as the business historian Alfred Chandler describes it, economies of speed:

> The rise of modern mass production required fundamental changes in the technology and organization of the processes of production. The basic organizational innovations were responses to the need to coordinate and control the high-volume throughput. Increases in productivity and decreases in unit costs (often identified with economies of scale) resulted far more from the increases in the volume and velocity of throughput than from a growth in the size of the factory or plant.[40]

In the American System companies increased output by adding more machines and more workers in the same ratio that already existed in the factory. In Mass Production, companies increased output not just by adding (scale) but by increasing the throughput (speed) of the machines so that less workers were needed per unit produced. This greatly

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[38]See Best, *op cit*, pp. 36-7, and Hounshell, *op cit*, p. 9. Interestingly, the only sector of the American System that seemed to truly focus on low costs were government-sponsored armament manufacturers.

[39]Hounshell, *op cit*, pp. 218-9.

[40]Chandler, *op cit*, p. 281.

increased fixed costs and the capital to labor (machine to worker) ratio, but also greatly lowered costs on each unit.[41]

As lowered costs meant prices could also be lowered, an internal logic came into play in the development of Mass Production. As prices were lowered, more people could afford the products and would buy them, resulting in greater sales and therefore greater production. A cycle was thus developed that fueled the growth of Mass Production companies.[42] This can be seen from the tremendous growth in Ford Model T sales that acccmpanied the continual lowering of its price, as shown in Table 2-4. In 1908, the Ford Motor Company produced slightly more than 10,000 automobiles (of all models), but grew to over 500,000 Model T's in 1916 as the price dropped from $850 to $360.[43] Total production grew to 2 million in 1923.[44]

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[41]See Chandler, **Scale and Scope: The Dynamics of Industrial Capitalism** (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1990), pp. 21-28.

[42]Best, *op cit*, pp. 47-55. See also Piore and Sabel, *op cit*, pp. 190-1. This cycle is in fact at the very heart of Mass Production, and will be fully explored in the next chapter.

[43]Hounshell, *op cit*, pp. 223-4.

[44]*Ibid*, p. 274.

Table 2-4. Price and Sales of Model T Fords, 1908-1916

Calendar Year	Retail Price (Touring Car)	Total Model T Sales
1908	$850	5,986
1909	950	12,292
1910	780	19,293
1911	690	40,402
1912	600	78,611
1913	550	182,809
1914	490	260,720
1915	440	355,276
1916	360	577,036

Source: David Hounshell, **From the American System to Mass Production 1800-1932** (Baltimore: The John Hopkins University Press, 1984), p. 224.

This cycle required the development and manufacture of *standardized products*, as any complexities or custom work would upset the production process and result in much higher costs. While this reached its zenith with Ford -- whose Model T's were virtually identical for years, right down to their black color -- an enduring principle of Mass Production is the notion of standardized products sold to homogeneous markets. One of the primary reasons Mass Production (as well as the American System) was developed so extensively in the United States was that the American market was always more homogenous than the markets of the industrialized countries of Europe.

This was the case for a number of reasons, with the homogeneity of demand very interrelated with the

standardization of output.[45] First, America never had the class distinctions that were common in Europe; therefore Americans did not have to differentiate themselves from other classes by what they purchased. Along the same lines income distribution was also much more equitable in the United States, resulting in more people clustered around similar needs and desires.

The American market was also much newer, without the long-held traditions common in Europe. Companies with new products did not have to divert their demand from the products of other suppliers, and so did not have to differentiate their products as much and in particular did not have to incorporate the idiosyncracies of previous products. Further, the American industrial market grew at a much faster rate than those in Europe. This was true not only because the growth rates of people and income were much greater in the United States, but the relative cheapness of both land and food resulted in higher relative demand for industrial products. A sellers' market ensued, where companies could more readily impose standards, while in Europe limited growth meant businesses had to cater more to customers' tastes to attract them. Related to both of these, because the firms serving the American market were also

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[45]Most of the information on the homogeneity of the American market can be found in Chandler, **The Visible Hand**, pp. 498-500 and Habakkuk, *op cit*, pp. 123-124 and 210-211.

newer, they did not have the investment in old production methods and could more easily move to the new methods of Mass Production. The low cost of standardized products that resulted from these Mass Production techniques itself helped maintain the homogeneity of American consumers.

As the throughput and scale of the manufacture of standardized products were so very important to maintaining low costs, the system of Mass Production became even more dependent on machinery and the division of labor than the American System. The *degree of specialization* of men and machinery clearly differentiated Mass Production from its predecessor. The importance of this distinction deserves an extended quotation from David Hounshell, whose detailed study **From the American System to Mass Production 1800-1932** examines the development of these two systems. Here is how he describes the implementation of the very first assembly line at Ford Motor Company:

> On April 1, 1913, workers in the Ford flywheel magneto assembling department stood for the first time beside a long, waist-high row of flywheels that rested on smooth, sliding surfaces on a pipe frame. No longer did the men stand at individual workbenches, each putting together an entire flywheel magneto assembly from the many parts (including sixteen permanent magnets, their supports and clamps, sixteen bolts, and other miscellaneous parts). This was no April Fool's joke. The workers had been 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. Having pushed it down eighteen or perhaps thirty-six inches, the workers repeated the same process, over and over, nine hours, over and over. Martin Sorensen, Emde and others

> [Ford production engineers] had designed what may have been the first automobile assembly line, which somehow seemed another step in the years of development at Ford yet somehow suddenly dropped out of the sky. Even before the end of that day, some of the engineers sensed that they had made a fundamental breakthrough. Others remained skeptical. Twenty-nine workers who had each assembled 35 or 40 magnetos per day at the benches (or about one every twenty minutes) put together 1,188 of them on the line (or roughly one every thirteen minutes and ten seconds per person). There were problems, to be sure. Some workers complained about aching backs because of stooping over the line; raising the work level six or eight inches would solve that problem. . . . Some workers seemed to drag their heels while others appeared to work too fast. . . . Soon they found that by moving magnetos at a set rate with a chain, they could set the pace of the workers: speed up the slow ones, restrain the quick. Within the next year, by raising the height of the line, moving the flywheels with a continuous chain, and lowering the number of workers to fourteen, the engineers achieved an output of 1,335 flywheel magnetos in an eight-hour day -- five man-minutes compared to the original twenty.[46]

The path to Mass Production led from artisans responsible for producing an entire product by their own means and at their own pace in Craft Production, to groups of craftsmen (still) working together on a defined product or at least a significant component of one in the American System, and finally to workers becoming specialized to such a degree that under the direction of a supervisor they performed the smallest of functions, over and over, in the assembly-line production of a single part.

The degree of specialization applied to machinery was similar. In Craft Production, craftsmen used a relatively

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[46]Hounshell, *op cit*, pp. 247-8.

small set of general-purpose tools to perform all of their operations. In the American System, general-purpose machines adapted to specialized purposes provided the means of producing greater numbers of more sophisticated products. But in Mass Production, the production process became critically dependent on specialized machines that performed only one function (often for only one product design, requiring retooling for any design changes). The extent of the specialization of machines was heavily influenced by the extent of the specialization of labor, for as the production process was broken down further and further with workers performing smaller and smaller tasks, these tasks became easier and easier to automate.[47]

The entire production process thus became completely dependent on the smooth-running operations of an assembly line of specialized machines and workers to achieve economies of scale and its advantages of greatly lowered costs. If, however, throughput in the factory were not maintained near capacity -- if anything went wrong with the machines, workers, or the pace of operations -- then unit costs would rise rapidly. To prevent this, companies maintained a strong *focus on operational efficiency*, which included the conspicuous use of buffers throughout the factory. Maintaining the productivity of machines and

[47]Piore and Sabel, p. 22.

workers each day and increasing their productivity over time -- at a predictable rate that became known as the "learning" or "experience curve" -- became paramount to company success and consumed an increasingly large cadre of foreman, supervisors, and managers.[48]

From this increased need for control was born *hierarchical organizations* and *professional managers*. Before 1850, most enterprises were small, family-owned firms, very few of which "needed the services of a full-time administrator or required a clearly defined administrative structure."[49] With the rise of the American System companies grew larger, required more administration, and, as it grew into the system of Mass Production, developed hierarchical organizations (first a single hierarchy and then a divisionalized form) to control the increasingly complex businesses. By 1917, the day-to-day operations of large businesses were clearly run not by entrepreneurial families but by professional managers.[50] These managers often used the precepts of what was called *scientific management*, or *Taylorism* after its famous proponent, Frederick W. Taylor.

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[48]Siegfried Giedion, in his study of the history of mechanization, *op cit*, calls "industrial production based on efficiency" the "dominant principle of the twentieth century" (p. 93).

[49]Chandler, **Strategy and Structure**, p. 19.

[50]Chandler, **The Visible Hand**, p. 491.

Strict Taylorism involved meticulous time and motion studies to find and eliminate any and all inefficiencies in workers' activities. This meant eliminating their knowledge and skills as well, as Taylor himself explains:

> The managers assume. . . the burden of gathering together all of the traditional knowledge which in the past has been possessed by the workmen and then of classifying, tabulating and reducing this knowledge to rules, laws and formulae which are immensely helpful to the workers in doing their daily work.[51]

While the precepts of scientific management were rarely followed to the letter, they had a tremendous effect on Mass Producers by focusing managers on planning the work of workers, thereby increasing their specialization, decreasing their skills, and in many cases replacing them with machinery.

The final principle of Mass Production, *vertical integration*, also grew out of the need to control production and was influenced by the rise of large, hierarchical organizations. As Chandler explains:

> As the new mass production industries became capital-intensive and management-intensive, the resulting increase in fixed costs and the desire to keep their machinery or workers and managerial staff fully employed created pressures on the owners and managers to control their supplies of raw and semifinished materials and to take over their own marketing and distribution.[52]

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[51]Frederick W. Taylor, **The Principles of Scientific Management** (New York: W. W. Norton, 1967; originally published in 1911), p. 36.

[52]Chandler, **The Visible Hand**, p. 282.

Thus, Mass Producers became concerned not only with production but "administered the flow from the suppliers of raw materials through all the processes of production and distribution to the retailer or ultimate consumer."[53] The Mass Producers became Mass Distributors as well.

This discussion of the principles of Mass Production, then, begins and ends with the principle of flow, which grew from its application to the assembly line to its application to the entire process of reaching consumers with goods. In between, we saw how additional principles were developed and mutually reinforced to create the system of Mass Production as we know it today.

While the diffusion of the American System of Manufactures throughout American industry was due primarily to the machine tool industry, the diffusion of Mass Production was very much due to the automotive industry and to Henry Ford and his production engineers in particular. They were very proud of their achievements, wrote books and articles about what they had accomplished in the Ford Motor Company, and opened their factories up to technical journalists who also communicated what was happening at Ford to the rest of American industry.[54] The other automobile companies soon

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[53]*Ibid*, p. 283.

[54]Hounshell, *op cit*, pp. 11 and 260-261.

adopted Ford's techniques, followed by other consumer durable manufacturers and so on into other industries until Mass Production became the dominant mode of manufacture in the United States.

Craft versus Mass Production

At the beginning of this chapter the use of machinery in production was presented as leading down two distinct paths, Craft and Mass Production. As can be seen from the preceding discussion, there are three key differences that could epitomize the distinctions between these two paths. First, whereas the use of machinery in Craft Production enhanced the skills of the artisan, in Mass Production machinery had the opposite effect of *deskilling* the worker. The result in Craft Production was more variety; in Mass Production it was less variety as standardized good production could more easily be mechanized and entailed significantly lower costs. Finally, while the ideal in Craft Production was "a world of small producers, each specialized in one line of work and dependent on the others," the practitioners of Mass Production foresaw "a world of ever more automated factories, run by ever fewer and ever less skilled workers."[55]

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[55]Piore and Sabel, *op cit*, pp. 19-20.

It was perhaps inevitable that two such diametrically opposed visions would not easily coexist. In the nineteenth and twentieth centuries these two paths did indeed collide in a battle for the hearts, minds, and wallets of company managers, workers, and consumers. The proponents of Mass Production proclaimed an ideological, almost missionary, zeal for the tremendous benefits available through the application of its principles. As just one example, in 1932 Edward A. Filene, a prominent Boston businessman, defined the system this way:

> Mass Production is not simply large-scale production. It is large-scale production based upon a clear understanding that increased production demands increased buying, and that the greatest total profits can be obtained only if the masses can and do enjoy a higher and ever higher standard of living. For selfish business reasons, therefore, genuine mass production industries must make prices lower and lower and wages higher and higher, while constantly shortening the workday and bringing to the masses not only more money but more time in which to use and enjoy the ever-increasing volume of industrial products. Mass Production, therefore, is *production for the masses*. It changes the whole social order. It necessitates the abandonment of all class thinking, and the substitution of fact-finding for tradition, not only by businessmen but by all who wish to live successfully in the Machine Age. But it is not standardizing human life. It is liberating the masses, rather, from the struggle for mere existence and enabling them, for the first time in human history, to give their attention to more distinctly human problems.[56]

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[56]Edward A. Filene, with Charles W. Wood, **Successful Living in This Machine Age** (New York: Simon and Schuster, 1932), p.1; quoted in Hounshell, *op cit*, p. 307. The capitalization of "Mass Production" is in the original.

Even though its benefits may have been exaggerated, it became clear in the middle of this century that Mass Production was the winner as its products allowed America to dominate world production in the years surrounding World War II. As Chandler summarizes his history of this victory:

> In the years after World War II the large managerial enterprise became ever more powerful. It acquired control of an increasing share of the nation's economic activities, as well as a growing part of the industrial production of Europe and the rest of the world. In 1947, the two hundred largest industrials in the United States. . . accounted for 30 percent of total corporate manufacturing assets. By 1963, after most of these enterprises had adopted the new strategy and the new structure, they were responsible for 41 percent of the value added and 56.3 percent of assets. By 1968, that last figure had risen to 60.9 percent. These giant enterprises. . . . were the same enterprises that continued to present the "American challenge" to European and other businessmen overseas.[57]

Through the American System of Manufactures the United States challenged the world production dominance of England in the nineteenth century and overtook it as the world's largest industrial producer in the 1880s.[58] Through the system of Mass Production, the United States extended that lead to more than three times its nearest national competitor (Germany) in the late 1920s,[59] and continued its dominance of world industrial production unchallenged

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[57]Chandler, **The Visible Hand**, pp. 482-3.

[58]W. W. Rostow, **The World Economy: History and Prospect** (Austin, Texas: 1978), pp. 52-3, cited in Chandler, **Scale and Scope**, p. 4.

[59]*Ibid.*

through World War II and into the latter half of the twentieth century.

The uniquely American system of Mass Production not only challenged the rest of the world, it challenged the very existence of the Craft Production system. But was Mass Production really the uncontested winner in its contest with Craft Production, as proponents such as Filene predicted it would be? Michael Piore and Charles Sabel in their book **The Second Industrial Divide** have shown that this outcome was neither inevitable nor absolute.[60] There is no infallible logic to how industrial firms should be organized for maximum efficiency. Tradeoffs abound in the three key differences between Craft and Mass Production given above: first, between skilled artisans and unskilled laborers; second, between variety and standardization of goods (along with their relative costs); and finally, between sectors of small, interrelated producers and large, vertically-integrated and automated firms.

In the first case there were many tasks, such as coal excavation, clay-getting, and the baking of bread, that "required nothing more than the effort of the laboring

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[60]Piore and Sabel, *op cit*, pp. 19-48.

body."[61] These could be mechanized without significant loss of skill. However, as the movement to mechanize the more laborious of workers' tasks that swept the industrial world in the nineteenth century, machinery was pushed to replace tasks that were heavily dependent on skills that could not easily be replaced. Glassmaking was one industry where the process was once performed entirely by the hands of skilled artisans and where company owners pushed the use of machinery too far:

> There were steady inroads made by machinery in this industry, but despite its labor-saving potential, glassmakers and their union organizations bitterly resisted and successfully impeded its progress. In 1878 one observer summarized the glassmakers' ambivalence: "If in many industries the substitution of mechanical for manual labor offers important advantages because it decreases a man's fatigue, we do not think it will have the same effect on the absolutely special work of the glass industry, and we fear that in depriving glassworkers of difficult tasks we will destroy their skill as well as the artistic talents of which glassmakers have the right to be proud."[62]

Today, despite over a hundred years of progress in process automation, the products of major segments of the glassmaking industry -- such as glassware, glass containers, and lead glass -- are still done by hand, by skilled

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[61]Shoshana Zuboff, **In the Age of the Smart Machine: The Future of Work and Power** (New York: Basic Books, Inc., Publishers, 1988), p. 37.

[62]*Ibid*, p. 38, quoting from Joan Wallach Scott, **The Glassworkers of Carmaux: French Craftsmen and Political Action in a Nineteenth-Century City** (Cambridge: Harvard University Press, 1974), p. 82.

artisans. In other segments, the process machinery cannot operate alone, but has to be tended by highly skilled operators.[63]

This is not solely because glassmakers refused to let their skills become a dying art. While the path of low-cost standardization of goods created huge markets of consumers who wanted and could afford those goods, smaller but significant markets for high-quality, unique products have always existed. From Waterford crystal to Paris designer originals to Lamborghini automobiles at the very "high end", and from glassware to tailored suits to Volvo's at the more affordable end, Craft Production persists.[64] In the second

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[63]Personal communication with Luis Rendón, General Manager of Glass Container Plant in Queretaro, Mexico, for Vitro, S.A. See also Phoebe Phillips, editor, **The Encyclopedia of Glass** (New York: Crown Publishers, Inc., 1981), p. 285.

[64]John Paul MacDuffie has identified a "neo-craft" production system, exemplified by Volvo, in **Beyond Mass Production: Flexible Production Systems and Manufacturing Performance in the World Auto Industry** (unpublished doctoral thesis, Massachusetts Institute of Technology, February 1991). The neo-craft model is not an extension of Craft Production, but rather a move *from* Mass Production *back* to some of the principles of craft work. The most notable feature at Volvo's Uddevala plant "is that it does away with the assembly line, in favor of six separate workshops in which work teams assemble entire cars at a single work station. . . .[T]his plant breaks from the continuous flow and machine pacing of mass production to return to the craft model of autonomous work stations and stand-alone tools" (p. 72). At Volvo and elsewhere, the neo-craft model "represents an effort to regain, for the autonomous work team, the autonomy of the craftsmen and the chance for identification with a 'whole product', by moving away from centralized

(continued...)

tradeoff, standardization may have overwhelmed variety in many industries due to its low prices, but it has yet to eliminate the production of distinctive, high-quality, high-priced goods via craft methods. In addition, mass-produced goods have never been as fully standardized as Henry Ford's famous Model T once was before consumers (not to mention Alfred P. Sloan and General Motors) forced him to make annual model changes.[65]

In the final tradeoff between visions of small, interdependent producers and large, vertically-integrated firms, it is clear that industry after industry is dominated by large firms. In automobiles, cigarettes, aluminum, breakfast cereals and scores of other industries large firms maintain huge market share advantages. In many of these industries,[66] as Table 2-5 shows, small firms (less than 100 employees) have a negligible presence of 1 or 2 percent

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[64](...continued)
authority and the technical interdependence of the assembly lines" (p. 74). Neo-craft production does not, however, return to the amount of variety available with Craft Production.

[65]Hounshell, *op cit*, pp. 263-301.

[66]In the following two tables "industry" is defined by 4-digit Standard Industry Classification (SIC) codes. For a complete description of this classification schema, see Executive Office of the President, Office of Management and Budget, **Standard Industrial Classification Manual** (Springfield, VA: National Technical Information Service, 1987).

(or less) of the total sales generated despite often making up 80 or 90 percent of the total number of firms.

But that is not the story of all industries. Large firms (5,000 or more employees) in fact employ just less than 20 percent of the total work force in America, while firms with fewer than 100 employees make up over 93 percent of the establishments and employ 45 percent of the work force.[67] And as Table 2-6 demonstrates, there are many industries where it is the small firm that dominates industry sales.

As Piore and Sabel noted, in the end analysis of Craft versus Mass Production "some firms in almost all industries and almost all firms in some industries continued to apply craft principles of production."[68] So, rather than Mass Production being the uncontested winner in the contest, it seems that both systems have coexisted this entire time.

In fact, "coexist" is exactly the right phrase as these two sectors of the economy are highly interdependent. Small companies make up a large percentage of the suppliers to large firms, notably in providing the special-purpose machinery (and other items) that mass production processes

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[67]David Birch, **Job Creation in America: How Our Smallest Companies Put the Most People to Work** (New York: The Free Press, 1987), p. 9.

[68]Piore and Sabel, *op cit*, p. 20.

Table 2-5. Industries with the least presence of small firms[a]

Industry	Small-firm presence % of sales	Number of small firms #	(%)
Cigarettes	0.03	9	(60)
Beet sugar	0.04	2	(17)
Motor vehicles	0.19	459	(92)
Aircraft	0.21	131	(84)
Space propulsion units	0.44	5	(56)
Household laundry equipment	0.47	24	(86)
Glass containers	0.48	41	(63)
Malt beverages	0.57	24	(48)
Primary aluminum	0.57	21	(78)
Tobacco stemming and redrying	0.58	9	(64)
Chewing gum	0.69	5	(56)
Alkalies and chlorine	0.76	37	(79)
Blast furnaces and steel mills	0.85	417	(83)
Cane sugar refining	0.88	15	(65)
Carbon black	0.89	6	(75)
Tires and inner tubes	0.92	76	(72)
Wet corn milling	1.00	19	(86)
Papermills	1.01	151	(69)
Cement, hydraulic	1.12	43	(58)
Cellulosic manmade fibers	1.13	49	(91)
Transformers	1.14	304	(84)
Pulpmills	1.15	72	(82)
Calculating machines	1.24	44	(85)
Soybean oil mills	1.28	30	(86)
Chewing and smoking tobacco	1.35	19	(79)
Electronic computing equipment	1.35	776	(84)
Gypsum products	1.44	58	(89)
Cereal breakfast foods	1.47	37	(88)
Metal cans	1.51	156	(79)
Internal combustion engines	1.54	142	(90)
Hard surface floor coverings	1.56	22	(88)
Aluminum rolling and drawing	1.67	31	(76)
Sewing machines	1.77	92	(92)
Men's footwear except athletic	1.86	114	(66)
Petroleum refining	1.95	265	(83)
Motors and generators	2.00	302	(82)

[a]A small firm is defined as one with fewer than 100 employees.

Source: Adapted from Zoltan J. Acs and David B. Audretsch, **Innovation and Small Firms** (Cambridge, Massachusetts: The MIT Press, 1990), pp. 66-67.

Table 2-6. Industries with the largest presence of small firms[a]

Industry	Small-firm presence % of sales	Number of small firms #	(%)
Fur goods	94.03	667	(99)
Cut stone and stone products	88.48	1,091	(99)
Logging	87.79	5,137	(99)
Wood pallets and skids	86.33	1,226	(99)
Commercial printing	85.29	521	(99)
Typesetting	84.30	2,333	(99)
Special product sawmills	84.11	417	(99)
Concrete block and brick	84.09	1,130	(98)
Jewelers' materials	82.23	639	(98)
Machinery, except electrical	79.23	22,358	(99)
Plating and polishing	79.04	3,154	(98)
Paving mixtures and blocks	77.76	436	(95)
Apparel and accessories	77.18	284	(96)
Machine embroideries	77.11	255	(99)
Architectural metalwork	75.45	1,848	(99)
Special dies, tools, jigs	73.37	6,811	(98)
Millinery	72.35	140	(95)
Screw-machine products	71.40	1,706	(96)
Nailed wood boxes	71.08	452	(95)
Buttons	69.54	129	(95)
Bookbinding and related work	68.30	936	(96)
Structural wood members	68.15	595	(97)
Industrial patterns	67.88	1,013	(99)
Wood partitions and fixtures	67.65	1,797	(98)
Signs and advertising displays	66.25	3,747	(98)
Presses and molded pulp goods	66.13	40	(93)
Leather goods	66.10	782	(98)
Fertilizers, mixing only	65.49	290	(98)
Leather & sheep-lined clothing	64.52	282	(93)
Lithographic services	64.20	255	(99)
Artificial flowers	63.83	285	(96)
Tire cord and fabric	63.77	14	(88)
Pleating and stitching	63.72	650	(95)
Processed textile waste	63.62	120	(91)
Apparel belts	63.21	284	(93)
Photoengraving	63.08	397	(95)
Petroleum and coal products	62.89	46	(98)

[a]A small firm is defined as one with fewer than 100 employees.

Source: Adapted from Zoltan J. Acs and David B. Audretsch, **Innovation and Small Firms** (Cambridge, Massachusetts: The MIT Press, 1990), pp. 64-65.

require but are too specialized to be produced in the same manner.[69] This can in fact be seen in Table 2-6 where the following industries are among the top 20 most dominated by small producers:

- Wood pallets and skids
- Machinery, except electrical
- Architectural metalwork
- Special dies, tools, jigs
- Screw-machine products

In addition, both large and small firms are dependent on the employees of the other type of firms as end consumers in their chains of distribution, for precisely the reason that neither type fully dominates.[70]

Despite all of the predictions that it would do so, Mass Production, then, has not eliminated Craft Production even as it was catapulting America to the forefront of world industrial production. The two systems have learned to coexist and become interdependent.

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[69]The idea that an inherent part of the system of Mass Production is the need for specialized machinery that cannot itself be produced by mass production methods is known as "industrial dualism," and can be found in Michael J. Piore, "Dualism as a Response to Flux and Uncertainty," and "The Technological Foundations of Dualism and Discontinuity," in Suzanne Berger and Michael J. Piore, **Dualism and Discontinuity in Industrial Societies** (Cambridge, England: Cambridge University Press, 1980), pp. 13-81.

[70]Interestingly, one would expect the executives of large, mass-production firms to be primary members of the target market segments of the high-quality craft producers of distinctive goods mentioned earlier. This may be a "market dualism" parallel to industrial dualism.

Beginning in the 1960s and accelerating in the '70s and '80s, the uniquely American system of Mass Production was itself challenged, and along with it America's dominance of world production. The United States share of total (not just industrial) world output dropped from 26 percent in 1960 to 18 percent in 1980. From 1971 to 1980, in fact, West Germany was the world's largest producer, maintaining a fairly steady 18 to 21 percent share. But the real story, of course, is Japan, which grew from just 6 percent of world output in 1960 to 12 percent in 1980.[71] As Table 2-7 shows,

Table 2-7. World Trade Shares in Technology-Intensive Products

	1954	1970	1980
United States	35.5	23.1	19.9
United Kingdom	19.0	10.1	9.0
West Germany	17.6	20.4	19.3
France	6.4	7.6	9.0
Italy	2.4	5.6	5.5
Japan	1.8	9.7	14.5

Source: Robert U. Ayres, **The Next Industrial Revolution** (Cambridge, Massachusetts: Ballinger Publishing Company, 1984), p. 22. The data is from the U.S. Department of Commerce.

[71]Bruce R. Scott, "National Strategies: Key to International Competition," in Bruce R. Scott and George C. Lodge, editors, **U.S. Competitiveness in the World Economy** (Boston: Harvard Business School Press, 1985), p. 27, computed from Federal Trade Commission data.

the decline was even more pronounced in those products with a high degree of technological content.

An even more dramatic story is told by the productivity rates of American workers. From 1965 to 1979, "U.S. productivity grew at only 1.6 percent per annum. The figure for 1979 was 0.5 percent, and for 1980 it was actually negative (-2.0 percent). Other countries have increasingly outperformed the United States since the 1960s,"[72] as seen in Table 2-8.

Table 2-8. Gross Domestic Product Per Capita Relative to the United States

	1960	1970	1980[a]
United States	100.0	100.0	100.0
West Germany	73.3	82.3	87.4
United Kingdom	66.5	64.9	58.6
France	61.6	75.9	80.0
Japan	31.5	61.9	70.2

[a]The data for France and Japan are from 1979.

Source: Irving Kravis, Alan Heston, and Robert Summers, "New Insights into the Structure of the World Economy," *Review of Income and Wealth* (December, 1981), pp. 348-9.

Finally, the challenge to America can be seen in the trade balances in manufacturing output. For the first time in the twentieth century, the United States' trade balance turned negative in 1972 as companies were battered by foreign

[72]Ayres, *op cit*, pp. 20-21.

competition. The figures fluctuated between a negative balance of $6 billion and a positive balance of $20 billion until 1982 when it turned sharply negative, reaching an almost $80 billion deficit in 1984.[73] While there are substantial macroeconomic reasons for the large trade deficits, the industries hardest hit by foreign competition seem to be those that are most predominantly based on the system of Mass Production, such as automobiles, steel, consumer electronics, textiles, and footwear.[74]

Behind all of this national data lies the circumstances of individual firms and industries that have become increasingly less and less competitive. The next chapter explains why this loss of competitiveness has predominantly hit those firms and industries most rooted in the very system that made America great in the first place: the system of Mass Production.

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[73]Stephen S. Cohen and John Zysman, **Manufacturing Matters: The Myth of the Post-Industrial Economy** (New York: Basic Books, Inc., 1987), p. 63. The data were compiled from the U.S. Department of Commerce, International Trade Administration.

[74]Dertouzos, et al, *op cit*, pp. 4-7. For an exposition of how successful and dynamic small firms have been in many industries hit hardest by technological and market change, see Zoltan J. Acs and David B. Audretsch, **Innovation and Small Firms** (Cambridge, Massachusetts: The MIT Press, 1990). For the development of the view that services can replace (large-scale) manufacturing as the bastion of America's international competitiveness, see James Brian Quinn, Jordan J. Baruch, and Penny Cushman Paquette, "Technology in Services", **Scientific American** 257:6, December 1987, pp. 50-58.

Chapter 3

Paradigms of Production

Mass Production as Paradigm

As discussed in Chapter 2, the tremendous growth in American productivity and economic strength in the twentieth century has been driven by the Mass Production system.[75] From its beginnings in the American System of Manufactures in the latter half of the nineteenth century, to its flowering at the hands of Henry Ford and his cadre of production engineers, to its diffusion throughout American industry in the 1920s and '30s, to its dominance of world industrial production in the years after World War II, Mass Production has become the dominant mode of manufacture in America. In fact, it has become virtually the only production system practiced by large manufacturers (other than internal prototype shops that are still predominantly craft-based).[76] But as a system its techniques have not been confined to large manufacturers. All of the principles discussed in Chapter 2 (listed in Table 2-3, page 30) have

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[75]Also see Alfred D. Chandler, Jr., **Scale and Scope: The Dynamics of Industrial Capitalism** (Cambridge, Massachusetts: The Belknap Press of Harvard University Press, 1990), chapters 1 and 2 in particular.

[76]Piore and Sabel, *op cit*, pp. 19-20.

been emulated by large service providers such as insurance companies and banks; even small manufacturing and service concerns view its techniques as keys to efficiency and growth, as witnessed by assembly-line production systems in fast-food outlets.

The tremendous success of Mass Production as the uniquely American system of production has created a view among American managers that its principles are *the* key to success. The system of Mass Production has become, in the words of the scientific historian Thomas Kuhn, a *paradigm*: "an accepted model or pattern" that establishes an informational framework and set of rules by which its practitioners view the world.[77]

As Joel Barker defines it, a paradigm "tells you that there is a game, what the game is, and how to play it successfully."[78] A paradigm can be a very powerful mechanism for ordering information and focusing research and practice on a common set of goals.[79] In this case, the paradigm of Mass Production has the shared goal of producing

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[77]Thomas S. Kuhn, **The Structure of Scientific Revolutions**, Second Edition, Enlarged (New York: New American Library, 1986), p. 19.

[78]Joel Arthur Barker, **Discovering the Future: The Business of Paradigms** (St. Paul: ILI Press, 1988), p. 14; emphasis eliminated.

[79]Kuhn, *op cit*, p. 35.

goods at a low enough price that nearly everyone can afford them. Since the time of Henry Ford, that has been the "game" to play in manufacturing, and the principles of Mass Production have told producers how to play the game to be successful. The primary goal of the game is shared not only among producers but, as Michael Piore and Charles Sabel point out, by consumers as well:

> In the world of mass production, consumers accepted standard goods; their acceptance facilitated the extension of the market and the reduction of prices, through increasing economies of scale; and the growing gap between the price of mass-produced goods and that of customized goods further encouraged the clustering of demand around homogeneous products.[80]

In this interplay between producers and consumers the paradigm of Mass Production has become a *dynamic system of reinforcing factors* -- a feedback loop -- that creates and reinforces standardized products, mass production techniques, and large, homogeneous markets.[81] It is worth spending some time understanding in more detail exactly how this feedback loop operates. The reinforcing principles of

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[80]Piore and Sabel, *op cit*, pp. 190-1.

[81]While the presentation is original, my understanding of Mass Production as a reinforcing feedback loop with inherent limits is heavily indebted to Michael Piore and Charles Sabel and their book **The Second Industrial Divide: Possibilities for Prosperity**, *op cit*. See Chapter 7, "The Mass-Production Economy in Crisis" in particular. Another example of this type of view (without limits, however) may be found in Robert Ayres and Ehud Zuscovitch, "Technology and information: chain reactions and sustainable economic growth", **Technovation**, 10:3 (1990), pp. 163-183.

this dynamic system of production, in one logical sequence, are as follows:

- A company must make profits to stay in business. The more profits made, the more successful the business. Simplistically but truthfully, selling the most product with the highest price and the lowest cost generates the most profit.
- More product can be sold in large, homogeneous markets than in other types of markets.
- High product volumes also reduce manufacturing cost through economies of scale.
- Demand is elastic; therefore, lowering the price along with the cost brings even higher volume and along with it greater revenue.
- The attractiveness of a very low priced item will expand its market. It will also expand the degree of customer homogeneity, as those on the "fringe" between homogeneous and niche markets succumb to the much lower prices.
- The niche markets that remain significant have different customer desires and relatively low volumes; attempting to go after them only increases costs. Therefore, ignore them. Leave them to the "little guys."

- In order to realize the lowest possible costs and therefore the largest market, the production process should be as automated as is reasonable to do. This means high fixed costs but low unit costs, further reinforcing the need for high volumes. Research on new process technology can also be a powerful driver of ever lower costs.
- The efficiency of the production process must be maintained at all times. Efficiency requires most of all stability: everything running smoothly with no delays, no interruptions, no surprises. Therefore,
  - Inputs must be stabilized: management must control employee wages and levels as well as supplier prices and ability to meet demand.
  - The process itself must be stabilized: management must control everything. The product must be as standardized as possible and the manufacturing process broken down into small constituent tasks. Workers and machinery must be highly specialized to drive down the costs of each individual task.
  - Outputs must be stabilized: management must control demand levels not only by ignoring niches but also by using high inventory levels to adjust to temporary demand level changes.

- The product life cycle should be extended as far as possible, reducing development costs and allowing the experience curve to operate to its fullest.
- The profits made this way allow for a long product development cycle to design and develop product extensions and new products that can be made for the mass market. A steady stream of new product technology can provide the stable base of products needed to maintain profits over the long run. Research and Development is focused on breakthrough innovations that can yield a product that can be mass-produced and mass-distributed for the mass market.
- And thus the system loops around with new or extended products.

This dynamic reinforcing system is shown in simplified form in Figure 3-1.[82] The main loop (shown in boldface) can be read "new products manufactured by a mass production process yield low-cost, consistent quality, standardized goods for homogeneous markets; this results in stable demand, causing long product life cycles, which allow for long product

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[82]We normally view things like the producer/consumer relationship as a linear chain of cause and effect, rather than as a system with reinforcing feedback loops. This latter view is promoted by the System Dynamics Group at MIT. For an understanding of this view of the world and more information on how to create and read diagrams like Figure 3-1, see Peter M. Senge, **The Fifth Discipline: The Art & Practice of The Learning Organization** (New York: Doubleday Currency, 1990).

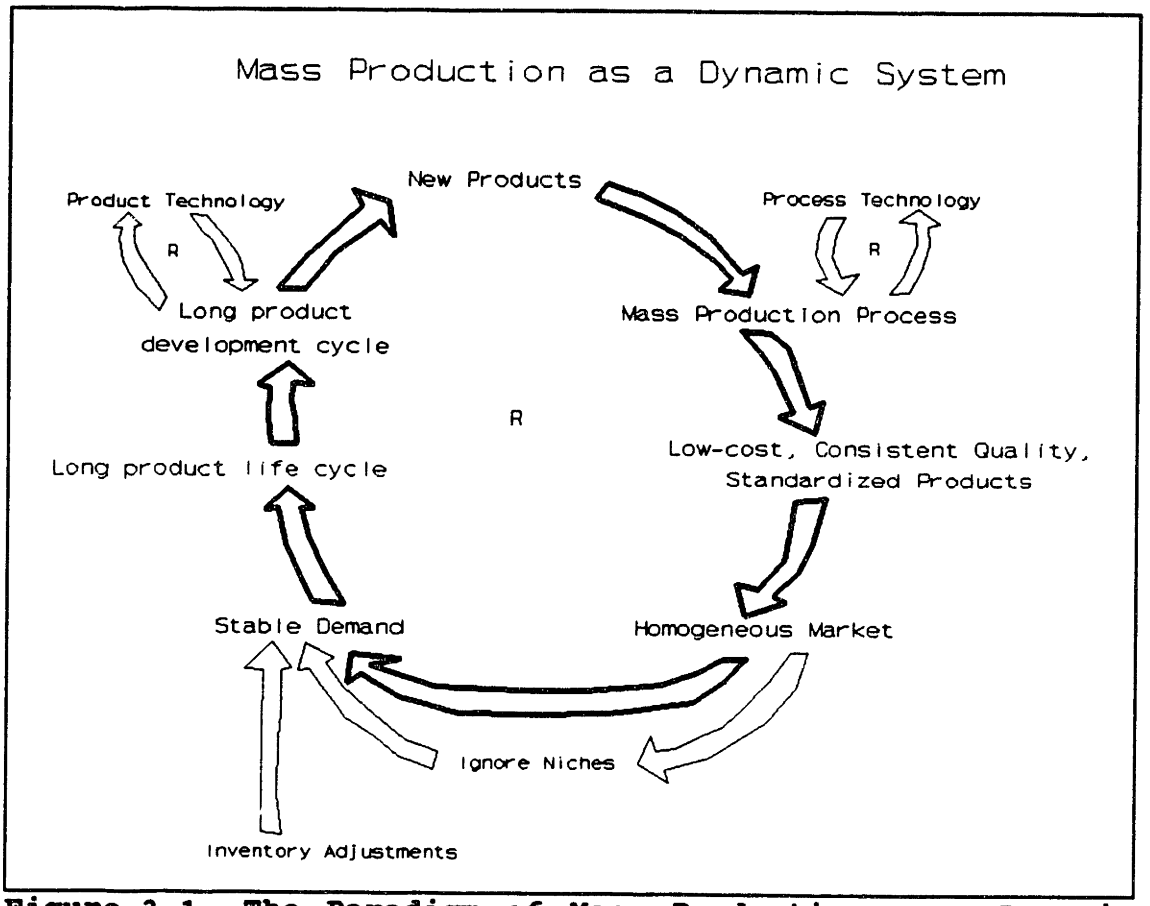

Figure 3-1. The Paradigm of Mass Production as a Dynamic System Feedback Loop

development cycles from which new products are created, and so on". The "R" indicates that this is a *reinforcing* loop that over time yields products that move more and more towards the ultimate goal of the highest volumes, using the most efficient manufacturing processes with the lowest possible costs, for the largest possible markets.

The secondary reinforcing loops indicate how new developments in product and process technology are key to the continued success of the system. However, at times the

large, homogeneous markets are not stable enough by themselves to maintain the efficiency of the production process. Ignoring niches and using inventory adjustments to stabilize demand are also key to the entire system's stability.

This, then, is the paradigm of Mass Production. Large or small company, manufacturing or service concern -- whoever holds to the paradigm of Mass Production implicitly views the world in this way. If how the paradigm is pursued could be summed up even more succinctly, it might be with the phrase *efficiency through stability and control*. If this is achieved, or so it is thought, all else will follow.

And for its practitioners throughout the twentieth century, profits have indeed followed: the paradigm of Mass Production has been wonderfully successful. Those who held to the paradigm first, and managed it best, became the giants of industry: the *Fortune 500* companies, the companies to be emulated.

Paradigm Lost

Because this paradigm has been so very successful in ordering the industrial world and enhancing profits, it was

extremely difficult for managers in the 1970s and '80s to realize that the world was changing. This is the dual-edged nature of a paradigm: while it is a powerful tool for ordering information and focusing goals, a paradigm will automatically filter out information contradictory to its world-view -- precisely *because* it is so powerful at ordering that world.[83] The seeds of the Mass Production paradigm's decline have always been present within the system itself, but they have not and could not be easily seen or understood by its practitioners.

Pure reinforcing loops such as that shown in Figure 3-1 are actually very rare;[84] generally, there are natural forces at work within a system to balance it and limit its growth. The *balancing* loops to Mass Production (indicated by a "B") are shown in Figure 3-2 along with other perils that make it a much more complete system dynamics view of the paradigm. This revised view demonstrates what has gone wrong with the American system of Mass Production over the last twenty years.

First, there are limits to the mass production process due to input stability. As just one example, to keep the system reinforcing on itself labor costs have to keep coming down

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[83]Barker, *ibid.*

[84]Senge, *op cit*, p. 83.

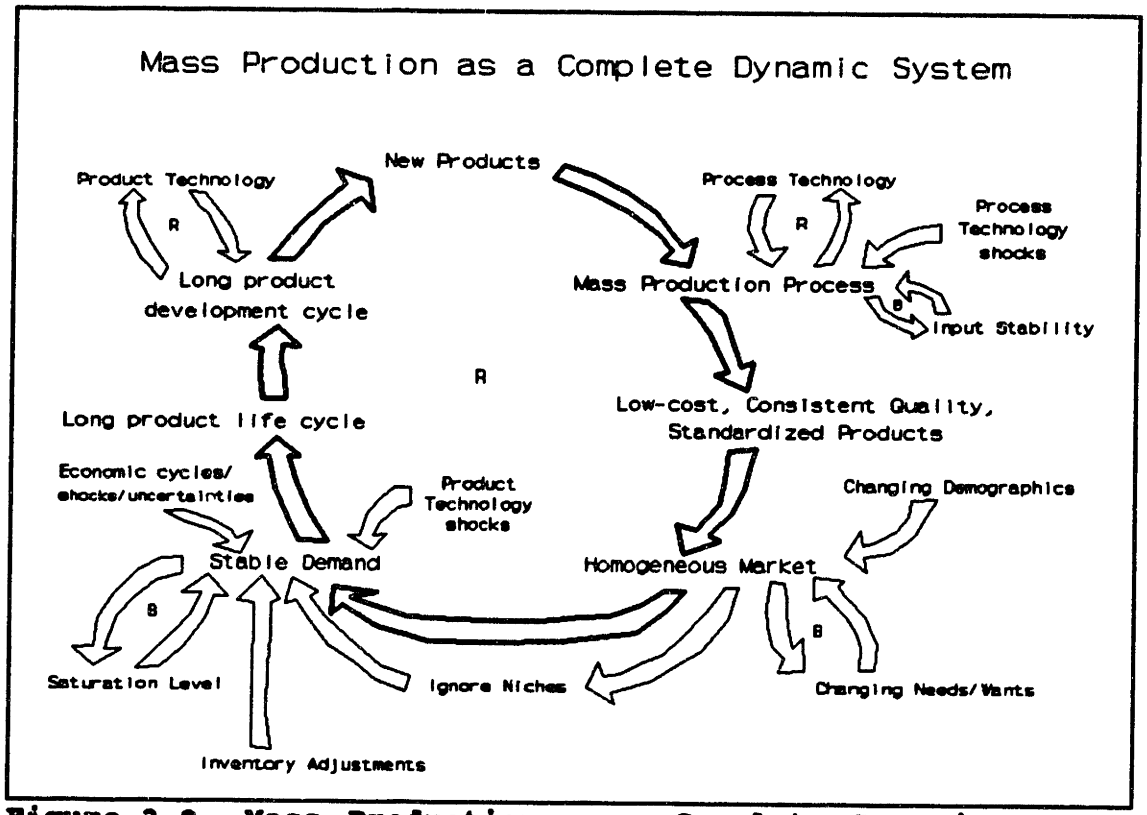

Figure 3-2. Mass Production as a Complete Dynamic System Feedback Loop

relative to the price of the product. This can be done with real wage decreases (relative to inflation) or by productivity increases. To the extent that relative and absolute productivity began to decline in the 1970s,[85] this limited the ability of the mass production process to lower real costs (and therefore lower prices and expand markets).

The mass production process (like any process) may also be severely impacted by process technology "shocks": new ways

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[85]Robert H. Hayes and William J. Abernathy, "Managing our way to economic decline", **Harvard Business Review** 58:4, July-August 1980, pp. 67-77.

of manufacturing that prove more adept at achieving production goals. The Japanese system of "lean" production, which was created to produce smaller volumes at lower costs than American mass-producers,[86] appears to be just such a process technology shock.[87]

Second, there are limits to the homogeneity of markets due to the changing needs and wants of consumers. Although the causes have been hotly debated,[88] the fact that American consumer tastes have changed -- and in particular have diversified into a widening array of variety demanded -- is not under question.

In Chapter 2, a number of reasons were given as to why the American market the late nineteenth and early twentieth centuries was inherently more homogeneous than the industrialized markets of Europe. Nearing the close of the twentieth century, every one of those factors no longer exists:

- American society itself is much less homogeneous, with consumers and producers alike much more heterogeneous

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[86]James C. Abegglen and George Stalk, Jr., ***Kaisha*, the Japanese Corporation** (New York: Basic Books, Inc., Publishers, 1985), pp. 67-90.

[87]See Womack, Jones, and Roos, *op cit*, pp. 80-82.

[88]Piore and Sabel, *op cit*, pp. 189-90.

with regard to distinctions of class, race, gender, and national origin. Drastically changing demographics have also greatly impacted American society.[89] The prototypical American family of working father, mother at home, and three (then two) children reflects an almost vanishingly small minority of households today. Changing lifestyles, immigration, family disintegration, prolonged lifetimes, aging baby boomers -- all have had tremendous effects on markets.

- Income distribution is much less equalized, allowing for great differences in disposable income with corresponding disparities in needs, wants, and desires.

- The American market is no longer new, and is no longer growing much faster than the rest of the industrialized world. Now, demand for new products frequently has to be diverted from older products. This makes it important for the new products to more completely meet customer needs, to be of high quality, and to simply be different than what is already out in the marketplace.

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[89]Stan Rapp and Tom Collins, **The Great Marketing Turnaround: The Age of the Individual - and How to Profit from It** (Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1990), pp. 12-14.

All of these reasons have caused a massive change in markets over the last 150 years, moving many of them from very homogeneous to very heterogeneous.

Third, there are limits to the stability of demand as eventually some sort of saturation level is hit. Industries and products grow and mature. While it is relatively easy to sell in a growth market and maintain some growth in a mature market, it becomes increasingly difficult as that market becomes saturated and most purchases become repeat purchases. A lasting stop to growth in volumes means a full stop to the reinforcing feedback loop of Mass Production.

Demand can also become unstable due to economic and technology effects. Many industries are very susceptible to downturns in the economy; the more tightly linked the industries are to recessions, and the more frequent or severe the recessions are, the more unstable demand becomes. In some industries, particularly those involving durables, purchases become soft not only in recessions but in any time of economic uncertainty. Further, the oil shocks of 1973 and 1979 were devastating to many sectors of the economy precisely because they were so destabilizing.[90]

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[90]Piore and Sabel, *op cit*, pp. 175-80.

Similarly, product technology shocks can be very destabilizing, in some cases overthrowing a dominant design well down the experience curve for a new design that requires revolutionary development and re-tooling.[91] Major examples include the automobile replacing horse-drawn carriages, computers replacing mechanical tabulating machines, calculators replacing slide rules and adding machines, and compact discs replacing records. A period of stability is when a manufacturer is in fact most vulnerable to these technology shocks as it is already "locked into" a product design and the (usually mass production) process to manufacture that design.[92] In some cases, the technology shock need not even be in the core technology of a product; relatively peripheral innovations have been known to completely destabilize demand for particular firms that could not quickly follow.[93]

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[91]William J. Abernathy and Kim B. Clark, "Innovation: Mapping the Winds of Creative Destruction", **Research Policy**, Number 14, 1985, pp. 3-22.

[92]James M. Utterback and Freddy F. Suárez, "Innovation, Competition, and Industry Structure", (Cambridge, Massachusetts: Massachusetts Institute of Technology, Sloan School of Management, The International Center for Research on the Management of Technology Working Paper #29-90, December 1990).

[93]Rebecca M. Henderson and Kim B. Clark, "Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms", **Administrative Science Quarterly**, 35 (March 1990), pp. 9-30.

As this discussion shows, there are indeed serious limits and perils to the system of Mass Production. When encountered, these can cause the breakdown of the entire system, as *efficiency*, *stability*, and *control* are all lost.

Paradigm Found: Mass Customization

In industries where this has occurred, the breakdown of the paradigm of Mass Production has not hit all companies equally. Indeed, a number of companies began to thrive in the new environment. While the Japanese seem to get all of the press, and have in fact led the way, many firms in Germany, Italy, and -- yes -- the United States found their way to a new paradigm by, as the title to Tom Peters latest book attests, "thriving on the chaos" of market fragmentation and exploding product variety.[94] Put succinctly, these companies did so by focusing on *variety and customization through flexibility and quick responsiveness*. What they have done, in essence, is bring the Mass Production feedback loop to a full stop and reverse it, creating and shifting to a new paradigm of production -- Mass Customization. A paradigm shift "is a change to a new

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[94]Tom Peters, **Thriving on Chaos: Handbook for a Management Revolution** (New York: Harper & Row, Publishers, Inc., 1987).

game, a new set of rules."[95] The logical tenets of this new and emerging paradigm, shown once again as a system feedback loop in Figure 3-3, are as follows:

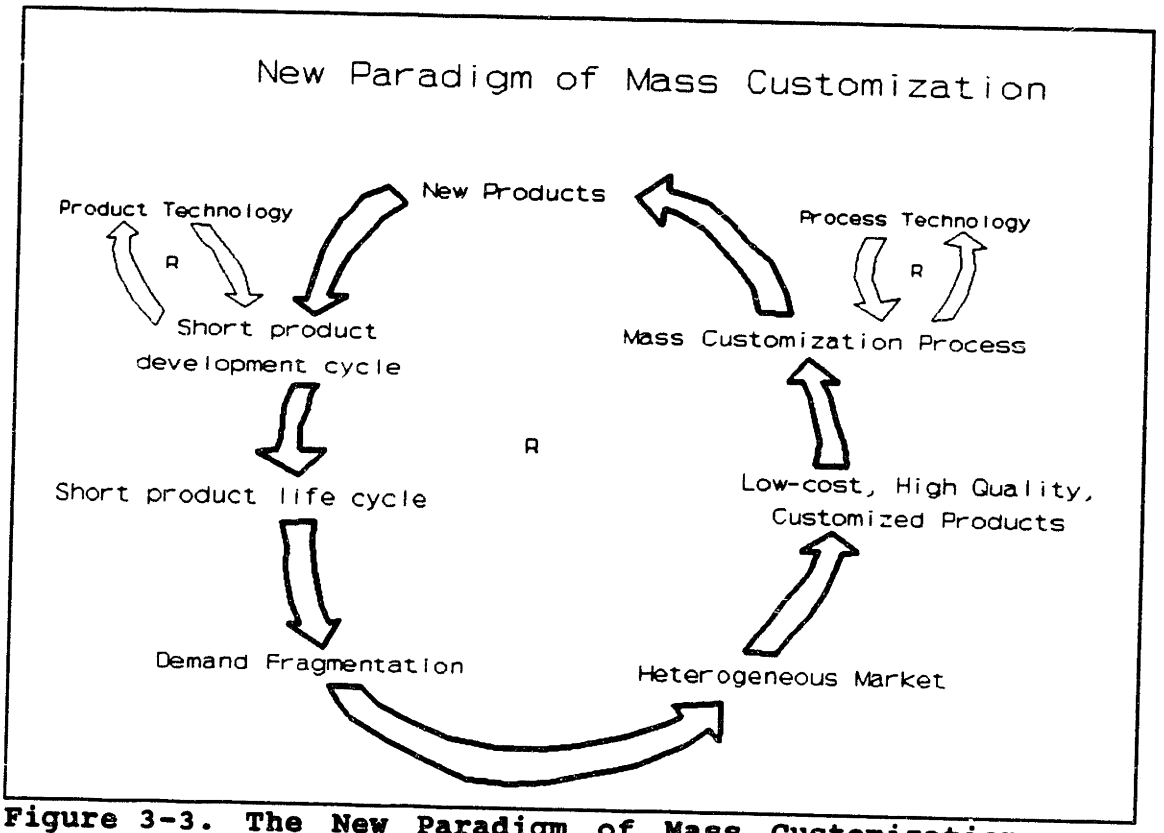

Figure 3-3. The New Paradigm of Mass Customization as a Dynamic System Feedback Loop

- Demand for individual products has become very unstable. What used to be large demand for standard mass market products has fragmented into demand for different "flavors" of similar products. The old ways of stabilizing demand no longer appear to work.

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[95]Barker, *op cit*, p. 15.

- This of course means that the large, homogeneous markets are fragmenting. Rather than being small groups of customers at the fringes of large homogeneous markets, *the niches are becoming the market*, creating demands for greater and greater variety.
- Since profits cannot be maintained the old way, a better choice seems to be to go after some of the niches with some of the additional variety desired and then try to meet the changing needs and wants of these niches. At first this can be done through post-production methods of customizing the product to niches, but this is an expensive alternative.
- Creating variety and customization in production cannot be done through the specialized techniques of Mass Production; creating variety requires most of all flexibility in manufacturing processes, the antithesis of Mass Production.
- The system must therefore be changed. While still producing as high a volume at as low a cost as possible, it must produce a number of different, high-quality products via short production runs, short changeover times, and low work-in-process. This requires general-purpose machinery and highly skilled workers.
- Because the resulting new products more closely meet customer desires, a premium price can in fact be

charged. This extra profit margin offsets any loss of efficiency due to the lower volumes.

- Because the new niche markets are smaller and constantly shifting, continued success can only be achieved by more quickly producing ever greater variety. The rate of product technology change increases dramatically; product development cycles must therefore be reduced just as dramatically.
- Along with this comes shorter product life cycles. Products and technologies are constantly improved upon and replaced.
- This results in less demand for each individual product -- demand fragmentation -- but increasingly stable demand for the company and its set of products relative to the old system and to its competitors. It is winning the war, and can go on looking for smaller niches and fill them with more variety.

This progression can thus be seen to positively feed back on itself, creating a reinforcing loop of greater and greater variety, through increasing flexibility, more and more quickly.

It is very important to notice two key points about this new paradigm. First, *the low prices due to economies of scale and other cost advantages of mass production processes are*

never overcome. Companies will be more successful if they can retain as much of these advantages as possible while still providing the variety demanded by their customers. If this were not true, they could simply go back to Craft Production. Whereas the variety and flexibility of Craft Production is required, its costs are just too high.

Second, as the feedback loop is reinforced, *the niche markets become smaller and smaller*; they begin reaching down closer and closer to the individual. "Greater and greater variety" blends into "more and more customized". In this regard, the logical conclusion of the feedback loop does indeed become the same as with Craft Production: individually customized goods.[96]

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[96]Obviously, there are limits and perils to this new paradigm just as there were to the old one. While not developed here, these include:

- lack of innovations in technology that can take the production process down economically to ever smaller units;
- limits to the amount the development process can be reduced;
- technological shocks that can replace a variety of products with a new, lower-cost dominant design;
- the ability of customers to understand and assimilate the explosion of product information that naturally occurs; and
- their willingness to accept the product and technology obsolescence that occurs with shortening product life cycles.

(continued...)

The new paradigm, then, is a synthesis of the two competing systems of production: the *mass production* of *customized goods*, or *Mass Customization*. Whether or not the process technologies exist (or could ever exist) in every industry to mass produce goods customized down to every individual's needs and wants is beside the point. How effectively firms can use the flexible technologies that do exist, can create new, more flexible processes, and can use the inherent flexibility of workers to more quickly develop and manufacture new products that more closely match individual tastes is the controlling focus of the new paradigm. As Stanley Davis, who coined the term "mass customization," says: "The general message is, the more a company can deliver customized goods on a mass basis, relative to their competition, the greater is their competitive advantage."[97]

Examples of many companies that today can deliver individually customized goods on a mass basis are given in the next chapter, along with some guidelines of how firms that want to mass customize products and services can begin.

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[96](...continued)
Managers operating in the paradigm of Mass Customization need to be aware of these dangers.

[97]Stanley M. Davis, **Future Perfect** (Reading, Massachusetts: Addison-Wesley Publishing Company, Inc., 1987), p. 157.

Chapter 4

Mass Customization as a Business Strategy

Responses to the Breakdown of Mass Production

For many firms, the paradigm shift from Mass Production to Mass Customization is done slowly, incrementally, even unknowingly. When the limits to the system of Mass Production are encountered, increasing variety and customization is the natural response of successful firms trying to continue to be successful when demand fragments, heterogeneous markets become the rule, and product life cycles decrease. Firms that do nothing in response to these limits will find that they can no longer effectively meet their customers needs and wants, that they fall behind technologically, that their product life cycles and development cycles are hopelessly longer than their competitors, and so on. As these firms become less and less competitive, some will decide to simply retreat from the more fragmented segments of their marketplace.[98]

The "strategies" of doing nothing and segment retreat are clearly both losing strategies (if they can be considered

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[98]James C. Abegglen and George Stalk, Jr., ***Kaisha*, the Japanese Corporation** (New York: Basic Books, Inc., Publishers, 1985), p. 89.

strategies at all). The strategy of incrementally providing more variety and customization -- often at higher costs -- is sufficient to stay in the ball game. But companies must do more than that to provide a truly sustainable competitive advantage. Once the system of Mass Production breaks down, the winning strategy is to knowingly provide a proliferation of variety and high levels of customization at low costs -- Mass Customization. This chapter gives examples of many companies that have not only greatly increased their variety and customization, but are in fact today mass producing individually customized products and services. Generalizing from these examples, guidelines and tools to help firms begin their own process of mass customization are provided.

Examples of Mass Customization

To mass customize, a firm must excel in either the right technology or the right people skills, or more likely the right mix of technology supporting people. This section provides examples of firms with core competencies in each area.

Mass Customization through Technology

In some cases, the strategy of Mass Customization can be based completely on some specific technological breakthrough.[99] Information and telecommunication technologies in particular increasingly provide great diversity for little extra cost. Here are some examples of mass customization based primarily on technology:

Mass Customized Books

Create-A-Book® is a line of children's books personalized to each child. Over a dozen generic books have been professionally written and illustrated; the buyer of any particular book is asked personal questions about the recipient (such as name, mother's name, place of birth, and so on). This information is entered into a personal computer, which sprinkles the information appropriately throughout the text of the book. Within 15 minutes, the pages of the book are printed on a laser printer and then bound into a normal book cover. For a price similar to quality books available in stores ($13.95), children receive

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[99]Davis, *op cit*, views mass customization as primarily a technological phenomena (see pp. 140-1, in particular).

their very own customized book -- mass customization through information technology.[100]

Mass Customized Cassette Tapes

There is a tremendous amount of variety available in music stores today; customers can choose from thousands of selections of numerous genres on records, cassette tapes, or compact discs. Personics Corporation, however, takes the consumer choice one step further to mass customization -- they have placed over 250 systems in music stores that make customized cassettes right in the store.[101] The customer goes up to the system and chooses his own selections from 4-5,000 individual songs. After a sales clerk enters the selections, a customized cassette pops out within 5 to 10 minutes, complete with a laser-printed label with the customer's name, desired title, selections, and copyright information.

This mass customization of music is accomplished with a personal computer specialized by Personics to attach to two compact disc jukeboxes that contain 60 CDs each. Personics uses special technology to compress that data on the CDs,

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[100]Create-A-Book company brochure.

[101]See Laura O'Connell, "Mixing and matching musical tastes," *Computerworld*, July 23, 1990, p. 16.

storing three times as many songs as standard CDs bought in a store and yielding a music data base of over 90 gigabytes available for mass customization.

Mass Customized Magazines

Farm Journal was founded in 1877 to service farmers in the Philadelphia area. They went national in the early 1900s, but farming became more specialized over the years, and the magazine began producing regional versions in 1952. Beginning around 1980, they went further and began customizing each of their 14 issues a year.[102]

Each subscriber is asked to fill out a questionnaire about his farm (including questions such as the crops or livestock raised, number of acres devoted to each crop and size of herd, etc), which is entered into an online data base. Each subscriber, then, receives an editorial core of about 50 pages along with individualized articles -- and advertising -- based on the information in the data base. Each month hundreds of different *Farm Journal*s are sent out to its 800,000 subscribers, and sometimes the number of customized

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[102]See Patricia W. Hamilton, "*Farm Journal* feels its oats," *D&B Reports*, July/August 1988, pp. 22-25.

versions is well into the thousands.[103] The technology behind this capability is

> a patented process called Selectronic Binding, developed by R.R. Donnelley & Sons in Chicago. . . Starting with the basic editorial pages, as each magazine works it way through the assembly line, the computerized equipment "reads" the subscribers's demographic data and adds those pages designated for him. Calipers built into the system measure the exact thickness of the magazine assembled for each subscriber, and it if its incorrect, the system rejects the magazine and assembles another.
>
> No human intervention is needed from the start to the end of the assembly line, where the magazines arrive ready for mailing.[104]

Each of these examples shows how technology alone can make mass customization a reality for many companies. There are many more companies that could be cited for their use of *flexible manufacturing systems* to provide much greater variety, if not individual customization.[105] There are those who believe that (at least some day) technology alone will be able to provide mass customization across all

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[103]Amy Cortese, "Greener acres ahead in publishing," *Computerworld*, September 4, 1989, pp. 55, 59.

[104]Hamilton, *op cit*, p. 24. See also Ed Pluzynski and Larry Ocamb, "Getting started in selective binding," *Catalog Age*, November 1990, pp. 117-122.

[105]For an excellent description of flexible manufacturing systems and all of their implications, see Hamid Noori, **Managing the Dynamics of New Technology: Issues in Manufacturing Management** (Englewood Cliffs, New Jersey: Prentice Hall, 1990).

industries. For instance, the futurist Alvin Toffler predicted this back in 1970:

> For the society of the future will offer not a restricted, standardized flow of goods, but the greatest variety of *unstandardized* goods and services any society has ever seen. . . . The end of standardization is already in sight. The pace varies from industry to industry and country to country. . . . Two economic factors encourage this trend: first, consumers have more money to lavish on their specialized wants; second, and even more important, *as technology becomes more sophisticated, the cost of introducing variations declines*. . . . Automation. . . frees the path to endless, blinding, mind-numbing diversity. . . . Many engineers and business experts foresee the day when diversity will cost no more than uniformity.[106]

Mass Customization through People

Twenty years after this was written, mass customization has come into its own and flexible manufacturing systems are playing an increasingly important role. However, it is still not clear that technology alone can provide individually customized products at the costs of mass-produced products in every industry of every country.[107] Many companies have

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[106]Alvin Toffler, **Future Shock** (New York: Random House, 1970), pp. 234-6. Emphasis in original.

[107]However, it can come close in many industries. Theodore Levitt's comment in **The Marketing Imagination**, new expanded edition (New York: The Free Press, 1986), p. 46, that "there is no conceivable way in which flexible factory automation dedicated to producing many customized lines of a specific product can achieve the scale economies of an equally modernized plant dedicated to the massive production of narrow standardized lines of that product" is first of (continued...)

created mass customized goods and services primarily through their people:

Mass Customized Mainframe Computers

The very first example of a truly mass customized product may have been the IBM System/360, announced in 1964. The System/360 revolutionized the computer industry by providing an extremely broad range of computing power under one common computer architecture -- from the user's standpoint, each System/360 was a completely standardized product.[108] However, each System/360 was also a completely customized product, as David Mercer described from his own experience with IBM:

> After spending some time in IBM it eventually dawned on me that in fact IBM had developed a near perfect marketing operation. The unit of this ideal marketing, however, was not the anonymous "average" consumer that I was used to in the consumer goods companies where I had previously worked. It was instead the very specific, identified, individual customer.

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[107](...continued)
all true because it is tautological, and second of all misses the point of flexible automation entirely. Massive economies of scale on a standardized product is of no use if not enough buyers can be found for that product to achieve the economies. Flexible manufacturing systems can provide very nearly the same economies *and* provide more customized products for waiting customers.

[108]Charles J. Bashe, Lyle R. Johnson, John H. Palmer, and Emerson W. Pugh, **IBM's Early Computers** (Cambridge, Massachusetts: The MIT Press, 1986), p. 583.

> Thus there was no significant market research commissioned to discover general needs, because the needs of *each* customer were investigated by the field force. . . . in great depth -- far more so than any market research could address, and of course quite specific to each unique customer. The overall IBM product strategy could be almost entirely technically based. . . because its job was only to provide a series of very generally applicable building blocks, from which the *field force* built ("configured" in the jargon) the unique end product that *exactly* matched the needs they had identified in the customer's business.[109]

The mass customization of the IBM System/360 was thus accomplished through IBM's field force. Obviously, it was very expensive for IBM to expend such a large amount of resource on every customer, an expense that was reflected in the price of the computer that moved it far beyond a price that would reflect the costs of these mass-produced computers. However, it was generally *cheaper* for the customer to have IBM provide this customization than to do it himself, as IBM's field force was much more experienced at it and could re-use at least some software created for previous customers.[110]

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[109]David Mercer, **The Global IBM: Leadership in Multinational Management** (New York: Dodd, Mead & Company, 1987), pp. 216-7.

[110]The cost of this approach to Mass Customization eventually led IBM to develop or have developed standard application software. It eventually gave up Mass Customization for Mass Production, and its relative lack of success since the mid-1980s is not unrelated to this. Its thrust to be market-driven and provide total solutions for customers is now moving IBM back in the direction of Mass Customization.

Mass Customized Lighting Controls

Lutron Electronics Company[111] designs and manufactures lighting controls (switches, dimmers, and systems to control sets of lights) for residential and office environments. They provide over 11,000 different controls through more than a dozen different product lines. Over 95% of Lutron's products have annual shipments of less than 100 units. In their electronic lighting systems line they have *never shipped the same system twice*. Each and every system is customized to the individual specifications of their customers -- but mass produced on a single assembly line from standard components.

Lutron does it not through flexible automation, but through flexible people: both engineers and production workers. Lutron hires only top-notch engineers and gives them extensive training. They spend an extensive amount of time with individual customers, making sure they get exactly the product to suit them. They have been known to spend so much application engineering time with a customer that they've virtually eliminated all of their profit on that one sale.

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[111]This example is based on a field visit to Lutron's facilities in and around Coopersburg, Pennsylvania. Because of the importance of understanding that high levels of flexible automation are not required for Mass Customization, this example goes into some detail.

But from that they gain not only a delighted customer but new ideas on how to extend their products with new variety.

What has happened over and over at Lutron during the last twenty years is that the engineers design a new product line that at first is rather standard with only a few options. Then, by working with individual customers, they extend the line with product after product, each one more designed from scratch than based on the previous products. Eventually, they may have, say, a hundred models that customers can purchase, and in production they are manufacturing the same one hundred different models. Then, engineering and production together "rationalize" the product line down to 15-20 standardized components that can be put together ("configured") into the same one hundred models that customers can purchase.

The production process is fundamentally based on the skills of the production workers. They perform the customization of Lutron's products in four different ways. First, as mentioned above, mass customization is performed by the assembly of standard components into a variety of unique configurations. Each of these products has the low costs of mass production but is customized to what the customer needs. Second, they may perform additional custom work to meet further customer requirements. One product family has

over 3000 different configurations; the majority of purchases are from a (relatively) "standard" set of about 1000 different products that are mass customized. The other 2000 or so products, however, require a degree of additional customization, such as machining a 5-gang faceplate (one with room for five controls). This level of customization does have significantly added costs, but the customer is only charged a price proportionally greater than 4-gang faceplates, as if only the amount of material differed.

The third way Lutron customizes their products is through what they call "specials," for which a charge is added. This can range from custom-matching a paint sample (should a customer want something other than the 14 colors Lutron provides), for which a small fee is charged, to integrating a lighting system with a separate security system. In the latter case, after the system is mass customized, production will take it to a special area, open it up, and perform the necessary modifications (with engineering assistance if required).

The final way customization is performed is via packaging for different distribution channels. Lutron markets many of their lines through electrical supply outlets, lighting showrooms, and mass merchandisers such as Home Depots and Grossman's. Each outlet wants the packaging to be different,

so Lutron purchases a variety of packages to meet the desires of its channels but, to match its own volatility of demand, the products are not placed into the packages until the last possible moment before shipping them out to their destination.

All of this is performed with very little automation. Lutron, by far and away the market share leader in lighting controls, demonstrates that mass customization can be performed primarily by people.

Mass Customization through People and Technology

Most companies, however, tend to require both people and technology in order to be able to mass customize.

Mass Customized Bicycles

The National Bicycle Industrial Co., a subsidiary of Matsushita in Japan, provides individually customized bicycles. Its factory "is ready to produce any of 11,231,862 variations on 18 models of racing, road, and mountain bikes in 199 color patterns and about as many sizes as there are

people."[112] Their process starts with shopkeepers that determine each customer's model, size, color, and design preferences and then precisely measure him on a special frame. The specifications are faxed to the factory where a computer creates custom blueprints for both craftsmen and robots. The robots measure each piece of the frame, weld the pieces together, and apply the base coat of paint. Skilled workers perform most of the assembly work and all of the final touches, including silkscreening the customer's name right on the frame. Each bike is assembled by one worker, which provides a distinct sense of satisfaction not present in most assembly lines.

Mass Customized Saws

The Peerless Saw Company developed a computer-driven laser system for cutting saws. They did not do it in order to customize their products, but to simply speed the time from customer order to delivery, which dropped from fourteen weeks to three. Peerless found, however, that

> orders started coming in with the phrasing: "The same as last time except. . . ." Peerless soon realized that customers were using the facilities to 'experiment' with their saw blade designs. . . . Taking advantage of this new market, Peerless started encouraging sales people to work more closely with customers to produce specialized blades that would fit their unique needs. The simplicity of their menu-driven computerized system

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[112]Susan Moffat, "Japan's New Personalized Production," *Fortune*, October 22, 1990, p. 132.

> allows their sales people to even take the terminal with them when they visit customers, tie into Peerless's computer over a phone line, pull their customers' last order up on the screen, and, together with the customer, modify it. Once the customer is happy with the new design, the salesman punches a button and the laser goes to work back in the Peerless plant cutting the blade.[113]

Unlike Create-A-Book or Personics, here the technology is only useful for mass customization when in the hands of sales people who can work with their customers to determine what their needs really are.

Mass Customized Watches

Mass production techniques were first introduced to the watch industry with the advent of digital quartz technology in 1968. With the prices of watches dropping dramatically as a result, watch buyers became increasingly fashion-conscious, often owning more than one watch and using it as an accessory that happened to also tell time.

This trend was spotted and accelerated by ETA S.A., the largest Swiss manufacturer of watches.[114] Beginning in 1983, they introduced a collection of fashion-styled watches

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[113]J. Meredith, "The Strategic Advantages of the Factory of the Future," *California Management Review*, Volume XXIX, No. 3, Spring, pp. 28-9, cited in Noori, *op cit*, p. 82.

[114]The information for this example is taken from the case study "Swatch" by Christian Pinson (Fontainebleau, France: INSEAD-CEDEP, 1987).

under the brand name Swatch (*Swiss* + *watch*) that was tremendously successful. The amount of variety in the watch industry increased dramatically, with ETA (followed to lessor degrees by others) first introducing Spring and Fall collections and then moving to six seasons each year. When their engineers developed a system of "perpetual innovation" that allowed them to renew their collections every six weeks, ETA discovered mass customization: with so much variety turned over so frequently, each and every customer could buy a watch and be virtually certain it would not be worn by anyone else he knew.

The success of ETA and the Swatch brand continues to be dependent on the flexible technologies used in manufacturing to provide variety and low costs, on the abilities of their designers to create and exploit the latest fashion trends, and on the abilities of their engineers to turn design into reality in a very short amount of time.

For National Bicycle, Peerless, and ETA, technology merely allows the possibility for mass customization; it is people that make the technology useful.

Implementing Mass Customization

A company that decides to make Mass Customization its strategy must look inward and examine the capabilities it has for technological innovation and for people flexibility in development, production, and distribution. As the examples above demonstrate, mass customization can be accomplished through technology alone, through people alone, and through the appropriate combination of technology and people. Only by examining and thoroughly understanding its capabilities in these dimensions can a firm begin to determine how it can implement a strategy of Mass Customization and what it is lacking in order to do so.

It is extremely important, however, that the top management of a firm understand all of the implications inherent in how it goes about mass customizing products. In particular, they need to understand how sustainable any competitive advantage gained would be. Advantages based solely on technology are inherently less sustainable. Nearly anyone with a personal computer and laser printer could copy Create-A-Book's idea, and the mass customization of tapes and magazines are only somewhat more difficult to copy should someone choose to do so. However, once the strategy is dependent on the knowledge and skills of people, it instantly becomes more of a sustainable competitive advantage. Trying to do what IBM did

with the System/360 and what Lutron has done with lighting controls for over twenty years would be virtually impossible for another firm to copy without tremendous investments in people and resources over many, many years.

To begin, then, the process of formulating a strategy for mass customizing products and services, managers need to ask themselves questions like the following:

- How can advanced technologies -- in particular but not limited to information, telecommunications, and flexible manufacturing technologies -- be brought to bear to provide increased variety and customization at little or no increased costs?

- Are there any breakthrough technologies in the realm of possibility that would by themselves achieve mass customization?

- What could be done in development to speed new products to market and provide increased variety and customization?

- How could production personnel be used to make manufacturing more flexible and more responsive?

- How could sales, service, and other people in the distribution process by used to customize standard products for the wants and needs of individual customers?

- How can the final manufacturing step be brought closer to the end customer?

- How sustainable is any advantage gained by any of these ways of mass customizing?

To provide some substance to these questions and the firm's process of strategy formulation, two tools may be particularly useful. First, a topology of product customization is provided to allow managers to fully explore the possibilities open to them on how products can be customized. Second, a value chain analysis is discussed that can similarly allow managers to fully explore the possibilities for how and where products can be customized.

Topology of Product Customization

There are five dimensions on which products can provide various degrees of customization. By explicitly examining a firm's product set with these five dimensions in mind, the

possibilities for the mass customization of that product set can become more apparent.

1. The extent to which a product can be *customized*. If a product is completely customized, then everything about the product can be customized by the firm.

2. The extent to which a product can be *customizable*. If a product is completely customizable, then everything about the product can be customized by the customer himself (or others in the distribution channel, such as business partners, that assist the end customer).

3. The extent to which a product has the capability of "open" or "closed" customization relates together the previous two dimensions. Completely "closed customization" means the firm has to perform all product customizations, while completely "open customization" means customers (or others) can perform any and all customizations.

4. The extent to which a product has continuous or discontinuous customization. "Continuous customization" means that within some range the product can be infinitely customized, while "discontinuous customization" means there are discrete steps in the level of customization.

5. The extent to which a product's use is modified by customization. "Same-use customization" means that the product performs exactly the same function after customization; "modified-use customization" means the product can perform different but related functions; and "different-use customization" means that the product can perform completely different functions after customization.

For an example of all of these terms, think of the differences between stereo systems and computer systems. Stereo system components are not *customized* at all by the manufacturers, but virtually any component will work in a system with components from other manufacturers, so that the system as a whole is very *customizable*. Computer systems, on the other hand, are both *customized* by the manufacturers, who can put different processor speeds and amounts of main memory or disk storage in the systems, and *customizable* by their users (and by third parties who often assist users in this task), who can buy or create hardware and software particular to their needs.

Stereo systems provide completely *open customization*, as users have to perform any and all customization, while computer systems are mostly *open*, as some of the customization must be performed by the manufacturer but much of it can be performed by the users.

Stereo systems have primarily *discontinuous customization*, as there are a set number of types of components that can be included in a system. Computer hardware is also primarily *discontinuous*, while software is *continuous*, as it can be almost infinitely customized if the users choose to do so.

Because of this, computer systems have *different-use customization*, as the same basic system can be customized, for example, for word processing for one customer and running a cash register for another. Stereo systems have distinctly *same-use customization*, as their purpose is to provide listening enjoyment in homes, although compact disc players that can be moved between cars and home entertainment centers may be considered to have *modified-use customization*.

For managers to apply this topology of customization to their own product line, it is helpful to graph that product line on each of these dimensions; to create, in essence, a Product Customization Profile. To see how this would look, Figure 4-1 provides the Product Customization Profile for a large, high-technology company that already provides a great deal of customization.[115] This profile indicates that the company's products are heavily customized (in manufacturing)

[115]The information in this profile was given by the corporation's Director of Market Analysis as part of the survey described in Chapter 6.

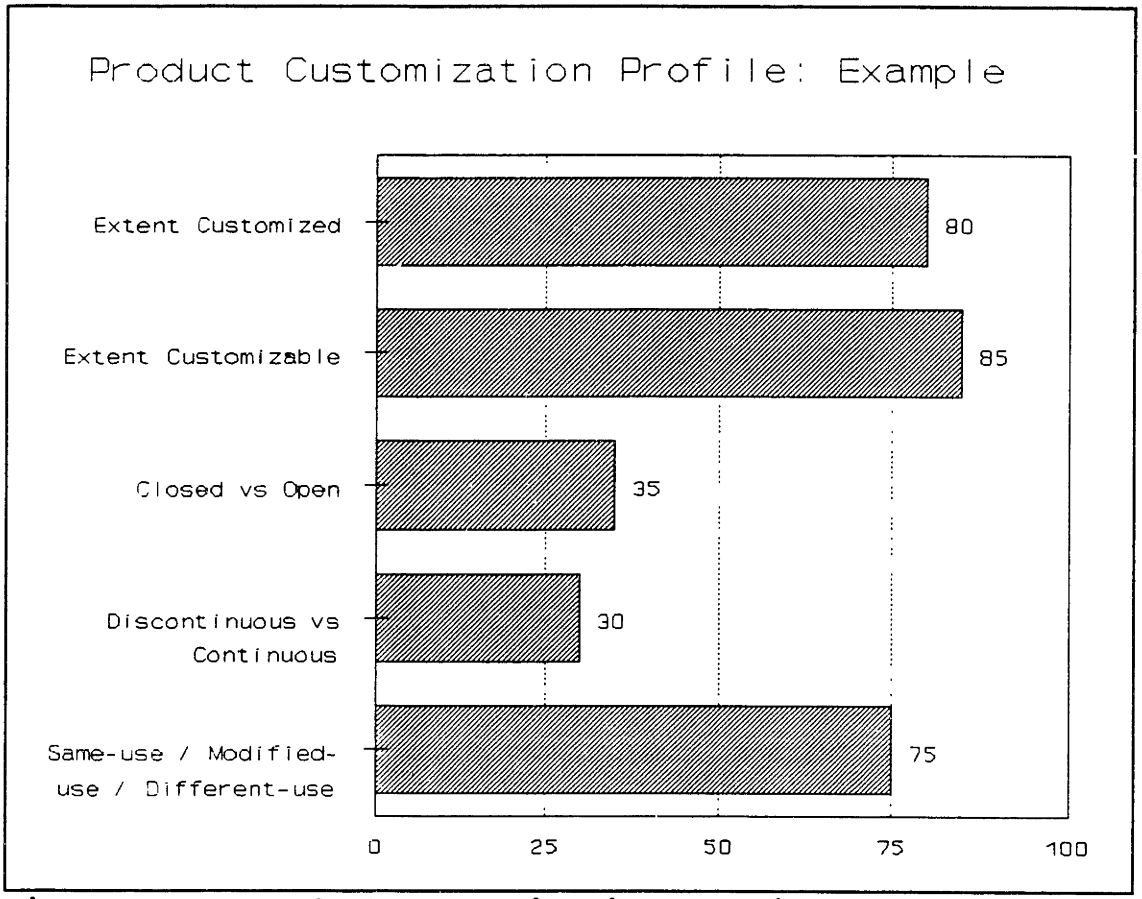

Figure 4-1. Product Customization Profile: Example of a Large, High-Technology Company

and customizable (after manufacturing); that most of the customization has to be performed by the business unit; that the customization is somewhat but not completely discontinuous; and that the customization allows the company's customers to use their products for fairly different functions.

From a profile such as this one, managers can determine where they are already strong and where they are weak in customization, and can then explore the possibilities for

full mass customization that present themselves during the examination process. The company whose products are represented in Figure 4-1, for example, could look at ways to open up more of their products to be customized outside of the company itself and at ways to provide more continuous customization. Further possibilities for this or any company can be found using value chain analysis.

Value Chain Analysis

This method of analysis was championed by Michael Porter as a way of disaggregating the tasks within a firm that add value to products in order to fully understand where competitive advantages exist and where they can be created. Figure 4-2 represents the generic value chain of a firm as envisioned by Porter.[116]

Based on extensive research into corporations that are practicing the strategy of Mass Customization, including those who were described earlier in this chapter, the following discussion provides insight into how each function of the value chain -- central administrative, financial,

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[116]Michael E. Porter **Competitive Advantage: Creating and Sustaining Superior Performance** (New York: The Free Press, 1985). This particular version of the value chain is adapted from Arnoldo C. Hax and Nicolas S. Majluf, **The Strategy Concept and Process: A Pragmatic Approach** (Englewood Cliffs, New Jersey: Prentice Hall, 1991), p. 287.

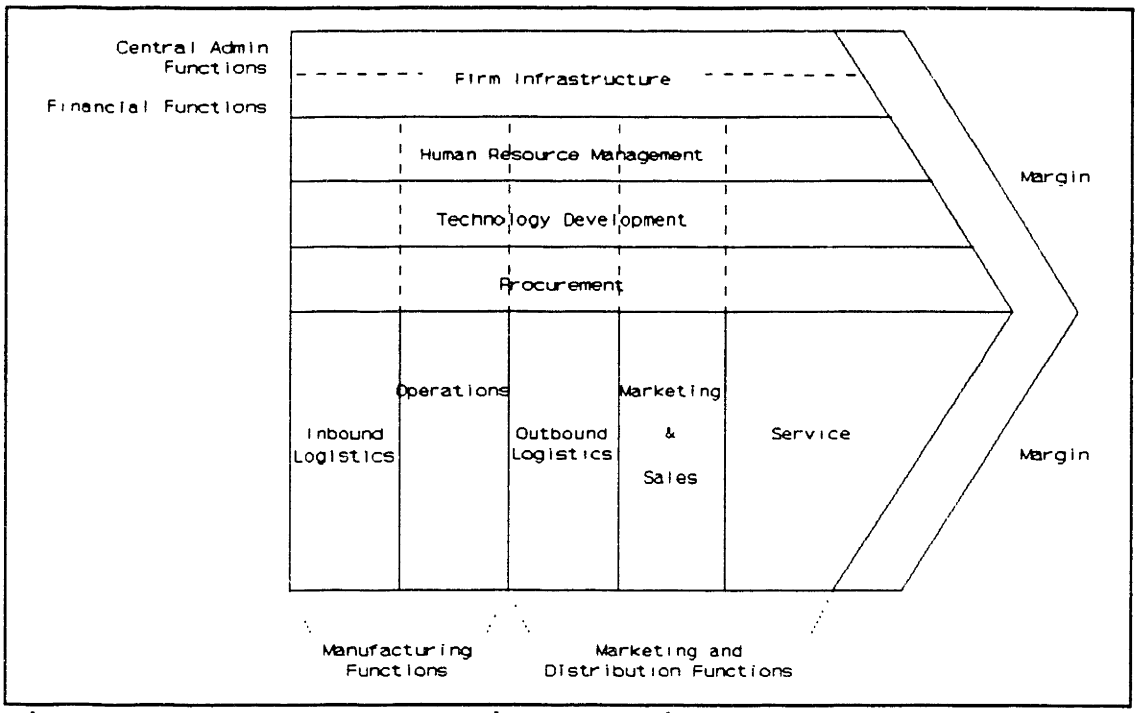

Figure 4-2. The Value Chain of a Firm

human resources, technology development, procurement, manufacturing, and marketing & distribution -- can contribute to this strategy.

Central Administrative and Financial Functions

Administrative and financial functions are by their nature support, not line, functions and therefore tend to contribute less strategically than other functions. However, in all of their activities, the people in these two functions need to keep clearly in mind what the firm is trying to accomplish with its strategy of Mass Customization. In particular, they need to remember that the

primary stakeholder of the firm is the *customer*, whose individual wants, needs, and desires have to be understood, met, and exceeded at every possibility.

There are those who claim that the way to quality in support functions is to view the group or area where the work goes next as a customer, and then to serve the needs of the people in that group as if they were end customers.[117] However, they are *not* customers; the only people that should be considered to be customers are those paying money for goods and services the company is providing (although this may include both end customers and distribution channels). A couple of administrative functions can be perfectly happy viewing each other as customers and servicing each other's presumed needs while totally missing what is important to the *real* customers. Who the real customers are should never be forgotten by support functions.

One further comment about the finance function. Flexible automation technologies that can be applied to mass customization are notoriously difficult to justify because the costs and benefits of potential extensions to future

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[117]See, for example, the otherwise outstanding book by Richard J. Schonberger, **Building a Chain of Customers: Linking Business Functions to Create the World Class Company** (New York: The Free Press, 1990).

applications are rather difficult to quantify.[118] The people in these functions, therefore, need to be fully cognizant of the inherent value of strategic flexibility and willing to accept and develop new methods of justification.

Human Resource Function

The same thing can to be said for the human resource function and the inherent value of strategic flexibility in *people*. As discussed above, a strategy of Mass Customization whose competitive advantage is based on the knowledge and skills of people is inherently more sustainable than one based on technology alone. The firm must therefore be willing to spend the time and money required to "mobilize the invisible assets" of its own people and marshall them towards the goal of Mass Customization.[119]

Procurement Function

The greatest value-add that the procurement function can have is providing economies of scale by centrally managing

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[118]For new techniques that adequately factor in strategic flexibility, see Noori, *op cit*, pp. 192-219, and H. Thomas Johnson and Robert S. Kaplan, **Relevance Lost: The Rise and Fall of Management Accounting** (Boston: Harvard Business School Press, 1987).

[119]See Hiroyuki Itami with Thomas W. Roehl, **Mobilizing Invisible Assets** (Cambridge, Massachusetts: Harvard University Press, 1987).

all procurement. This needs to be balanced by the need for each manufacturing facility to be flexible and responsive to changing demands, but in general a high degree of central purchasing can be of great benefit in achieving the low costs of mass production while still individually customizing goods.

Also, Japanese corporations -- indisputably the world's leaders in providing variety and customization at low costs -- have taught us two things (among so many others) about the procurement function in the value chain. First, suppliers need to be viewed as an integral part of the firm, and can in fact provide much of the responsiveness and customization desired.[120] Second, the Japanese production system that has been dubbed "lean production," which integrates suppliers into a fragile flow of operations that exposes any and all problem areas for improvement, is particularly well-suited for high-variety, low-cost manufacturing.[121] While doing all of this is beyond the control of procurement, this function needs to understand how its suppliers can contribute to the strategy of Mass Customization, and may in fact be able to initiate activities in this area.

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[120]Kuniyasu Sakai, "The Feudal World of Japanese Manufacturing," *Harvard Business Review*, November-December 1990, pp. 38-49.

[121]Womack, Jones, and Roos, *op cit.*

Technology Development Function

In most companies, technology and product development is, unlike the above functions, a line function. As the Lutron and Swatch examples showed, the primary ways that development can create mass customized products are by drastically reducing the development cycle and by creating a process that cost-effectively produces customized products.

To be effective at this the entire organization must have what Andrew Boynton and Bart Victor call *dynamic stability*: "the ability to serve the widest range of customers and changing product demands ('dynamic') while building on existing long-term process experience and knowledge ('stability')."[122] It is crucial for the firm to first have a process base (development and production) that is stable and capable of instantly applying people's knowledge, experience, and skills *before* mass customization is really attempted. The Japanese did not set out to provide high levels of variety and customization; they set out to have lower costs at lower volumes than America's mass producers. Only after their development and production processes met this goal did they discover that they could also enjoy a

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[122]Andrew C. Boynton and Bart Victor, "Beyond Flexibility: Building the DYNAMICALLY STABLE Organization," unpublished paper (draft), April 13, 1991, p. 9.

proliferation of products at lower costs.[123] Just as the tradeoff between quality and costs was found to not really exist, neither does the tradeoff between variety and costs.

Development can also create value for individual customers by designing products that are *customizable*. The Personics system is one example. Last year, Gillette introduced the Sensor razor that automatically adjusts to the differing curves of each face.[124] Steelcase Inc. provides another example with a line of chairs, the Criterion™ series, that are continuously customizable on six dimensions (back height, arm height, foot ring height, back angle, seat angle, arm width) and discontinuously customized on a number of others (options for: mechanical or pneumatic height adjustment; upholstered, plastic, or soft armcaps; armless; foot ring, foot plates, hard casters, soft casters, or glides; and so on).[125]

The development function is also crucial for its part in designing products that can be customized in production.

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[123]Abegglen and Stalk, *op cit*, pp. 67-90.

[124]Yumiko Ono, "Gillette Tries to Nick Schick in Japan," *Wall Street Journal*, February 4, 1990, pp. B1 and B6. Note that since this mass customization of shaving was based solely on technology, Schick was able to quickly copy it with its own Tracer brand.

[125]"Criterion. The chair that works hard for hardworking people," Steelcase Inc. brochure.

Perhaps surprisingly, the key to customization in manufacturing is standardization: the standardization of components that can be configured into a wide variety of end products. The economies of scale are provided by the components, the customization by the end products.

That is how Lutron has been customizing lighting controls for twenty years. The paramount importance of this to how most firms can accomplish a strategy of Mass Customization merits some additional examples:

- Nearly all computer systems are manufactured in this way. They have a tremendous number of options available on them, such as the processor speed, the amount of main memory, the number and type of disk drives, and numerous other features. However, each option and its interface to the computer is standardized so manufacturing can just "plug" the right options in to create a customized system.

- In the early 1970s, Black & Decker decided to completely redesign their line of power tools to incorporate a key safety feature. Purely to reduce costs, they took the opportunity to standardize every

component possible. The results were 122 basic tools with hundreds of variations all manufactured from a relatively small set of standardized components. Mass customization was accomplished not only in manufacturing, but in development:

> As new product concepts emerged, much of the work in design and tooling was eliminated because of the standardization of motors, bearings, switches, gears, cord sets, and fasteners. Design and tooling engineers working on a new product had only to concern themselves with the "business end" of the product and to perfect its intended function. New designs could be developed using components already standardized for manufacturability. The product did not have to start with a blank sheet of paper and be designed from scratch.[126]

The principle of customization through standardization also applies to process industries, where instead of standardized components configured into various end products, standardized *materials* can be *mixed* into various end products:

- Paints have historically been mass produced, having significant changeover costs and economies of scale. However, paint stores have been providing mass customized paints for many years by simply mixing together standardized paints according to a formula

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[126]Alvin P. Lehnerd, "Revitalizing the Manufacture and Design of Mature Global Products," in Bruce R. Guile and Harvey Brooks, Editors, **Technology and Global Industry: Companies and Nations in the World Economy** (Washington, D.C.: National Academy Press, 1987), pp. 61-2.

provided by the manufacturer. Benjamin Moore & Co. "has taken the process even further. They supply paint dealers with a computer that measures the light frequencies of a color sample and therefore allows for a mix to match perfectly."[127]

- Fertilizer is another commodity that has moved from total standardization to mass customization. Today, fertilizer can be custom blended for each hectare of a farm according to the type of soil, slope, amount of sun, etc. Some in the business believe that some day they will "customize the blend for each square meter, right as it is mixed into the earth."[128]

These examples also demonstrate another guideline for mass customizing products: move the manufacturing closer and closer to the customer. This guideline can also be seen in the examples of Create-A-Book and Personics, which both took standardized components (stories, paper, and book covers for Create-A-Book and cassette tapes for Personics) and customized them through manufacturing the final products at the point of sale. Point-of-sale customization is the norm in service industries, which by their nature tend to provide customized services at the point of customer contact. But

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[127]Davis, *op cit*, p. 176.

[128]Anonymous manager, quoted in *Ibid*, p. 160.

customized services are often very costly to provide; service industries can *mass* customize by also using the principle of customization through standardization:[129]

- Hyatt Legal Services is as close to mass production as law firms get, but still delivers the individual customization inherent in the nature of legal work. They achieve their low costs by standardizing on the key written components -- tax documents, wills, estate plans -- that are specifically designed to be customizable to individual needs.

- Vacation tours are one service that has always been very standardized. However, TWA Getaway Vacations, Inc., provides customized tours at the prices of standard vacation packages. To do it, they created an information system that "could mix and match all the components of a tour -- airlines, hotels, surface transportation and entertainment options -- on a real-time basis and bring back a single price for the customer within six minutes."[130]

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[129]The statement of this principle applied to services, and additional examples, can be found in James Brian Quinn and Penny C. Paquette, "Technology in Services: Creating Organizational Revolutions," *Sloan Management Review*, Volume 31 Number 2, Winter 1990, pp. 67-78.

[130]Craig Pavlus, quoted in Paul Gillin, "Custom tours at package prices? No problem," *Computerworld*, August 6, 1990, pp. 63 and 69.

Just like mass customization in manufacturing, at TWA Getaway Vacations the tour components are bought in bulk -- providing economies of scale -- and configured together to create the end "product." When a firm examines its value chain for ways to mass customize, one of the best places to look is in the development/manufacturing interface for opportunities for customization through standardization.[131]

Marketing & Distribution Function

The easiest place to start, however, is in the marketing and distribution function. Products that are completely standardized coming out of development and manufacturing can still be customized by people in the distribution channels, as the example of the IBM System/360 demonstrated. In fact, it appears that most companies beginning down the path of mass customization start with post-production customization because it is the easiest to do, following a principle of standardized products with customized services. Marketing and distribution can change the product, add features, combine it with other products (not necessarily the same

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[131]Toshio Suzue and Akira Kohdate have written a book detailing exactly how to do this entitled **Variety Reduction Program: A Production Strategy for Product Diversification** (Cambridge, Massachusetts: Productivity Press, 1990).

company's), and provide a host of services that allows each customer to receive the individual attention they want.

While it tends to be resource-intensive and therefore costly, the value added here is usually high enough to be able to charge a higher price (unless a competitor is already mass customizing in development and/or manufacturing). Also, by beginning here, a firm can often give its development and manufacturing functions the time to develop the stable processes they need to dynamically increase variety and customization.

One thing is clear: to be able to effectively execute a strategy of Mass Customization, all of the functions in a firm's value chain need to be able to work together. While this is true of any strategy, it is especially true of one that attempts to provide both low costs and individual customization, and that is so dependent on both technology and people across the value chain to satisfy the individual needs and wants of each and every customer.

Implementing Mass Customization: Guidelines and Principles

For managers who have decided to embark on the path of Mass Customization, this chapter has provided a number of things

that should be helpful in beginning this journey: examples of other companies that are already mass producing individually customized goods and services, a topology of customization that can be useful in understanding on what dimensions product customization can be provided, and principles and guidelines from value chain analysis for how and where mass customization can be performed. These principles and guidelines can be summarized as follows:

- The easiest path to mass customization is through standardized products with customized services: begin customizing in marketing and distribution by adding value-added services to existing products.

- Mass customization in development and manufacturing can be accomplished by the principle of customization through standardization. Standardize and gain economies of scale on components that can be configured into a variety of end products.

- Development can also create value for individual customers by designing products that are customizable to their needs.

- Point-of-sale customization can be accomplished by moving the final manufacturing function as close as possible to the end customer.

- Flexible manufacturing technologies can be used to produce tremendous variety at relatively low costs. However, mass customization that is provided by the inherent flexibility of people (whether in development, manufacturing, or marketing/distribution) yields a much more sustainable competitive advantage than mass customization dependent solely on technology.

- Organizations that mass customize in development and production need to have dynamic stability: a stable process base that is capable of instantly applying people's knowledge, experience, and skills to the widest range of customers and changing product demands. The process needs to be in place and stabilized before mass customization can really begin.

Before being able to apply any of these guidelines and principles, of course, managers must first decide that they want to implement a strategy of Mass Customization. For those in industries traditionally operating under the paradigm of Mass Production, the breakdown of that system of production can certainly provide the proper motivation -- if

they can first recognize and respond to it themselves by making the paradigm shift from Mass Production to Mass Customization.

Chapter 5

Predicting the Paradigm Shift

The Degree of Paradigm Shift

Not every company needs to shift to the new paradigm and implement a strategy of Mass Customization. Just as Mass Production never did completely replace craft methods, Mass Customization appears to be on its way to supplanting Mass Production as the paradigm of many, but not all industries. And where it is occurring, the degree of shift can vary dramatically.

Some industries never left the system of Craft Production. This appears to be the case when high skill levels are required and when every transaction is necessarily customized to what the individual wants. Most service industries are this way. Restaurants, construction, plumbing, and legal/consulting services, for example, all involve trained work forces -- often by some form of craft apprenticeship -- performing customized services for premium prices.

However, as the examples of Hyatt Legal Services and TWA Getaway Vacations demonstrated in the last chapter, the

power of mass customization can still be brought to bear here. Fast food chains such as McDonald's are approaching mass customization from the other side: even though in a service industry, their food is essentially mass-produced.[132] Even so, they are able to maintain a high degree of menu variety that seems to be increasing every year. Burger King has even based its strategy on allowing some degree of customization of individual menu items (as witnessed by their advertising themes: "Have it your way!" and "Sometimes you've gotta' break the rules"). While this was standard operating procedure twenty-five years ago when the first fast-food restaurants were still craft-based, in the 1980s it was a "novel" idea.

Other industries are a hybrid somewhere between Craft and Mass Production. The home electronics industry has always had a proliferation of products with new features being added almost continually. But as discussed in Chapter 4, home electronics products are modular -- standardized around interfaces -- so that individuals can customize their own "entertainment center." In a fiercely competitive environment, precious few individual products have been able to move down very far along the experience curve before they have been changed or replaced. Companies in this industry,

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[132]James Teboul, "De Industrialise Service for Quality," *International Journal of Operations and Production Management*, 8:3, 1988, pp. 39-45.

while continually striving for efficiency and economies of scale, have had to be very responsive to customers and maintain very flexible production processes, gaining experience effects only over a series of enhanced products.

Some industries have viable, healthy products that have been unchanged for decades: Coca-Cola® (the original, Classic, formula, of course) and Ivory Soap™, for example. But even here the large, homogeneous markets these products used to serve no longer exist. Despite maintaining or gaining revenue over the years, both of these products have greatly reduced market shares due to the fragmenting of their markets. The soft drink market has been divided into an ever-increasing array of segments: diet-conscious (eg, sugar-free), health-conscious (eg, caffeine-free), even anti-health-conscious (eg, caffeine-rich brands like Jolt Cola), and so on. There are even more categories of soap.

One of the primary characteristics of these industries in recent times is market saturation: every purchase is a repeat purchase. To get customers to change brands requires differentiating a product from its competitors, which means increasing variety. There is more than just brand proliferation going on here. Campbell Soup, for example, is customizing soups for regions of the country, making soups spicier in the Southwest than with the very same brands sold

elsewhere in the country.[133] But there are individuals all over the country that like their food spicier than average; some day Campbell may figure out how to profitably reach them wherever they may be.

Finally, some industries are well on their way to making the paradigm shift -- or at least many of the companies competing in these industries are making the shift. With the development of the lean production system, for example, Japanese competitors in the automobile industry are able to increase variety, flexibility, and responsiveness *and* maintain significant cost and quality advantages.[134] In the steel industry, US mini-mills have won large market shares in much the same manner: variety, flexibility, and responsiveness.[135] Many of the large, mass-producing firms in these industries are still trying to figure out how to handle market saturation, how to recover from the latest economic shock, how to meet changing customer needs -- and especially what to do with this new form of competitor.

These are the companies most in need of the paradigm shift to Mass Customization.

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[133] "Marketing's New Look: Campbell leads a revolution in the way consumer products are sold", **Business Week**, January 26, 1987, pp. 64-69.

[134] Womack, Jones, and Roos, *op cit*, pp. 84-88.

[135] Piore and Sabel, *op cit*, pp. 208-211.

The Predictor: Market Turbulence

Whenever it has occurred, the transition from Mass Production to Mass Customization has left some companies unable or unwilling to effectively compete in the new environment. As discussed earlier, this is largely because Mass Production is indeed a *paradigm*; that is, it is a way of viewing the world that filters all information to either fit that world-view or be discarded as irrelevant.[136] People that hold to a particular paradigm have "informational blinders" on. They simply cannot comprehend new information that contradicts the paradigm until the preponderance of information is finally so great as to bring this world-view crashing down. By then, it is usually too late.

It is crucial for managers in individual companies to understand where their firms stand and exactly where their industry stands in this paradigm shift. Companies need a way of viewing their world that allows them to take off the blinders, remove the filters, and finally assimilate the available information into a meaningful, cogent, and independent view of the world. A tool for predicting the paradigm shift and its degree is therefore needed.

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[136] Barker, *op cit*, p. 42.

The basis of this tool becomes clear in re-examining the discussion in Chapter 3 on how the paradigm of Mass Production has broken down. The limiting factors in the Mass Production feedback loop are the primary points where this has happened. Once again, these are:

- Decreases in the levels of *input stability* that can be maintained
- *Changing needs and wants* of customers
- *Changing demographics* of customers
- *Saturation level* of a product within its marketplace
- *Economic cycles, shocks, and uncertainties* that affect the market
- *Technological shocks* that overthrow the current dominant design in the marketplace and replace it with another

All but the first of these are market-oriented; that is, they describe what happens in (or to) a firm's marketplace, causing great uncertainty or instability for the firm. Whereas companies can still exhibit some degree of control over input stability (eg, by vertically integrating or de-integrating, signing long-term contracts at set prices, etc), increasingly they can no longer control what happens in the marketplace as they could before. With the controlling focus of the paradigm "efficiency through

stability and control," companies that lose all stability and control over their markets can no longer maintain the efficiencies to produce low-cost products.

This, then, becomes the primary predictor of the paradigm shift from Mass Production to Mass Customization: the amount of *market turbulence* within the industry and firm. The greater the amount of market turbulence, the more likely the industry is moving towards Mass Customization, and the more likely the firm *has* to move in order to remain competitive.

"Market turbulence" is certainly an imprecise term, but is meant to connote the amount of instability, uncertainty, and lack of control present within a firm's marketplace. Think of the turbulence encountered flying in an airplane. It is up and down and side to side; it is uncertain and unpredictable. But most of all it is discomforting, and as a passenger, there is nothing you can do to make it better. Such is market turbulence.

In Table 5-1 a number of factors are proposed to describe where industries stand on the continuum between low and high market turbulence. By determining where their firms and industries lie in each of these factors, managers can determine the level of overall market turbulence their companies are encountering and the degree to which they must

Table 5-1. Market Turbulence Factors

Low Market Turbulence	High Market Turbulence
Demand Factors:	
Stable and predictable demand levels	Unstable and unpredictable demand levels
Necessities	Luxuries
Easily defined needs/wants	Uncertain needs/wants
Homogeneous desires	Heterogeneous desires
Slowly changing needs/wants	Quickly changing needs/wants
High price consciousness	Low price consciousness
Low quality consciousness	High quality consciousness
Low fashion/style consciousness	High fashion/style consciousness
Low levels of pre- and post-sale service	High levels of pre- and post-sale service
Structural Factors:	
Low buyer power	High buyer power
Independent of economic cycles	Dependent on economic cycles
Low competitive intensity	High competitive intensity
High price competition	High product differentiation
Low to medium levels of saturation	High saturation levels
Few substitutes	Many substitutes
Long, predictable product life cycles	Short, unpredictable product life cycles
Low rate of technological change	High rate of technological change

make the paradigm shift to Mass Customization.

It is therefore imperative to understand each of the factors of market turbulence and how they affect the amount of variety and customization in an industry. The factors are divided into two categories: demand factors and structural factors.

Demand Factors

Demand factors indicate the degree to which the *firm* can control, stabilize, and reduce uncertainty within its markets. The logic of why these factors predict the shift to variety and customization, along with some illustrations, is discussed below.

Stability and predictability of demand levels: Demand stability, meaning demand that grows steadily without unpredictable up or downswings, is a hallmark of the Mass Production paradigm (see Figure 3-1). It encourages and is encouraged by homogeneous markets, and as long as demand for a product is stable and predictable, then production levels, development cycles, and life cycles will all likewise be stable and predictable. On the other hand, when demand fragments -- creating new market segments -- and become

unpredictable, smooth production will be disturbed and economies of scale will deteriorate. As seen in Figure 3-3, demand fragmentation is a key characteristic of the Mass Customization paradigm.

For example, when demand for Chrysler's products was declining in the late 1970s, it created the concept of a minivan, which was so successful it destabilized demand for both station wagons and (full-sized) vans. This new market soon fragmented into "car-like minivans" (eg, the Dodge Colt Vista) and "van-like minivans" (eg, the Ford Aerostar), and in addition a new category of "tall cars" (eg, the Honda Civic Shuttle) formed.[137] The end result is much less demand stability for individual automobiles -- and much more variety available to consumers.

Basic necessities vs. complete luxuries: Products that fill basic needs (commodities in particular) are much more likely to be standardized than are luxuries, which by their nature tend to be more distinctive, higher-priced, and more customized. For example, there is much more variety and customization available in most four-star restaurants than in most fast-food outlets. Basic clothing needs are met

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[137]For a complete description of this fragmentation example, see Antony M. Sheriff, **Product Development in the Automobile Industry: Corporate Strategies and Project Performance** (unpublished Master's thesis, Massachusetts Institute of Technology, May 1988), pp. 8-10.

"off-the-rack", while at the luxury end suits and gowns may be tailor-made and/or fitted.

Easily defined vs. uncertain customer needs/wants: If customer needs and wants are uncertain, then it is difficult to provide them with a single product that meets their needs. It is more likely that a number of different products will be created (often by a number of firms) to try to find pockets of needs within the market and more fully determine those needs.

Uncertainty of customer needs is the common situation in new markets, resulting in what William Abernathy and James Utterback have called a "fluid pattern of innovation" that leads to diverse product variety.[138] For example, Japanese companies, especially those in the rapidly-changing consumer electronics field such as Sony, will often create a proliferation of products in a new market segment (both at one time and by rapidly developing replacement products) because they do not know exactly what the market will respond to.[139] The historical pattern identified by Abernathy and Utterback, shown in Table 5-2, is that

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[138]William J. Abernathy and James M. Utterback, "Patterns of Industrial Innovation," *Technology Review* 80, 7 (June-July, 1978), pp. 40-47.

[139]Jacob M. Schlesinger, "Japanese Get First Crack at New Gadgets as Firms Use Local Stores to Test Demand", *The Wall Street Journal*, December 3, 1990, pp. B1 and B7.

Table 5-2. Patterns of Industrial Innovation

	Fluid Pattern	Transitional Pattern	Specific Pattern
Competitive emphasis on:	Functional product performance	Product variation	Cost reduction
Predominant type of innovation:	Frequent major changes in products	Major process changes required by rising volume	Incremental for product and process, with cumulative improvement in productivity and quality
Product line:	Diverse, often including custom designs	Includes at least one product design stable enough to have significant production volume	Mostly undifferentiated standard products
Production processes:	Flexible and inefficient; major changes easily accommodated	Becoming more rigid, with changes occurring in major steps	Efficient, capital-intensive, and rigid; cost of change is high

Source: Adapted from William J. Abernathy and James M. Utterback, "Patterns of Industrial Innovation," *Technology Review* 80, 7 (June-July, 1978), p. 40.

product/markets move from this fluid pattern of innovation, characterized by a diversity of products, to a transitional pattern where a dominant design begins to emerge, and finally to a specific pattern of incremental innovation where products are mass-produced. The breakdown of the Mass Production paradigm in many industries, however, has also broken this pattern, resulting in what Abernathy has

elsewhere called "de-maturity", a move away from certainty of needs and standardization to uncertainty of needs and product innovation and proliferation.[140] Wherever there is uncertainty of what exactly customers want, there will tend to be a greater variety of products available.

Homogeneous vs. heterogeneous demand: This category directly gets at a key difference between the two paradigms of production: a company operating under Mass Production requires its customers to have basically the same desires so they can be filled by standard products, while those under Mass Customization revel in differences in demand that can be met with greater product variety and customization.

Rate of change in customers needs/wants: If customer needs are fragmented but evolve very slowly, it may be possible for mass producers to continue along with the system of standardized products, long product life cycles and development cycles, and lower but real economies of scale. If, however, customer needs and wants change quickly and constantly, this system will break down: life cycles shorten, followed by development cycles (if, that is, the

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[140]Abernathy, Clark, and Kantrow, *op cit*, pp. 15-29 in particular. For a discussion by Utterback of how the Japanese have been very successful at entering an industry after a dominant design has emerged (which was previously unheard of) through continual product innovation, see Utterback and Suárez, *op cit*, pp. 29-35 in particular.

company is to keep up with changing demand), and economies of scale diminish drastically as retooling becomes more frequent and total volume decreases. Companies that do keep up with demand, that shorten their development cycles, and that figure out how to reduce retooling and changeover costs to maintain economies of scale are finding their way to Mass Customization.

This process can be seen in the women's apparel industry, which used to be based on a two-season cycle: summer and winter. As consumers became more fashion-conscious, spent more money on clothing, and maintained a higher level of "inventory" in their closets, their needs and wants began to more quickly evolve. The apparel and retail industry responded by instituting spring and fall lines, and more recently have added even more seasons, so that new lines of clothing are produced six, seven, and even eight times during the year. Some companies that have discovered the new paradigm, such as The Limited, gauge what is selling and what is not during the first week or two of each new season and then change the production schedules of their suppliers to meet the evolving desires of their customers.[141]

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[141]See Jeremy Main, "The Winning Organization," *Fortune*, September 26, 1988, pp. 27-28, and Stalk and Hout, *op cit*, p. 109.

Price consciousness: The more price conscious customers are, the more willing they will be to accept standardized goods. The less price conscious they are, the more important other differentiating factors -- such as quality, fashion, and service, which are separately discussed below -- become and the more likely customers would pay for some level of customization. As the competitive environment moves from one based on the price competition of standardized goods to these other factors, the more turbulent that environment becomes.

Quality consciousness: As alluded to above, higher levels of quality desired by customers increase the demands placed on firms in order to be able to compete. Quality itself can become a dimension along which variety is increased, and it also can allow customers who formerly viewed a type of product as a standardized good (to be bought solely on price) to see how much more it can be. Meeting these new desires moves firms towards providing more variety and customization.

Fashion/style consciousness: The same circumstances that apply to quality apply to fashion and style. In addition, there are few things that can increase variety in an industry more than trying to meet the changing desires of a customer base intent on following the latest fashions. That

is certainly why the apparel industry has so much more variety than any other, why customized goods that no other individual owns (or at least no on else in the consumer's circle of friends) are held in such high regard by consumers.

This is an important factor in many other industries as well. For example, there was traditionally a great amount of variety in watches, which were predominantly made by craft producers in Switzerland. With the advent of digital quartz technology in 1968, however, mass production techniques were introduced to the watch industry by Hamilton and Texas Instruments in the United States. Watch production was soon dominated by Japanese firms (primarily Seiko, Citizen, and Casio), who made no more than a dozen brands in the 1970s and many less models than had been prevalent in previous decades. The number of models increased greatly in the 1980s, however, as prices decreased and features increased (both due to the underlying digital technology); watch buyers became increasingly fashion-conscious, often owning more than one watch and using it as an accessory that happened to also tell time.[142] As discussed in Chapter 4,

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[142]Pinson, *op cit*. Interestingly, the Swiss watch industry was devastated by a classic paradigm shift. It was the Swiss who invented digital quartz technology in 1967, but within their paradigm of watchmaking, it wasn't really a watch unless it had gears, springs, and jewelled bearings (Barker, *op cit*, pp. 57-60). As a result, the digital watch (continued...)

this trend was spotted and accelerated by ETA S.A., whose Swatch brand watches are mass customized.

In addition to fashion consciousness leading directly to more variety in this manner, it also penalizes Mass Production firms because of their inherent inflexibility to changes in demand. It is axiomatic that what comes into fashion can also go out of fashion. Those firms that are flexible enough to quickly change designs and production have a distinct advantage over those that cannot.

Level of pre- and post-sale service: The level of service demanded by customers is directly related to how much customization they desire, as service is inherently customized to what the buyer needs at the time. Producers and marketers of standardized goods can still differentiate them by the amount and type of service provided. For example, in the computer industry, most hardware system models sold by any particular manufacturer are fairly standard; the primary differences in what customers receive are gradations of features like processor speed and the amount of memory or disk space. However, each system is

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[142](...continued)
was first marketed and mass-produced not by the Swiss but by American firms, with dominant production soon moving to Japan and then on to Hong Kong. Because of their inability to recognize this paradigm shift, the Swiss craft producers watched their share of world production go from 80% in 1948 to just 13% in 1985 (Pinson, p. 3).

customized by the software, the number and type of terminals, how it is set up and used, and a host of other factors. This customization is a pre-sale service; the ongoing (post-sale) adjustment and maintenance of the system is necessarily customized to the extent the system is.

As can be seen from this discussion, the demand factors listed in Table 5-1 help determine how turbulent a company's market is, and therefore will tend to indicate how much variety and customization they will need to provide. It is important to note that many of these factors can in fact be manipulated by the firm. For example, a firm could retreat from the more turbulent segments in which it competes in order to stabilize demand and be able to more easily determine customer needs;[143] or it could ignore substitutes or label them "inferior" or "noncompetitive" when in fact they may be gaining market share.[144] While

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[143]As just one example, for a description of how segment retreat in the face of Japanese competition caused the British motorcycle industry to continue believing it was profitable and viable until it was finally overwhelmed, see The Boston Consulting Group Limited, **Strategy Alternatives for the British Motorcycle Industry: A Report Prepared for the Secretary of State for Industry** (London: Her Majesty's Stationery Office, 1975).

[144]Hertz Rent-a-car, for example, maintained at one point that it was gaining market share in the car rental business, when in fact it was quickly losing share to off-airport competitors like Enterprise Leasing. Hertz simply did not count off-airport rentals as part of the same

(continued...)

this is to some degree a natural and expected thing to do from their perspective, manipulating these factors becomes very insidious to the extent that it hides the fundamental paradigm shift from being seen within the firm. While factor manipulation can delay the effects of the paradigm shift, it cannot forestall them forever. Companies that recognize the paradigm shift will not so much manipulate the market to regain stability as revel in its uncertainties to gain significant advantages over competitors still stuck within the old paradigm.

Structural Factors

Structural factors reflect the basic nature of the industry itself and are therefore less manipulatable by individual firms. They may be manipulated, however, by larger entities such as trade associations and governments. But this, too, is a dangerous thing to do that will likely have the effect of decreasing the competitiveness of firms within the industry, making them even more vulnerable to the shift in paradigms when its full effects eventually arrive.[145]

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[144](...continued)
business it was in, even though airline passengers were using them.

[145] Protectionism, for example, can indeed protect industries from foreign competition, increasing industry and (continued...)

The logic of why each of the structural factors[146] listed in Table 5-1 predicts the shift to variety and customization, along with appropriate illustrations, is discussed below.

Buyer power: The more power and leverage buyers have in an industry the less companies can control their environment. When it is the firms that hold all of the advantages (eg, where there are a few, large firms and many, small buyers such as in utilities), they will tend to standardize products, increase economies of scale, and maintain higher margins (or, as in utilities, be regulated down to a "reasonable rate of return"). In other words, they will tend to become typical mass-producing companies.

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[145](...continued)
firm stability and profits. To the extent that it decreases competition, however, it also has the tendency to decrease competitiveness. It seems that when American firms have been protected from foreign competition they use it primarily to increase domestic profits. While Japanese firms may be among the most protected, the Japanese government seems particularly adept at heightening competition among domestic firms. The industry and government together channel the protectionism and competition into highly competitive foreign exports. American inability to do this appears to be both the fault of management and government. For supporting themes, see, Chalmers Johnson, "How to think about economic competition from Japan," **Journal of Japanese Studies**, 13-2, 1987, pp. 415-427; and Michael E. Porter, **The Competitive Advantage of Nations** (New York: The Free Press, 1990).

[146]Many of the structural factors are directly related to Porter's concept of industry structure and dynamics as given in **Competitive Strategy: Techniques for Analyzing Industries and Competitors** (New York: The Free Press, 1980).

Significant buyer power, however, decreases the chances that the Mass Production system will work because companies lose control and have to respond more to what their customers need and want. This will usually result in significant price competition -- if that is what the buyers most desire -- but will also result in more variety and customization as firms attempt to differentiate their products -- especially where the buyers value variety and customization at least as much as price. This is the case in a great number of consumer markets where "the customer is king" and can easily switch among competing brands, such as toiletries. The articles that are not valued very highly by consumers (such as toilet paper) will tend to be characterized by price competition and less by product differentiation, while those articles more highly regarded by consumers (such as shampoo) will tend to be characterized by both price competition and product proliferation.

There is one seeming exception to high buyer power leading to more variety: the case of standards. When firms hold the power they will tend to differentiate their products in such a way to "lock in" their customers with high switching costs, making it difficult for them to change brands. This is particularly troublesome to customers when a number of products are interrelated within a system, such as plumbing or wiring within buildings or computer systems within

networks. These kinds of products simply have to fit or work together for the system as a whole to work. Therefore, as customers gain power they can demand that standards be created and enforced to their benefit, with a corresponding loss in variety.

However, this often just leads to change in the locus of differentiation: manufacturers differentiate their products along new dimensions to re-create high switching costs, and new companies use the standards as a way to enter the field of competition with instant credibility. For example, as customers in the computer industry gained power in the 1980s many began to demand that the UNIX™ operating system[147] be made a standard. This has been very successful, with a loss of variety as some proprietary operating systems have essentially "gone out of business". However, no two UNIXes are alike as manufacturers have differentiated them with features and services to make their offerings more attractive. More importantly, a host of start-ups have used the UNIX standard as an easy way to enter the computer systems business, and a host of applications have appeared for UNIX. So, with the operating system standard, the locus of variety changed to system hardware and to application software and services.

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[147]UNIX™ is a trademark of American Telephone & Telegraph.

This is not an isolated example. The same thing has happened with the DOS operating system standard for personal computers, the VHS video cassette standard, and on the low-tech side, plumbing fixtures.

Degree of influence of economic cycles: The degree to which firm and industry sales are influenced by economic cycles of recession, recovery, and expansion also indicates how much control individual firms have over their market environments. As discussed in Chapter 3, when these firms lose their ability to control and stabilize their demand, they can no longer maintain the system of Mass Production. Further, economic or other external shocks that localize and intensify recessionary impacts to particular industries can have tremendous destabilizing effects. Piore and Sabel, in fact, trace the breakdown of the Mass Production paradigm in large measure to five external shocks to the system over the last twenty-five years: the social unrest of the late 1960s and early '70s, the international movement to floating exchange rates in 1971, the two oil shocks of 1973 and 1979, and the worldwide economic recession of 1980-82.[148] These events penalized mass producers by creating tremendous uncertainty, destabilizing both their demand and their production inputs, and greatly increasing their costs. At the same time these events *rewarded* those companies that

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[148]Piore and Sabel, *op cit*, pp. 165-183.

were flexible enough to handle the uncertainty and provide the variety of products that would see them through the crises.

Competitive intensity: How many competitors exist in an industry, how strongly they compete, and the extent to which they battle for market share can have a great impact on where the industry stands in the paradigm shift from Mass Production to Mass Customization. Companies within an industry that maintains a "club" atmosphere -- everyone is relatively happy with their position or afraid to rock the boat -- have little incentive to innovate and create a proliferation of products. They have the stability so necessary for mass production. In the United States, the automobile and oil industries used to be this way before the onslaught of global competition, and the trucking industry was this way before deregulation in the late '70s and early '80s. High competitive intensity, on the other hand, can result in (as well as be caused by!) uncertain demand, the need to differentiate, and the search for niches to fill -- all signs of market turbulence and the breakdown of the Mass Production system.

Price competition versus product differentiation: As discussed earlier in this chapter, price consciousness among customers and high buyer leverage both lead to high market

turbulence and increased variety. However, if companies in an industry are forced to respond to these forces by pure price competition, there will in fact be little variety and customization in that industry. This is the case of any number of commodity products, from wheat to copper to toothpicks. Customers will pay nothing extra for differentiation, buying only from the lowest-priced producer they have easy access to. Obviously, the extent to which firms can respond with product differentiation strategies will increase the amount of variety and customization in the industry.

Level of saturation: This factor is very important; saturating a market brings an immediate end to the positive feedback in the system of Mass Production (see Figure 3-2). It is no coincidence that the 1960s and '70s, when the system began to break down, saw many consumer durables reaching their saturation points. By 1970, refrigerators, television sets, radios, and electric irons had all reached 99 percent of US households; washing machines, toasters, and vacuum cleaners were all over 90 percent; and by 1979 there was one car for every two people in the United States.[149]

Note that movement from low to medium levels of saturation would by itself have little effect on variety and

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[149]Piore and Sabel, *op cit*, p. 184.

customization; it is the movement to high levels that limit growth and thereby cause the breakdown of the Mass Production system. Companies that still want to grow in a saturated market can do any (or all) of five possibilities:

1. Invade foreign markets with current products.
2. Create alternative uses for current products to "break through" a natural saturation limit.
3. Create extended products for alternative uses.
4. Increase the rate of innovation to decrease the time to replacement.[150]
5. More closely meet customer needs -- meaning increase the amount of variety or customization -- to gain a larger share of the new and replacement sales.

Each one of these inherently increases variety -- either in the current, alternative, or foreign market. The order of the five alternatives also traces the paradigm shift: the first two or three are the only responses of those still stuck within the paradigm of Mass Production; the addition of the last two or three show the responses of a company making the shift to Mass Customization. One such company is Mars, maker of M & M's and other candies. Precisely because they hit a saturation level in candy consumption in the late

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[150]Decreasing product reliability to decrease time to replacement ("planned obsolescence") is another alternative that merits no further discussion.

'80s (at about 19 pounds per year per person), Mars greatly increased the amount of variety in their products, introducing more new products in 1990 than in all of the previous 25 years. The new products even tended to be customized versions of older products, such as Peanut Butter Snickers and Milky Way Dark.[151]

Vulnerability to substitute products: The logic here is simply that the more vulnerable a firm's products are to being replaced by substitutes, the more time it is going to spend on exactly meeting its customers' needs and therefore the more variety and customization that ensues. Investing with securities brokers, for example, used to be one of the few ways that people could invest their money for high returns. Over the last twenty years a number of substitute products to securities have become increasingly important, including real estate, money market funds, and insurance. Similarly, investing in securities, real estate, and money market funds has become a substitute for "whole" or "universal" life insurance policies. Each of these different types of products has seen a staggering amount of variety as a result.

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[151]Jennifer Pellet, "A Surge in New Candy Products," *Discount Merchandiser*, Volume 30 Number 9, September 1990, pp. 56-59.

Product life cycle length and predictability: As seen in Chapter Three, long and predictable product life cycles (defined as the time from the first shipment of a product to its replacement or withdrawal[152]) are an integral part of the Mass Production system. They reinforce and are reinforced by stable demand and homogeneous markets. By the same token, decreasing product life cycles, particularly if they become unpredictable, indicate the reversal of the system and a move toward Mass Customization.

Rate of product technology change: One of the primary reasons why product life cycles are decreasing in many industries is that the rate of change in product technology is increasing. This is to some degree the natural consequences of growth in any economy: as the economy grows, more dollars are put into product research and development (even at stable or slightly declining rates of R & D to sales for the average firm). This increases the amount of product technology becoming available, although not necessarily its rate of change. But, increased dollars are also put into the research and development of *process* technologies and into the increased applications of capital that allow new products to be developed more quickly and

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[152]In particular, I am not using the term "product life cycle" in the sense of the cycle that entire classes of products go through: introduction, growth, maturity, and decline.

manufactured more productively. These factors together increase the *rate* of product technology change.

In 1970, Alvin Toffler published the book **Future Shock** in which he described how very great the rate of technological change had become.[153] Since that time the rate has only accelerated, with the still growing application of information technology to research, development, and production in the last twenty years being the most significant trend that has intensified the rate of technological change.[154] Those industries that have seen this rate increase the most will tend to be those industries that have been unable to maintain the system of Mass Production.

Market Turbulence and the Degree of Paradigm Shift

The preceding discussion demonstrating how each of the demand and structural factors of market turbulence can lead to increased variety and customization was somewhat simplified to make it easier to explain each environmental factor. In reality, a high degree of any single factor would

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[153]Toffler, *op cit*, pp. 20-34 in particular.

[154]See Tjerk Huppes, **The Western Edge: Work and Management in the Information Age** (Boston: Kluwer Academic Publishers, 1987).

rarely by itself denote the paradigm shift to Mass Customization. What matters most is the *overall level of market turbulence* as defined by the total set of environmental factors and *how fast the set as a whole is changing from low to high levels of turbulence* over time.

Managers can use the set of factors to map where their firm stands today in overall market turbulence, where it stood in the past, and where they expect it to go in the future.

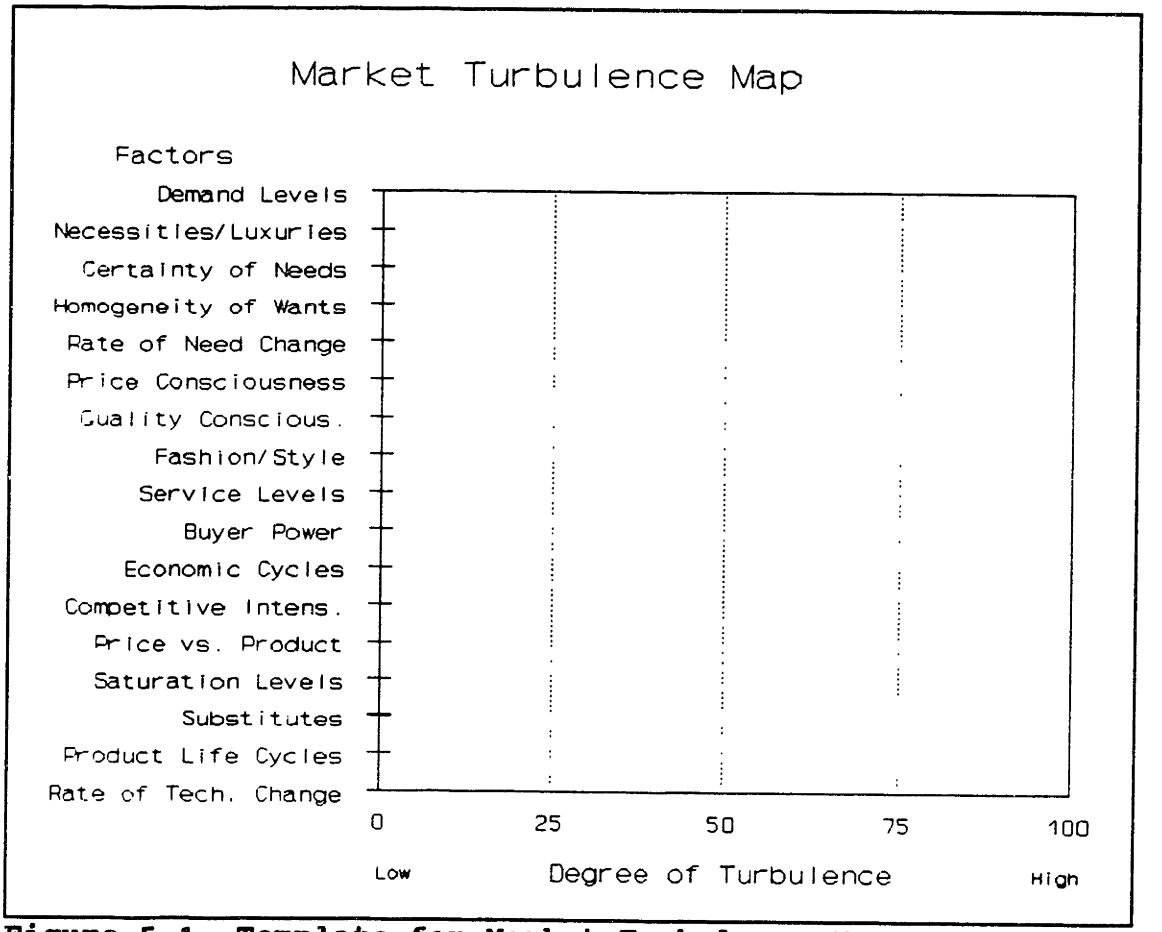


Figure 5-1. Template for Market Turbulence Map

Figure 5-1 provides a template for this *Market Turbulence Map* that, it is proposed, can be used as a tool to predict the paradigm shift. For ease of use, the continuum between very low and very high market turbulence is placed on a scale between 0 and 100.

The actual Market Turbulence Map for one large, high-technology company -- the same company whose Product Customization Profile was given in Figure 4-1 -- that is today undergoing this shift is shown in Figure 5-2 for 1980 and 1991. The need for the paradigm shift is demonstrated by the high degree of overall market turbulence in 1991 as well as the increased turbulence over time. The average factor in 1991 has a turbulence of 61 on the 100-point scale, an increase of 50 percent since 1980.

Of course, the responses of individual firms can differ dramatically. Instead of going with the paradigm shift to Mass Customization, firms can try to manage within the paradigm of Mass Production by focusing on fewer products, retreating from the more turbulent segments of the market, serving the increasingly smaller group of homogeneous customers, and so on. Market turbulence can predict the *need* for the paradigm shift and in general can predict that an industry is moving towards higher levels of variety and customization, but it cannot predict whether or not any

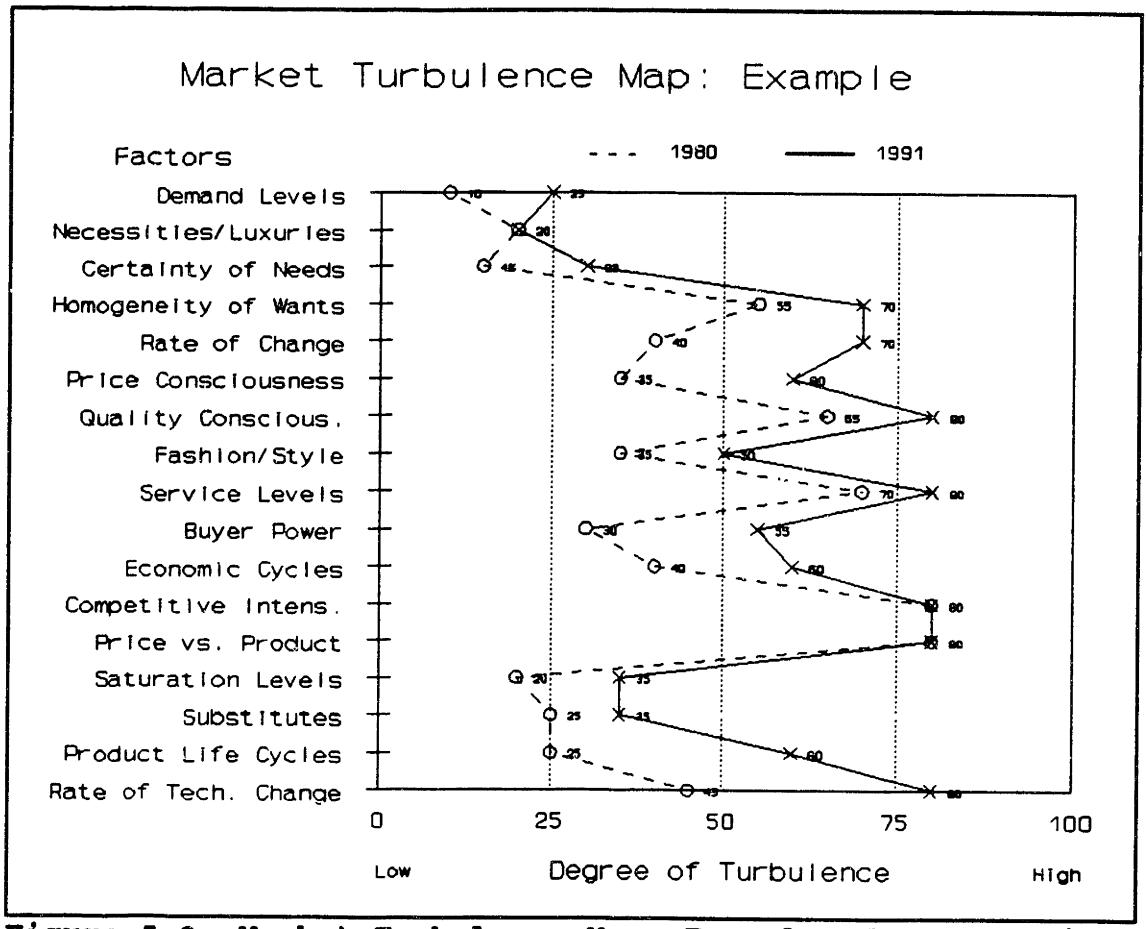


Figure 5-2. Market Turbulence Map: Example of Large, High-Technology Company

particular firm is actually doing it.

Demonstrating that market turbulence can indeed predict the paradigm shift from Mass Production to Mass Customization through empirical data is the subject of the next chapter.

Chapter 6

Validating Market Turbulence as the Predictor of the Paradigm Shift

To validate that market turbulence can indeed predict the paradigm shift from Mass Production to Mass Customization, a survey instrument was devised where the degree of correlation between the market environment factors given in Chapter 5 and the amount of variety and customization present in companies' products could be determined. The primary hypothesis to be tested is that firms with higher levels of market turbulence and with greater changes in their turbulence will tend to have higher amounts of product variety and higher levels of customization.

The final version of the survey designed to test this hypothesis can be found in Appendix A. More detailed results and analysis of individual factors and additional data not related to the primary hypothesis is provided in Appendix B. *For those readers who do not wish to delve into the statistically-oriented results and analysis included in this chapter and in Appendix B*, browsing through the chapter by reviewing each of the figures will give a good sense of the analysis presented. In addition, a summary is provided at the end of this chapter, beginning on page 206.

Survey Design

Prior to finalizing, a draft survey was pre-tested with five individuals and additional comments on design and wording were gathered from several professors. The resulting survey consisted of four parts. Part One asked demographic information about the respondents' companies and business units so they could be grouped together. Part Two asked about each of the 17 market environment factors and how they had changed in the last decade. Part Three, comprised of 16 questions, inquired about the products of the business units, including how much variety and customization were present and had increased over the last decade. Finally, Part Four asked 6 questions about the business units' processes and organization.

Each Part is discussed in more detail below. Please note that questions will be referenced by both the Part of the survey and the number within that Part, such as Question 2-1 for the first question in Part Two.

Part One: Demographic Information

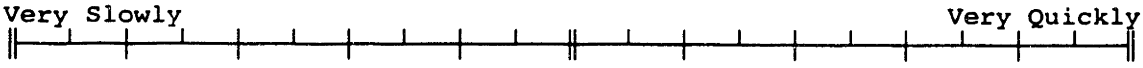
As mentioned above, respondents were asked to identify the business unit of their company that they were most familiar with, which became the unit of analysis for the survey. For

many respondents, this was the entire company. The respondents were asked to state the primary business of their companies and business units so they could be grouped according to their Standard Industrial Classification (SIC) codes.[155] The survey also asked the size in revenue and employees for both the companies and the business units.

Part Two: Market Environment Perceptions

For each of the individual market environment factors discussed in Chapter 4, the survey asked respondents to indicate (with an 'X') where their business unit stood today on a scale between two defined endpoints that described low and high market turbulence. For example, for the fifth factor, the rate of change in customer needs and wants, Question 2.5 asked:

5. At what rate are the needs and wants of your customers changing?



After responses for all 17 factors were given, the respondents were then asked to think back across the last decade or so to 1980 and the changes, if any, that had happened in their business units' market environment. Then, they were asked to go back to the set of 17 questions and

[155]**Standard Industrial Classification Manual**, *op cit.*

indicate (with an 'O') their perceptions of their business units' market environments in 1980.

A decade was used to measure the change in market turbulence to avoid the "boiling frog phenomenon", where small changes accumulated over time into large changes go unnoticed. The timeframe needed to be long enough that distinct differences in the market environment factors would be discerned.

For each of the responses in 1991 and 1980, numerical values between 0 (on the far left) and 100 (on the far right) were determined. In this way, the level of market turbulence in 1980, in 1991, and its degree of change between the two timeframes could be ascertained for each of the individual factors and for the 17 averaged together. This information could then be graphed in the Market Turbulence Map as defined in Chapter 5, an example of which was seen in Figure 5-2 (page 148) for one large, high-technology company.[156] Note that many respondents did not answer the questions for 1980, and selective "blanks" were not infrequent for individual questions.

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[156]Managers who use the Market Turbulence Map for understanding their business unit's own market environments would be wise also to project the degree of turbulence in the future. This was not asked of the survey respondents, as it would have made an already long survey too long.

A 100-point scale was used throughout the survey instead of the normal 5- or 7-point scales to provide the respondents with an opportunity for finer gradations of differences. It was felt that the normal scales would not show sufficient differences between the two timeframes, or across factors. The respondents could view the response line visually and place their marks in line with their perceptions, as opposed to any exact analytical determination between 0 and 100 that would be impossible to know. This appeared to work well, as no comments were returned indicating any difficulty with the method.[157]

At the end of each section of the questionnaire are a few open-ended questions to give the respondent the opportunity to provide more detail on his particular circumstances. In Part Two, the first open-ended question asks what the most profound changes in the business unit's market environment have been since 1980. The second asks for the respondent's opinion of the causes behind these changes. The third open-ended question asks directly whether or not the business

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[157]Some respondents placed their marks only on the vertical bars, others only between the bars (except for the 50-point mark), while others used the full range of numerical possibilities. For those respondents that only used the spaces between the bars, each space was assumed to be at a 5-point level, as the respondents obviously did not intend any greater level of precision than that. The first space was assumed to indicate a 0 and the last space a 100, with 50 indicated by a mark right on the double-vertical line in the middle (which was not an uncommon occurrence amidst every other mark being in a space between the lines).

unit's customers are demanding more variety or customization since 1980, and, if so, why.

Part Three: Product Perceptions[158]

The key questions in Part Three represented different ways of ascertaining the amount of variety and customization present in the business units. Questions 3-1 and 3-12 asked how the amount of variety and level of customization, respectively, in the business units' products today relative to 1980. Questions 3-2 and 3-13 asked whether the business units planned on providing more or less variety and customization, respectively, in the future. (Note that Questions 3-12 and 3-13 were generally not answered by those whose business units had little or no customization in their products.) Finally, Question 3-10 asked the extent to which the products were *customized* today to individual customers and Question 3-11 the extent to which the products were *customizable* today by individual customers (or others outside of the business unit who assisted end customers). Each question used the same 100-point scale as those in Part Two. For example:

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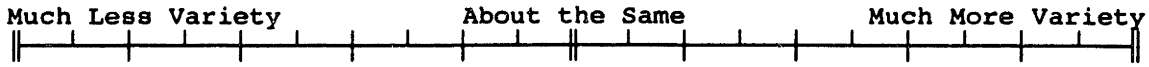
[158]While the survey used words like "product" and "production" throughout, respondents from service companies were asked to translate "product" into "service", and so on. A handful of respondents indicated that the wording was inappropriate for them, most of whom were either consultants or in the defense industry.

1. How does the amount of variety in your business unit's products today compare with 1980?



Together, these six questions provide a profile of the amount of product variety and customization in the business units' past, present, and future. This *Variety & Customization Profile* can be graphed to visually show the level of variety and customization, as seen in Figure 6-1 for the same company whose Market Turbulence Map was given in Figure 5-2 (page 148), and whose Product Customization Profile was given in Figure 4-1 (page 99).

As this Map shows, this business unit has greatly increased the amount of variety and customization present in its products during the 1980s, and plans to continue to do so in the future.

Questions 3-3 through 3-9 were designed to determine how much each of the following additional issues, which follow the paradigm of Mass Customization given in Chapter 3, correlated to greater market turbulence and increased variety and customization:

- Length of product life cycles, today compared to 1980. In addition to the 100-point scale, respondents were asked for the actual lengths of their product life cycles for the two timeframes.
- Quality of products, relative to 1980.

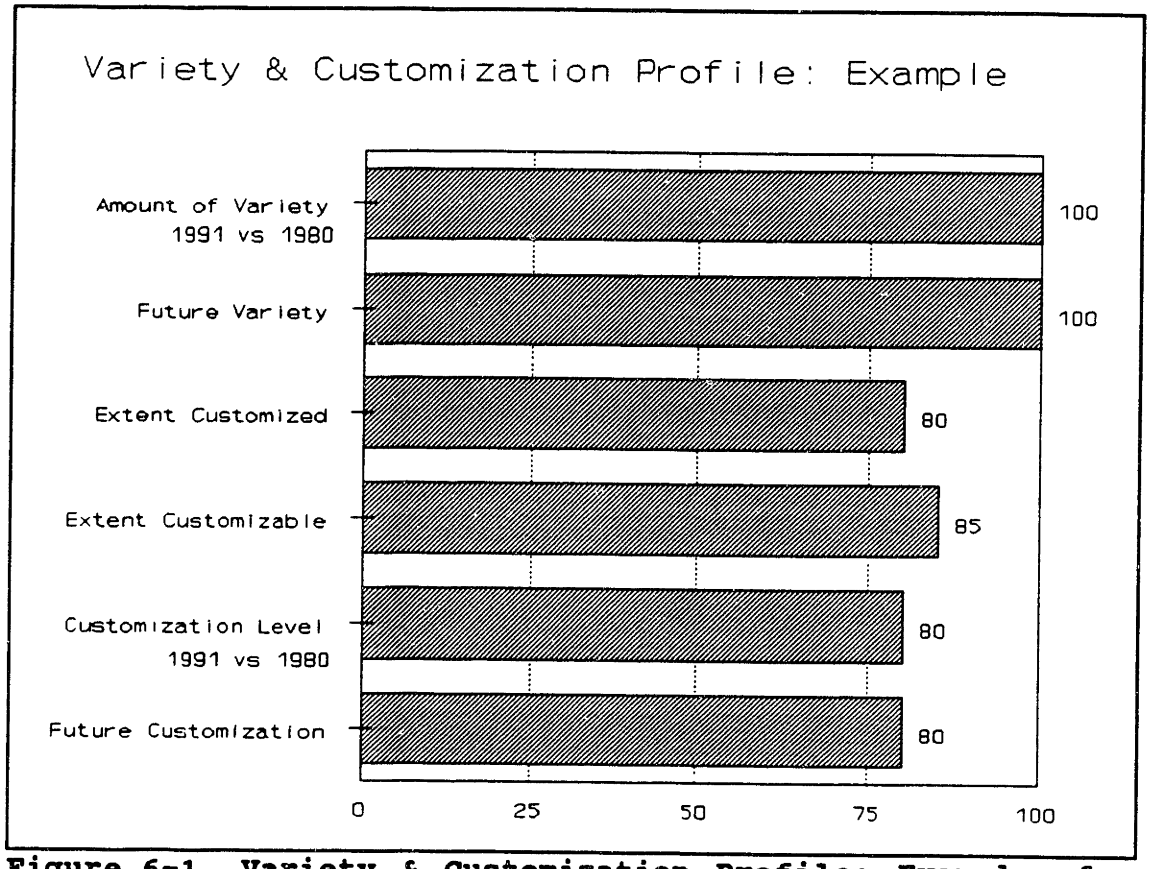


Figure 6-1. Variety & Customization Profile: Example of a Large, High-Technology Company

- Manufacturing/production costs, relative to 1980.
- Meeting customer's complete needs and wants, relative to 1980.
- Importance of responding quickly to changes in demand with new or modified products, relative to 1980.
- Importance today of product innovations to the success of the business unit.
- Importance today of incremental versus breakthrough innovations to the success of the business unit.

The results and analysis of these additional questions can be found in Appendix B.

Finally, Questions 3-14 through 3-16 complete the Product Customization Profile, described in Chapter 4 (page 98), that examines how the business unit has designed its products for customization. This Profile begins with Questions 3-10 and 3-11 on the extent to which products are customized and customizable today. Then, Question 3-14 places the products on a continuum between completely "closed customization" and completely "open customization". Question 3-15 places the products on a scale between "continuous customization" and "discontinuous customization". Lastly, Question 3-16 provides a scale that moves from "same-use customization" through "modified-use customization" to "different-use customization".

Part Three ends with two open-ended questions that ask those whose business unit is indeed providing more variety or customization in its products since 1980 first why and then how far the respondent thinks the trend will go.

Part Four: Process and Organization Perceptions

Question 4-1 asks respondents to place their business units' production process on a scale from one-of-a-kind manufacturing to full mass production. This will provide additional demographic information to understand the survey sample. Question 4-2 asks how the production process

compares to 1980 and Question 4-3 asks if the process will change along this scale in the future.

Question 4-4 inquires as to how much more or less flexibility exists in the production process today as compared to 1980. The length of product development cycles, relative to 1980, is requested in Question 4-5. Just like the question in Part Three on life cycles, respondents were asked for the actual lengths of their product development cycles for the two timeframes. Finally, Question 4-6 asks to what extent the structure of the business unit's organization and its processes have changed since 1980. The analysis of these additional process and organization questions is provided in Appendix B.

Part Four and the survey close with two open-ended questions asking for further information on how the business unit's processes and organization have changed to provide more variety or customization, if that has occurred.

Survey Participants

A total of 97 surveys were mailed to executives in companies that, based on research or first-hand knowledge, were thought to be undergoing a change in market turbulence or in

product variety or customization. In the great majority of the cases, the change was towards greater turbulence, variety, or customization; in some cases, however, the change was decidedly in the other direction. Since the intent of the survey is to determine if increased market turbulence correlates with (and causes) increased variety and customization -- and not to just see if increased turbulence exists -- targeting companies in this way should not significantly bias the results.

Some surveys were sent to individuals within different business units of the same company to gather broader information about large companies, and an attempt was made to gather information from a number of companies in the information technology, automotive, and telecommunications industries to understand the extent of the paradigm shift (if any) in these particular industries.

To encourage participation, more than half of these individuals were contacted beforehand by telephone, most of whom personally agreed to respond to the survey. The proper level of expectation on survey length was set during this conversation and to everyone in the cover letter.[159] A

[159]A few executives indicated they felt the survey was too long. On the other hand, the chairman of one company spent two and a half hours responding to the survey because he felt it was extremely useful in thinking about his company and its marketplace.

self-addressed, stamped envelope was also included with the survey to encourage a high level of response.

To increase the breadth of the survey across a number of industries and to ensure enough responses to fully validate the market turbulence hypothesis, a second set of mailings was made. This second group were all graduates of the Sloan School of Management at the Massachusetts Institute of Technology. Mailing lists were obtained from the MIT Alumni Association for samples of graduates of the Management of Technology Program, the Sloan Fellows Program, and the two-year Master's Program. From these lists a total of 930 surveys were mailed, with attempts made to avoid retirees and recent Master's graduates (who were probably not in industry in 1980). To encourage participation, the cover letter sent to these individuals set the proper level of expectation on the time it would take to complete the survey, requested a response due to the Sloan School connection, and included a self-addressed, stamped envelope.

As shown in Table 6-1, despite the survey's length the participation rate was quite high. Over 50% of the "researched" group and over 20% of the Sloan group responded. The total participation rate was approximately 25%. In addition, over 40 people wrote back to indicate that they were unable to complete the survey, usually because

Table 6-1. Survey Participation Rates

	# Mailed	# Responses	Participation Rate
Researched Group	97	50	51.5%
Sloan Group	930	205	22.0%
Total	1027	255	24.8%

they had retired or worked for a company that they felt was, unfortunately, not really suitable to the survey's questions.

Survey Results and Analysis

This section analyzes the results of the survey. First, the demographics of the survey population are discussed. Then, the validation of the market turbulence hypothesis is examined across all of the survey participants. Further analysis is performed for a number of different industry groups that had twenty or more responses. As mentioned above, investigations into correlations of individual market environment factors and the results of additional information gathered by the survey but ancillary to the main hypothesis are given and discussed in Appendix B. Note that many of the respondents did not answer all of the questions. Each piece of analysis takes into account as many responses as possible.

Participant Demographics

The 255 surveys represented 227 business units within 164 companies. Table 6-2 gives the distribution of the size of the companies in revenue and number of employees. Table 6-3 provides the same information for the business units represented in the survey. The survey was heavily weighted

Table 6-2. Distribution of Company Size

Size in Revenue	# Companies		Size in Employees	# Companies	
< $5 million	28	11%	< 50	30	12%
$5m - $50m	18	7%	50 - 500	26	10%
$50m - $500m	42	17%	500 - 5,000	42	17%
> $500 million	164	64%	> 5,000	154	60%
Not given	3	1%	Not given	3	1%

Table 6-3. Distribution of Business Unit Size

Size in Revenue	# Business Units		Size in Employees	# Business Units	
< $5 million	39	15%	< 50	39	15%
$5m - $50m	30	12%	50 - 500	46	18%
$50m - $500m	68	27%	500 - 5,000	76	30%
> $500 million	116	46%	> 5,000	92	36%
Not given	2	<1%	Not given	2	<1%

towards large companies, with over 60% of the responses, but was somewhat more evenly weighted across business units.

Table 6-4 gives the number of business units from each industry division, as defined by the **Standard Industrial Classification Manual.**[160] Every division was represented in the survey except for agriculture, forestry, and fishing. A majority (55%) of the participants came from manufacturing business units, with 35% from all of the service industries (Divisions 5-9), 4% from various branches of the government (but mostly from the armed services due to their

Table 6-4. Distribution of Business Units by Industry Division

	Industry Division	# Business Units	
1	Agriculture, Forestry, and Fishing	0	0%
2	Mining	9	4%
3	Construction	2	<1%
4	Manufacturing	140	55%
5	Transportation, Communications, Electric, Gas, and Sanitary Services	32	13%
6	Wholesale Trade	5	2%
7	Retail Trade	2	<1%
8	Finance, Insurance, and Real Estate	15	6%
9	(Other) Services	35	14%
10	Public Administration	11	4%
11	Nonclassifiable (or unknown)	4	2%

[160] *Op cit.*

participation in the Sloan School programs), and another 4% from mining and construction.

There are five specific industry groups that were heavily represented in the survey demographics, enough so that separate analyses could be done to determine whether the paradigm shift has occurred in each industry group or whether its extent differs across them. The industry groups are:

- Information technology companies (including computer and semiconductor manufacturers, software providers, and internal information system business units), which had 35 (14%) of the responses;
- Automotive companies (including automobile manufacturers and their suppliers), which had 22 (9%) of the responses;
- Telecommunications companies (including AT&T, the Regional Bell Operating Companies, or RBOCs, and others), which had 31 or (12%) of the responses;
- The defense industry (including the armed services and defense contractors), which had 35 (14%) of the responses; and
- Commodity companies (including oil and gas production, petroleum products, mining, and utilities), which had 21 or 8% of the responses.

One other useful piece of demographic information was obtained from Question 4.1, which asked the participants to place their business units on a scale between one-of-a-kind production (where each final product is different from the next) and fully standardized mass production. A histogram of

the responses to this question is shown in Figure 6-2, which shows that the full breadth of responses were given. The histogram is weighted towards the full mass production end, with a mean response of 60.

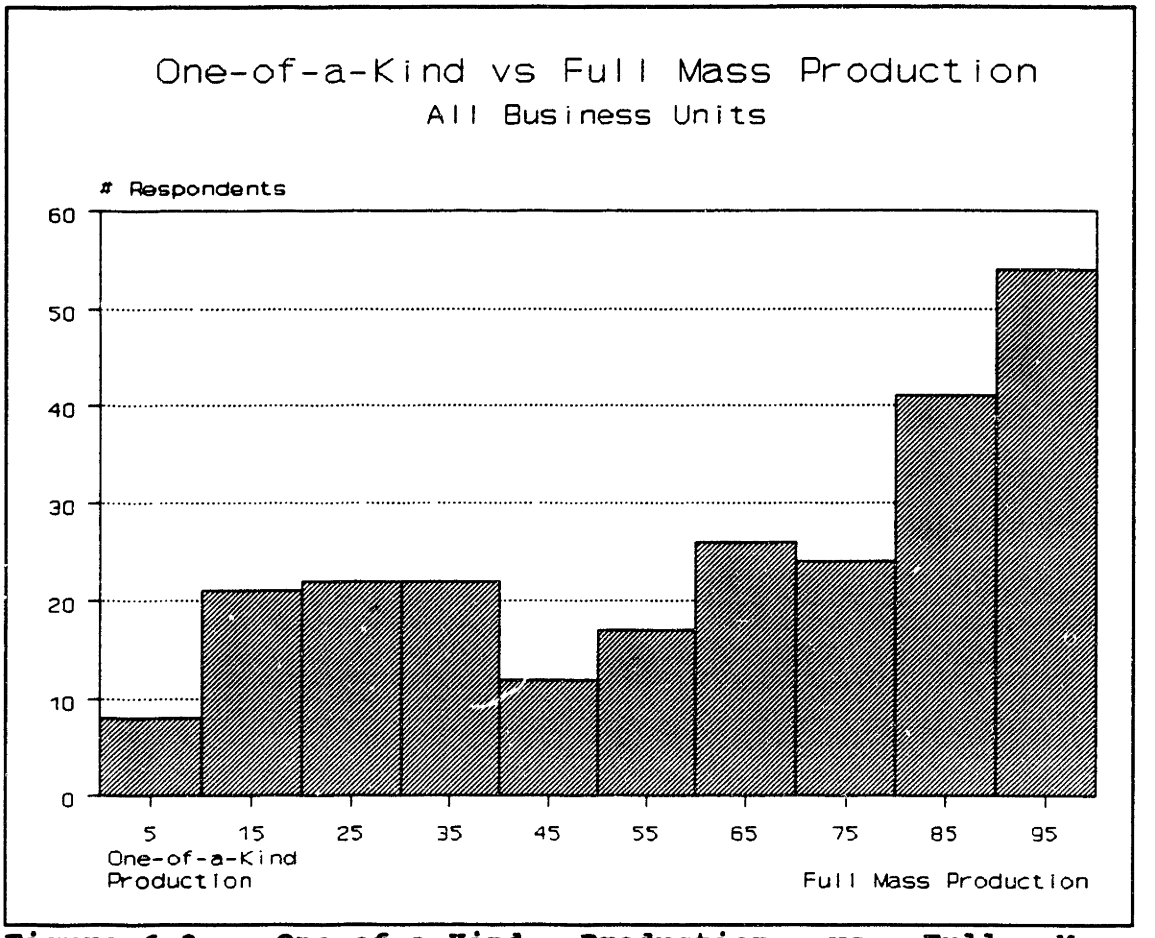


Figure 6-2. One-of-a-Kind Production vs Full Mass Production: All Business Units

The results for business units in manufacturing and service industries are given in Figures 6-3 and 6-4, respectively. Again, the full breadth of responses were given for *both* types of business units. The responses for services were quite flat across the entire spectrum. Their mean response

(49) was lower than that for manufacturing (63), but respondents in service industries clearly did not hesitate to state that their business unit's "production" process was fully a mass production process. The possibility for operating within the paradigm of Mass Production certainly exists even for service companies.

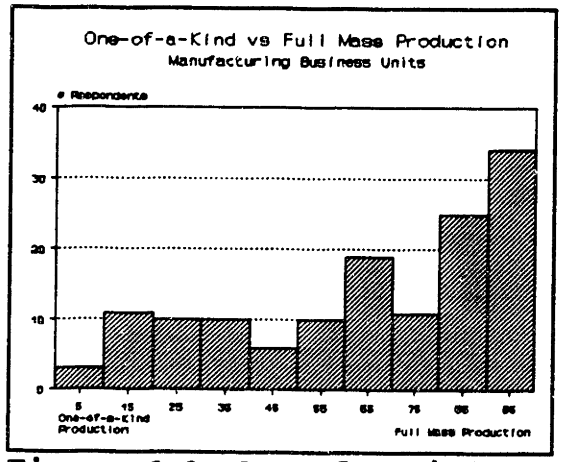


Figure 6-3. One-of-a-Kind vs. Full Mass Production: Manufacturing Business Units

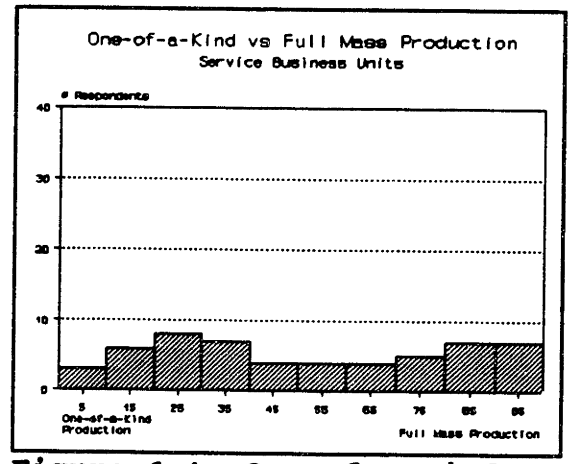


Figure 6-4. One-of-a-Kind vs Full Mass Production: Service Business Units

Finally, Figures 6-5 through 6-8 provide the same histograms for business units that are very small (less than 50 employees), small (50-499 employees), medium (500-4999), and large (more than 4999 employees).

As can be seen, full mass production processes not only exist but predominate within each business unit size. The larger the firm, however, the more likely it resides on the full mass production end of the spectrum. The mean responses

for the four sizes of firms are 52, 56, 63.0, and 63.2, respectively.

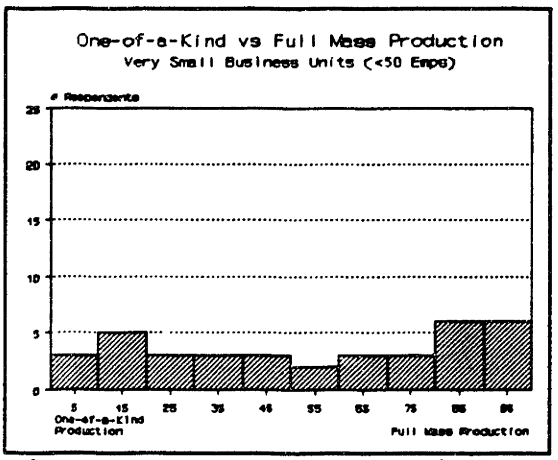


Figure 6-5. One-of-a-Kind vs Full Mass Production: Very Small Business Units

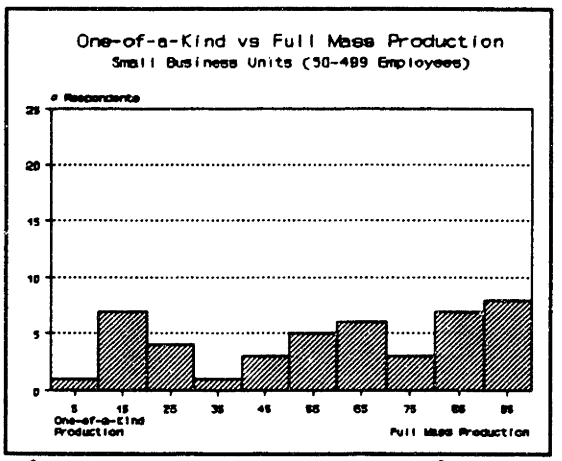


Figure 6-6. One-of-a-Kind vs Full Mass Production: Small Business Units

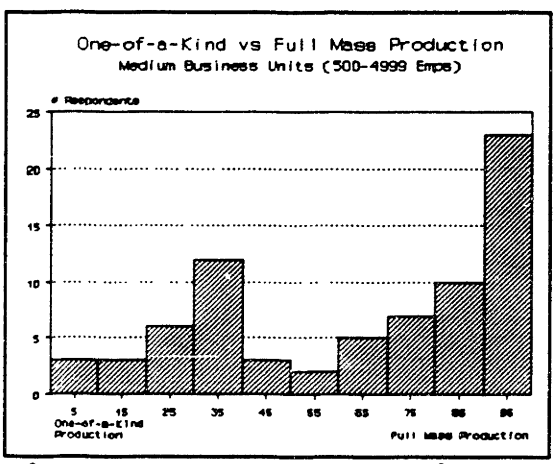


Figure 6-7. One-of-a-Kind vs Full Mass Production: Medium Business Units

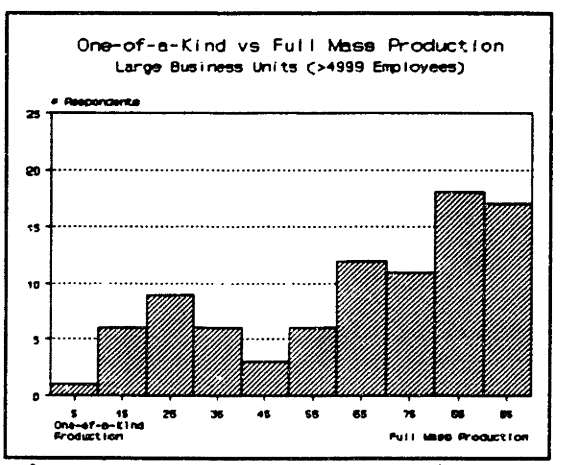


Figure 6-8. One-of-a-Kind vs Full Mass Production: Large Business Units

Primary Hypothesis Validation

To validate the primary hypothesis that increased market turbulence leads to more variety and customization -- and

therefore that market turbulence can be used to predict when industries are, or should be, making the paradigm shift to Mass Customization -- correlations were analyzed between each question having to do with market turbulence on the one hand, and those having to do with the amount of variety and customization on the other. As previously discussed above in the section **Survey Design**, Questions 2.1 through 2.17 determined the level of market turbulence today and in 1980 for each of the seventeen market environment factors. The mean results of each question are given in the Market Turbulence Map shown in Figure 6-9.

As can been seen from this figure, the market turbulence for the average business unit did indeed increase, as expected, between 1980 to 1991. Averaging the seventeen factors together for 1980 yields an average market turbulence of 44, which grew to 53 by 1991, an increase of 9 points. This is not as much of an increase as might be expected, but it is the average of a large number of responses[161] with a wide degree of variation between individual business units. The business unit with the greatest increase (a large provider

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[161]51 respondents did not answer any of the questions for the 1980 timeframe, while others did not respond to particular questions. The mean results provided in Figure 6-10 averaged however many respondents answered each question, which varied from 198 to 203 for the 1980 questions and 245 to all 255 respondents for the 1991 questions. 183 respondents answered all 17 questions in Part Two for both timeframes.

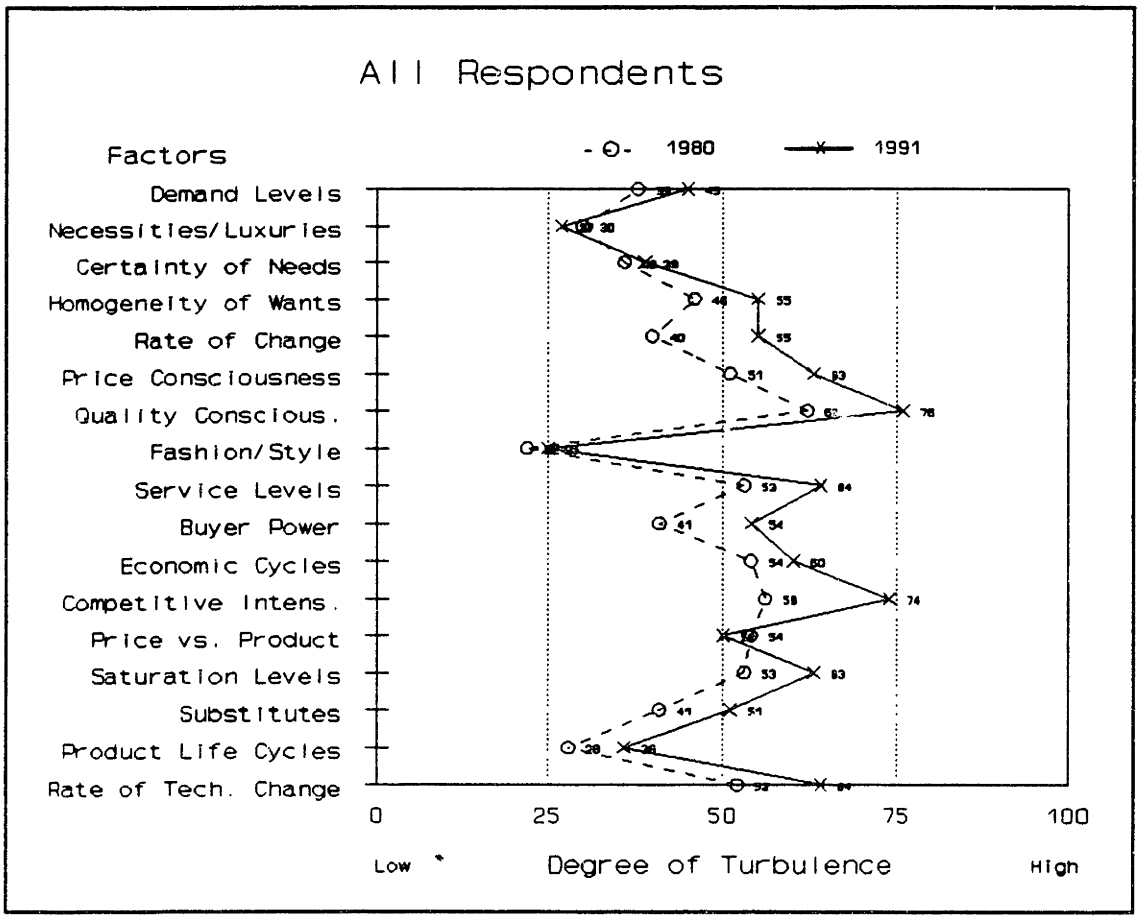

Figure 6-9. Market Turbulence Map: Mean Survey Results of All Respondents

of telecommunications services) saw its turbulence increase 39 points, from 27 to 66. Twenty-three business units saw a decrease in turbulence, including one from 63 to 49, a decrease of 14 points (which was, interestingly, a supplier of telecommunications products).

Figure 6-10 provides a histogram of the average change in the 183 business units whose respondents answered all 17 market environment questions for both 1980 and 1991. A small majority of business units clustered between zero and a 10-

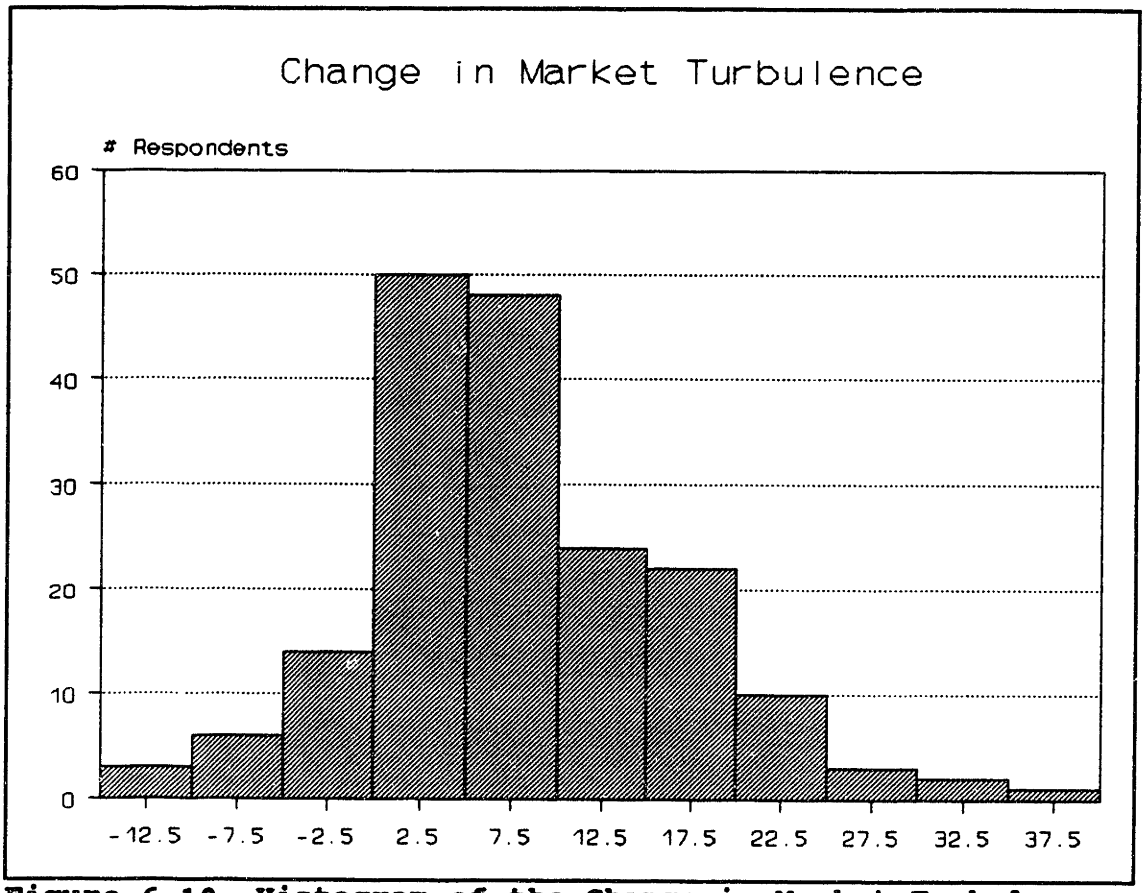

Figure 6-10. Histogram of the Change in Market Turbulence

point increase, with a second major cluster between 10 and 20 points.

Table 6-5 ranks each of the individual factors by how much they changed, on average, since 1980. While 15 of the factors increased in turbulence, two of the factors in fact decreased in market turbulence since 1980: there were small changes of products moving further away from the luxury end of the scale towards becoming even more necessities (30 to 27), and from the basis of competition being product differentiation towards price competition (54 to 50). This

Table 6-5. Mean Survey Results: Individual Factors Ranked by Increased Turbulence

Market Environment Factors	1980	1991	Change
Competitive Intensity	56	74	18
Rate of Need/Want Change	40	55	15
Quality Consciousness	62	76	14
Buyer Power	41	54	13
Price Consciousness	51	63	12
Rate of Technology Change	52	64	12
Service Levels	53	64	11
Saturation Levels	53	63	10
Substitutes	41	51	10
Heterogeneity of Wants	46	55	9
Product Life Cycles	28	36	8
Demand Levels	38	45	7
Economic Cycles	54	60	6
Fashion/Style Consciousness	22	25	3
Certainty of Needs	36	39	3
Necessities/Luxuries	30	27	-3
Price vs Product Competition	54	50	-4

does not, however, mean that these factors do not correlate positively with the amount of variety or level of customization. This issue is discussed in more detail in the Appendix B.

The average Variety & Customization Profile for all of the respondents is given in Figure 6-11. As expected, there has been a tremendous increase in variety and customization since 1980, a trend that is projected to continue into the future. The customization has manifested itself more in products that are *customized* as opposed to *customizable*.

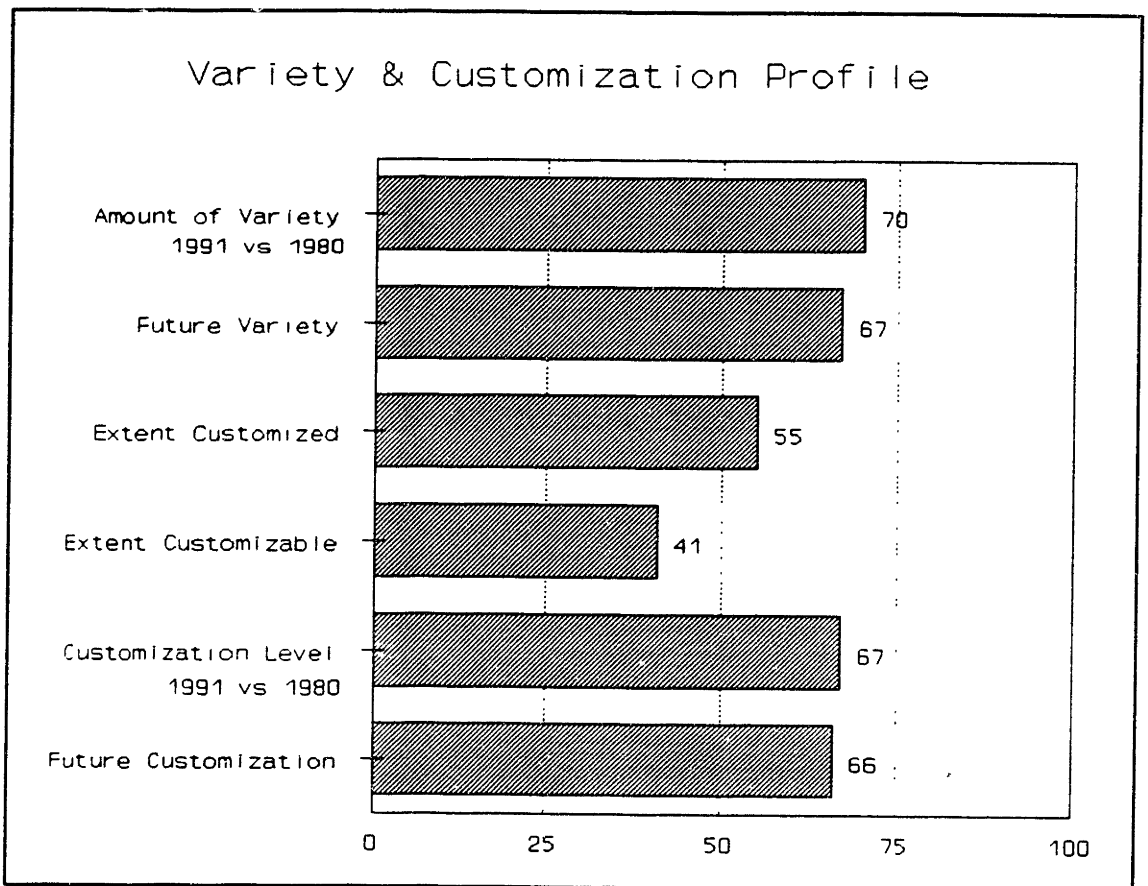

Figure 6-11. Variety & Customization Profile for All Respondents

These two results -- an increase in market turbulence along with an increase in variety and customization -- do not by themselves show that the increases are related. To validate that these are indeed correlated events, two primary

measures of market turbulence were defined: (1) the set of 17 responses for 1991 averaged for each respondent, and (2) the set of differences between 1980 and 1991 averaged for each respondent. The set of 17 responses for 1980 averaged for each respondent was also analyzed to provide additional insight, but it was not considered to be a primary measure.

Least-squares regression analysis[162] was then performed to determine the best linear fit of these two primary measures of overall market turbulence when correlated against the six primary measures of the paradigm shift given in the Product Variety & Customization Profile: (1) the amount of variety relative to 1980, (2) the amount of future variety, (3) the level of customization relative to 1980, (4) the level of customization in the future, (5) the extent products are customized today, and (6) the extent they are customizable today.

In addition to these six indicators, two new indicators were included in the analysis. The variable MAXIMUM of Variety, Customization takes the maximum of each respondent's answers to Questions 3.1 and 3.12 on the relative levels of variety and customization, respectively. Similarly, the variable MAXIMUM of Future Variety, Customization takes the maximum

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[162]Least-squares regression determines the line that best fits the data by minimizing the squares of the distances of all of the data points to that line.

of each respondent's answers to Questions 3.2 and 3.13 on the levels of future variety and customization, respectively. The intent of these two indicators is twofold: (1) to capture the fact that the paradigm shift can manifest in increased variety *or* customization (as well as both), and (2) to eventually use these two variables as proxies for all of the variety and customization questions, to boil the amount of information provided down into a more manageable whole.

Table 6-6 provides the statistical data for each of these regression analyses. The statistics provided are:

- Slope, the slope of the regression line. This gives the amount of change in the indicator on the left side of the table for every one point change in the measure at the top of the table. A positive slope means a positive correlation (more turbulence correlating to more variety/customization), while a negative slope means a negative correlation (more turbulence, less variety or customization).

- Correlation, an indicator of how strongly correlated the two variables are. Correlation figures lie between -1 and 1, with negative values indicating negative correlations. The further the number is from zero, the stronger the correlation. Correlations will tend to go up and down with the slope of the regression line.

- R Squared, an indicator of how much spread exists in the data around the regression line. R squared figures range between 0 and 1. The lower the number, the more spread there is around the line; the higher the number, the more the points will tend to lie on or around the line.

- *t*-Statistic, a measure of how much confidence you can have that a correlation in fact exists between the two variables. A *t*-statistic above 2 indicates that you can be 95% sure that a real positive correlation exists.

Table 6-6. Results of Correlations of Measures of Market Turbulence to Indicators of the Paradigm Shift

Indicators of the Paradigm Shift	Measures of Market Turbulence: Market Turbulence in 1980	Market Turbulence in 1991	Change in Market Turbulence
Amount of Variety			
Slope	-.00	.47	.68
Correlation	-.038	.237	.304
R Squared	.001	.056	.092
t-Statistic	-0.51	3.73	4.29
Future Variety			
Slope	-.00	.55	.84
Correlation	-.041	.295	.402
R Squared	.002	.087	.162
t-Statistic	-0.55	4.74	5.91
Level of Customization			
Slope	-.15	.29	.60
Correlation	-.098	.189	.340
R Squared	.010	.035	.115
t-Statistic	-1.22	2.67	4.45
Future Customization			
Slope	-.26	.37	.75
Correlation	-.162	.220	.408
R Squared	.026	.049	.167
t-Statistic	-2.04	3.19	5.53
Extent Customized			
Slope	.83	.97	.21
Correlation	.291	.324	.061
R Squared	.084	.105	.004
t-Statistic	4.07	5.22	0.82
Extent Customizable			
Slope	.39	.86	.53
Correlation	.135	.287	.154
R Squared	.018	.082	.024
t-Statistic	1.82	4.54	2.09
MAXIMUM of Variety, Customization			
Slope	.01	.50	.63
Correlation	.004	.313	.350
R Squared	.000	.098	.123
t-Statistic	.06	5.05	5.03
MAXIMUM of Future Variety, Customization			
Slope	-.05	.51	.71
Correlation	-.039	.342	.436
R Squared	.002	.117	.190
t-Statistic	-0.52	5.58	6.51

Similarly, a *t*-statistic below -2 means that you can be 95% sure that a real negative correlation exists. The 95% confidence level is generally accepted as the proper level for claiming correlation. *t*-Statistics above about 2.6 (or below -2.6) indicate 99% confidence, and above 4 correspond to greater than 99.99% surety that the two variables are correlated.

To more fully understand the statistical information given in Table 6-6, consider one example: the market turbulence in 1991 versus the amount of variety. Figure 6-12 is a scattergram where each point represents one survey respondent's results for these two variables. The regression line has a slope of .47, indicating that for every increase in one point in market turbulence, variety increases by almost one-half a point. The R squared statistic is .056, which means that there is a great deal of spread around the regression line, which Figure 6-12 clearly shows. Despite the amount of spread, the correlation is .237 and the *t*-statistic of 3.73 leaves little doubt that these two variables are indeed positively correlated. We can be over 99.9% sure that higher levels of market turbulence in 1991 is positively correlated to greater amounts of variety in 1991 relative to 1980.

Given this background on what all of the individual statistics mean, what does the data in Table 6-6 say about market turbulence and variety/customization? First, note that all of the R squared statistics in Table 6-6 are below .2 and most of them are below .1. This indicates that there

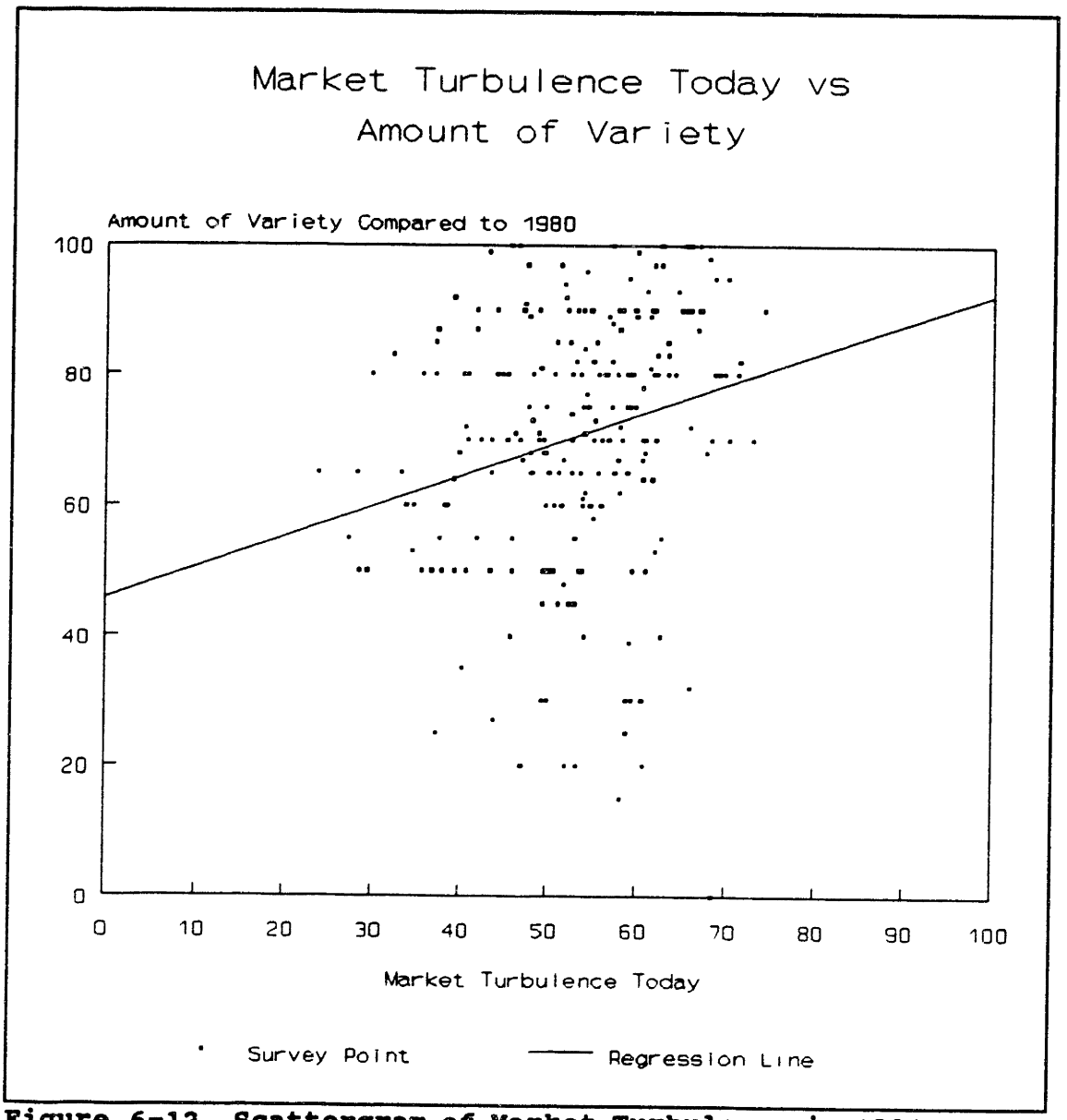

Figure 6-12. Scattergram of Market Turbulence in 1991 versus the Amount of Variety in 1991 Relative to 1980

is a great deal of spread in all of the data; in no comparisons do the survey points lie on anything close to a straight line. This is not surprising, because the relation between market turbulence and variety/customization was not expected to be a mechanical, automatic relationship. First, many firms provide high degrees of variety and customization

without necessarily being in a particularly turbulent environment. In some cases it is because the nature of the business is craft-based, such as consultants or model shops, and in some cases it is technology alone that provides a business with the means for mass customization, such as with Create-A-Book and Personics (described in Chapter 4).

Second, for most business units, the increases in variety and customization are generally the result of a series of incremental decisions that the business units' managers make to deal with the increased turbulence that they face in their market environment. At least up to this point in time, managers have been unable to immediately switch gears from Mass Production to Mass Customization.

It is also true that some managers choose *not* to switch gears but instead retreat in the face of market turbulence -- offer less variety and customization instead of more.[163] This strategy has in fact been advanced by many consultants and authors, to "stick to your knitting", and "focus" on only those segments where you can be number one or two in market share. While these are correct admonishments in the appropriate context, interpreted too broadly or in an inappropriate context, they can only lead

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[163]This phenomenon was discussed in Chapter 5 at the end of the section on **Demand Factors.**

to defeat in the face of market turbulence. That segment retreat is occurring in the survey sample was attested to by several participants' responses to the open-ended questions. For example, the market turbulence of one business unit increased from 45 to 68 between 1980 and 1991. In the face of this greatly increased turbulence, the respondent said that they dramatically decreased the amount of variety the business unit provided by getting out of several business segments, but provided much more customization in the remaining segments. (His response of zero on the amount of variety question can be seen in Figure 6-12 at the 68 mark of market turbulence.)

There is unfortunately no way to test if the data represents a two-pronged distribution, but it may be that the phenomenon of segment retreat is present in the data. Figure 6-13, for example, repeats Figure 6-12 showing the regression line between the market turbulence today and the amount of variety. Two lines, however, have been added to indicate what *may* be happening: most of the business units are providing increased variety with increased market turbulence (the line moving up and to the right), but a minority may be retreating and providing less variety (the line moving down and to the right).

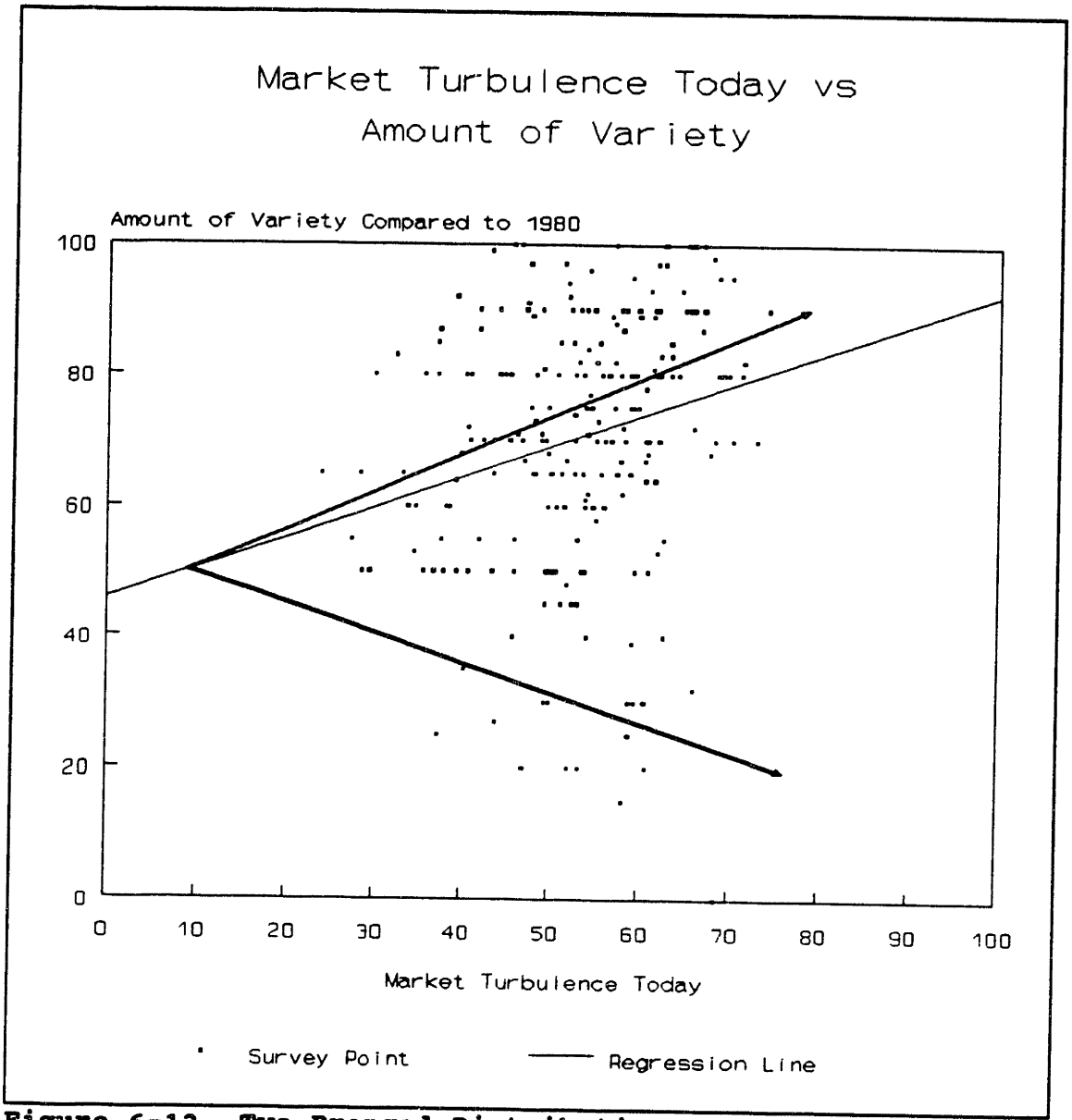

Figure 6-13. Two-Pronged Distribution Added to Scattergram of Market Turbulence in 1980 versus the Amount of Variety in 1991 Relative to 1980

A second point that can be made from the data in Table 6-6 is that there is no positive correlation between the level of market turbulence in 1980 and the amount of variety or customization in 1991 relative to 1980. In fact, this measure of market turbulence appears to be *negatively*

correlated with the level of customization; that is, the higher the turbulence in 1980, the less customization that was designed into products during the ensuing decade.

However, the major point that the data demonstrates is that *every indicator of the paradigm shift is positively correlated to the market turbulence in 1991 and to the change in market turbulence*. Each one of these correlations is statistically significant with only a single exception: while the correlation between the extent products are customized and the change in market turbulence is positive, it is not statistically significant. In all but one other case (extent customizable to the market turbulence change) the *t*-statistics indicate a confidence level at and usually well above 99%.

The slope of the regression line is higher in every case for the market turbulence change than it is for the static level in 1991, indicating that a higher degree of correlation exists for the measure of change in market turbulence. In general, an increase of one point in either the static or dynamic level of market turbulence will -- on average -- result in an increase of .5 to 1 in the various indicators of the paradigm shift.

Therefore, *the data strongly validate the hypothesis that increased market turbulence correlates with increased variety and customization*. The positive correlations do not indicate causality, only a relationship. However, market turbulence causing increased variety and customization can perhaps be discerned from examining all of the correlations, including the unexpected and seemingly inconsistent results of the measure of market turbulence in 1980. This measure had almost no correlation to the amount of variety in 1991 or in the future and most unexpectedly had small *negative* correlations to the level of customization in 1991 and in the future (with the latter conclusion being statistically significant at the 95% confidence level). Interestingly, this same measure of past turbulence had strong *positive* correlations with the extent to which products are customized and customizable in 1991 (with the former conclusion much stronger and statistically significant).

Combined with the information given above about the other two measures of market turbulence, what the data may indicate is this:

- Higher levels of market turbulence *in the 1970s* caused firms to add customization to their products. This manifested itself more in customized products than in customizable ones (which can also be seen in Figure 6-

10, the Variety & Customization Profile). The customization done in this timeframe was probably post-production, added in a somewhat ad hoc manner to a standardized product to increase its sales, which would conform to the model of Mass Customization presented in Chapter 3. The focus on customization was continued in the 1980s, which is why the extent that products are customizable and especially customized are highly correlated to the market turbulence in 1980.

- Continued and increased turbulence in the 1980s through today caused even more customization, as indicated by the very strong correlations between the market turbulence in 1991 and the extent products were customized and customizable in 1991. An increase of one point in 1991 turbulence correlates to almost a full point increase in the extent that products were customized, at .97 the highest slope in all of Table 6-6. However, it seems that the turbulence in the 1980s resulted even more in increased variety, for the 1991 turbulence is more strongly correlated to the relative amount of variety in 1991 than to the relative level of customization.

- The scenario that customization came first and then variety would also explain why the level of market

turbulence in 1980 is negatively correlated to the relative level of customization in 1991, and even more correlated to future levels of customization. If the firms with higher turbulence in the 1970s began customizing in the 1970s using post-production processes and then turned their attention to increasing variety within production, then their relative levels of customization in 1991 could indeed be less than those firms whose turbulence started in the 1980s and began customizing in the 1980s.

- The correlations of the change in market turbulence between 1980 and 1991 further supports this scenario. This measure is less correlated to the extent products are customized (it is the only correlation that is not statistically significant for this measure), indicating that the customization may have indeed been more caused by earlier turbulence. The extent to which products are customizable has a stronger correlation, but the amount of variety is still stronger yet, again supporting the movement from customized products to more and more variety.

- Firms also appear to be extrapolating their past experience into the future. The change in market turbulence is much more highly correlated to future

variety and customization than it is to the relative levels in 1991, and this correlation is much stronger than that of the static market turbulence in 1991. This appears to be indicating that while the increased levels of customization and then variety in the 1970s and '80s may have originally been the result of incremental decisions, many of the firms undergoing an increasingly turbulent market environment now understand that it does not appear to be going away and acknowledge that it is increasing; they therefore recognize that the future will bring even more variety and even more customization. These may be the firms that are making the paradigm shift to Mass Customization.

There may be other possible scenarios about what the conglomeration of survey results indicate, but one thing is clear: for this survey sample, *increased market turbulence appears to have led to increased variety and customization.*

It appears from the survey results that the change in market turbulence is the more effective predictor of increased variety and customization, as all of the slopes for this measure are higher than those for the level of turbulence in 1991. To determine if that is the case, multiple regression analyses were performed between these two primary measures

of market turbulence[164] and the two primary indicators of increased variety and customization (the MAXIMUM variables, using them as proxies for the entire set). This type of analysis attempts to filter out the interrelationships among the independent variables (in this case, the two measures of market turbulence) specifically to determine to what extent they each correlate to the dependent variable (in this case, each of the two indicators of variety/customization, one at a time).[165]

The multiple regression analyses are summarized in Table 6-7. These data show that, first, the two measures of market turbulence together are highly correlated at statistically significant levels to the two indicators of variety and customization. A one-point increase in both of the measures yields eight- to nine-tenths of a point increase in variety/customization relative to 1980 and in the future.

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[164]It is of no use to include the measure of market turbulence in 1980 in this analysis, as this variable can be perfectly predicted by other two (subtracting the degree of change from the level in 1991). The regression program used automatically eliminates independent variables that can be predicted by the others.

[165]In this case, the multiple least-squares regression analyses are three-dimensional analogs to the two-dimensional analyses of Table 6-6, or as seen in Figure 6-14. The slopes calculated are not of lines but of the planes through the three-dimensional space. Adding the two planes together for each of the measures of turbulence yields the best-fit three-dimensional plane for approximating the dependent variables, in this case each of the MAXIMUM indicators.

Table 6-7. Results of Multiple Regression Analyses of the Two Primary Measures of Market Turbulence to the Two Primary Measures of Variety and Customization

Indicators of the Paradigm Shift	Measures of Turbulence: 1991	Change	Together[a]
MAXIMUM of Variety, Customization Questions			
Slope	.32	.49	.81
Correlation	.350	.310	---
R Squared	---	---	.159
t-Statistic	2.80	3.69	---
MAXIMUM of Future Variety, Customization Questions			
Slope	.29	.59	.88
Correlation	.339	.436	---
R Squared	---	---	.225
t-Statistic	2.87	5.07	---

[a]The R squared statistic is calculated on the two variables together, while the other statistics are calculated individually. The slopes of the two variables are added to determine the total effect on the indicators to the left.

Second, the change in market turbulence is much more important for predicting the overall level of variety and customization than is the static measure. For the levels relative to 1980 it is 1.5 times more important (accounting for 60% of the .81 total), while for the future levels it is fully twice as important (accounting for 67% of the .88 total). This finding means that managers should weigh how much their market turbulence is changing much more heavily than its static level in trying to determine whether their industry is undergoing the paradigm shift to Mass Customization.

Industry Group Analysis

As discussed in the section Participant Demographics, there are five industry groups that are sufficiently represented in the survey sample to undergo additional analysis. These are: information technology business units (which had 35 responses), automotive business units (22 responses), telecommunications business units (31), defense industry business units (35), and commodity business units (21).

Table 6-8 gives the average market turbulence measures for each industry group, ranked by the turbulence in 1991. A very interesting picture emerges from this data, one that

Table 6-8. Average Market Turbulence Measures for the Industry Groups

Industry Group	1980	1991	Change
Automotive	53	61	8
Information Technology	48	60	12
Telecommunications	36	54	18
Defense	50	54	4
Commodity	35	39	4
Other Business Units	44	51	7
All Business Units	44	53	9

conforms to what is known about these industry groups and the possibility of the paradigm shift in each.

Automotive Industry Group. Note that the highest turbulence in 1980 (53) was in the automotive group, whose turbulence then increased by 8 points in 1991. It was automobile manufacturing that was one of the first -- if not the *very* first -- industries to be hit by market turbulence in the 1970s. As seen in the Market Turbulence Map in Figure 6-14, the most turbulent factors in 1980 were the dependence on economic cycles, reflecting the oil shocks of the 1970s; price consciousness, always a big factor in the industry; saturation levels, which came into play in the industry in the 1960s and 1970s; and then quality consciousness, competitive intensity, and service levels -- all reflecting the tremendous success of the Japanese imports in the 1970s.

By 1980, Japanese automobile manufacturers had already made the paradigm shift and were increasing the number of models produced each year while decreasing the product life cycle of each model. This increased the turbulence even further for the American manufacturers. Between 1980 and 1991, the competitive intensity, quality consciousness, and service levels increased even further in turbulence. In addition, consumer wants became more heterogeneous and the rate of

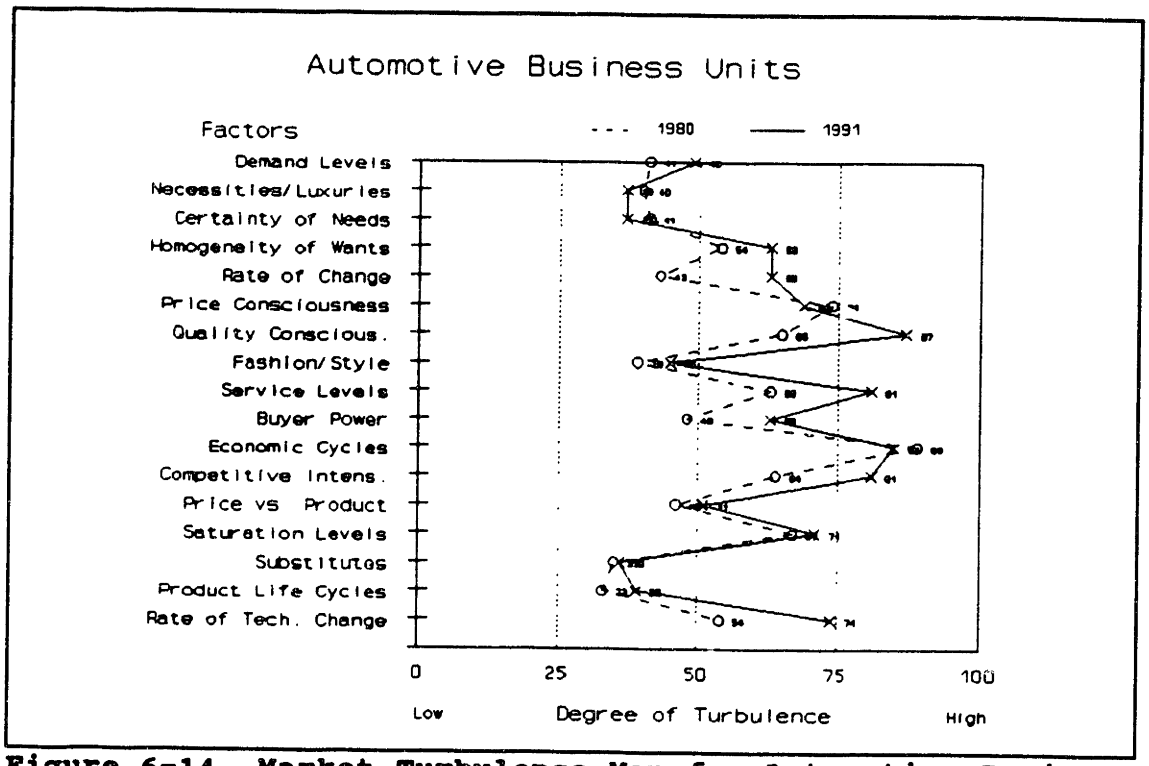

Figure 6-14. Market Turbulence Map for Automotive Business Units

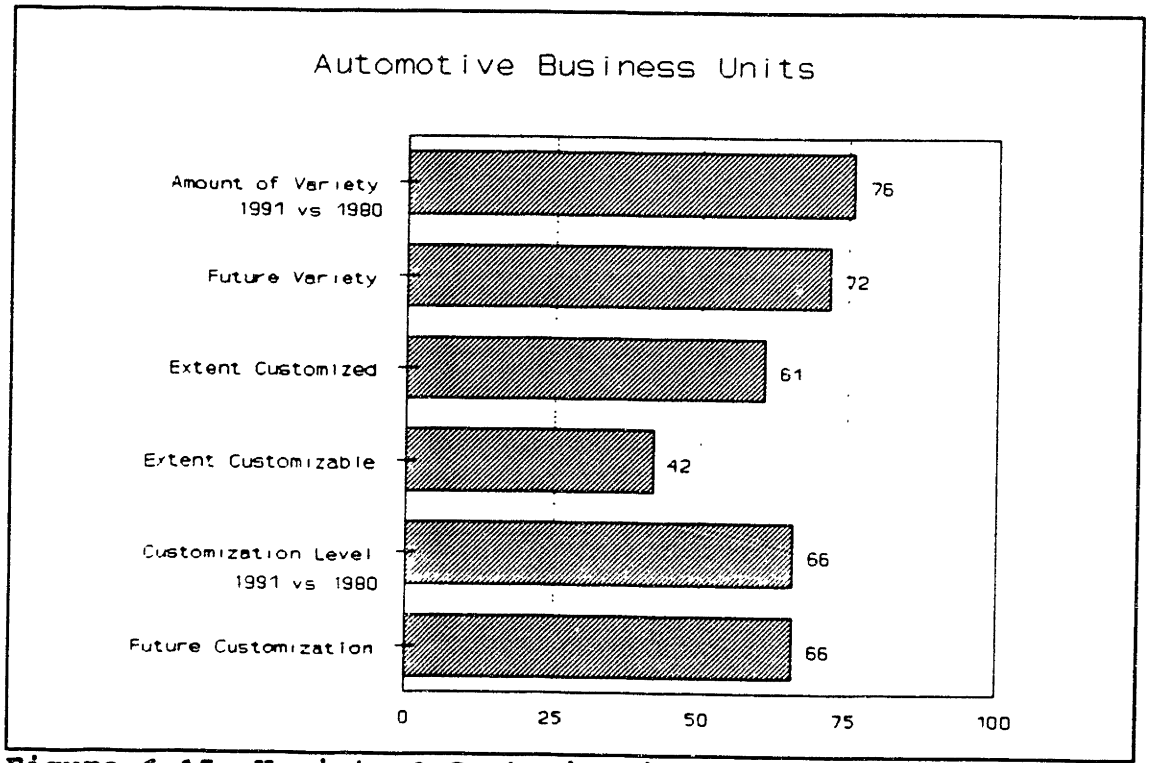

Figure 6-15. Variety & Customization Profile for Automotive Business Units

change in their desires as well as in the rate of product technology change both increased dramatically. This was due to the tremendous variety that became available to them in the 1980s from Japan -- and from America. As Figure 6-15, the Variety & Customization Profile, shows, in the face of the market turbulence of the 1970s and '80s, American manufacturers also greatly increased their variety and, to a lesser extent, their levels of customization. This trend will continue into the future.

It appears that the increased variety and customization in this industry is not just the sum of incremental decisions but reflects a true shift from the paradigm of Mass Production to the paradigm of Mass Customization. As an executive at one of the American automobile manufacturers stated in response to one of the open-ended questions:

> [Customers] are demanding more variety to meet their new needs/circumstances. The manufacturers have demonstrated that they can customize products to meet these new expectations and I believe the trend will be endless as automakers find more ways to economically justify smaller production runs, while providing more variety/choice to the customer. . . . Obstacles to economical justification will surface from time to time but will be overcome.

While this may not reflect the attitude of every executive in the industry that was the birthplace of Mass Production, the attitude of this particular executive is certainly that of one who has made the paradigm shift. The need for more executives to change their mental models of the industry was

addressed directly by a respondent from another of the large automobile manufacturers: "I think the capability to get to a lot size of one is critical - if nothing else than to get your 'mind right!'"

Information Technology Industry Group. The information technology group had the second highest turbulence in 1991 (60), just one point behind the automotive group, but the movement was greater: 12 points since 1980. Figures 6-16 and 6-17 provide more detailed information in the Market Turbulence Map and Variety & Customization Profile for this industry. As the Map shows, four factors became less turbulent in the 1980s (demand levels, necessities/luxuries, certainty of needs, and price competition versus product differentiation), while every other factor not only became more turbulent but moved greatly in that direction. Leading the way were saturation levels, which were not a factor in the industry back in 1980; competitive intensity, which has become a significant factor in virtually every segment of the industry; vulnerability to substitutes, as the segments have blurred, where personal computers in local area networks can substitute for minicomputers, minicomputers for mainframes, and so on; and quality consciousness, which did in fact hit the information technology industry in the 1980s just as it had hit the automobile industry in the 1970s.

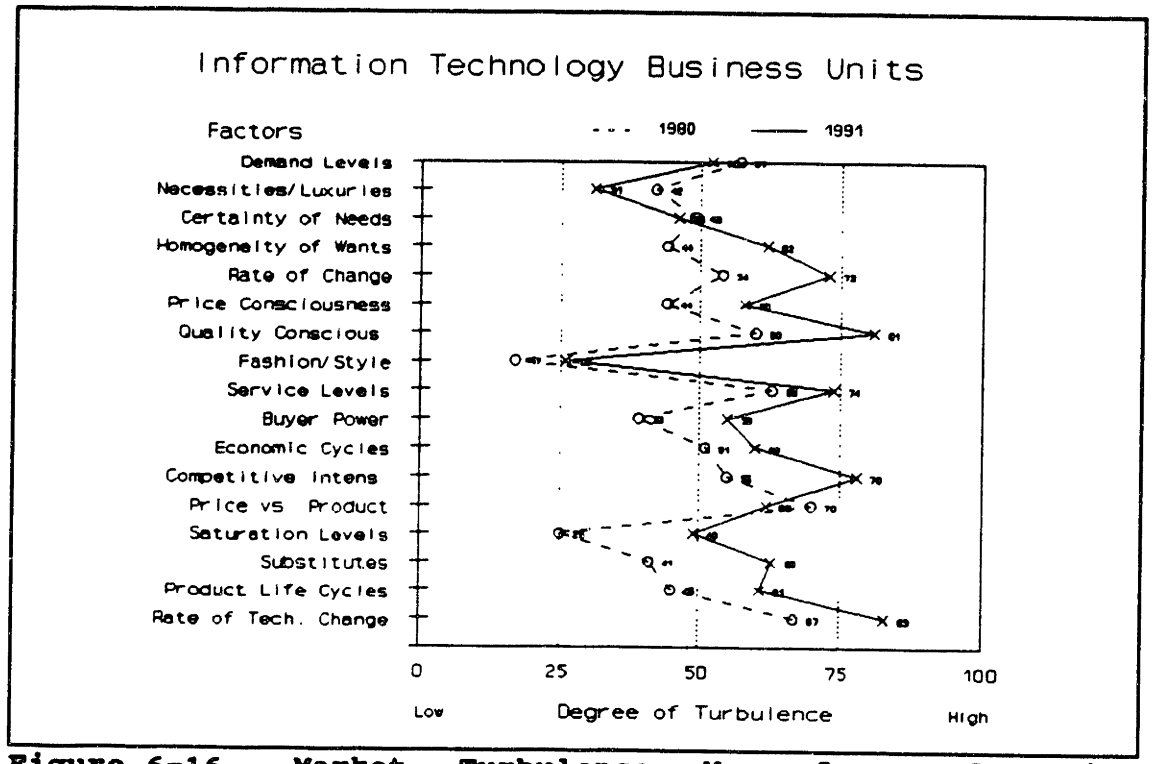

Figure 6-16. Market Turbulence Map for Information Technology Business Units

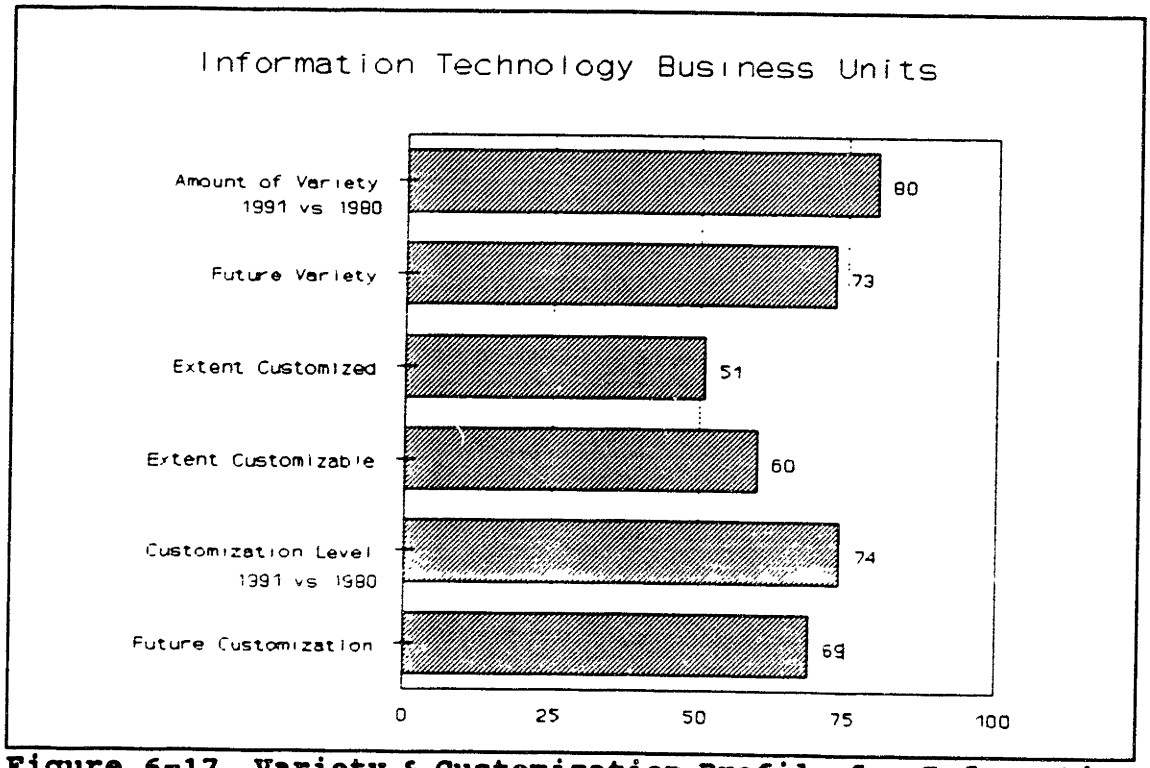

Figure 6-17. Variety & Customization Profile for Information Technology Business Units

As the Variety & Customization Profile demonstrates, during the 1980s the amount of variety and customization increased dramatically -- in an industry already renowned for high degrees of both. This industry is the only one of those analyzed whose products are more customizable than they are customized. Many of the business units surveyed appear to be moving in the direction of Mass Customization, as a sample of responses indicates:

> [The trend towards more variety and customization] will continue at [an] accelerated pace. Ultimately [the] overwhelming majority of systems will be tailored & customized. Only commodity items will not. . . . The product[s] will have "no" limits to customization. Software can do that. The limiting factor will be skilled people.
>
> The trend toward customization will continue into the foreseeable future. There is the potential that products will be customized for individual customers. It occurs today in some cases.
>
> Our software now requires a method for self customization or it won't sell. In 1980, a fixed application was OK.

But the computer industry is also noted for coming under increasing pressure from its customers to standardize both hardware and software, so they are not "locked in" to one manufacturer but can easily switch vendors. A respondent from a computer manufacturer that uses the industry-standard UNIX operating system stated that

> No, on the contrary, [customers] want less variety / customization and more standards. The economics of standard hardware and software products are compelling. The trend will move as far and as fast as we (vendors) can push it because it is a competitive weapon.

However, as seen in Chapter 4 in the discussion of buyer power, standards do not remove the need for variety and customization but change its locus from operating systems, for example, to hardware and application software. The great number of minicomputer manufacturers going after particular market segments would not be possible if they could not pick up the UNIX operating system "off the shelf" to reduce their development costs, and they would make few sales if their products didn't operate (thanks to standards) in computer networks with equipment from other manufacturers. Similarly, the proliferation of hundreds and hundreds of personal computer models would not be possible without the DOS operating system standard.

To view the powerful trend towards industry standards as customers demanding less variety and customization, as the respondent above appears to have done, is a dangerous thing to do. This same respondent answered that his business unit was in fact providing a great deal more variety (90 on the 100-point scale) and customization (60) than in 1980, and would provide even more in the future (70 on both). And yet, his paradigm of the industry was so wrapped up in standards that he would say customers wanted less variety and customization. Just as automobile buyers want to be able to switch from model to model without having to learn all over again how to drive each one, many computer customers want to

be able to switch from model to model without having to learn how to operate each one -- provided first that it can be customized to solve their unique business problems.

Telecommunications Industry Group. The telecommunications industry underwent by far the greatest increase in market turbulence, from 36 to 54. The reason, of course, is the breakup of the old Bell system in 1984. In 1980, the average turbulence in telecommunications was essentially the same as that of commodity business units (36 and 35, respectively), because, with the regulation of AT&T, telephone service *was* essentially a commodity. The breakup of AT&T, however, unleashed new market forces on that giant company as well as on the Regional Bell Operating Companies (RBOCs) that changed the face of telecommunications in the United States.

As the Market Turbulence Map in Figure 6-18 shows, every market environment factor became more turbulent except for price competition versus product differentiation, which remained at the same level. The competitive intensity in the industry skyrocketed from 35 to 73, as did the vulnerability to substitutes (29 to 60). Other factors that increased by 20 or more points were: the rate of change in both product technology and customer wants; buyer power; shorter product life cycles; and price consciousness. All of these can be directly attributed to the Bell system breakup.

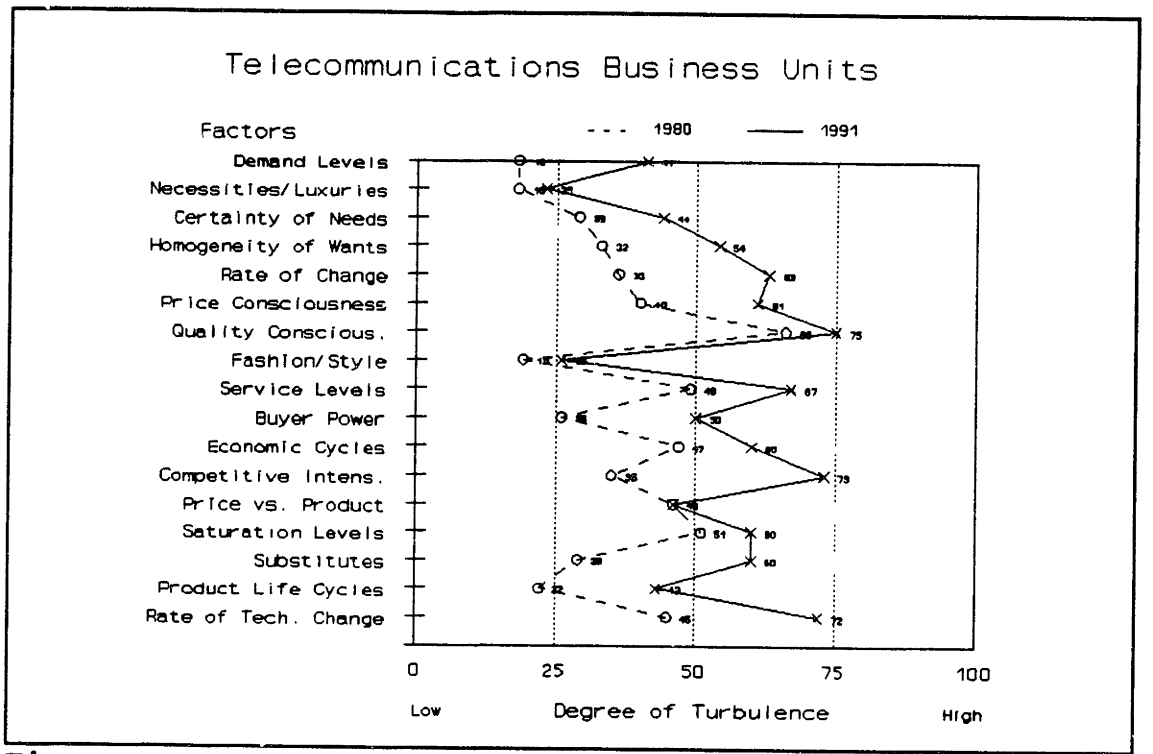

Figure 6-18. Market Turbulence Map for Telecommunications Business Units

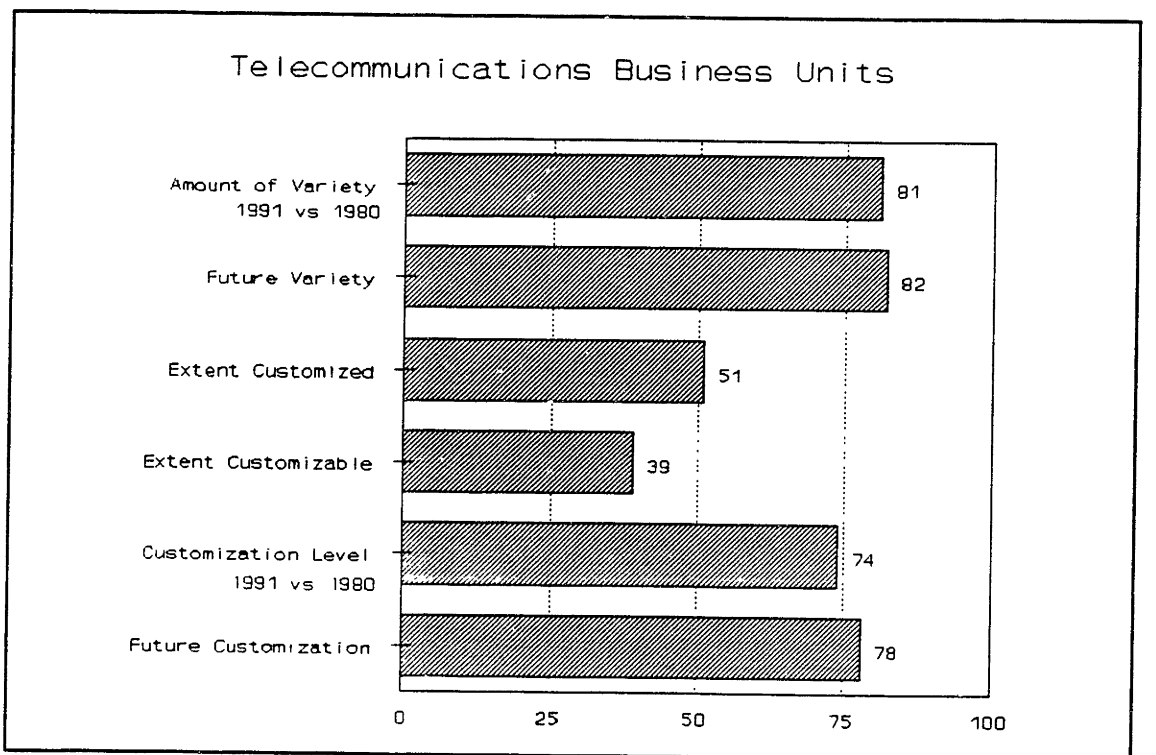

Figure 6-19. Variety / Customization Profile for Telecommunications Business Units

The results of the dramatically increased turbulence can be seen in Figure 6-19. The amount of variety and level of customization relative to 1980 is almost identical to that of the information technology industry group, but owing to the rate of change in its market environment the telecommunications industry is forecasting more variety and customization in the future -- more than the information technology industry, and much more than its own recent past.

As Figure 6-20 demonstrates, despite consisting of service companies, the telecommunications industry is very much an industry of mass production processes. If the responses to the open-ended questions are any indication, this industry understands better than any other that mass-produced products and services can still be individually customized -- and that the paradigm of Mass Customization is a key part of its future. Respondent after respondent acknowledged the power of individual customization. As just a sample:

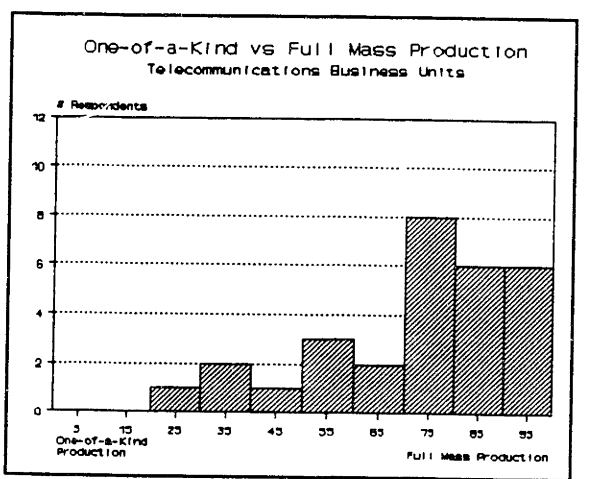

Figure 6-20. One-of-a-Kind vs Full Mass Production: Telecommunications Business Units

> Micro-level need can eventually be met on a custom basis at the same unit cost as today's mass production.

> Price is still the dominant selection factor [but] the post-industrial shift toward customization is likely to accelerate in this industry. . . . [There is] no technological limit - individual customization will be available if the market wants it.
>
> [Regarding variety and customization, there will be] far more! This is because [customers] have seen what can be done and imagined the extensions that should be available. This will ultimately lead to "mass customization" where customers will "create" their own versions of products to their own specifications.

Both the information technology and telecommunications industry have the software and hardware technology to provide full mass customization -- individually customized products and services for virtually the same price as standardized goods. It appears that the telecommunications industry is striving to reach that point first.

Defense Industry Group. The defense industry group (including the armed services, which were mostly research laboratories or product development groups) had the second highest turbulence in 1980 (50), and didn't change all that much by 1991, increasing its turbulence by "only" 4 points. As a glance at its Market Turbulence Map in Figure 6-21 shows, none of the factors changed as dramatically as any of the other industries discussed so far. The biggest change (17 points) was in price consciousness, no surprise given the budget arguments of the 1980s. Competitive intensity, quality consciousness, and vulnerability to substitutes were the only other factors to increase by 10 or more points. The

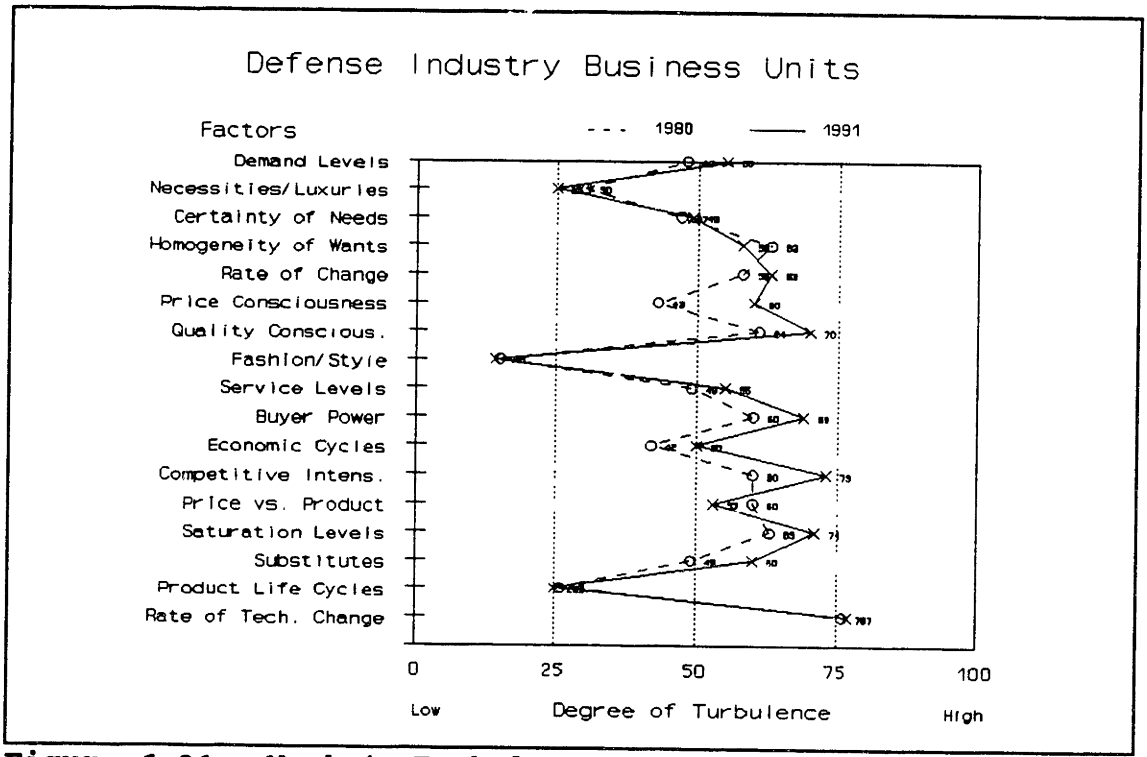

Figure 6-21. Market Turbulence Map for Defense Industry Business Units

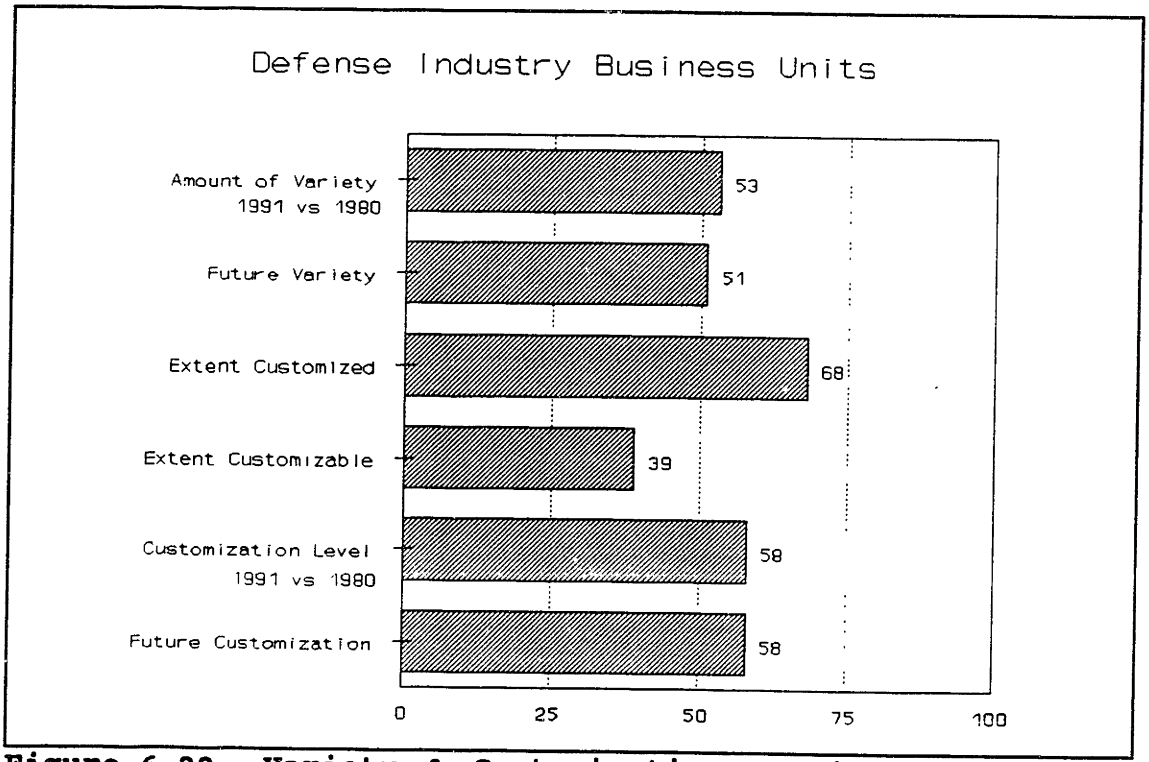

Figure 6-22. Variety & Customization Profile for Defense Industry Business Units

only factor to reach the 75-point mark (which it did in both timeframes) was the rate of product technology change, which has always been significant in the defense industry.

Directly corresponding to the small increase in market turbulence was the small increase in variety and customization, as seen in Figure 6-22. However, a market environment in the 50- to 54-point range is still quite turbulent, and the base amount of variety and particularly customization in the defense industry is quite high. Note that the extent that products are customized in 1991 (68) is far higher than any other industry group. As one defense contractor stated: "What they want and pay for they will get."

It would be difficult to say, however, that the defense industry has made the paradigm shift to Mass Customization, for most contractors have never really operated under the paradigm of Mass Production or "mass" anything. Defense products are generally of much smaller lot sizes than general industry and are customized to the exacting specifications of the Pentagon and its various branches, whose contractors are not generally known for focusing on the low costs and volume production that are the hallmarks of mass production. As Figure 6-23 shows, the defense sample in this survey was indeed weighted towards one-of-a-kind production.

While the "military-industrial complex" as a whole may not be operating under either paradigm, Figure 6-23 demonstrates that there are companies that are fully mass producers. At least one of them may have the mindset of a Mass Producer:

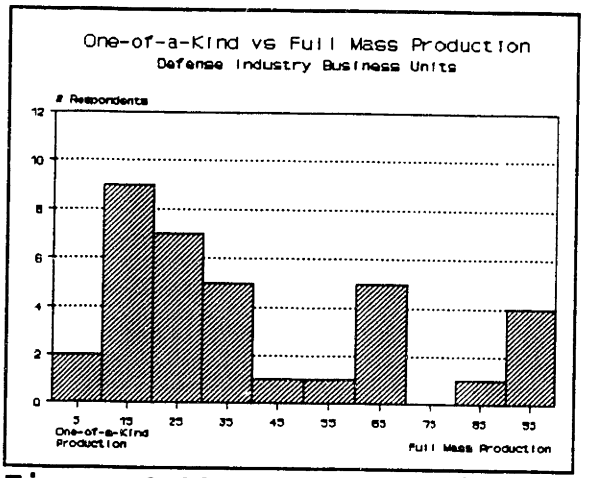

Figure 6-23. One-of-a-Kind vs Full Mass Production: Defense Industry Business Units

> With squeezing defense $, economies of scale and learning curve effects are required, which means less customization.

And at least one may have discovered Mass Customization -- if not as a paradigm then as a business strategy -- from roots in Craft Production:

> Old approach was "custom from the ground up." New approach is stable set of core products off the shelf which are tailored to meet <u>most</u> of the desired functionality.

<u>Commodity Industry Group</u>. The business units providing commodity products (eg, oil and gas production, petroleum products, mining, and utilities) had low turbulence in 1980 and low turbulence in 1991. As Figure 6-25 shows, there were no large changes in any of the factors. The Variety & Customization Profile in Figure 6-27 is exactly what one would expect: only small increases in variety and

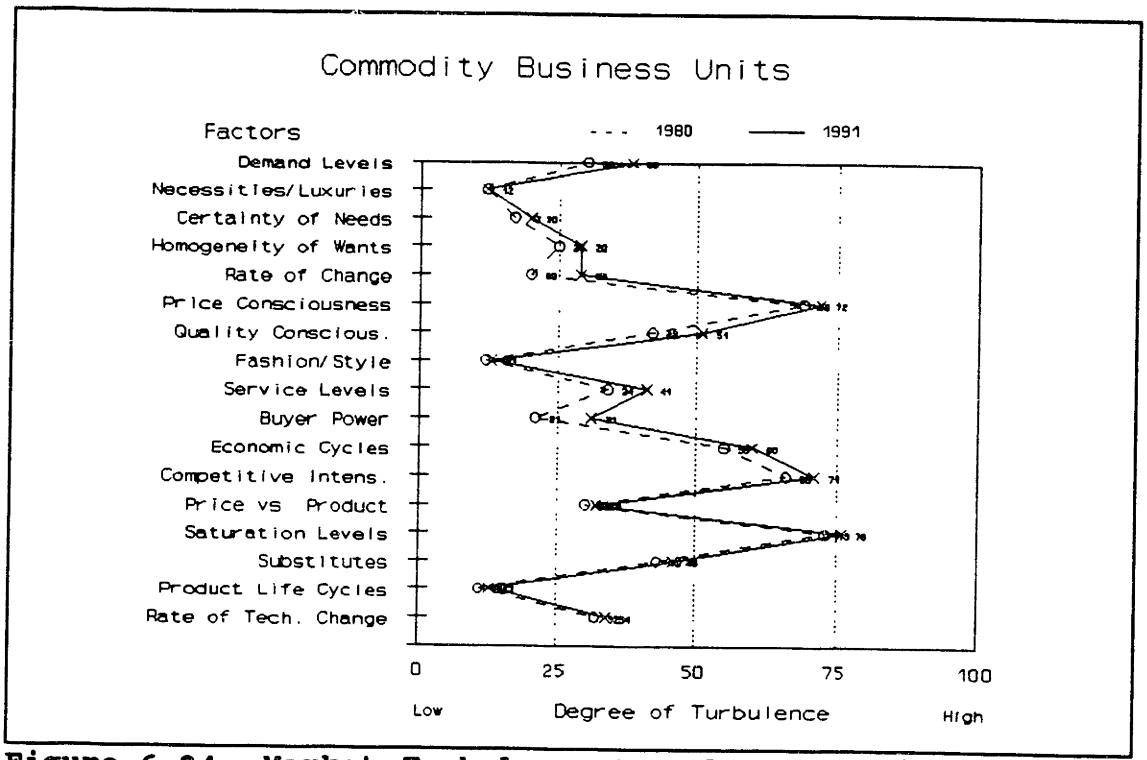

Figure 6-24. Market Turbulence Map for Commodity Business Units

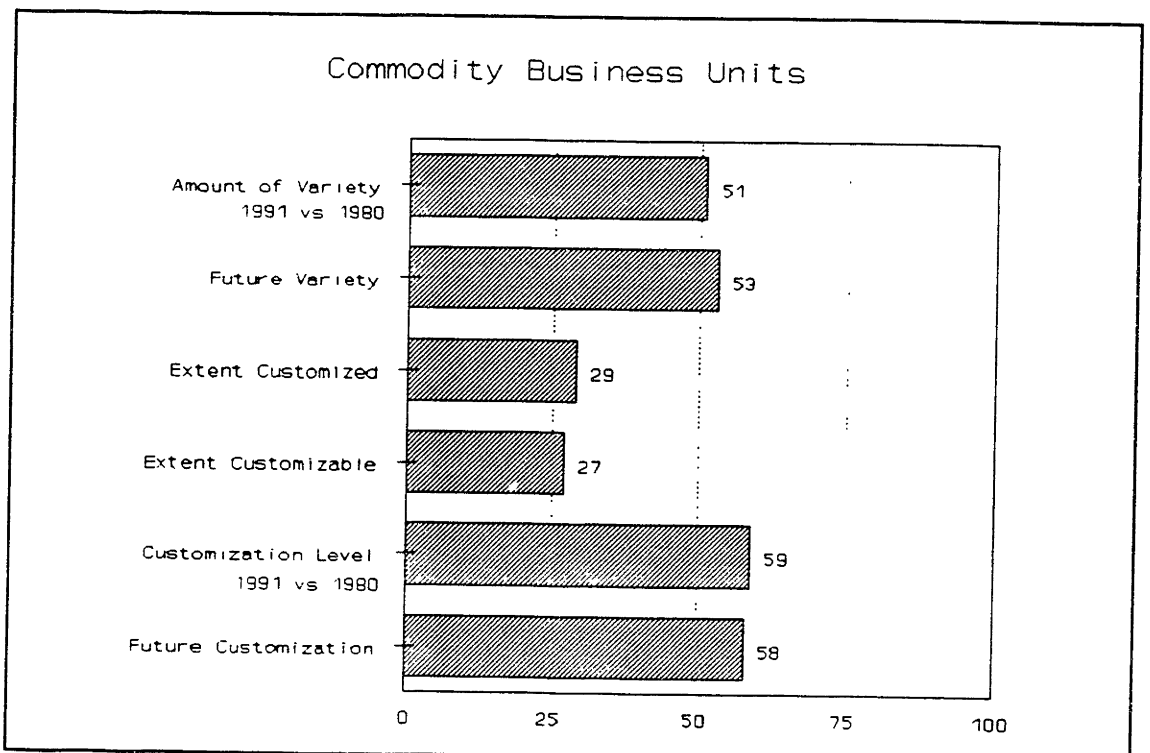

Figure 6-25. Variety & Customization Profile for Commodity Business Units

customization relative to 1980 and in the future, with little customization today's products. (Interestingly, the averages for the two variety and the two customization questions are almost exactly the same as those for the defense industry, which shared a 4-point increase in turbulence. The extent customized and customizable averages are, of course, much lower.)

Obviously, no paradigm shift is occurring in commodity businesses. In reply to the open-ended question on whether customers are demanding more variety or customization, one respondent simply indicated "not applicable."
However, over time the potential may be there. Saturation levels, competitive intensity, and price consciousness are all highly turbulent already. Demand levels have become a little less stable and predictable; the rate of change in customers' needs and wants has increased slightly; quality consciousness has moved over into the turbulent half of the scale; and buyers are gaining more power. While it is unlikely that something as cataclysmic as the breakup of the Bell system will occur to move these other commodities into a highly turbulent market environment almost overnight, something like utility deregulation, a prolonged oil glut, or the innovation of cheap, efficient alternative fuels could move segments to explore significantly higher levels of variety and customization.

The last ten or twenty years have, for example, produced multiple varieties of gasoline available at the pump (unleaded in addition to "regular" and diesel, as well as up to five different octane levels of unleaded). Several respondents from electric utilities noted that, while they can't provide much variety, customers do want customized rate structures. And, a provider of petroleum lubricants said that many customers are demanding more variety and customization, demand that is going not to the large producers but to "specialty houses."

While commodity companies appear to be in no immediate danger of a shift to Mass Customization as the dominant paradigm in their industries, managers in these companies should track their market turbulence and understand that the situation may change.

In summary, the analysis of these five industry groups reveals that all differ in the degrees of change in market turbulence and variety/customization encountered in each, and that these differences conform to what is known about each industry group. Through the use of the Market Turbulence Map and the Variety & Customization Profile, we were able to discern whether or not the paradigm shift of Mass Production to Mass Customization is occurring in each, and to what extent the new paradigm has taken hold. This

further strengthens the case that these tools should be used by managers to determine the fate of their own companies and industries.

Summary of the Survey Results and Analysis

The survey of 255 respondents described in this chapter has allowed extensive testing of the hypothesis that increased market turbulence can be used as the predictor of the paradigm shift from Mass Production to Mass Customization. With each analysis performed, the hypothesis has been validated.

First, higher static levels of market turbulence in 1991 and increased levels between 1980 and 1991 were found to strongly correlate with increased amounts of variety and increased levels of customization, now and in the future. Detailed analysis pieced together support for a scenario whereby increased market turbulence in the 1970s resulted in higher levels of post-production customization by the 1980s, with still greater turbulence in the 1980s yielding much more product variety and some production customization by 1991, with both variety and customization expected to increase in the future for those firms whose turbulence continues to increase. In each case, higher levels of

turbulence correlate to higher levels of variety and customization. This scenario follows closely the description of Mass Customization given in Chapter 3.

Second, the analysis of five very different industry groups demonstrated that levels of market turbulence differ across industries and that the differing levels and their degrees of change directly correspond to how much variety and customization increased in each industry. Those industries that have experienced high and increasing turbulence have not only greatly increased their variety and customization but in fact appear to be moving to the paradigm of Mass Customization. Those industries that have not had high market turbulence have not greatly increased their variety and customization -- but the potential may exist for increased turbulence in the future.

Third, analysis of the individual market environment factors (presented in Appendix B) found that, while there was much variation across the 408 correlations analyzed, each of the 17 factors were positively correlated at the 95% confidence level to one or more indicators of variety and customization. Further analysis yielded a ranking of the factors in importance, with the rate of change in customers' needs and wants a strong first and saturation levels dead last. Saturation levels appeared to be last because high

levels of saturation may be the most important reason that some companies decided to retreat from turbulent market segments, rather than stay and fight by increasing variety and customization.

Finally, analysis of additional product, process, and organization questions included in the survey (also presented in Appendix B) found the responses to fit very well with the paradigm of Mass Customization. Firms that are producing more variety and customization have -- on average -- higher quality products at lower costs than they used to; understand the importance of responding quickly to customers' changing needs, of product innovations to their success, and of incremental versus breakthrough innovations; do a much better job of meeting their customers' complete needs and wants; have shorter product life cycles and product development cycles; are moving away from mass production processes more towards one-of-a-kind production; have much more production flexibility than they used to; and have undergone drastic changes in organizational structure and processes to accomplish the increased variety and customization that both causes and is caused by all of these activities -- in accordance with the feedback loop presented in Chapter 3 as representing the system of Mass Customization.

From the results of this survey, it is evident that the Market Turbulence Map and Variety & Customization Profile can indeed be tools that managers can use to analyze their industries to determine if they, too, should undergo the paradigm shift from Mass Production to Mass Customization.

One more piece of analysis provides managers with some guidelines regarding how much market turbulence is "enough" to indicate the paradigm shift. Figures 6-26 and 6-27 group all of the respondents into categories by their change in market turbulence and their static level of turbulence in 1991, respectively. The bars then indicate the mean of the two primary indicators of increased variety and customization: (1) the MAXIMUM value of the answers to the questions on amount of variety and level of customization relative to 1980, and (2) the MAXIMUM value of the answers to the questions on the future levels of variety and customization. These figures not only confirm that variety and customization increase with increased turbulence, they provide information as to where the shift begins.

Figure 6-26 shows that the average amount of variety and customization differs very little for any negative change in turbulence and for small positive changes up to 10 points. After that, variety and customization increase dramatically and proportionally to the change in market turbulence.

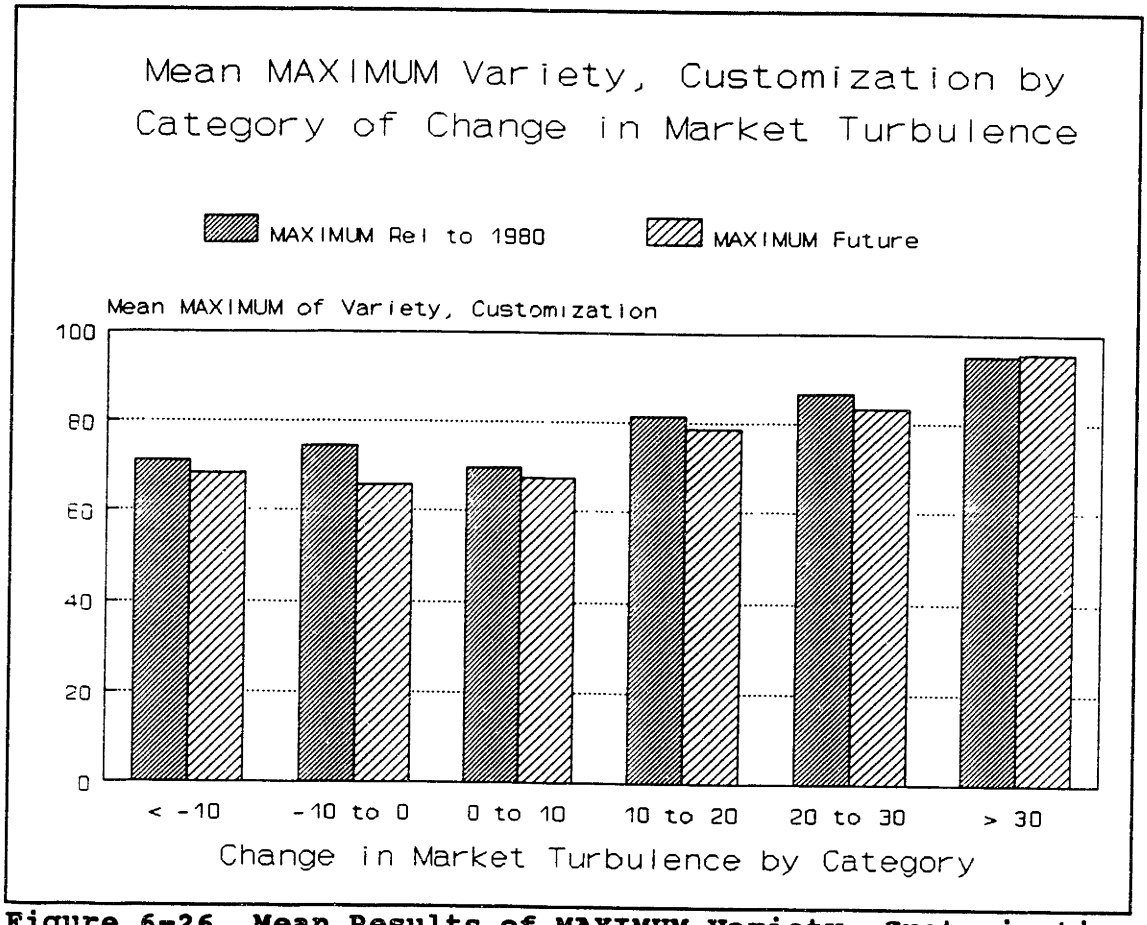

Figure 6-26. Mean Results of MAXIMUM Variety, Customization Indicators by Category of Change in Market Turbulence

Figure 6-27 shows that the average amount of variety and customization differs very little for static levels of turbulence up to 40 points. Between 40 and 60 points the amount increases somewhat, but after 60 points variety and customization increase dramatically.

Therefore, managers who use the Market Turbulence Map should keep in mind the following guidelines:

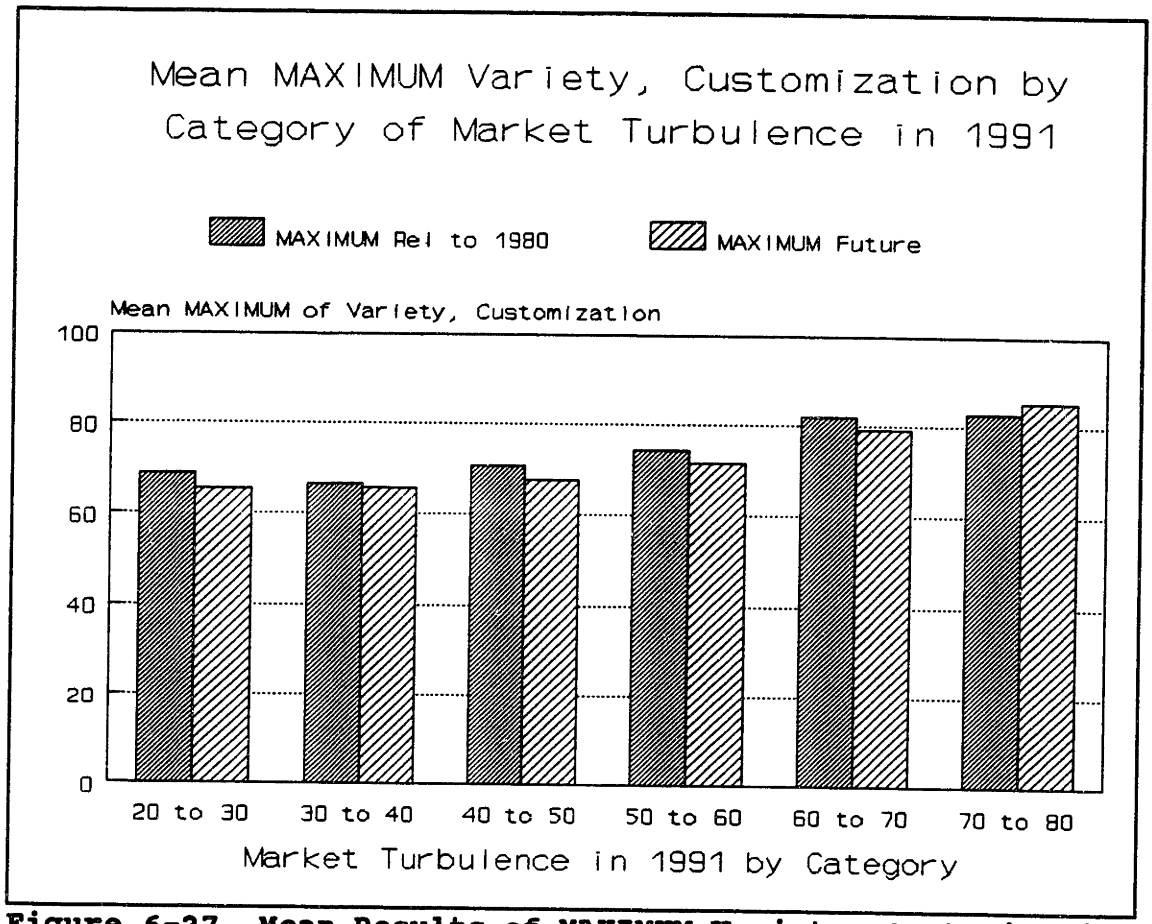

Figure 6-27. Mean Results of MAXIMUM Variety, Customization Indicators by Category of Market Turbulence Levels in 1991

- If the current level of market turbulence in their industry is more than 60 points or especially if the change in turbulence over the past decade has increased by 10 or more points, managers should expect their industry to be undergoing the paradigm shift.

- If the current level of turbulence is between 40 and 60 points or the level has begun increasing and is expected to continue to do so in the future, managers should look closely for additional signs that their

industry may (or may soon) be undergoing the paradigm shift.

With these tools and these guidelines, managers whose firms are still operating within the old paradigm of Mass Production can analyze their industries to see beyond the informational blinders it contains concerning markets, demand levels, technologies, and products. With this new information presented in the appropriate light, managers can determine if they and their firm should shift from the paradigm of Mass Production to the paradigm of Mass Customization.

Chapter 7

Conclusion

Once there was an economic power that dominated the world's industrial production. This country was the world's leading manufacturer and its dominant exporter of goods. Much of its success was based on its basic research, on its ability for invention, and on its unparalleled technological leadership.

However, a time came when this country began to decline relative to its international competitors and was challenged by another, which happened to be west across the ocean. They had only a few decades earlier been at bitter war with each other, but now were allies. After the war the upstart country focused on its manufacturing prowess, and eventually became renowned for its new and unique production processes that produced goods of high quality.

At first, the dominant country had nothing to fear from the other one. This other country focused only on the low-end, where margins were smaller. And all of its products were basically improved imitations; there was little or no truly inventive activity. But then as this upstart continued to gain market share, fears arose that it would eventually

overwhelm its larger ally with its imports, putting firms and maybe entire industries out of business.

People began to examine how and why this was happening. Many articles, commission reports, and books were written to explain the new and powerful manufacturing processes of the upstart country and to recommend how it could best be emulated. Many factors were identified to explain its success, including:

- A manufacturing process that was focused, orderly, and systematic, and that depended on the combination of highly skilled workers, automated machinery, and a new way of moving materials and goods through the factory.
- Strong and continual gains in productivity and quality, thanks to the involvement of workers in improving the process. Workers were not only highly skilled but were well educated, maintained clean work environments, and had high attendance marks.
- Continuous, incremental technological innovations.
- A level of cooperation among national competitors, which helped the rapid diffusion of process innovations.
- A high degree of reliance on subcontractors for innovations and production skills.
- A strong education system, which was a national priority.
- A culture that was unique and very homogenous.

In this story, the country in fear of losing its dominance of world manufacturing is not America; it was England in the latter half of the nineteenth century. The country whose manufacturing prowess it feared was of course not Japan, but

the United States. The way of manufacturing developed in this country was not known as "lean production," but as the American System of Manufactures.[166]

Despite the efforts of many countrymen, the English never quite caught on to this new way of manufacturing, and England eventually did lose its dominance of world production and exports to America. This episode did not happen overnight, but took many decades. Over time, America won the economic battle with highly skilled and educated workers, high quality goods, low costs, rapid innovations,

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[166]While this story has been stylized to some degree to better hide the fact that it is not about America and Japan, all of the descriptions given are essentially true of England and America in the mid-1800s. Most every point can in fact be found in the introduction and the 1854-5 reports from English observers included in Rosenberg, **The American System of Manufactures**. A partial listing of particular references includes:

- Focus on the low-end of product categories: pp. 281-2.
- Imitators of products, not inventors: pp. 65-6.
- Fear of overwhelming England with imports: p. 193.
- Advice to emulate the American System: pp. 128-9.
- Manufacturing system based on workers, machinery, and flow of materials: p. 193.
- High skills of workers and their productivity: pp. 15, 27-29, 121-2, 283.
- Worker cooperation to constantly improve quality of products: p. 14.
- High attendance and cleanliness of workers: p. 194.
- High education level of workers and praise for education system: pp. 28, 283.
- Rapid diffusion of innovation to somewhat cooperating competitors: pp. 59-60, 65.
- Reliance on subcontractors: pp. 116-7.
- Homogeneous culture: pp. 7, 282.

and technological leadership. In hindsight, it seems an inevitable victory.

Need history repeat itself in the current battle between America and Japan? Will it seem just as inevitable to the people of the next century should Japan take over as the world's dominant producer?

No, the battle has not yet been won; the outcome is not inevitable. England lost it leadership not through the compelling inevitability of America's manufacturing prowess, but through the daily decisions of the thousands of managers in English businesses, as well as those of their counterparts in America. It is the daily decisions of American managers today that will determine whether or not America retains its own leadership position.

As we have seen in this thesis, those decisions are affected by the paradigms of the managers making them. The paradigm of Mass Production was absolutely key to America gaining its world manufacturing dominance. It was a powerful mechanism for focusing American managers on providing world-class, low-cost goods that would be readily accepted by national and international markets. No other country was able to grasp this paradigm in the way America did.

But a paradigm is powerful for only as long as it accurately portrays and explains the world at hand. As that world changes, more and more situations appear that cannot be accurately understood; more and more facts appear that cannot be explained. Eventually, a shift to a new paradigm is needed, one that once again describes the nature of the "game" and how to be successful at it.

The ever-present danger to a paradigm, however, is that its practitioners cannot easily see the need for a shift to a new paradigm. The old paradigm will continue to be successful at explaining much (but not all) of the world at hand and at helping its practitioners solve many (but not all) of their problems. The situations that cannot be explained and the problems that cannot be solved are not seen as failures but as "special cases" that will eventually be handled, given time.

Such is the paradigm of Mass Production. In many industries, this paradigm can no longer explain what is happening to markets, demand levels, technologies, and products. It cannot adequately deal with highly heterogeneous markets, with fragmented demand, with rapid technological change, with shortening product life cycles and shortening development cycles, with product proliferation and customization. Practitioners of the old paradigm try to

handle the problems generated by a world characterized by market turbulence, but are only partially successful; the paradigm of Mass Production is simply not up to the task. As market turbulence increases for a company operating under the old paradigm, the problems become greater, the solutions less manageable, the company less successful. This company must eventually make the paradigm shift to Mass Customization or risk its very existence.

Not every company in every industry needs to make this shift, and some have more time to respond than others. The difficulty of being able to step outside of an operating paradigm and see the world without its informational blinders is so great, however, that managers often need assistance in this task. This thesis has proposed and validated a set of tools that managers can use to examine their market environments and determine if their companies need to make the paradigm shift from Mass Production to Mass Customization. Applying the Market Turbulence Map to a firm's market environment will allow its managers to see -- for the first time, perhaps -- exactly how turbulent that environment is. If the turbulence is high or increasing, then the firm should almost certainly make the paradigm shift to Mass Customization. If, on the other hand, the market turbulence is low and stable, the paradigm of Mass Production may continue to be perfectly adequate in focusing

the energies of the firm. (However, there may be opportunities for engaging mass customization as a business strategy even within environments of low turbulence, for customized goods at the price of standardized goods will clearly be a winner in any marketplace.)

The Variety & Customization Profile can also be used to determine to what extent the firm is already providing more variety and customization -- whether because of the new paradigm, incremental decisions, or a business strategy -- and to what extent competitors are doing so. This view of the degree of variety and customization in an industry can provide clues to whether competitors have made the paradigm shift themselves or are still operating within the old one.

Finally, the Product Variety Profile and set of guidelines and principles derived from value chain analysis and examples of companies who are already mass customizing can point the way to how the firm's products can be designed, manufactured, and distributed to achieve increased variety and customization -- even to the point of mass producing individually customized goods.

This is the promise of the paradigm of Mass Customization.

Appendix A

Survey Instrument

This Appendix gives the survey instrument used to test the hypothesis that market turbulence can predict greater variety and customization. Please note that the questionnaire included here differs slightly in format from that mailed out due to thesis margin requirements.

PRODUCT VARIETY AND CUSTOMIZATION SURVEY

Joe Pine

Master's Degree Candidate in Management of Technology

Sloan School of Management

Massachusetts Institute of Technology

Joe Pine
MIT Management of Technology Program
107 Glezen Lane
Wayland, MA 01778
(508) 358-0074

PART ONE: Demographic Information

Instructions: Please provide the demographic information requested below on you and your company. Note that your individual and company responses throughout this survey will not be revealed, only summarized in the aggregate.

Name: _____

Company: _____

Title: _____

What is the primary business of your company?

This survey will ask you questions about the "business unit" with which you are most familiar. This may be your entire company, a division, or some other business unit. Please give the name of the business unit for which you will be responding and its primary business:

Please indicate the size of your company (with a "C") and your business unit (with a "B") in both annual revenue and number of employees in the appropriate spaces below:

Revenue: ___ < $5m ___ $5-$49m ___ $50-$499m ___ ≥ $500m

Employees: ___ < 50 ___ 50-499 ___ 500-4999 ___ ≥ 5000

How long have you been with this business unit (years)? ____

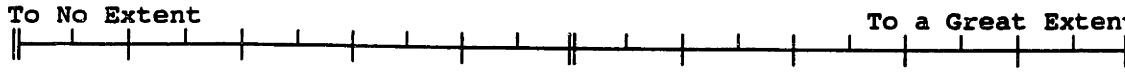
With the company? ____ In the same or similar industry? ____

You may find as you take this survey that you have two or more marketplaces that would yield different replies. If so, please respond for your primary or most familiar marketplace, and indicate here which marketplace you used:

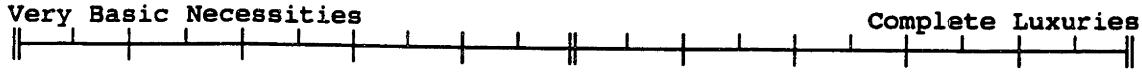
PART TWO: Market Environment Perceptions

Instructions: Here are 17 questions about your business unit's market environment. Each question asks for your perception of where your business unit stands today on a scale between two defined endpoints. Please take a moment or two to think about the question and then place an X at the point on the given line that matches your initial perception. The scale is divided into 100 percentage points with markers at every 5 and 10 points, but please use the level of precision that is meaningful to you.

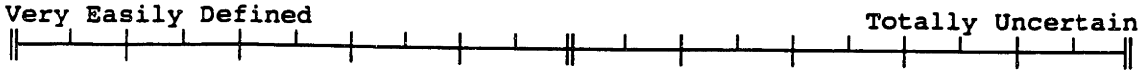
1. To what extent are the demand levels of your business unit's products stable and predictable?



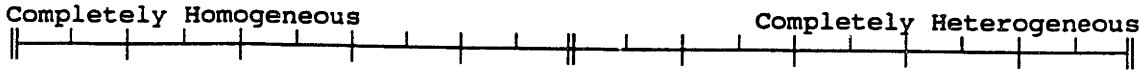
2. Do your products fill very basic needs, or are they complete luxuries in the minds of your customers, or are they somewhere in between?



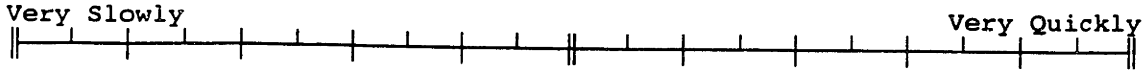
3. Are your customers' needs and wants easily defined and understood, or are they uncertain and difficult to ascertain, or are they somewhere in between?



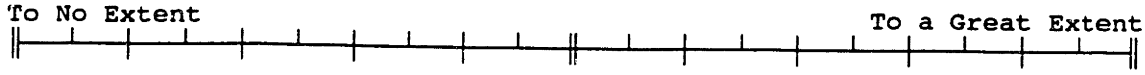
4. Do all of your customers desire basically the same products (completely homogeneous), or do they each demand something unique (completely heterogeneous), or do they lie somewhere in between?



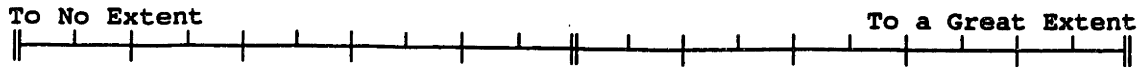
5. At what rate are the needs and wants of your customers changing?



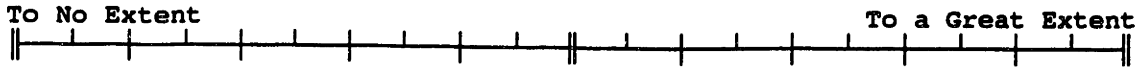
6. To what extent does the price of your products influence your customers in their decision to buy your business unit's products?



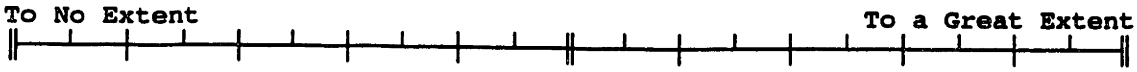
7. To what extent does the quality of your products influence your customers in their decision to buy?



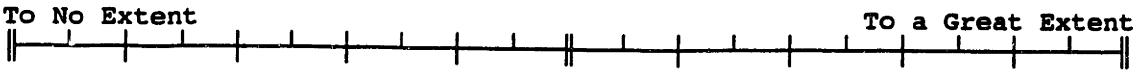
8. To what extent do fashion and style influence your customers in their decision to buy?



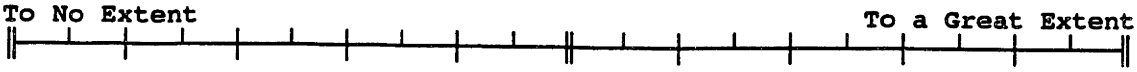
9. To what extent does the level of pre- and post-sale service influence your customers in their decision to buy?



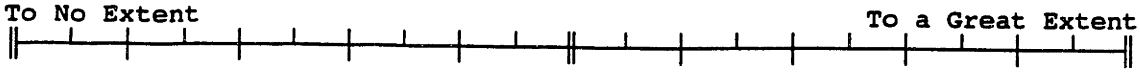
10. To what extent can your customers dictate the prices, conditions, and features of your business unit's products?



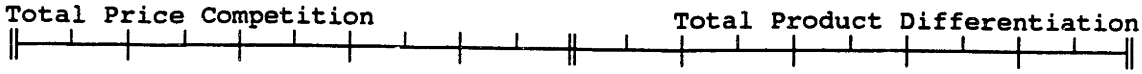
11. To what extent are your business unit's sales affected by economic cycles (recession, recovery, and expansion)?



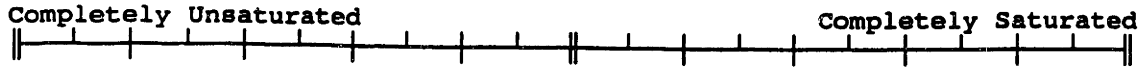
12. To what extent do you and your competitors battle for market share in your business unit's markets?



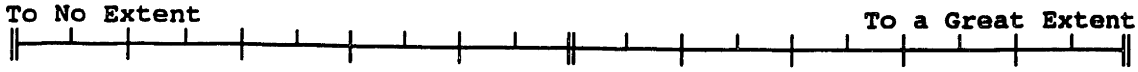
13. Is competition in your industry based totally on product differentiation, totally on price competition, or is it somewhere in between?



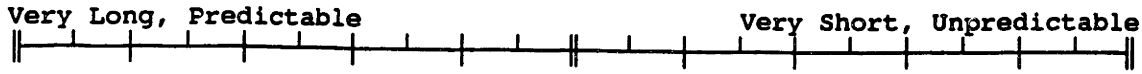
14. Are your business unit's markets completely unsaturated (all sales are to entirely new customers), completely saturated (all possibilities of sales are replacements of or additions to existing products), or somewhere in between?



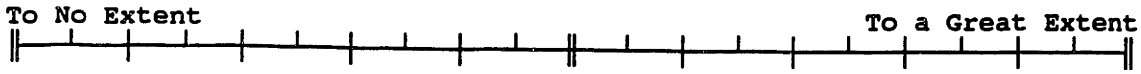
15. To what extent are your existing products vulnerable to being replaced by substitute products that are of a different nature but perform similar functions?



16. Are the product life cycles (first shipment to replacement or withdrawal) of products in your business unit's industry very long and predictable, very short and unpredictable, or somewhere in between?



17. To what extent is the rate of product technology changing in your business unit's industry?



Thank you for your perceptions of your business unit's current market environment!

Instructions: The questions you have just answered are about <u>today's</u> market environment. It is important to understand how much each of these factors has changed over time. Therefore, please think back across the last decade or so to 1980 and the changes, if any, that have happened to your business unit's market environment since 1980.

Then, please take another couple of minutes to go back to the 17 questions above and quickly indicate your perceptions of your business unit's marketplace in 1980. (Please use an "O" to mark each line to differentiate between your previous "X"s.) It is all right if you are not as familiar with the environment back then (you may not have even been around); what is important are <u>your perceptions</u> of the marketplace environment at that time.

Instructions: The questions below are open-ended questions so you can provide more detail about your business unit's market environment. Please provide your answers in the space provided, or attach another sheet if you so desire.

1. What do you think are the most profound changes in your business unit's market environment since 1980?

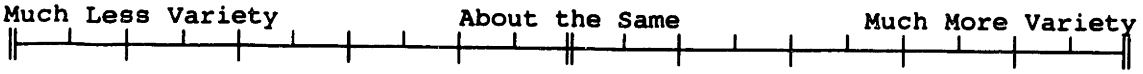
2. What do you think are the causes behind these changes?

3. Do you believe your business unit's customers are demanding more variety or customization today than in 1980? Why or why not? If so, how far do you think this trend will go?

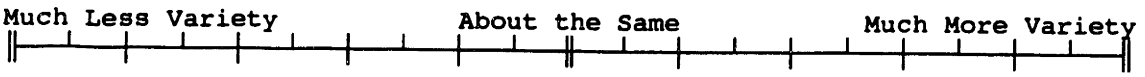
PART THREE: Product Perceptions

Instructions: Given below are a group of 16 questions about your business unit's products. (If your business unit is in a service industry, please interpret the word "product" as "service".) Again, each question asks you to place <u>your perception</u> of where your business unit stands today on a scale between two defined endpoints. Please take a moment or two to think about the question and then place an X at the point on the given line that matches your initial perception. (Note that you will not be asked to go over this section twice; many of the questions refer directly to the changes that have occurred since 1980.)

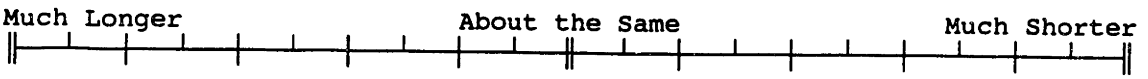
1. How does the amount of variety in your business unit's products today compare with 1980?



2. Does your business unit plan on providing more or less variety in the future?



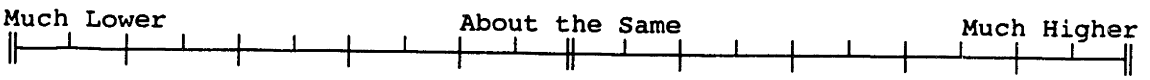
3. Are your product life cycles (first shipment to withdrawal or replacement) longer or shorter than in 1980?



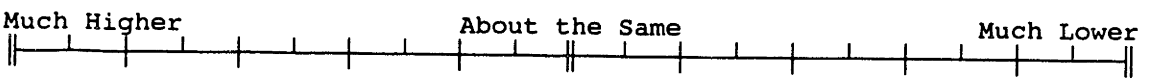
If possible, please indicate the approximate average life cycle length (in years and/or months) of your products now and in 1980:

Today: _____ 1980: _____

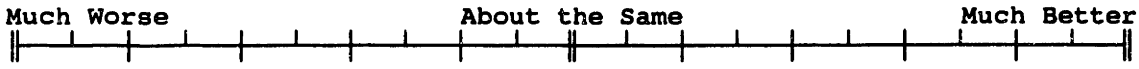
4. How does the quality of your products today compare with the quality of your products in 1980?



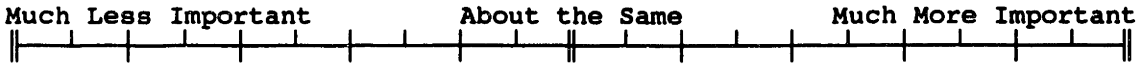
5. How do the manufacturing/production costs of your products today compare with the costs of your products in 1980?



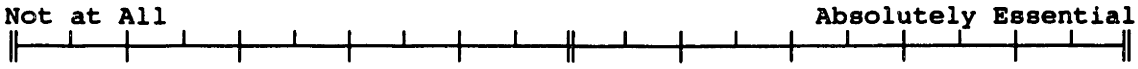
6. How do today's products compare with those in 1980 in meeting your customers' complete needs and wants?



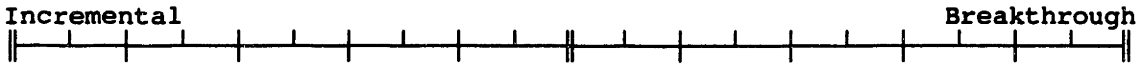
7. Is it more or less important to respond quickly to customer demand changes with new or modified products?



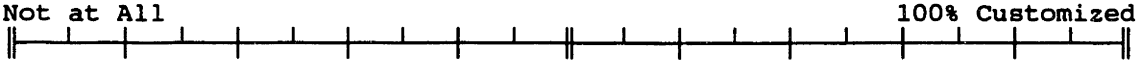
8. How important are product innovations (eg, new features, new technologies, new products) to the success of your business unit?



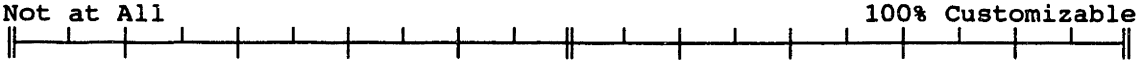
9. How important are *incremental* product innovations (eg, new features, modified products) versus *breakthrough* innovations (eg, new products, new technologies) to the success of your business unit?



10. To what extent are your products *customized* to individual customers?

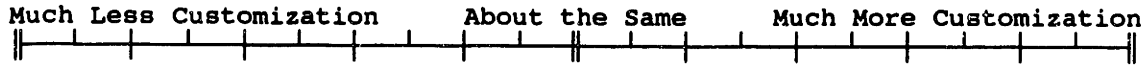


11. To what extent are your products *customizable* by individual customers (or others outside of your business unit who assist your end customers)?

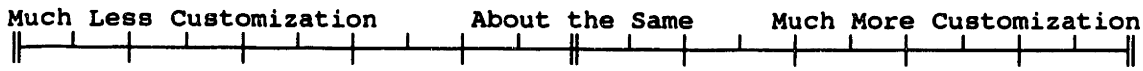


Instructions: If your responses to questions 10 and 11 were <u>both</u> "Not at All", please skip the questions on the next page and proceed directly to the open-ended questions on the page after that.

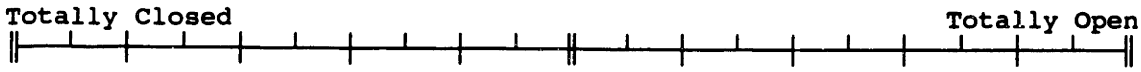
12. How does the level of customization (regardless of who does it) in your products today compare with 1980?



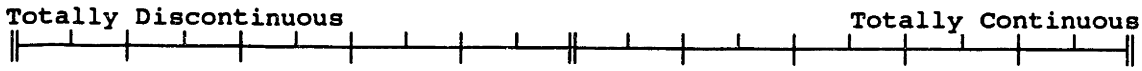
13. Does your business unit plan on providing more or less customization in the future?



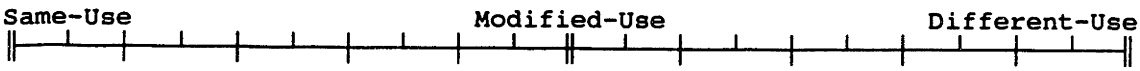
14. Completely "closed customization" means your business unit has to perform all product customization; completely "open customization" means your customers (or others) can perform any and all customizations that can be performed. To what extent are your products closed or open?



15. "Continuous customization" means that, within some range, your products can be infinitely customized; "discontinuous customization" means there are discrete steps in the level of customization. Where do your products fall on this scale?



16. "Same-use customization" means your products perform exactly the same function after customization; "modified-use customization" means they can perform different but related functions; and "different-use customization" means your products can perform completely different functions. Where do your products lie on this scale?



Thank you for your perceptions of your business unit's products!

Instructions: The questions below are open-ended questions so you can provide more detail about your business unit's products. Please provide your answers in the space provided, or attach another sheet if you so desire.

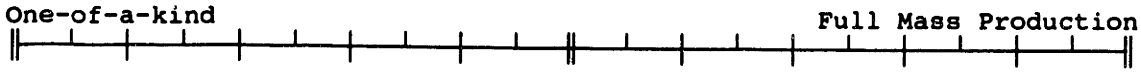
1. If you are providing more product variety and customization today than in 1980, why? If not, why not (and then skip to the next page)?

2. How far do you think the trend towards more variety and customization will go? What are the product limits to customization for your business unit, or is it foreseeable that products could be economically customized for individual customers?

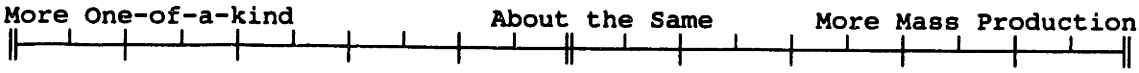
PART FOUR: Process and Organization Perceptions

Instructions: Given below are 6 questions about your business unit's processes and organization. Again, each question asks you to place <u>your perception</u> of where your business unit stands today on a scale between two defined endpoints. Please take a moment or two to think about the question and then place an X at the point on the given line that matches your initial perception.

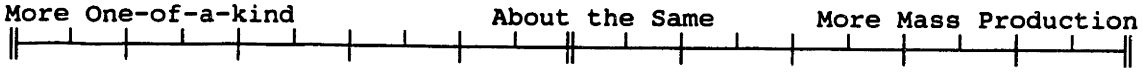
1. Where does your business unit's production process lie on the scale between one-of-a-kind production (where each final product is different from the next) and fully standardized mass production?



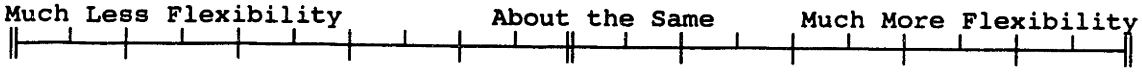
2. How does this compare with 1980? Today's process is:



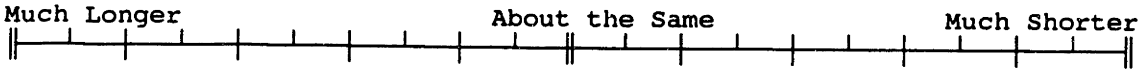
3. What do you think your business unit will do in the future?



4. How much more production flexibility (meaning the ability to quickly change between products) exists in your production process today than in 1980? Today's process has:

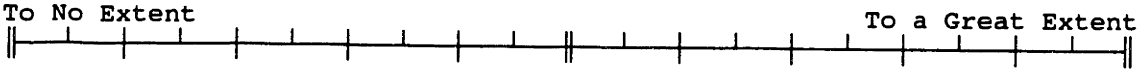


5. Is your product development process (project initiation to product shipment) longer or shorter than in 1980?



If possible, please indicate the approximate development process length (in years and/or months) of your products now and in 1980:
Today: _____ 1980: _____

6. To what extent has the structure of your organization and your processes changed since 1980?



Instructions: The questions below are open-ended questions so you can provide more detail about your business unit's processes and organization. Please provide your answers in the space provided, or attach another sheet if you so desire.

1. If your business unit is providing more product variety and customization today than in 1980, how is it being done? How have your processes changed?

2. If you are providing more variety and customization, how has your business unit's organization (including employee and supplier relations) changed to provide this variety?

This completes the survey. ***Thank you very much for your participation!*** Please place the survey in the accompanying envelope and mail.

Appendix B

Additional Survey Results and Analysis

This Appendix expands on the results and analysis of the survey presented in Chapter 6. It provides more detailed analysis of the 17 individual market environment factors and of additional questions asked in the survey but not central to the basic hypothesis it was designed to test.

Analysis of Individual Market Environment Factors

The individual market environment factors were analyzed to determine how well each one correlated with increased variety and customization. It could be that some of the factors do not correlate well and could then be eliminated from the Market Turbulence Map to simplify it, or that some are in fact negatively correlated and should be reversed. Table 6-5 on page 171 ranked all of the factors by the amount that their turbulence changed between 1980 and 1991; the two factors whose turbulence actually decreased between 1980 and 1991 -- the scale between necessities and luxuries as well as that between price competition and product differentiation -- seem like good candidates for negative correlation on an individual basis.

This analysis involved a total of 408 individual correlations: 17 market environment factors times 3 measures of market turbulence times 8 indicators of the paradigm shift (including the MAXIMUM variables).

For brevity's sake, the results to all 408 correlations are not given. (The correlations to the two MAXIMUM variables are provided in Tables B-1 and B-2.) While there is a lot of variation in the individual correlations, one fact stands out in the analysis: *every single market environment factor*

Table B-1. Correlations of Individual Factors to MAXIMUM Variety, Customization

Market Environment Factors	1980	1991	Change
Demand Levels	0.103	0.159*	0.026
Necessities/Luxuries	0.124	0.055	-0.077
Certainty of Needs	-0.010	0.137*	0.086
Heterogeneity of Wants	-0.170*	0.114	0.285**
Rate of Need/Want Change	0.045	0.309**	0.318**
Price Consciousness	-0.105	-0.049	0.118
Quality Consciousness	-0.028	0.156*	0.172*
Fashion/Style Consciousness	0.029	0.146*	0.193**
Service Levels	0.088	0.218**	0.183*
Buyer Power	-0.272**	-0.129*	0.214**
Economic Cycles	0.045	0.082	0.167*
Competitive Intensity	-0.098	0.058	0.220**
Price vs Product Competition	0.080	0.203**	0.068
Saturation Levels	-0.247**	-0.141*	0.161*
Substitutes	0.088	0.130*	0.097
Product Life Cycles	0.119	0.282**	0.316**
Rate of Technology Change	0.066	0.278**	0.262**

* Statistically significant at 95% confidence level
** Statistically significant at 99% confidence level

Table B-2. Correlations of Individual Factors to MAXIMUM Future Variety, Customization

Market Environment Factors	1980	1991	Change
Demand Levels	-0.101	0.123*	0.166*
Necessities/Luxuries	-0.077	0.039	0.220**
Certainty of Needs	-0.034	0.105	0.084
Heterogeneity of Wants	-0.090	0.241**	0.393**
Rate of Need/Want Change	0.025	0.417**	0.449**
Price Consciousness	0.046	0.131*	0.163*
Quality Consciousness	0.058	0.254**	0.233**
Fashion/Style Consciousness	0.021	0.074	-0.063
Service Levels	0.081	0.240**	0.245**
Buyer Power	-0.161*	-0.077	0.165*
Economic Cycles	0.044	0.083	0.122
Competitive Intensity	-0.186*	0.030	0.287**
Price vs Product Competition	-0.035	0.118*	0.084
Saturation Levels	-0.190**	-0.157*	0.050
Substitutes	0.043	0.098	0.056
Product Life Cycles	0.079	0.278**	0.346**
Rate of Technology Change	-0.137*	0.250**	0.386**

* Statistically significant at 95% confidence level
** Statistically significant at 99% confidence level

is positively correlated at the 95% confidence level to one or more indicators of variety and customization. For example, as Figure B-1 shows, a positive change in necessities/luxuries -- even though its average turbulence actually decreased in the decade or so between 1980 and 1991 -- is highly correlated to more variety and customization in the future, at the 95% and 99% confidence levels, respectively. Positive correlations that are statistically significant also exist for the second factor that decreased in turbulence.

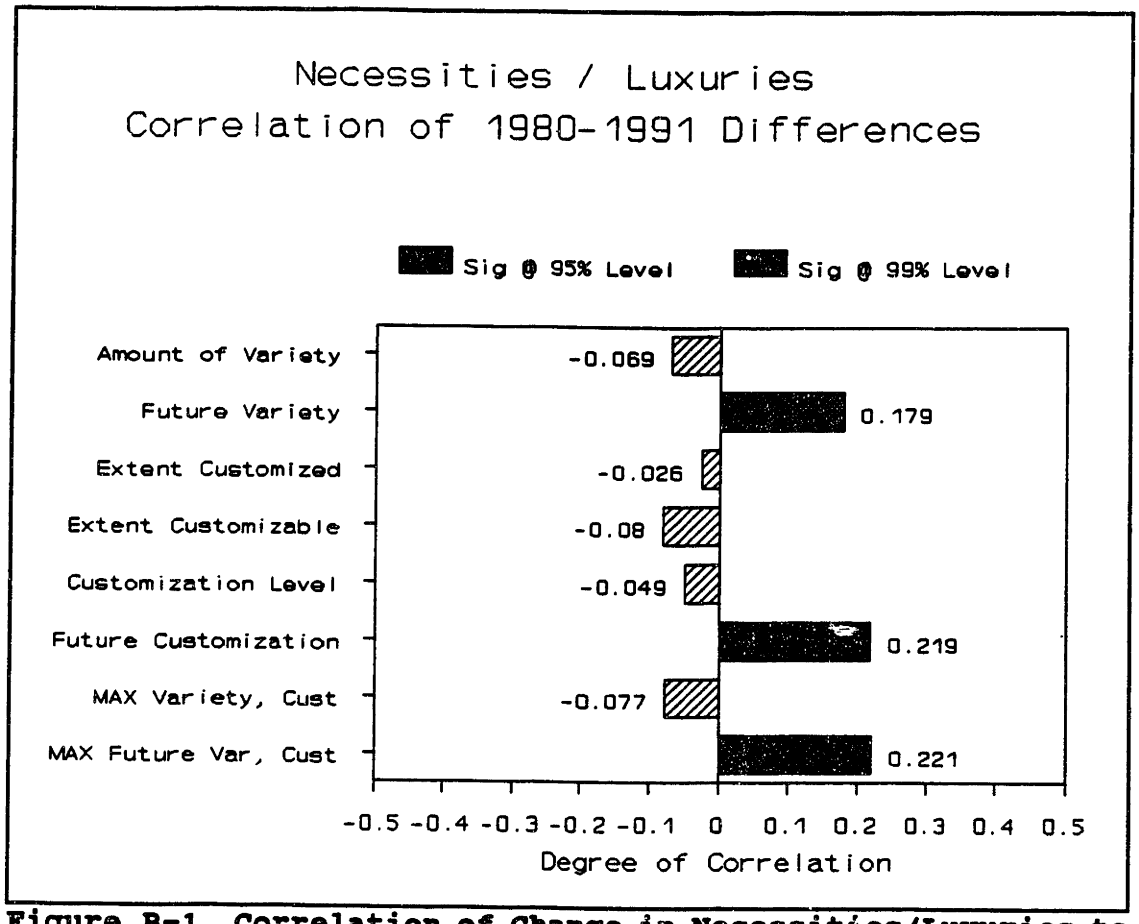


Figure B-1. Correlation of Change in Necessities/Luxuries to Indicators of Variety and Customization

Table 6-5, therefore, is not necessarily a reliable indicator of the importance of individual factors in determining the extent to which variety and customization increase in an industry. To determine the level of importance of each factor, two rankings were developed using the two MAXIMUM variables as proxies for the set of variety and customization indicators. These two variables were correlated against the individual factors for both 1991 and for the change between 1980 and 1991 (see Tables B-1 and B-2). Rankings were made for each of the two timeframes by

simply adding together the two MAXIMUM correlations for each factor, and are given in Tables B-3 and B-4.

A third ranking was performed for the factors in 1980, but since the market turbulence in 1980 had strong positive correlations only with the indicators of the extent to which products were customized and were customizable, these were the two variables used. This ranking, given in Table B-5, was again determined by adding the correlations of these two variables.

Table B-3. Individual Factors Ranked by Additive Correlations of 1991 Turbulence to MAXIMUM Variety, Customization and MAXIMUM Future Variety, Customization

Market Environment Factors	1991
Rate of Need/Want Change	0.726
Product Life Cycles	0.560
Rate of Technology Change	0.528
Service Levels	0.458
Quality Consciousness	0.410
Heterogeneity of Wants	0.355
Price vs Product Competition	0.321
Demand Levels	0.282
Certainty of Needs	0.242
Substitutes	0.228
Fashion/Style Consciousness	0.220
Economic Cycles	0.165
Necessities/Luxuries	0.094
Competitive Intensity	0.088
Price Consciousness	0.082
Buyer Power	-0.206
Saturation Levels	-0.298

Table B-4. Individual Factors Ranked by Additive Correlations of Change in Turbulence from 1980 to 1991 to MAXIMUM Variety, Customization and MAXIMUM Future Variety, Customization

Market Environment Factors	1980-1991
Rate of Need/Want Change	0.763
Heterogeneity of Wants	0.678
Product Life Cycles	0.662
Rate of Technology Change	0.648
Competitive Intensity	0.507
Service Levels	0.428
Quality Consciousness	0.405
Buyer Power	0.379
Necessities/Luxuries	0.297
Economic Cycles	0.289
Price Consciousness	0.281
Saturation Levels	0.211
Demand Levels	0.192
Certainty of Needs	0.170
Substitutes	0.153
Price vs Product Competition	0.152
Fashion/Style Consciousness	0.130

Table B-5. Individual Factors Ranked by Additive Correlations of 1980 Turbulence to Extent Customized and Extent Customizable

Market Environment Factors	1980
Heterogeneity of Wants	0.285
Buyer Power	0.264
Quality Consciousness	0.240
Product Life Cycles	0.231
Rate of Need/Want Change	0.213
Necessities/Luxuries	0.172
Demand Levels	0.162
Service Levels	0.159
Price vs Product Competition	0.158
Rate of Technology Change	0.120
Competitive Intensity	0.108
Economic Cycles	0.090
Substitutes	0.076
Certainty of Needs	0.073
Price Consciousness	0.069
Fashion/Style Consciousness	-0.050
Saturation Levels	-0.237

These three rankings agree in many ways: the rate of need/want change, product life cycles, and the heterogeneity of wants are three of the top six in every case, for example. However, some apparent anomalies are striking. The most striking is that the factor of buyer power is negatively correlated to increased variety and customization for the 1991 data, but has a very strong correlation to the 1980 and to the change in 1980-1991 measures; in fact, it has the second highest correlation for 1980. Right behind it is the factor of saturation levels, which is negatively correlated in 1980 and 1991 -- and the last factor in each timeframe -- but is fairly positively correlated to the change between 1980 and 1991.

A closer look at the buyer power factor for 1980 is provided in Figure B-2. It turns out that it is only positively correlated to the extent that products are customized in 1991, which is to be expected since powerful buyers can dictate that products be customized to their needs. It is, however, negatively correlated to every other indicator, and to most of them quite strongly. Other than the one strong positive correlation to Extent Customized, the buyer power and saturation level factors share the same basic characteristics:

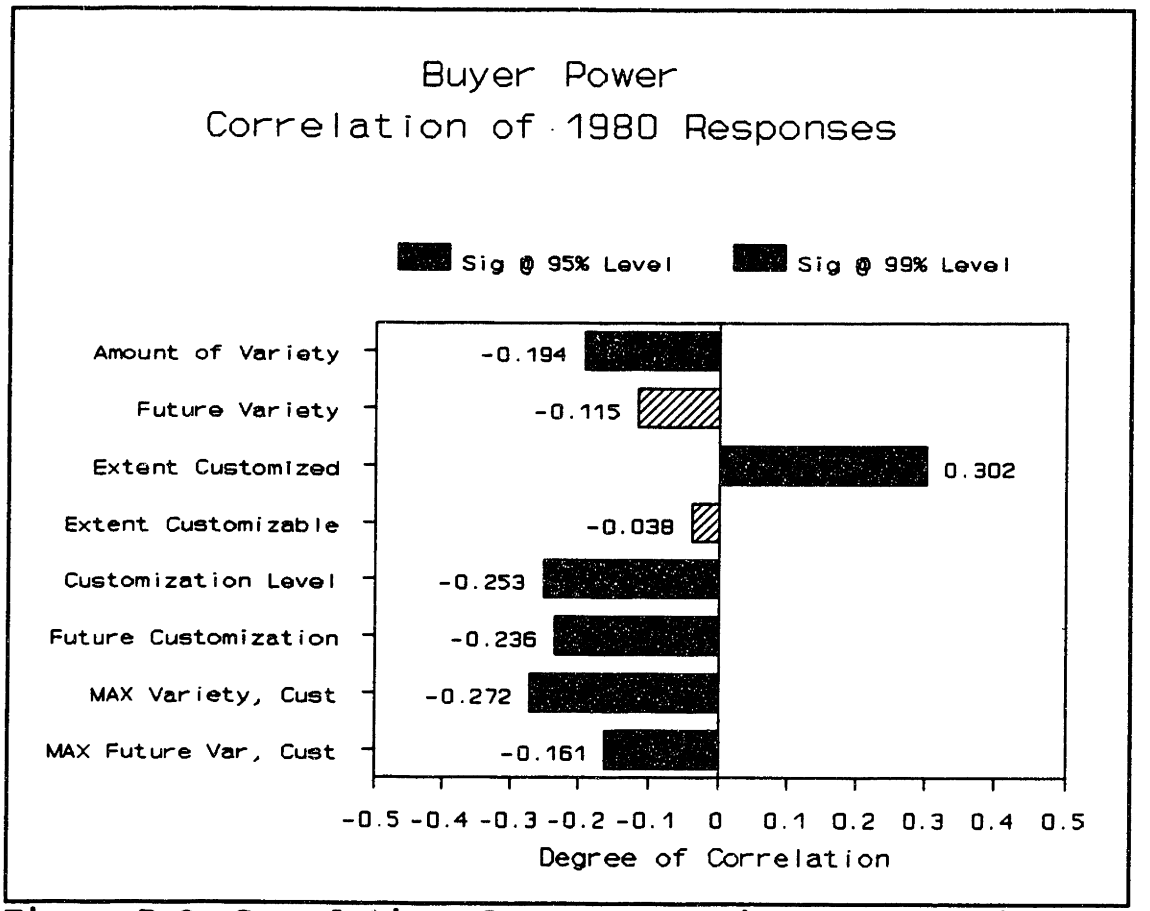


Figure B-2. Correlation of Buyer Power in 1980 to Indicators of Variety and Customization

- The levels of buyer power and saturation in 1980 are both negatively correlated to increased variety and customization in 1991 and the future.
- Their levels in 1991 are both negatively correlated to increased variety and customization.
- However, the difference in their levels between 1980 and 1991 are both *positively* correlated to increased variety and customization.

No other factors share these characteristics, which are very difficult to explain. They are especially troublesome because these two factors were described in Chapter 5 as among the most important for predicting the paradigm shift.

A clue to a tentative explanation, however, may be found in the one difference between the two factors -- the very positive correlation of buyer power to the extent that products are customized -- for in the analysis of industry groups, the defense industry had a very high degree of customized products (68 to an overall average of 55). It also turns out that the defense industry was alone in having a high degree of buyer power in 1980. This can be seen by glancing back at the Market Turbulence Maps in that section; for convenience the figures are repeated in Table B-6.

Therefore, the buyer power anomaly may have been caused in large part by the 14% of the responses representing the defense industry relative to the other 86% of the responses. That is, high buyer power existed in 1980 only in the defense industry, which had only a small change in variety and customization due to low overall change in market turbulence.

The defense industry also led the field in buyer power in 1991, but was dead last in the degree of change. This

Table B-6. Buyer Power by Industry Group

Industry Group	1980	1991	Change
Automotive	48	63	15
Information Technology	39	55	16
Telecommunications	26	50	24
Defense	60	69	9
Commodity	21	31	10
Other Business Units	43	53	10
All Business Units	41	54	13

corresponds to overall negative correlations between high buyer power in 1980 and 1991 to increased variety and customization, as well as a positive correlation to the change in buyer power between the two timeframes. Further, as noted above, the strong positive correlation of high buyer power in 1980 to the extent products are customized fits with the high degree of customized products in the defense industry. Note also that the second highest industry group in buyer power and in extent of customized products was the automotive group for both sets of years.

The same tentative explanation may hold for the anomaly of saturation levels. This time, as Table B-7 shows, commodity business units lead the rest in high degrees of saturation levels, but there was little change between 1980 and 1991.

Table B-7. Saturation Levels by Industry Group

Industry Group	1980	1991	Change
Automotive	67	71	4
Information Technology	25	49	24
Telecommunications	51	60	9
Defense	63	71	12
Commodity	73	76	3
Other Business Units	52	61	9
All Business Units	53	63	10

The commodity industry group was low, however, on the extent that their products are customized, which corresponds to the fact that saturation levels in 1980 or 1991 did not positively correlate to this variable as buyer power did.

In addition, it is reasonable that high saturation levels and buyer power in the 1970s and '80s may have been the key factors for those firms who decided to retreat from market segments, reducing variety. Further, low saturation levels and buyer power are characteristic of emerging industries -- before the growth and maturity phases -- that by their nature have high degrees of variety and customization. While tentative, these observations help to explain the anomalies of these two market environment factors.

Table B-8. Individual Factors Ranked by Weighted Averages of the Importance of the Two Primary Measures of Market Turbulence

Market Environment Factors	Weighted Average
Rate of Need/Want Change	0.750
Product Life Cycles	0.626
Rate of Technology Change	0.610
Heterogeneity of Wants	0.559
Service Levels	0.440
Quality Consciousness	0.406
Competitive Intensity	0.357
Economic Cycles	0.242
Demand Levels	0.231
Necessities/Luxuries	0.228
Price vs Product Competition	0.217
Price Consciousness	0.204
Certainty of Needs	0.197
Substitutes	0.180
Buyer Power	0.162
Fashion/Style Consciousness	0.156
Saturation Levels	0.022

A final ranking of the individual market environment factors is given in Table B-8 to provide managers with the best list, based on the survey data, of what factors are most important in determining the potential extent of the paradigm shift to Mass Customization. This ranking uses the weights determined by multiple regression analysis at the end of the Hypothesis Validation section of Chapter 6 (see page 186). This analysis found that 60% of the values of the MAXIMUM of Variety, Customization variable were found to be explained by the change in market turbulence, with the remaining 40% explained by the static level of turbulence in

1991; and that 67% of the values of the MAXIMUM of Future Variety, Customization variable were found to be explained by the change in turbulence. Therefore, the final ranking in Table B-8 used these weights to determine the weighted average correlation of each factor to the two MAXIMUM variables, and then added the two weighted averages together.[167]

In the table, the factors have been separated by a blank line whenever a significant gap exists in the correlation data. By far, the best individual factor as a predictor of increased variety and customization is the rate of change in customers' needs and wants. Figure B-3 demonstrates just how strong its 1991 levels, for example, correlate to all of the variety and customization questions: every single correlation is statistically significant at the 99% confidence level.

On the opposite end of the spectrum, the factor of saturation levels appears to be by far the least important.

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[167]The precise formula for each factor in calculating the rankings in Table 6-14 is:

(.6 x correlation of turbulence change to MAXIMUM of variety, customization
+ .4 x correlation of 1991 turbulence to MAXIMUM of variety, customization)
+ (.67 x correlation of turbulence change to MAXIMUM of future variety/customization
+ .33 x correlation of 1991 turbulence to MAXIMUM of future variety/customization)

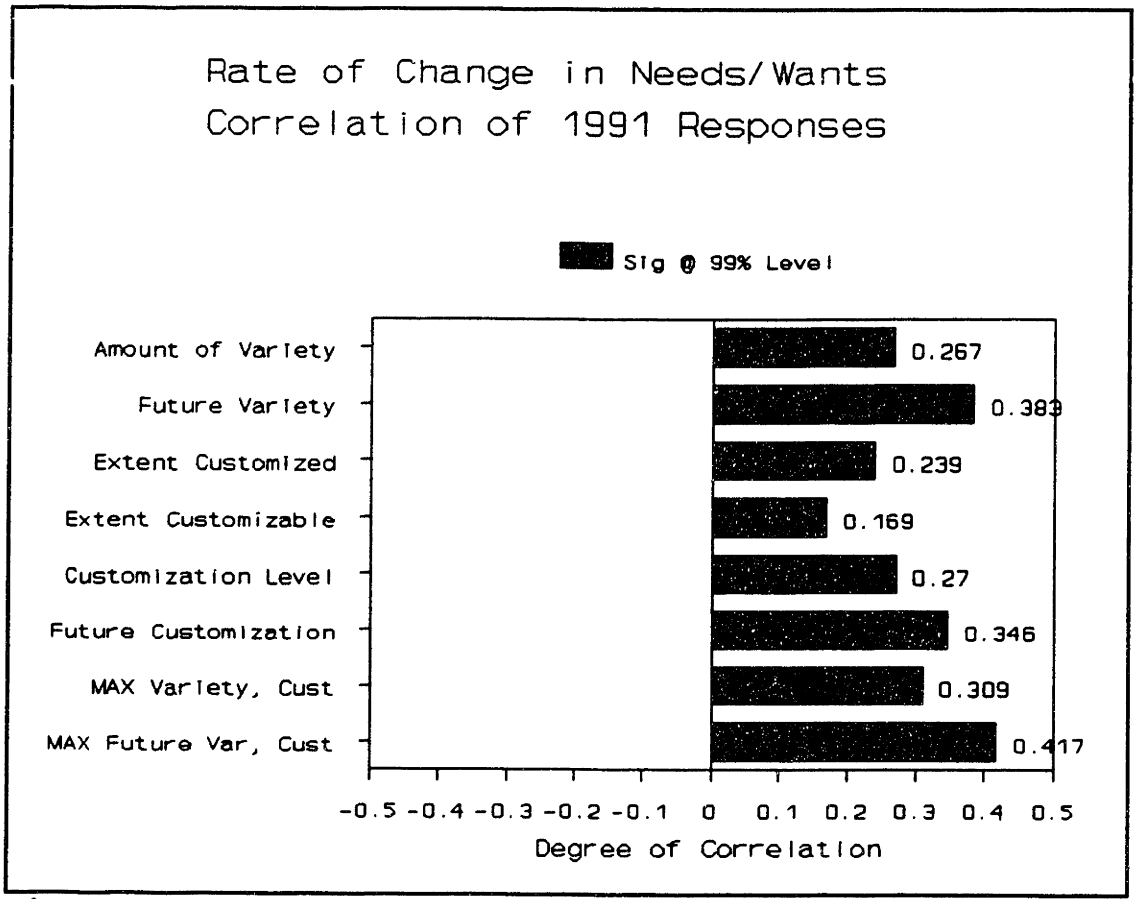

Figure B-3. Correlations of 1991 Responses to the Rate of Change in Customers' Needs and Wants to the Indicators of Variety and Customization

Although the data do indicate some statistically significant positive correlations for this factor, its lack of overall strength, combined with the anomalous results discussed earlier, might warrant the elimination of this factor from the Market Turbulence Map.

Analysis of Additional Questions

As discussed in the **Survey Design** section of Chapter 6, respondents were asked additional questions beyond those needed to validate the basic hypothesis to see if and how increased market turbulence and variety/customization affect companies' products, processes, and organizations. (See Appendix A for the exact wording to the questions, and the direction of the 100-point scale in each case.) To simplify this analysis, regressions were made only against the primary measure of market turbulence, the change between 1980 and 1991, and the summary indicator of the paradigm shift, the MAXIMUM of variety and customization.

Table B-9 gives the regression analysis statistics for all of the additional product questions in Part Three of the survey. The results of each analysis are given below.

Q3.3: Length of Product Life Cycles. The shortening of product life cycles is *very* strongly correlated to both the change in market turbulence and the MAXIMUM of variety and customization. In fact, of all of the analyses performed, the first correlation to market turbulence is the absolute strongest relationship in all four statistical

Table B-9. Results of Correlations of Additional Product Questions to the Change in Market Turbulence and the MAXIMUM of Variety, Customization

Additional Product Questions	Change in Market Turbulence	MAXIMUM Variety, Customization
Length of Product Life Cycles		
Slope	1.08	.49
Correlation	.527	.417
R Squared	.278	.174
t-Statistic	8.35	7.18
Quality of Products		
Slope	.43	.20
Correlation	.294	.216
R Squared	.086	.047
t-Statistic	4.71	3.49
Manufacturing/Production Costs		
Slope	.10	.16
Correlation	.060	.101
R Squared	.004	.010
t-Statistic	0.80	1.59
Meeting Customers' Complete Needs and Wants		
Slope	.05	.29
Correlation	.031	.338
R Squared	.001	.114
t-Statistic	.42	5.66
Importance of Quick Response		
Slope	.66	.38
Correlation	.386	.386
R Squared	.149	.149
t-Statistic	5.62	6.60
Importance of Product Innovations		
Slope	.76	.45
Correlation	.299	.327
R Squared	.089	.107
t-Statistic	4.20	5.44
Importance of Incremental vs Breakthrough Innovations		
Slope	.19	.28
Correlation	.076	.198
R Squared	.006	.039
t-Statistic	1.01	3.15

measures.[168] A one-point increase in market turbulence yields, on average, slightly more than a one-point movement in the scale towards shorter product life cycles. A one-point increase in variety and customization similarly yields a half-point movement towards shorter life cycles.

This goes along perfectly with the description of the paradigm of Mass Customization in Chapter 3. Products are constantly improved and replaced to stay ahead of the changing tastes of customers.

Q3.4: Quality of Products. The quality of products relative to 1980 is also strongly correlated to higher levels of turbulence and variety/customization. Those firms still providing more standardized goods have not tended to improve the level of quality as much as those moving more towards customized goods. The demands for quality by customers will tend to be less for those encountering lower turbulence (note that quality is more strongly correlated to the measure of turbulence), but those producing more variety in their products have to have high quality in their processes to accomplish the feat, which will tend to yield higher quality products also.

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[168]There is some bias here in that one of the 17 market environment factors is itself the length of product life cycles, which is also true of some of the other questions in Part Three. Nonetheless, the very strong, positive correlation is absolutely without doubt.

Q3.5: Manufacturing/Production Costs. Interestingly, those firms providing more variety and customization relative to 1980 also tend to report lower manufacturing and production costs relative to that timeframe. While increased market turbulence will tend to bring with it increased pressure for lower prices and therefore costs, the correlation to increased variety/customization is stronger, although neither are statistically significant. Still, the *t*-statistic of 1.59 translates into an 88% probability that the correlation is above zero. Again, it appears that to produce the increased variety and customization that goes with the new paradigm, firms have to develop processes that yield lower costs. The extent to which processes and organization change with the paradigm shift will be seen below when the questions from Part Four are discussed.

Q3.6: Meeting Customers' Complete Needs and Wants. Although a firm's ability to accomplish this is only marginally correlated to increased market turbulence, it is highly correlated to providing more variety and customization. After all, better meeting customers' complete needs and wants is the whole point of the paradigm of Mass Customization. The results to this survey question confirms that firms are able to accomplish it much more effectively than those providing more standardized goods.

Q3.7: Importance of Quick Response. Similarly, being quickly responsive to customers changing needs is an integral part of the new paradigm. Both variables are very highly correlated to firms' success at accomplishing this relative to 1980. Interestingly, the slope is much higher for increased turbulence than it is for increased variety/customization; this may reflect that as firms' market turbulence increases, they recognize the importance of responding quickly before actually being able to accomplish it.[169]

Q3.8: Importance of Product Innovations. Product innovations (new features, new technologies, new products) become increasingly important as firms' turbulence and variety/customization both increase. Since new innovations are so important to providing the increased variety and customization, it was surprising that the slope of the regression line is lower for this indicator. This may reflect the same situation as with providing quick response, since the question asked about the *importance* of innovations to the success of the business unit, as opposed to the actual *development* of those innovations.

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[169]Note that the identical correlations and R squared figures given in Table 6-12 for these regressions, despite differing slopes and *t*-statistics, are not typographical errors. They reflect the differing number of responses to the questions making up the two variables.

Q3.9: Importance of Incremental vs Breakthrough Innovations. As Chapter 3 discussed, it is an inherent part of the feedback loop of Mass Production that the attitude towards innovations takes on a breakthrough mentality -- a search for the "magical" product that will yield mass market success. The Mass Customization feedback loop, on the other hand, contains a mentality of incremental innovations that more closely match customers' changing needs and wants. This is born out in these results, as movements towards both increasing turbulence and variety/customization correlate to incremental innovations becoming more important. The stronger correlation to the second indicator -- a reversal of the situation from the last two questions on the importance of particular paradigm features -- as well as the lower slopes of both regression lines may indicate that changing the mentality of breakthrough innovations is more difficult to do than to understand that quick response and product innovations themselves have become more important.

Table B-10 gives the regression analysis statistics for all of the additional process and organizational questions in Part Four of the survey. The results of each analysis are given below.

Table B-10. Results of Correlations of Additional Process and Organizational Questions to the Change in Market Turbulence and the MAXIMUM of Variety, Customization

Additional Process and Organizational Questions	Change in Market Turbulence	MAXIMUM Variety, Customization
One-of-a-Kind vs Full Mass Production -- Today		
Slope	.24	.03
Correlation	.071	.015
R Squared	.005	.000
t-Statistic	0.96	0.23
One-of-a-Kind vs Full Mass Production -- Relative to 1980		
Slope	-.08	-.17
Correlation	-.037	-.146
R Squared	.001	.021
t-Statistic	-0.49	-2.30
One-of-a-Kind vs Full Mass Production -- in the Future		
Slope	-.30	-.17
Correlation	-.133	-.137
R Squared	.018	.019
t-Statistic	-1.79	-2.15
Production Flexibility		
Slope	.24	.27
Correlation	.138	.281
R Squared	.019	.079
t-Statistic	1.86	4.55
Length of Product Development Process		
Slope	.42	.36
Correlation	.194	.305
R Squared	.038	.093
t-Statistic	2.65	4.97
Change in Organizational Structure and Processes		
Slope	.81	.35
Correlation	.319	.247
R Squared	.102	.061
t-Statistic	4.50	3.97

Q4.1: One-of-a-Kind vs Full Mass Production -- Today. This question was used extensively in Chapter 6 to understand the demographics of the sample and various segments of it. The

correlations against the two variables in Table B-10 have small but not statistically significant positive results. This may indicate that firms on the mass production side of the scale are somewhat more likely to encounter market turbulence, a portion of which will respond with more variety and customization.

Q4.2: One-of-a-Kind vs Full Mass Production -- Relative to 1980. Continuing this line of explanation, those business units in the survey sample who have provided more variety and customization over the last decade or so have at the same time moved towards the one-of-a-kind production side of the scale. This is a statistically significant result, and one perfectly in line with expectations. The movement for those with increasing market turbulence is not as strong (or significant), again probably because not all of these have gone on to provide as much variety and customization.

Q4.3: One-of-a-Kind vs Full Mass Production -- in the Future. Those providing more variety and customization foresee that they will continue to move away from mass production and towards one-of-a-kind production. The slope of movement is even higher for those experiencing greater market turbulence (although not quite statistically significant). Finishing the story begun in the previous two paragraphs, this might indicate that those who have

undergone increased market turbulence but have not yet added as much variety and customization foresee that they will have to do so in the future, and will have to move further towards one-of-a-kind production in order to accomplish it. The results of all three of these questions are very much in line with the paradigm of Mass Customization.

Q4.4: Production Flexibility. Relative to 1980, those encountering more market turbulence and producing more variety and customization are -- on average -- increasing their production flexibility. While the slopes are similar, the result of the correlation to the MAXIMUM of variety and customization variable is highly significant, reflecting the fact that production flexibility is a prerequisite to providing variety and customization in production.

Q4.5: Length of Product Development Process. Just as we saw with product life cycles above (although more strongly there), the product development process on average gets much shorter as market turbulence and variety/customization increase. The results of the regressions to both variables here are statistically significant and both align perfectly with the paradigm of Mass Customization. To meet the changing needs of customers in fragmenting markets, products must be produced more quickly. And since product life cycles are not as long, the development process must shrink as well

lest a mismatch develop where it takes longer to develop a replacement product than its predecessor lasts in the marketplace. (There were several respondents with identical product development and life cycles.)

Q4.6: Change in Organizational Structure and Processes. Very significant, positive correlations were realized in the regression analysis of this question to the two variables, reflecting the tremendous change in organizational structure and processes that accompany market turbulence and increased variety/customization. The very high slope of the former regression -- a full eight-tenths of a point increase in structure and process change for every one point increase in turbulence -- may indicate that as a firm encounters market turbulence and decides to respond to it, it changes its organizational structure and processes before it increases variety and customization, precisely because it *has* to change *in order to* increase its variety and customization.

To summarize this analysis of the additional questions on products, processes, and organizations, while we cannot be sure that all of the analysis given above is descriptive of what has actually happened in the survey sample, the data results are very consistent with the paradigm of Mass Customization as it was described in Chapter 3.