Columbia Project: Use of Software to Achieve Competitive Advantage

AUTOMOBILES: TOYOTA MOTOR CORPORATION

Gaining and Sustaining Long-term Advantage Through Information Technology

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SOFTWARE AS A TOOL OF COMPETITIVE ADVANTAGE: AUTOMOBILE INDUSTRY

Introduction: Objectives of this Benchmarking Study

This automobile study for Toyota Motor Corporation (TMC) was completed under a three-year research grant from the Sloan Foundation. The project's overall purpose has been to examine in a series of case studies how U.S. and Japanese firms which are recognized leaders in using information technology (IT)[1] to achieve long-term sustainable advantage have organized and managed this process. While each case is complete in itself, each is part of this larger study.[2]

This case for a large automobile producer, together with other cases, support an initial research hypothesis that leading software users in the U.S. and Japan are very sophisticated in the ways they have integrated software into their business strategies. They use IT to institutionalize organizational strengths and capture tacit knowledge on an iterative basis. In Japan this strategy has involved heavy reliance on customized and semi-customized software (Rapp 1995) but is changing towards a more selective use of package software managed via customized systems. This case is illustrated by Toyota's development of its system to automate its traditional "just-in-time" (JIT) ordering from suppliers, its new intelligent transportation system (ITS) and its new smart cars. Conversely, U.S. firms, such as Merck, who have often relied more on packaged

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[1] In this paper and the study, software, information technology (IT) and systems are used interchangeably. In addition, when referring to the firm as a whole, the text uses "it", but when referring to management, "they" is used.

[2] There is no comparable US auto company case. However, the industries and firms examined are food retailing (Ito-Yokado), semiconductors (NEC and AMD), pharmaceuticals (Takeda and Merck), retail banking (Sanwa and Citibank), investment banking (Nomura and Credit Suisse First Boston), life insurance (Meiji and Nationwide), autos (Toyota), steel (integrated mills and mini-mills, Nippon Steel, Tokyo Steel and Nucor), and apparel retailing (Isetan and Federated). Nationwide has replaced USAA, as the latter was unable to participate. These industries and cases were generally selected based on the advice and research of specific industry centers funded by the Sloan Foundation. These are the computer and software center at Stanford, the semiconductor and software centers at Berkeley, the financial services center at Wharton, the pharmaceutical and auto centers at MIT, the steel project at Carnegie-Mellon, the food services project at the University of Minnesota and the apparel center at Harvard. The case writer and research team for this case thus wish to express their appreciation to the Alfred P. Sloan Foundation for making this work possible and to the Sloan industry centers for their invaluable assistance. They especially appreciate the guidance given by the auto center at MIT as well as the staff at Toyota who were so generous with their time. Still, the views expressed in this case are those of the author and are not necessarily those of Toyota or its management.

software, are now customizing more. This is especially true for the systems needed to integrate software packages into something more closely linked with a firm's business strategies, markets, and organizational structure.

Thus, coming from different directions, there appears to be convergence in the strategic approach of these leading software users. The cases confirm what some other analysts have hypothesized; a coherent business strategy is a necessary condition for a successful IT strategy (Wold and Shriver 1993).[3] These strategic links for Toyota and Japan's automobile industry are presented in the following study.[4]

Business strategies are important in understanding IT strategies. This case along with the other case studies illustrate that the implementation and design of each company's software and software strategy is unique to its competitive situation, industry, and strategic objectives. These factors influence how each chooses between packaged and

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[3] These and other summary results are presented in another Center on Japanese Economy and Business working paper: William V. Rapp, "Gaining and Sustaining Long-term Advantage Through Information Technology: The Emergence of Controlled Production," December 1998. Also see: William V. Rapp, "Gaining and Sustaining Long-term Advantage Using Information Technology: Emergence of Controlled Production," Best Papers Proceedings, Association of Japanese Business Studies, Salt Lake City, UT, June 1999.

[4] All the cases are being written with a strategic focus. That is, each examines a firm's IT strategy rather than the specific software or IT systems used. In this sense, they illustrate how IT is used to improve competitiveness rather than what specific software a firm is using. The latter is generally only noted to illustrate and explain the former. This emphasis was not specified when the project began but evolved as research progressed. There are three major reasons the cases became focused this way. First, at a detailed level, all these firms have unique software and IT systems due to the way each weaves organization with packaged and custom software. There is thus little others could learn if a study just explained each firm's detailed IT system or systems. Further, the cases would be long and would quickly drown the reader in data since IT pervades all aspects of these very large corporations. This was apparent at an early stage in the research when the project team tried to develop IT organization charts for Takeda, Merck and NEC. The second reason is that at a general level, differences in firm IT systems can be almost trivial since there are only a limited number of operating system options, e.g. IBM mainframes, Unix workstations, and Windows or MAC based PCs. Third, information technology changes very rapidly and thus each firm is constantly upgrading and evolving its systems. So detailed descriptions of each IT system would rapidly become obsolete. For these reasons, focusing the cases on strategic principles developed as the best way to explain to readers something they could use and apply in their own situations. This reasoning has been confirmed when the material has been presented in different forums as discussants have commented favorably on the approach. Equally importantly, in our interviews and conversations with management, this is where they have focused their responses. That is, as the various cases illustrate, the firms manage their IT decision-making by following a set of strategic principles integrated with their view of their competitive environments. This is similar to Nelson and Winter's (1982) rules and routines for other kinds of management decisions and innovations, and illustrates these firms' evolutionary approach to IT use and development. Their basic reasons for this incorporate the points noted above, i.e. each firm's unique system, the limited operating system options, and IT's rapid technical change. Based on what the case study teams have learned, therefore, it is these firms' strategic approaches, including the concept of controlled production explained later, that seem to have the widest applicability

customized software options to achieve specific goals, and how each measures its success. Indeed, as part of each firm's strategic integration, Toyota and the other leading software users examined, have linked their software strategies with their overall management goals through clear mission statements that explicitly note the importance of information technology to the success of the firm.

Each has also coupled this view with active CIO (Chief Information Officer) and IT-support group participation in the firm's business and decision-making structure. Thus for firms such as TMC the totally independent MIS (Management Information Systems) department is a thing of the past. This may be one reason why out-sourcing has not been a real option for TMC, except to captive subsidiaries (Rapp 1995). The company's successful business performance in automobiles and other vehicles is not based solely on software, however. Instead, as is described below, software is an integral element within its overall management strategy with respect to producing, selling and servicing automobiles. It also plays a key role in serving corporate goals such as enhancing plant productivity by improving production scheduling, reducing inventories or strengthening customer relations. The systems are thus coupled with the company's approach to marketing, design, production, customer service, new product development and constant cost reduction. This reflects Toyota's clear understanding of its business, its industry, and its competitive strengths within the context of its industry.

This clear business vision, especially of the smart car, smart design and smart production strategies described below, has enabled TMC's management to select, develop and use the software they believe is required to assist TMC's plants to operate at

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and offer other organizations the most potential insights without becoming dated in how to use IT to improve competitiveness. The detailed strategy described here, though, only applies to vehicle production and primarily autos.

a higher and more consistent level of performance and customer support. In turn, TMC has integrated this support to its plants into a total support system for the firm, including its overseas affiliates, which is coupled with the company's overall operations including parts and steel ordering. Since this vision impacts other corporate decisions, TMC has also developed good human resource and financial characteristics (see Appendices I & II on Strategy & Operations as well as Firm & Industry Data).

Toyota does share some common IT approaches with other leading software users, such as the creation of large proprietary interactive databases that promote automatic feedback between various stages of the design, order, production, delivery, and the service process. Its ability to use IT to economize on traditional production systems and inventory practices, such as the amount of steel that must be held for various automobile models, is also a common issue for other leading software users. In addition, TMC has been able organizationally and competitively to build beneficial feedback cycles or loops that increase productivity in areas as different as design, customer warranty service and product availability while reducing cycle times and improving the production and delivery of products and replacement parts to the customer.

TMC's management recognizes that better cycle times between client orders and ultimate delivery reduce costs and improve business forecasts since projections are for shorter periods (Fujimoto 1999). Similarly, more rapid design cycles more quickly incorporate the latest technologies in its new model cars (Sealy 1991 and Sobek 1997). Therefore, customer satisfaction is improved through the more timely completion of the sales process as well as the constant product enhancement. One example of this use of IT to improve competitiveness through faster cycle times is TMC's new parallel and buffer stock production system that permits Toyota to reduce assembly times compared to the traditional continuous track approach (Fujimoto 1999 and company visit). In sum, IT inputs are critical factors in TMC's and other leading users' overall business strategies, yielding strong positive results for doing it well and posing potentially negative implications for competitors.

An important consideration in this respect is the apparent emergence of a new strategic production paradigm, "controlled production" ("CP"), where TMC is clearly a leader. Mass production dramatically improved on craft production through economies of scale using standardized products, and lean production improved on mass production by making production more continuous and tying it more closely to actual demand. "Controlled" production seems to significantly improve productivity through monitoring, controlling and linking every aspect of producing and delivering a product or service, including after sales support and product changes. Such effects are described for Toyota in what follows in terms of its new smart car combined with its smart design and smart production scheduling.

However, controlled production (CP) is only possible by a firm actively using IT systems to continuously monitor and control functions that were previously parts of a business structure that only responded to changes in expected or actual demand. Now it can actually influence or stimulate those changes. This may be why such firms and several industry analysts see the skillful use of IT as important to these firms' success, including Toyota's (Brogan 1997a and Matsushima 1998). But this is only true when IT is integrated with the firm's business from an operation, product and organization standpoint, reflecting its overall business strategy and clear competitive vision.

This is one reason why at Toyota the software and systems development people are part of the decision-making structure within each plant and operation. So Seagate Technology is certainly correct for Toyota when it states in its 1997 Annual Report: **"We are experiencing a new industrial revolution, one more powerful than any before it. In this emerging digital world of the Third Millennium, the new currency will be information. How we harness it will mean the difference between success and failure, between having competitive advantage and being an also-ran."**

However, the key in TMC's case to using IT successfully, as with the other leading software users examined, is to develop a mix of packaged and customized systems that support the firm's business strategies and differentiate it from competitors. TMC's management has achieved this by using IT to enhance its organizational and product strengths rather than trying to adapt TMC's organizational structure or products to the software used. They have also looked to functional and market gains to justify the additional expense incurred in customizing certain systems, including the related costs of integrating customized and packaged software into a single IT system while training employees to use it. This integration is done by first assessing the possible business uses of software within the organization, its operations and its products. Particular focus is placed on IT's role in enhancing Toyota's core competencies in developing, producing and delivering many different qualities and types of vehicles (Appendix II). Management therefore rejects the view that IT systems are generic products best developed by outside vendors who achieve low cost through economies of scale and who can more easily afford to invest in the latest technologies.[5]

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[5] Toyota and the other cases have been developed using a common methodology that examines cross-national pairs of firms in key industries. In principle, each pair of cases focuses on a Japanese and American firm in an industry where

Approach: Methodology and Questions

In undertaking this and the other cases to assess the importance for each firm of the IT related issues noted above, the project team sought to answer key questions while recognizing firm, country, and industry differences. These have been explained in the summary paper referenced in footnote 3 and are set forth for Toyota in Appendix I as well. TMC's profile is presented there based on company interviews and other research. Readers that wish to assess Toyota's strategies and approaches to using IT in summary form prior to reading the case may find it a useful outline.[6]

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software is a significant and successful input into competitive performance. Excepting Nationwide Insurance, the firms examined are ones recommended by the Sloan industry centers as ones using IT successfully. A leading securities analyst recommended Nationwide as a replacement for USAA. So all are recognized by their industries as being good at using IT to improve competitiveness. To develop these "best-practice" studies the research team combined analysis of current research results with questionnaires and direct interviews. Further, to relate these materials to previous work as well as the expertise located in each industry center, the team talked with the industry centers. In addition, it coupled new questionnaires with the materials used in a previous study to either update or obtain a questionnaire similar to the one used in the 1993-95 research (Rapp 1995). This method enabled the researchers to relate each candidate and industry to earlier results. The team also worked with the different industry centers to develop a set of questions that specifically relate to a firm's business strategy and software's role within that. Some questions address issues that appear relatively general across industries such as inventory control. Others such as managing the IC manufacturing process are more specific to a particular industry. The focus has been to establish the firm's perception of its industry and its competitive position as well as its advantage in developing and using a software strategy. The team also contacted customers, competitors, and industry analysts to determine whether competitive benefits or impacts perceived by the firm were recognized outside the organization. These sources provided additional data on measures of competitiveness as well as industry strategies and structure. The case studies are thus based on detailed interviews by the project team on IT's use and integration into management strategies to improve competitiveness in specific industries, augmenting existing data on industry dynamics, firm organizational structure and management strategy collected from the industry centers. Further, data was gathered from outside sources and firms or organizations that had helped in the earlier project. Finally, the US and Japanese companies in each industry were selected based on being perceived as successfully using software in a key role in their competitive strategies. In turn, each firm saw its use of software in this manner while the competitive benefits were generally confirmed after further research. In the case of automobiles the team was particularly aided by presentations given by the MIT automobile group at the annual Sloan Industry Center Meetings from 1997-99 as well as the book produced by that Center (Womack, Jones and Roos 1990).

[6] The questions are broken into the following categories: General Management and Corporate Strategy, Industry Related Issues, Competition, Country Related Issues, IT Strategy, IT Operations, Human Resources and Organization, Various Measures such as Inventory Control, Cycle Times and Cost Reduction, and finally some Conclusions and Results. The questions cover a range of issues from direct use of software to achieve competitive advantage, to corporate strategy, to criteria for selecting software, to industry economics, to measures of success, to organizational integration, to beneficial loops, to training and institutional dynamics, and finally to inter-industry comparisons. These are summarized for Toyota in Appendix I.

Introduction to Case

The TMC case begins by placing Japan’s automobile industry in a competitive context and then examines the governmental policies, economic factors, and competitive dynamics affecting the Japanese and global automobile markets and its producers. As Japan's leading auto producer, and one of the world’s largest (Appendix II), Toyota's evolution, competitive situation and current strategies are integral to this picture. Its situation illustrates well many of the competitive issues facing the world automobile industry. As competitive pressures mount, many Japanese firms are being absorbed by global groupings such as GM, Ford, Daimler-Chrysler, and Renault. These expanding groups are aggressively challenging the leading Japanese producers, Toyota and Honda, in both export and domestic markets. It is therefore critical to TMC’s long-term strategy that it successfully maintains its position, as the world’s most efficient vehicle producer, while managing its planned transition to a new competitive model (Appendix II).

This is because vehicle production and related businesses, such as replacement parts and finance, represent virtually all its revenues, operating earnings and invested capital (Table 11). At the same time, TMC’s organizational structure and software product choices help one understand the company's use and demand for IT while the case describes how it is using and plans to use IT as a tool to create a competitive advantage in producing, selling and delivering automobiles. But to appreciate IT’s role within TMC, some auto industry, market and economic characteristics need to be explained.

The Industry Context: The Japanese and Global Automobile Industries

“Since its establishment, Toyota’s principle has been to strive constantly to build ‘better products at lesser costs.’ To this end, Toyota has developed its own unique production method. This system is based on the idea of 'just in time' (i.e. producing only the necessary amount of parts just at its needed time), the idea of Toyota Founder Kiichiro Toyoda. This system also seeks to thoroughly eliminate all sorts of waste in order to reduce prime costs. Toyota also places a maximum value on the human element, allowing an individual worker to employ his capabilities to the fullest through participation in the productive management, and improvement of his given job and its environment. With the motto 'Good Thinking, Good Products,' each individual worker is making his best effort to assure Toyota's customers the highest quality product, with an understanding that it is in his work process that quality is built in," (TMC 1994).

Using these principles, by the late 1970s and early 1980s, TMC was firmly established as the world's most efficient and lowest cost producer of high quality automobiles (Womack, Jones and Roos 1990 and Fujimoto 1999). The reasons for this were then explained during the late 1980s through a series of studies organized by MIT's Automobile Industry Center culminating in 1990 in Womack, Jones and Roos' seminal work on lean production. As a result, U.S. and European producers became well aware of lean production principles and have spent several years benchmarking and trying to catch Toyota. In addition, they expanded through global groupings to combine global scale and scope with improved design and manufacturing efficiency.

Therefore, competitive pressures began to shift significantly during the 1990s for Japanese auto producers from two industry-based sources. One was the emergence of these larger global and more efficient competitor groupings such as Ford, GM, Renault, Daimler-Chrysler and Volkswagen. The second was the serious decline in domestic auto demand as the Japanese economy felt the combined pressures of the Bubble collapse and a continuing strong yen (TMC 1999, Brogan 1997a and Appendix II). On top of these conditions, the strong yen made Japanese auto exports less competitive in world markets, stimulating foreign direct investment (FDI) by Japanese producers, which further reduced export demand for Japanese cars. As seen in Appendix II, these cumulative effects were only moderately ameliorated by increased export demand due to a rapidly expanding Asian economy. Indeed, due to local content and production requirements, Japan's high Asian market share did not help Japanese auto producers all that much in using excess Japanese production capacity despite the region's rapid growth. In 1995, for example, out of total vehicle sales of about 3.9 million units in Asian markets other than Japan, roughly 3.5 million units in total were produced in those Asian countries (including exports outside of Asia). In turn only 600,000 units were imported from Japan, which was only a 100,000 units' increase from 1991. So the impact of Asia's economic expansion during this period on Japanese vehicle exports and production capacity utilization was fairly modest (MacKnight 1997).

While Japanese vehicle shipments (exports plus domestic demand) hit an all time high of 13.6 million units toward the end of 1991, domestic production peaked at 13.5 million in 1990 with the end of the Bubble. It subsequently fell to 10 million units by 1998 (TMC 1999). Further as indicated in Table 3 (Appendix II), exports fell from about 6.6 million units in 1986 to 3.3 million in 1998, while domestic demand, which peaked in 1990 at 7.8 million units, fell by about 1 million units during the 1990s. At the same time, overseas production rose dramatically from very low levels in 1986 to several million units a year by 1998 (Tables 3 and 8). So the combined and interactive effect of a strong yen and FDI on exports has created substantial excess Japanese production capacity. The drop in domestic demand due to the recession has just added to that extra capacity. Further, this extra capacity is unlikely to be absorbed via either a Japanese recovery or exports since domestic demand is currently saturated at around 7 million units (MacKnight 1997) and overseas production is still expanding.

However, this excess capacity has created real downward pressure on prices, while increasing domestic and export competition. Yen appreciation has had a direct effect on profits and competition (Table 9), but there have been indirect and strategic effects too. These stem from the fact that in a declining market, the low cost producer has a great advantage. This is because that firm can afford to continue to invest in capacity and research and development (R&D) as well as develop new models. It can also afford to price lower to maintain market share and keep its factories operating profitably and close to capacity. In a capital-intensive fixed investment industry like automobiles, this yields tremendous operating advantages that tend to compound over time since the natural reaction of weaker competitors is to rationalize and cut back in areas like R&D, capacity additions or new model development. If the decline in demand is short-term, these actions may have minimal strategic effects. But when weaker demand and excess capacity becomes protracted, as it has for Japan in the 1990s, the competitive effects of decreased innovation and older-looking models become important since consumers correctly perceive that the low-cost producer's products are both cheaper and technically superior. In addition, the low-cost producer can invest in new plant and equipment or production capacity that can further increase cost competitiveness.

This appears to have been the situation for Toyota and Honda compared to firms such as Mazda, Nissan and Mitsubishi.[7] As seen in Table 9, the latter tried to solve their negative margin problems (Table 6) by rationalizing production and reducing or just maintaining R&D. These solutions to the effects on automobile demand of the Bubble collapse and a strong yen were generally not successful, though, since they did not close the productivity gap with the industry leaders, Toyota and Honda (footnote 7). Toyota particularly was able to continue to increase profits through process and product design improvements while both Toyota and Honda expanded their product offerings (Table 9). Throughout the 1990s Toyota and Honda remained profitable while their Japanese competitors faced loses and more pressure to rationalize and keep R&D and model changes low. Since Toyota and Honda continued and even increased their heavy R&D investment and new model introduction, however, they were constantly able to bring new and improved products to the market and especially innovative vehicles such as the hybrid car (Tables 5 and 8; Brogan 1997a). But while this approach helped TMC to maintain, and perhaps even improve, its competitiveness, it did not raise production at TMC's domestic plants. This is because TMC still had to lower domestic output as production shifted overseas in response to a strong yen, weak domestic demand (Table 8), and foreign governments' regulations and investment incentives (MacKnight 1997).

[7] Fujimoto (1999) and Smitka (1993) note that in the 1970s and early 1980s Japanese automobile producers were the world's lowest cost. Fujimoto cites several studies that indicate Japan's productivity advantage may have been double the U.S. and three times Europe. At a 200 plus yen-dollar exchange rate this translated into an almost 50% cost advantage. However, due to the strong yen, which roughly doubled its value after 1985, and the productivity gains of Western producers, especially U.S. firms, "the overwhelming unit cost advantages of the average Japanese car maker that existed in the early 1980s had been basically wiped out by the mid-1990s," (Fujimoto 1999). This is why Smitka (1993) was basically correct in predicting the Japanese industry's decline. At the same time averages can disguise substantial cost differentials among firms. So while Western producers had caught the Japanese average, "Toyota's cost advantage over other Japanese firms was estimated to be at least several hundred dollars per car in the early 1990s." Therefore, as seen in Appendix II, it was the relatively weaker Japanese firms and particularly Nissan that bore the greatest effects of the change in market demand and global competitive pressures.

This situation indicates how for Japanese automobile producers trade and international competition now have a much different impact compared to the period before September 1985 and the Plaza Accord's impact on the global competitive environment. Prior to the Accord the Japanese were the acknowledged cost leaders worldwide in producing high quality small cars (Smitka 1993 and Fujimoto 1999). As Smitka (1993) and Fujimoto (1999) explain, the effect of the big yen appreciation in late 1985 was to close the cost gap with most foreign producers. Then when these foreign producers began to understand and apply lean production techniques as well, the efficiency gap began to close too (Smitka 1993 and Fujimoto 1999). So while exports have been an important source of demand for Japanese producers since the 1960s (Rapp 1972) and continue in auto parts as an area of trade negotiations with the U.S., Japanese cars no longer are in short supply or sell at a premium in the U.S. market. Rather, a strong or weak Yen relative to the dollar affects prices for Japanese produced cars both overseas and in Japan. In addition, with over 50% of sales being tied to foreign markets (Tables 1, 8 & 10), events external to Japan such as the U.S. stock market boom or the Asian financial crisis can affect Japanese producers' business results, such as Toyota's, both positively and negatively. So, more than ever before, international circumstances and exchange rates impact profitability and the demand for Japanese brand vehicles in domestic and overseas markets (Matsushima 1998).

This competitive situation raises several important strategic issues once one recognizes that the global market for automobiles is not static. That is, there are several important trends occurring within the industry that are inter-linked. First, unit growth in automobile demand is no longer in the advanced countries but in developing ones

(MacKnight 1997). However, in the advanced countries, including Japan, there has been a dramatic demand shift from sedans to recreational vehicles (RVs), so that the growth in demand for new RVs has been quite strong.[8] At the same time Japan, several European countries and states such as California, which is the fifth largest car market in the world (Sealy 1991), have introduced increasingly stringent environmental and mileage standards (Brogan 1997a). These affect the ability of producers to meet these standards and still respond to the increased demand for RVs that tend to be less fuel-efficient. This is because these standards are frequently on a fleet-sold basis. Therefore, automobile companies need to have more cars with better mileage and emission performance in order to sell many of their high-margin RVs. In addition, it is likely that many developing countries such as China that are already facing serious pollution issues will need to implement similar regulations in the future.

In combination with their economic situation, this strategic landscape has several important implications for Japanese producers. One, it indicates there is excess capacity in Japan of three to four million cars that will not be used in the foreseeable future for meeting either domestic or export demand (Keller 1997, MacKnight 1997 and Appendix II). Therefore, plant closings are inevitable, and Nissan has already announced some. In addition, to fully use the remaining capacity, firms will need to shift production both towards RVs and environmentally sensitive vehicles. This has already happened to a large degree in RVs (Matsushima 1998), but only Toyota and Honda have made significant strides with respect to the latter. Furthermore, since several other advanced

[8] This demand shift has benefited TMC because Toyota is able to use the same parts for regular cars and RVs, but RV prices and margins are higher. So the fact that this market has grown is good from a business viewpoint. Also Toyota can still benefit from its scale and low cost parts supplies.

countries have excess supply plus what is being added in developing countries (Keller 1997 and MacKnight 1997), Japanese FDI in automobiles will need to be efficient. They will also need to produce vehicles that are responsive to demand in terms of size, price, fuel economy, local conditions and the environment.[9] Recently, the biggest and fastest growing vehicle market has been Asia, and with about an 80% market share, the Japanese currently dominate it since they saw its potential very early (MacKnight 1997). They were also pushed in this direction by the combination of Japan's recession and the strong yen. However, this size and growth is inviting strong challenges from the new global auto groupings (Keller 1997 and MacKnight 1997). This is quite logical since the potential here is very great when one recognizes that in the U.S. there is one vehicle for every licensed driver, but in the developing countries it might be one for every ten or twenty. In addition, just India and China have populations exceeding 1 billion. This is why the major global groupings are pushing into Asia.

The global groups have been aided in this belated initiative by several fortuitous developments. One, the Asian financial crisis has forced three major Korean producers, Hyundai/Kia, Daewoo and Samsung, to restructure, including possible foreign ownership. The Asian crisis plus Japan's continued recession has forced the weaker Japanese automobile producers including Nissan, Mitsubishi and Mazda into progressive rationalizations and periodic losses (Appendix II). Since Toyota and Honda, as explained above, have been able to take advantage of this situation given their greater financial resources and lower production costs, the weaker Japanese firms have been pushed into the arms of the global groups. Mitsubishi has joined Daimler-Chrysler; Mazda has

[9] Keller (1997) notes global excess capacity could be as much as 15 to 20 million vehicles per year. In Japan, such excess capacity and a weak Japanese economy has caused several firms to close plants such as Nissan's Zama plant.

strengthened its ownership ties with Ford; and Renault has acquired Nissan. In addition, Nissan has had to sell its interest in Fuji Heavy (Subaru) to GM, which now has a 20% stake in that firm and effective control in addition to its positions in Isuzu and Suzuki. Thus, except for Toyota and Honda, Japan's remaining car producers have now clearly joined the U.S. and European dominated global groups and will be dependent on them to meet the various cost, model and environmental issues facing the global industry.

Since these other Japanese producers are under cost, demand, and revenue pressures and have limited resources for new models and R&D (Appendix II), they will depend on participation in the global groups for new technologies, new models and an expanded market network. At the same time, their sharing in the allocation of resources and demand will be driven by each group's global strategy and sourcing decisions that will depend on demand for certain vehicles and exchange rates. Given these conditions, it will be very difficult for these Japanese producers to fully anticipate either prices or demand. Furthermore international pressures will be exacerbated by Japan's continued economic weakness that limits demand generally and puts pressure on all producers to fill capacity while further rationalizing production.

While the weakening of such Japanese competitors would seem to be beneficial to Toyota, this combination of events has not left TMC unaffected. Its domestic auto revenues and profitability have declined during the 1990s as these competitors rationalized production and lowered prices to generate sales even at a loss (Appendix II). In addition, now that these competitors have joined one of the major global groups, their continued competitive existence in some form is assured, since they will have greater access to new model designs and technical resources. They will also be able to contribute to their groups' competitive capabilities in foreign markets where Toyota also competes and sees its future market growth.[10] This is an important consideration when one recognizes that certain of these Japanese competitors are strong in selected product-market segments, such as Mitsubishi in RVs. With proper group support, this strength can increase global competitive pressures on Toyota. For example, not only in the U.S. but also in Japan, RVs, including vans, SUVs (sport-utility-vehicles), and station wagons, have become very popular, going from 14.4% of the Japanese market in 1991 to 40.8% in 1997 and 51% in 1998 (Matsushima 1998). This demand shift particularly affected Honda and Mazda whose RV sales went from 0% and 10% of Japanese sales respectively to 63.5 % and 70.3%, while Mitsubishi who has always produced lightweight trucks, saw RVs go from 32.3% to 62.8% of sales. On the other hand, while Toyota's RV sales grew too from 11% to 35.3%, it was not as marked as for its competitors, reflecting its improved position in traditional cars. But even here import competition has increased, rising from less than 1% before 1985 to over 6% of the total car market by 1996 and over 30% in the very profitable large car segment. So even the Japanese market has now become subject to global competitive forces.

Furthermore, TMC's overseas sales and production grew substantially during the 1990s (Appendix II). Indeed, sales growth is now mostly overseas and Toyota expects that eventually global sales will be over 65% of revenues, compared to 48% in 1994 (Matsushima). Therefore competition will be global in all markets against large global

[10] Asian growth is especially key for TMC. "Top Toyota executives see Asian markets-where the world's number-three automotive producer sold 433,000 vehicles in 1995 versus nearly 1.1 million in the United States and almost 2.1 million at home-as key to the success of plans to boost global sales to 6 million units a year early in the next decade from an estimated 4.7 million now. Much larger sales in China and India are central to Toyota's Asian strategy," (MacKnight 1997). This is one reason why TMC recently increased its ownership in Daihatsu to over 50% given the latter's strength in the Chinese market.

competitors. So Toyota must continue to meet certain primary strategic objectives in order to manage these challenges of global expansion, shifting demand and stronger competitors. First, it must continue as the global low-cost producer; second, it must expand further into emerging markets (footnote 10); and third, it must develop and produce new cars and technologies that meet its vision of the future. Further, it must accomplish this as its own independent global group. Rationalizing its operations as its Japanese competitors other than Honda have done is not a logical approach to addressing these considerations. Rather, the strategy it has developed seeks to build on existing strengths to produce more efficiently a wider model range responsive to existing or emerging demands. A strategic problem for Toyota in implementing this approach, though, is how to substantially differentiate its product and services, including new ones, from those of its competitors, even if it continues to be the world's most efficient and lowest cost producer domestically and overseas.[11]

This is because, as explained above, all its competitors were able to effectively follow the demand shift to RVs. Even Honda, which primarily had produced sedans, was able to extend its line into small sports cars, sport utility vehicles, and vans. So with the support of the larger global groups, Toyota's competitors should be able to make similar future shifts, including possible increases in value added through new features or technologies. Acquisitions and affiliations have also been easily emulated. Indeed almost all large Japanese auto producers have been able to find similar solutions given the same business and economic environment in terms of geographic or product diversification

[11] Toyota wants its Japanese production to be about 13,000 units per day. This is because if production drops below 12,000, TMC would have to go under an 8-hour day. But this level is affected by the exchange rate. Every 10 yen change impacts profits by 1 billion yen. Thus, despite changes in the market, if the yen went to 130 from 140, for example, profits would fall. However, as TMC is the strongest Japanese producer globally in costs, profits, technology, management, and economics, such a yen change would make them stronger relative to Japanese competitors.

possibilities, global affiliation and cost reduction initiatives. This is why TMC has recognized for some time that another strategic approach is required to address the changing nature of the industry, the increase in global group-based competition and periodic excess capacity. And it must be one that is not easily emulated by competitors, even the more formidable competition that will emerge from the well-financed and well-staffed mega-groupings with their recently expanded Japanese ties.

Without such a strategy the firm's major business and the company could continue to be adversely impacted by events largely outside its control such as exchange rate fluctuations, global economic developments and industry consolidation. On the other hand if Toyota can succeed in its objective of efficiently selling to existing and new customers a wider range of specialized or even unique products and services that cannot be easily copied, then sales and earnings should increase, while global market share will expand. This is the key strategic issue TMC has been facing. The solution has been to develop a smart-design, smart-production and smart-product strategy that can efficiently offer customers an expanded range of customized products and services in ways that cannot be easily copied or adopted by competitors. A key element within this strategy involves the use of both organizational and embedded information technologies.

Toyota's Multi-faceted Global Strategy

To meet a globally diverse market and competitive challenge TMC has developed an equally diverse and global strategic response. While there are many elements to this, two aspects stand out as particularly important. One is the use of IT to enhance Toyota's lean production and lean design strategy so that it evolves into a smart production and design strategy. The other is to design and develop vehicles that are also smart. In this way they are responding to Mr. Okuda's vision of the future evolution of the global automobile industry (Okuda 1998), where he states in "When the Ground Rules Change": "I now have discussed three watersheds in the history of the automobile industry. Each time, a new business model changed the ground rules for the industry. Each time the new model seemed invincible. And each time, it gave way to changing circumstances and a new business model. ... Our old business model is breaking down for four main reasons. One, we need to decentralize our manufacturing and R&D activities ... Two, the product and process paradigms that Henry Ford established are themselves breaking down ... Three, information technology is transforming the inner workings of the automobile. It is also transforming the way we develop and make and sell our products. And four, the changing product paradigm and the growing role of information technology will open our industry to a vast array of competitors." One aspect of this perspective bears on the way TMC produces its products since this influences both product design and competitiveness and has been central to Toyota's development as the world's low cost producer. A second impacts the products and services TMC will be selling in the future.

Smart Production

While seemingly contradictory due to its impact on prices and profits (Appendix II), one benefit for Toyota of Japan's rapid economic expansion during the late 1980s was that many Japanese auto producers added capacity. This is because most of this expanded capacity during the Bubble period went into highly automated plants that turned out to be economically inefficient due to high capital and maintenance costs combined with excessive downtime due to complex production processes (Fujimoto 1999). Toyota, on the other hand, while experimenting with sophisticated automation off-line, avoided a large commitment to this approach by sticking to its basic philosophy of keeping it simple and using the “human element” and its “capabilities”, as quoted from the company’s manual at the beginning of the previous section.

As Fujimoto (1999) explains: “when automation technologies are adopted, the Toyota-style factories tend to take a conservative stance, both economically and technologically. For example, these plants have tended to authorize only low-cost robots whose unit investment cost can be repaid back in one or two years (i.e., equivalent of a year’s labor cost). Technologically, they tend to choose simpler equipment that has ‘just enough’ functions, rely on mechanistic automation rather than sophisticated numerical control whenever the latter does not seem to be reliable enough, and use semi-automation rather than full automation methods whenever the former seems to be cost-effective.” Thus, the emphasis here for Toyota as in other areas, including using IT, is on total cost effectiveness and reliability, while avoiding using technology for its own sake. This policy has in turn improved relative profitability and return on investment.

In addition, it was this orientation that led Toyota to develop its multi-faceted strategy that incorporates a smart multi-path design and produce strategy together with the strategic use of IT to enhance both organizational and product performance. To differentiate this approach from TMC’s traditional lean production strategy, this case will refer to it as TMC’s smart design, smart production and smart car strategy, or just “smart” strategy. The first part of this new smart strategy, i.e. smart design and production, is described by Fujimoto (1999) in some detail and so will only be summarized here. However, IT’s role in supporting this new approach will be described more fully, both because it is the focus of this case, and because Fujimoto touches on it very briefly. The second part of TMC's new approach, or smart product strategy, while explaining the growing role of embedded software and electronics in automobiles generally, will emphasize its role in implementing TMC's twin initiatives in environmentally sensitive vehicles and intelligent transportation systems (ITS) respectively. Toyota believes this dual approach that emphasizes both organization and product will meet its strategic requirements including that competitors will find it difficult to emulate.

We know from Womack, Jones and Roos (1990) and other researchers that TMC had already developed a comprehensive lean production system by the early 1970s. As other Japanese producers such as Mazda and Mitsubishi emulated it, the whole Japanese industry began to achieve similar productivity improvements. Indeed, as already explained above, the Japanese industry had a huge productivity and cost advantage by the early 1980s, which was only eliminated in the early 1990s by a large yen appreciation and the U.S. industry's strong productivity improvements (Fujimoto 1999 and Smitka 1993). By this time, though, TMC had almost 30 years of experience with lean production compared to perhaps five to ten for Western firms. Further, lean concepts were totally integrated into TMC's organization and strategic thinking. Therefore, as Toyota began to feel the competitive pressures discussed above and the need for a new approach, it was in the best position to assess the strengths and weaknesses of its own production system. In making this assessment, Toyota shows its tremendous ability to learn and think in an evolutionary manner (Fujimoto 1999).

In its simplest terms TMC recognized that despite its production efficiency due to just in time delivery, its lean production line was still a line. There were also limits to the benefits of assembling larger “black-box” units delivered from suppliers (Fujimoto 1999). Operations in both cases had to be done sequentially rather than in parallel. Secondly, there were certain steps in the assembly process where TMC had improved productivity to a point where further improvements were marginal. These limited the speed at which the entire line could improve. Thirdly, the labor force was aging, and, despite the recession, in the long-term there was likely to be a shortage of assembly workers leading to more older workers, part-timers or returnees, such as women, working in its plants. This thought process led to a complete rethinking of the assembly line. The new process was initiated in a new plant in Kyushu in 1992, and then migrated to Toyota City in 1995 to produce the small RAV4 SUV (Economist March 1995). Success there led to a revamping of the plant in Georgetown, Kentucky in 1999 as well as the Motomachi plant in Toyota City that the case writer visited in November of 1999.

Fujimoto (1999) explains the dramatic productivity improvements of this new smart production system as due to the “ the autonomous complete assembly line concept.” Under this concept the line is broken into 5 to 12 segments with buffer stocks to manage the differences in timing between completing various assembly functions. Therefore one already sees important differences in this approach from the lean production system where the producer tries to have everything operate continuously and where in-process inventories are kept to a minimum (Womack et al 1990 and Fujimoto 1999). Further, whereas previously assembly tasks might be unrelated but were driven by the timing or sequencing of assembly tasks, now related tasks are assigned by segment. As described by Fujimoto (1999) and seen by the author on previous visits, “the final assembly process at Toyota’s conventional factories of the 1980s … can be characterized as follows: Toyota's volume factories adopted the Ford-style moving assembly lines …; there is nothing unique in the body transfer mechanisms and basic layouts of Toyota's conventional assembly lines. … The conveyer lines tended to be separated into three line segments: trim, chassis, and final. Different conveyer systems tended to be used among them. However, no buffer body was allowed between the line segments, so the assembly process was operated as if there had been one long and continuous line."

The new system, however, while retaining many elements of the old (such as just in time parts delivery) is substantively different. "A group of functionally related assembly tasks (e.g. piping) are assigned to one segment. Toyota defined 108 subcategories of assembly tasks and changed the task assignments so that each subcategory was completed within a group of workers. … A quality check is located at the end of each line segment. … Each line segment corresponds to a group (*kumi*) of about twenty workers, within which job rotation and training are conducted. The function and responsibility of group leaders are strengthened. Each group leader, now in charge of a semi-independent line segment, enjoys more discretion in managing the group's operations. For example, each segment can fine-tune its line speed within a certain limit. Other supporting equipment for line control (line speed controllers, switches for planned line stops), information sharing (monitoring, displays and on boards) and self-actualization … is set up for each line segment." In addition, "the automation zone and the manual assembly zone coexist on the same assembly line," and "a group of assembly workers on the line, rather than off-line maintenance staff, are in charge of operating the equipment." Such integration of human and machine elements together with worker responsibility for improving performance is of course a Toyota core competency. So the end result was “generally consistent with what the process engineers had aimed for: … As each set of assembly jobs assigned to a work group became more meaningful and easier to understand, and since each group could self-inspect quality more effectively, the productivity and quality of the autonomous complete line was generally higher than the conventional assembly line, particularly during the start-up period.”

Such improvement was measurable. “The lead time for mastering a job was shortened to about a half. According to a survey of Toyota Kyushu assembly workers, over 70 percent of the respondents said they became more quality conscious and that their jobs became easier to understand, compared to the previous assembly lines. Also, because the body buffer areas absorbed the impact of line stops at other segments, overall down-time decreased.” In this way the system helped workers focus and avoid being “swamped by the complexity and confusion of the line, partly owing to the unrelatedness of tasks assigned to them.” So Toyota’s new system achieved its objectives of substantial improvements in quality and productivity while making it easier to use and absorb a more diverse work force. What is not stated in Fujimoto’s excellent description and analysis, though, is the complex IT system that lies behind this “simpler” more productive assembly process.

For example, for buffer stocks not to become excess in-process inventory but to just manage the assembly flow from one segment to another in order to decrease assembly time, each segment must know in real time what the line speed and buffer stock levels are at each other segment. In addition, the overall layout is represented by three large “U”s. One U is composed of line segments assembling the body. A second U consists of those assembling the chassis; and a third has segments completing the engines and transmissions that have arrived almost ready to install from the engine factory. The third U's biggest task is to put the engine and transmission together. The completed engines with transmission are mounted on the chassis in-line and the U with completed chassis, engine and transmission then intersects with a completed body coming from another U-shaped set of segments dedicated to body assembly. The car then continues down the assembly line to receive the parts that are needed to complete the process.

Because several operations are now done in parallel, in-process inventories despite the buffer stocks are substantially reduced compared to the process beginning with the chassis and having the parts, including the body, added in sequence. At the same time, making sure that the right chassis, engine, and body come together for a given order requires sophisticated and complex real time data management. This might not have presented great difficulties for the first Henry Ford since all Model T's were the same and all were black. However, for Toyota every car is unique in terms of color, equipment, engine configuration, etc., etc. Thus the precise chassis with the particular engine to go with a certain color and style body must all come together at the precise point that the U's converge. Furthermore, they must do this while allowing for the fact that the different segments may be operating at different line speeds so that particular modules may entering or leaving the buffer stocks at different times. This is why the new production system is "smart".

Furthermore, under the old "just in time" system, parts were delivered to the assembly lines according to the production schedule sent to first-tier parts suppliers. This process is well documented in Womack et al (1990) as well as Fujimoto (1999) and Ahmadjian (1997a) among others. Recently this communication has moved from data transfer by computer to a real time on-line system in which the parts suppliers participate. That is, the parts suppliers are now directly connected to Toyota's production information system so that they can automatically access the information they need for just in time parts delivery, rather than receiving a delivery schedule on a batch basis based on planned production. Effectively they know where each car is in the production process at any point in time, though the production schedule usually becomes set about four days ahead of actual production (Fujimoto 1999).[12] This real time system allows the suppliers greater flexibility in planning their own production, and enables them to respond to changes that occur in real time.

Further, logistical instructions are now included in this data because the industry's (and particularly Toyota's) success has led to increased scale and traffic congestion near its plants, as suppliers try to deliver parts at the same time to the same factory. Indeed, Smitka (1993) notes that by the early 1990s parts inventories on trucks were Toyota's largest inventory item. To solve this situation Toyota developed a sophisticated logistical and traffic-control system that is now coupled with its on-line just in time parts delivery system, so that delivery routes and times are part of the demand pull ordering system. In this way, Toyota is using IT to control every aspect of its production system while enhancing and further institutionalizing the benefits of its existing supplier network.

[12] TMC itself explains (Toyota 1993 & 1999): "auto manufacture involves bringing together tens of thousands of parts. And we have now introduced assembly line control (ALC) to control this complicated process. Computers and Robots are utilized in each production line, bringing quality to the automaking process at the system level." But apparently this attention to detail and organization has been part of Toyota's culture from the beginning. In 1937 Toyoda Kiichiro observed that "an automobile consists of thousands of parts, each one essential for building a flawless, complete vehicle. It is no easy task to coordinate their assembly. Without perfect organization of the assembly process, even a

These benefits include the willingness of suppliers to commit to firm-specific investments including the IT investments needed to become part of TMC's real time on-line network. As Ahmadjian (1997) explains suppliers are willing to invest in firm-specific assets such as a new or upgraded IT system. This is due to their feeling of support by Toyota, which it has built over 30 years of business, plus equity ownership that cements supplier ties and indicates TMC's commitment. Importantly, this feeling and inter-action also supports a similar willingness on the part of the supplier to invest in new designs and the systems needed to improve cycle times.

Smart Design

Traditionally U.S. and European auto producers have designed vehicles based on inputs from marketing and have then left it to production to manufacture that design (Sealy 1991, Sobek 1997 and Fujimoto 1999). Once manufacturing developed a prototype, it could then cost the final product and set the price. In the case of Toyota and subsequently other Japanese manufacturers, however, the production engineering group (PE) is intimately involved in the design process from the beginning. This is because marketing initially establishes a target for a market segment in terms of both style and price. Since roughly 80% of a vehicle's costs are fixed in the first 20% of the design process, it is very important that the product design can be manufactured and at the target cost or lower. Furthermore, this approach is strategically sound because a great product design wont sell if the product is not produced at a price that customers will pay (Sobek 1997). This led Toyota to develop an integrated concurrent engineering and design organization, which has reduced design costs and sped new product and new model

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mountain of parts fails to become a single vehicle. For the task of coordinating the assembly of thousands of parts, we must design a unique pattern of control and organization." (Excerpted from Guiding Principles of Toyota.)

introductions. In addition, this approach logically recognizes the interconnections and interactive impacts between the product and production. Product design will affect the design of the production process, the equipment used, the cost of the product, reliability of the process, and product quality (Sealy 1991, Sobek 1997 and Fujimoto 1999).[13]

Toyota's PE (production engineering) group is a separate organization from product engineering and seconds its representatives to be part of new model or product design teams. They also have their own groups within each plant so they can assess how a car will actually be produced, though Toyota has applied standard process procedures at each plant so it is relatively easy to shift model production between plants (Sobek 1997 and Fujimoto 1999). Its project involvement has five major aspects covering design standards, design reviews, prototype builds, receiving drawings and designing the manufacturing process, including equipment. Early in the product design process, the PE engineers transfer data on the latest production standards and capabilities including any recent improvements due to kaizen. This is where close knowledge of what is happening in each plant is critical. Then during design review, the PE representatives informally suggest design changes or solutions that can improve product manufacturing. These suggestions become more concrete as a model's prototype is actually built. In addition, TMC does not wait for the vehicle's entire design to be competed before releasing

[13] Sobek (1997) calls Toyota's special approach to concurrent engineering "set-based concurrent engineering." Sealy calls its "design-for-manufacture" that integrates "the industrial design and engineering design process." This reflects analytic design technique that rearranges or modifies designs that are already known to achieve new goals or lower costs, e.g. PE's upwardly revised standards. One such goal for TMC is to efficiently produce personalized automobiles to reflect individual customer needs (Sealy 1991). This can already be done using smart production techniques but it also requires that the vehicle's design allow for such flexibility in terms of options and various features. This is smart design because the designer is solving customers' problems. Because CAD systems facilitate such multiplicity, they are integral to the smart design process, while telecommunications facilitates global dissemination to TMC's overseas production locations as well as local design features. Also, by speeding the process and shortening model life cycles such systems help contain R&D costs for new models, while getting new technologies to the customer faster. At the same time value engineering, value costing and target costing insure that the customer will pay for them. Finally, smart design includes working closely with parts suppliers as they produce almost 70% of the vehicle's value added (Fujimoto 1999).

drawings to the PE group and parts suppliers. Rather as they are finished, PE can start developing the necessary materials and equipment, significantly speeding the design to production cycle. Further, all observers agree that because PE is involved from the beginning, design and manufacturing operate hand and glove, and that this is a key aspect of Toyota being and remaining the industry benchmark for production in terms of quality and efficiency. Also, since PE standardizes processes across the corporation (Sobek 1997 and Fujimoto 1999) and is constantly upgrading those standards, improvements in productivity get translated across the corporation and positively affect the production of all vehicles.

Furthermore, the design team knows that if a design conforms to the currently published production process standards, it can be manufactured. This reduces the time needed to engineer that part since production engineering for it does not have to be repeated. Yet, because the standards indicate a range of possibilities, there is generally sufficient flexibility for the design team to meet its goals. This allows the team to allocate more engineering effort to those items that are really new or different. The newer the product or design, such as the hybrid car, the more the PE engineers will be involved in the design process to insure both production capability and cost efficiency. Because of cooperation and teamwork and the fact the PE personnel are assigned to new models for the life of the project, Toyota uses about half the personnel on a design team as the typical U.S. firm (Sealy 1991).

Sophisticated IT is needed not only to support design through the advanced use of CAD (Computer Aided Design)/CAM (Computer Aid Manufacturing) systems but is also critical to the efficient communication of those designs among the project team and between TMC and its suppliers. Frequent design changes in developing a new product or model only enhance this fact. This has become more critical as TMC has moved more and more towards "bundled outsourcing." This is a black box system where using "approved drawings" "a parts supplier conducts detailed engineering of a component it makes for an automobile maker on the basis of the latter's specifications and basic designs," (Fujimoto 1999). IT greatly speeds and facilitates the interchange of the engineering and other information between supplier and TMC with respect to the precise component, while 3D displays permit TMC's engineers to quickly evaluate the part proposed within the context of the total vehicle. The black box approach thus extends TMC's own successful routine of integrating design with ease-of-manufacture to parts design and manufacture. In turn TMC's supplier management strategies give the suppliers which already specialize in such parts manufacture a profit incentive to improve quality and cost by using such an integrated "design & manufacture routine" (Fujimoto 1999). In this way TMC's smart design and production strategy builds on its existing supplier networks and is an extension of the lean production supply system they have developed over the last 35 years.

IT and Management of Supplier Networks

In other words, the success of smart production and design must be seen not only in the context of how TMC designs and produces vehicles but also in how it manages its supplier relationships.[14] This is because as Ahmadjian (1997) explains "suppliers in Japan

[14] Womack et (1990), Ahmadjian (1997) and Fujimoto (1999) all describe in some detail the structure of TMC's supplier network and how it is managed to optimize the use of dedicated networks to capture the benefits of learning and evolutionary learning. Rules and routines with in this organizational system abound and are partially institutionalized via IT. Low transaction costs and low governance reduce overhead, while Toyota controls distribution

have a strong incentive to continuously reduce costs. The written contract contains no fixed prices; rather, twice a year, an automaker announces general price reduction targets and then renegotiates prices with each parts maker individually. A supplier that is able to reduce its cost significantly below the price without compromising quality can pocket the difference-at least until the next round of price negotiations. If it cannot meet its target, a supplier may lose preferred status or even be required to submit to reorganization." For this reason "auto parts tend to be highly customized to specific automakers and models, and as a result, necessitate considerable investment in non-redeployable assets.

Investment in customer-specific sites is common-as seen in the concentration of Toyota suppliers in Toyota City and its immediate environs. Japanese auto parts suppliers also make considerable investments in specific human capital. Guest engineers, dispatched by suppliers to an automaker's facilities, learn everything from how it manages the development process to the shorthand it uses for notes on its drawings. Suppliers develop informal networks with an automaker's managers and engineers, to obtain information and get things done." Also as Ahmadjian (1997) notes: "while U.S. makers have begun to adopt the form of these practices- e.g. increased cooperation with

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of profits to achievers and reduces duplication. Thus it does not extract profits but builds incentives to improve via cooperation and productivity as keys to success. Managing this network is a clear core competency of Toyota (Ahmadjian 1997a) as seen in fact " Toyota is significantly more profitable than its suppliers, and has twice the ROA of the second most profitable automaker, Honda. Nissan, on the other hand, is not significantly more profitable than its suppliers, while Isuzu is significantly less profitable." Also, Honda does not have a formal supplier relationship group and asserts more arms-length relationships with its suppliers (Ahmadjian 1997a). It would appear that Toyota is thus the leader in exploiting network benefits, which it has now cemented through sharing and linking of IT systems in addition to cross-shareholding and other interactions. Further, the consistent high level of investment by suppliers in customer specific assets is well established for Toyota (W, J&R 1990, Ahmadjian 1997a and Fujimoto 1999) and "are key factors behind the high levels of quality, flexibility and cost competitiveness that have made the industry a formidable global competitor." This has "facilitated transfer of technology of customer to supplier, and promoted the diffusion of such developments as the kanban system, statistical quality control, value engineering and value analysis, and advances in human resource management. Highly specialized networks of suppliers who work closely with their customers have allowed Japanese manufacturers to reduce development time and squeeze costs out of the system from the earliest stages of product development through the manufacturing process." However, with respect to IT, with the exception of the logistics project and the replacement steel project, its role has been to improve and speed the excellent existing communication and interchange of production data and engineering designs with suppliers rather than fewer suppliers-they have been much slower in adopting the substance, in particular, the notion that an automaker has an obligation to protect its suppliers." Thus what IT has done is to speed, facilitate and enhance already successful routines that existed for TMC and its suppliers while helping them to meet the requirements of the new smart design and production system. This is key to improving the twin goals of quality and efficiency as such "cooperation between assemblers and their suppliers has allowed Japanese automakers to drastically reduce new model development time, to endure endless rounds of cost-cutting, and to respond quickly to changes in demand. By outsourcing a large percentage of parts development and manufacture to independent, yet closely linked suppliers, Japanese automakers have been able to exploit the incentive benefits of market relationships while reaping the learning and coordination benefits of hierarchy." (Ahmadjian and Lincoln 1997)

Toyota has also built on the existing trust and commitment within its supplier network to persuade suppliers to invest in new IT systems that directly impact costs and productivity such as the logistical and navigation system that improves delivery times and reduces in-truck inventories. A similar large joint IT development project is the auto replacement parts and replacement steel project that TMC has initiated with Nippon Steel (Rapp 2000). Under this program Toyota is working with NSC to develop a massive database and complex analytical algorithm that will help predict the actual demand for replacement parts based on factors such as where cars are located, the number being driven, accident and repair records, shipping times, and commonalty. This analysis will permit NSC to lower the steel inventories it maintains to satisfy such demand with the

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materially altering the relationships. Thus, its effect has generally been evolutionary rather than revolutionary as compared to the new website proposed by U.S. producers.

millions in cost savings to be shared between NSC and Toyota. Toyota is also participating in NSC's new e-commerce steel ordering system, which permits it to efficiently track its steel supply on-line in real time (Rapp 2000).

These uses of IT to either enhance TMC's existing organizational structures or to directly reduce inventory costs are excellent examples of how TMC is actively using IT to control and improve the organizational aspects of its business. Yet, it is taking a cautionary approach to the new suppliers website proposed by the large U.S. auto producers (Evans and Wurster 1999).[15] A closer look at the proposed structure of this

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[15] As reported in The Japan Times, there are two separate types of websites for parts. One is for OE (original equipment) and the other for replacement parts. Toyota has announced its own separate site based in California for replacement parts, which will compete against GM's TradeXchange and Ford's Auto-Xchange. For OE parts, though, Ford and GM have merged their sites, and Daimler-Chrysler has joined along with the Renault-Nissan group. However, while TMC and Honda may join the exchange, "analysts expect their role to be limited to purchasing raw materials and simple parts." This is because while there "could be merits in raw materials procurement, … Toyota and Honda develop many parts together with their suppliers and it's hard to imagine they will go through the site to get these when information might be exposed." This is why Toyota with "its own Intranet system that links it with 1,250 parts companies" will join only if "it guarantees the freedom in how Toyota uses the system and erects credible fire walls to protect corporate secrets." Indeed, the reporter correctly observes that officials at Toyota and Honda have questioned the trend towards universally available common parts – a trend they see as taking the competition out of carmaking." Further, "suppliers could reduce costs during the first year … tempting assemblers to bulk-buy from only one supplier, but the assembler could easily be at the mercy of price hikes … the next year."
The large U.S. producers naturally have a different view. Their strategy and its potential impact is well described and analyzed in Evans and Wurster (1999). They observe that "the Automotive Network Exchange, ANX, is the world's largest extranet, already involving over five thousand companies in the automotive supply chain worldwide. … ANX will provide the industry with a nonproprietary, global communications network that is built on Internet technology. … It supports communications across all participating companies, and also provides 'virtual private networks' for its members, allowing employees within a company to communicate securely with one another. … Over time, ANX will promulgate a series of standards for different kinds of transactions, which will then be mandated by the major OEMs. … Production and logistics will become closely coupled across the entire supply chain. … Automated supplier-bidding standards will enable contracts to be announced and bid among companies who hardly know each other. Teams will be able to share applications on ANX servers so that engineers from different companies around the world can swap computer-aided design and engineering files and see one another's changes in real time during meetings. The most obvious and immediate impact will be on costs. Currently, OEMs and their big, Tier One component suppliers use proprietary networks to communicate with each other. … As these systems are replaced with a single open network, communication costs will plummet … but also speed up communication and eliminate errors. Today a specification change announced in Detroit takes about ninety days to be communicated along the entire supply chain, … ANX will reduce that to a matter of minutes. Much more important, however, ANX will lower costs indirectly by intensifying competition throughout the supply chain. The new standards will make it easy for buyers to post supply requirements on electronic bulletin boards, manage a real time bidding process, and maximize comparability among their would-be suppliers. … For many suppliers, … this means the intensification of what is already a very competitive marketplace. … ANX will generate big opportunities for players with genuinely better mousetraps. … ANX opens the possibility of leapfrogging the traditional supply chain hierarchy and enabling direct collaboration among players at noncontiguous levels. ANX will also allow small suppliers to collaborate much more easily … to share resources, design products together in real time… a sea change in managerial thinking … ANX provides the beginnings of an infrastructure that allows the kind of rich, recombinant innovation that Silicon Valley is famous for, but enables it to flourish across barriers of geography, industry, and corporate culture." While the U.S. Big Three are clearly behind this, Toyota and Honda remain justifiably skeptical based on their experience and successful routines. Only time will tell who is right.

venture, however, indicates why. This is because expanding the range of potential suppliers who can respond to a bid on an auto producer's published standard would seem to move in the opposite direction to TMC's black box approach emphasizing larger modules, simplified assembly, and more supplier interaction. No matter what opportunities the car companies have built into the new website for suppliers to participate in a greater degree of cooperation with the assemblers (including participation in the design phase), under this system the risks for suppliers in committing to undertake relationship-specific assets have actually increased.

For this reason it will be difficult for the U.S. producers to replicate on their website the networking efficiencies of the Toyota system regardless of their ability to have design-in as part of the bidding process. Suppliers will be reluctant to spend the money to offer specialized engineering or customer specific investments when they know that next year or the next model cycle they can be replaced. So while for Japanese suppliers "it is safe to invest in relationship-specific assets," (Ahmadjian 1997), there is nothing in the description of the new U.S. website that indicates it will be able to overcome the risks felt by their suppliers in making such investments. The best the U.S. buyers can hope for is a modification of a supplier's existing products. On the other hand, if to attract such a commitment, the assemblers sign an exclusive arrangement and are dependent on this supplier for a product, they risk being exploited in subsequent rounds so the supplier can be sure to realize a return on its investment (footnote 15). Indeed, it owes this obligation to its shareholders. Therefore it is not clear that the reciprocal commitment tradition is so easily replaced just by putting auto parts supply in an e-commerce framework. Indeed, the success of the NSC e-commerce strategy works because it builds on such existing reciprocity as well as greater -- not lesser -- customization.

Therefore, if a black box strategy and the willingness to "make the investments in relationship-specific assets" along with periodic price reviews remains a superior sourcing strategy to assure continuous cost declines, improved productivity and better quality, then this new U.S. website is strategically flawed. This is true even if it moves the industry towards standardized parts used by several producers. Furthermore, the site does not exclude Toyota, Honda or others from using it to the extent such standard parts would be lower cost and offer no special quality or other enhancements to the completed vehicle. So Toyota wins in both cases. It gets cheaper standardized parts when that is strategically beneficial, and it can source proprietary high-quality, low-cost black box parts when they add value. In fact, Toyota seems very good at this kind of mixing to get the optimum combination in terms of cost and quality.

If the industry standard is fine, TMC will use it, but if its network suppliers can offer something exclusive, which is better and cheaper, it will use that and that part will never appear on the industry website, while it will enhance the final product. Therefore U.S. producers are fooling themselves in thinking that by going high tech, they have used IT to achieve lower costs and to better access parts improvements since there is nothing specific in the website that will build the commitment and credibility that will get suppliers to make model or firm-specific investments. If such investments remain a necessary condition to get continuous productivity and quality gains, then this new Internet sourcing approach is flawed. Indeed, to the extent this e-commerce website greatly expands the scope of possible suppliers and aggressive bidding to fill capacity, some suppliers may actually see their risks as rising. This will make them even more reluctant to commit to expensive engineering or other costly procurement strategies where the returns and buyer commitment are very uncertain.

In some respects the initiative seems a step backwards, since it lends a high-tech and “wave of the future” mantle to what has already been shown as an inferior parts-sourcing strategy since it puts U.S. assemblers back in the annual low-cost bidding environment. Since this was a past core competency for them and one to which they no doubt would like to return, this development has perhaps been greeted with enthusiasm. But several studies have indicated that this sourcing strategy is not competitive compared to Toyota’s approach, including Womack et al (1990). Thus it would seem to again demonstrate that one cannot make a good strategy just by converting it to high tech. An IT initiative will only be successful if it is used to enhance a sound business strategy. This is why Toyota has approached the invitation to join the site (ANX) with caution and has indicated it will only participate to the extent that purchasing or moving to a standardized part makes sense. For Toyota, the key to smart production and design remains that “cooperation between automaker and supplier continues throughout the manufacturing process, with a constant search for cost-reducing redesigns and improvements through value analysis and value engineering,” (Sealy 1991).

Smart Marketing

TMC knows it needs to create new marketing methods that will be effective in an “information’ society” such as developing and introducing sales information networks and creating a new information-receiving system that utilizes multimedia (TMC 1999).

This includes establishing new ways to increase sales through the Internet.[16] In Japan this would extend its computerized ordering system where customers can currently order a car to their specifications with the expectation of three-week delivery (Fujimoto 1999). Though Toyota's goal is to be able to produce customer-specific cars in five days (Los Angeles Times 12/12/99), the present system still significantly reduces the potential cost of dealer inventories (financing and space), year-end sales, and customer rebates. At the same time, customer satisfaction is increased because customers get the precise car they want. In the showroom, the customer gets to model his or her car on a 3-D screen, and once the selection is made, the order is entered directly into the computer controlling TMC's production system.[17] In the U.S. this can be done remotely through TMC's website, Toyota.com, with the car priced for the customer, who is then referred to a local dealer that has the particular car in stock. In this way, TMC is developing IT based marketing systems responsive to local conditions. Also, it is a way for TMC to expand its channels and sales to young people, a prime marketing target, since they more actively use the Internet.

Responding to Demand Changes Through Smart Production & Design

However, using IT in this manner is only part of Toyota's global marketing strategy in which IT plays various supporting roles. For example, in the emerging markets where Toyota sees much future growth, it has had to develop smaller simpler

[16] Mr. Matsushima of Nikko Research noted that while TMC was not yet using the Internet to sell new cars in Japan due to registration requirements, it was using it to sell used cars. This gave TMC experience it could expand later. Another reason for this approach is that Toyota discovered that most people using the Internet are searching. Thus, a used car is OK, but a new car involves more details and issues, so that a search-mode is not so appropriate.

[17] Toyota (1993) explained this as follows: "Toyota cars are delivered to customers through our nationwide network of 310 dealers. All Toyota dealers in Japan are linked directly to Toyota via an online computer network. Through this network, customer orders from anywhere in the country go straight to our production system in preparation for delivery. Through our showrooms to improve communication with customers, new techno shops, and the expansion of our overseas rental and leasing service network, we aim to further improve our marketing and service activities."

cars that are more in tune with these countries' economic conditions.[18] In addition, to achieve some efficiency and scale Toyota has had to develop local sourcing techniques. TMC's solution in the Asean market has been especially creative, and, as MacKnight explains, also complex. "The perennial top seller in the region with a market share estimated around 21 percent, Toyota has factories in Indonesia, Malaysia, the Philippines and Thailand. In 1995 these plants, generally run in partnership with local interests,

[18] Because Toyota does not produce mini-cars but has relied on its affiliate Daihatsu for this, their subcompact vehicle (Corolla) is relatively expensive for the Asian market and not a good entry vehicle compared to Suzuki's (GM Group) and Honda's mini-cars. This was particularly apparent in the important China market where Daihatsu had established a joint venture. Thus, in 1995 TMC bought a controlling interest in Daihatsu as part of its long-term global strategy. Similarly, because of the importance of trucks to these markets, it acquired Hino as well, though in both cases this meant Toyota had to integrate them into TMC's global IT system (MacKnight 1997 and Ahmadjian 1997).

assembled just over 301,700 cars, light trucks and commercial vehicles. Close to half of this output came from the firm's Thai businesses. By Toyota's reckoning almost two-thirds of its Asean-produced vehicles have a local content of at least 40 percent. Counting towards this total are products purchased from the expanding OE parts industries of the four countries in which it builds. Higher-value parts often are sourced from the plants set up in the area by such big, traditional Toyota suppliers as Denso Corp. Still others come from the company's own parts factories in Asean.

Toyota makes gasoline engine blocks in Indonesia, power steering gears in Malaysia, transmission parts in the Philippines, and diesel engine parts and body stampings in Thailand. Under the Brand-to-Brand Complementation plan initiated in 1988 by the governments of those four countries and the replacement Asean Industrial Cooperation Program now being phased in, Toyota can ship parts among the participating economies at preferential tariff rates. This flexibility … promotes economies of scale and, in turn, cost containment. Equally important, the BBC and AICO schemes count parts so traded as locally made for the domestic content calculations of the relevant government," (MacKnight 1997.) However, to manage this complex arrangement as well as to compute the optimal sourcing strategy based on tariffs, fees and local regulations requires significant IT support. In addition, the ability to design and produce new models in 24 months or less gives Toyota the ability to respond quickly to changes in demand whether in the advanced countries, such as the switch to RVs, or in the emerging markets.

Smart Cars

This ability to rapidly develop, design and produce new cars for different markets has been key to TMC's "smart" strategy. Perhaps nowhere has this been more apparent than in the rapid merging within the automobile of software, mechanics and electronics.[19] Therefore, while IT has played an important role in enhancing Toyota's organizational efficiency to design, produce and sell vehicles, it is also starting to play a more direct and somewhat different role in helping TMC meet its future strategic goals through its impact on the vehicle itself. This is due to the increased use of electronics and software in automobiles. Car stereos, car phones, car faxes, navigation systems, car TVs, electronic fuel injection, climate control, cruise control, automatic transmissions, air bags, anti-lock brakes, computerized engine management, smart restraint systems, keyless entry, etc. all confirm this important trend (Cogan 1995).[20]

Many such automotive electronic products have been developed in Japan, location of the world's dominant consumer electronics firms. So logically Japanese car manufacturers have been leaders in introducing these features. Indeed, the close relationship between these two sectors and the worldwide presence of Japanese electronics firms has given Toyota another important element in its global strategy. As Ahmadjian and Lincoln (1997) explain "one of the most important developments in automotive technology has been the increased importance of electronics. 'Car electronics" … includes not only electronically controlled mechanical systems such as electronic fuel injection and electronic power steering but also a new category of add-ons,

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[19] In the 1980s, the Japanese coined the word mechatronics to explain the merging of electronics and mechanical devices in many of their products. In areas like automatic focusing and sophisticated computer peripherals such as printers and camcorders, they have now added sophisticated software embedded in the product that controls the electronics and the mechanics. This merging of software, electronics and mechanics into something that might be termed "sometronics" will be an important aspect of Japanese industry's competitiveness in the 21st Century.

[20] Mr. Matsushima at Nikko Research also believes that electronically controlling the car is a key to the industry's future. This is clear in the case of ITS but it is also true for the hybrid car. He explained this is why TMC took over development of its own chips and built its own factories to produce the required chips. In addition, he noted that TMC has observed that the technology is advancing every month and that being directly involved is the only way to keep pace and make sure new designs incorporate the latest electronics and IT. Indeed, Matsushima sees this development as really favoring Toyota, especially as the development of the hybrid car's engine control system is the critical component and this requires very sophisticated embedded software. Indeed, because TMC is so far ahead in this regard, he believes that selling this engine may become a source of profits for TMC further promoting its lead in this area.

including navigation systems and even karaoke players. Electronic components are an increasingly important percentage of an automobile’s value-added – particularly top-of-the-line models. Perhaps even more important is that new generations of navigation and other electronic control systems represent the future in a maturing industry. Navigation systems have attracted particular interest. These systems have been described as the ‘brains’ of the automobile, and there is a perception in the industry that what for now is a clever gadget in high-priced cars will be essential in differentiating between models in the future.” (Ahmadjian and Lincoln 1997)

Indeed, TMC clearly recognized that electronics was becoming a critical aspect of automobile design that any lack competence in this area could evolve into “a competence destroying innovation for automakers,” (A&L 1997). In addition, developing the embedded software needed to instruct many of these devices required understanding vehicle mechanics and the whole car. These were competencies only the assemblers possessed and not the electronics producers. So strategically it became important for TMC to take this competency in-house rather than to rely completely on suppliers for black box parts that would include any required electronics and embedded software.

Toyota’s management also recognized that they needed more expertise in the parent company, and they would need to increase their affiliations with major consumer electronics producers. This led to several actions. First, they loosened their dependence on Nippon Denso for electronic components (A&L 1997). Second, TMC built its own electronic-related parts factory at Hirose in 1989 with electrical engineering capability covering electronic parts, antilock brakes, navigation systems and ICs. Third, Toyota actively recruited electrical engineers, even mid-career, further emphasizing the important strategic nature of its move into electronics and embedded software. Fourth, it announced in 1996 the formation of a joint venture with Texas Instruments to manufacture semiconductors via its affiliate Toyoda Loom. And fifth, it built an additional electronics parts factory in Miyagi in 1998.

This major strategic initiative into electronics and embedded software is another illustration of Toyota's capacity for evolutionary learning, as described by Fujimoto (1999) and is an important element in its development of the new smart production and design systems. It also illustrates its multi-faceted and multi-path approach to strategy and the complexities of the global auto market. TMC's vision of what is required for competitive success is not limited to smart production and design coupled with a well-manage supplier network and computerized marketing. Rather, it recognizes that success in utilizing these strengths still depends on good technologically advanced products for sale. Furthermore, such products must respond to changes in consumer tastes and needs in the 21st Century.

This strategic demand requirement is partly met by Toyota's aggressive introduction of new cars by collapsing the design to production cycle through smart design and congruent engineering. Even during the 1997-98 Japanese recession, Toyota was able to announce the introduction of 15 new models globally, more than any other producer (Brogan 1997a). Shortening cycle times in turn reduces forecasting errors while allowing one to rectify mistakes more quickly (Fujimoto 1999). As Matsushima (1998) notes, in 1996 TMC recognized that responding quickly to market changes would be necessary to "survive and be a winner", given new "intense global competition". Indeed, Toyota's management definitely saw this as a "change in substance of competition."

Previously “being competitive … meant beating rival’s production in terms of quality and price.” While still important competitive issues, “establishing an industrial ‘de facto standard’ is” now emerging as “the key.”[21] Combined with this development is that the diversification of customer needs is shortening the product life cycle for automobiles, putting a premium on “being able to create new products faster than competitors. So that creativity and speed will be the most important factors to stay ahead of competitors.” This is the strategic vision and basis for creating smart design and production and in turn the smart products that are all part of the Vision 2005 TMC announced in 1996.[22]

IT has played an evolutionary strategic role in this regard through its contribution to smart design, smart production and improved black box parts supply capability. Suppliers use IT to participate in the design phase and supply those parts on a just-in-time basis benefiting from on-line information and a cooperative environment where Toyota suppliers have done well. Further, this has generally extended overseas through parts suppliers’ FDI. On top of this, computerized ordering has tied marketing into this organizational process and its computerized links. In this way, IT has enhanced and institutionalized many aspects of Toyota’s evolving production system. However, IT also plays a critical role in the smart car component of Toyota’s total strategy.

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[21] Evans and Wurster (1999) also observe “Once a standard achieves critical mass, the interconnectedness of *all* physically defined industries ensures that it will inexorably spread to fill the entire domain in which it is competitively advantaged.”

[22] Some specialized subsidiaries have been created to support this strategy. Toyota MACs develops, manufactures and services specialized measurement-control systems and equipment. Nippon Idou Tsushin Corp handles car telephones. Toyota Digital Cruise is a registered type II VAN (Valued Added Telecommunications Network). Toyota System Research develops and sells computer systems related to the development and manufacture of automobiles. Toyota Soft Engineering develops and sells auto development related computer systems, especially CAD/CAM. Toyota System International develops and sells business administration software. Toyota Caelum develops, sells and services CAD/CAM software and hardware. Satellite Positioning Information Services provides navigation related information, which will be an important element in developing ITS.

While market changes in the advanced countries are leading to more electronics and embedded software in every automobile along with rapid changes in those elements, these can and have been emulated by competitors even if with a lag.[23] In addition, some electronics are dealer installed options supplied by consumer electronics companies. Thus Toyota must run very hard to stay ahead. It is for this reason that another aspect of its strategy has focused on smart car technologies that are not easily copied. These efforts have focused on the environment and on intelligent transportation systems (ITS) as important strategic trends that can give Toyota a longer-term advantage. The idea is to reverse the current situation where cars are just commodities and everyone has similar models or ones that can be quickly copied and introduced, especially as American firms have closed the quality gap (Keller 1997) and remain close on the productivity gap.

Environmentally Smart Cars

Developing environmentally smart cars has been part of a three-year strategy begun in 1996, related to the environment, cars, and IT (Matsushima 1998). This concept appears to be quite sound since the environmentally sensitive hybrid cars introduced in 1997 initially sold out at 2000 per month, and though not yet profitable, they soon will be. But in addition to their popular appeal, TMC has also recognized that in the advanced countries, environmental regulations for vehicles are getting increasingly stringent. California, which is the world 5th largest car market and is often copied by other states, "currently plans to reduce auto emissions through a plan that divides autos into four emission level groups, including ultra-low emission vehicles (ULEVs)" (Brogan

[23] In January 2000, Ford announced its "Internet on Wheels" concept car (24-7 vehicles) to meet the new competition that "involves computer chips, electronic sensors, Internet access and other wireless communications, and the ability to

1997a). Even in emerging markets where policymakers see the auto and auto-parts industries as revenue-enhancers, demand will be impacted by the fact that "in places like China and Thailand, … big cities already are plagued by the problems of pollution from tailpipe emissions and traffic congestion." So "vehicle taxes and fees intentionally or otherwise do double-duty as regulatory tools," (MacKnight 1997). This global market reality is thus the source of TMC's "strategic activity to gain publicity and reputation as the No. 1 company for environmental protection," which it has implemented already in its new Prius hybrid car. This car, which can get up to 80 miles a gallon and has less than half the pollution of a normal car, is currently being sold 4-5 years ahead of U.S. producers. Only Honda has a competitive model. Further, "Toyota is confident that its hybrid could qualify as a ULEV" (Brogan 1997a). This would permit TMC to substitute the hybrid for a certain number of mandated electric cars, which are more expensive, and still meet its fleet mileage and emission targets.[24]

The reason the hybrid car is difficult to emulate is because it requires sophisticated embedded software to use both an electric motor and a small gasoline engine as its power source. Controlling the interplay between these two motors under different driving conditions is a complex task requiring equally complicated control systems. This system is called THS or Toyota Hybrid System, and it manages such tasks as how and when to recharge the battery powering the system, managing the switch between a parallel and series based system to achieve both optimal power as well as the best fuel/engine/motor efficiency. "THS calculates the desired operating condition and

exploit those devices and systems to sell more than cars and trucks" (The Japan Times 1/2/00)

[24] TMC is also experimenting with compact electric vehicles and direct injection engines, but only the hybrid is assessed here since it is currently produced and sold (TMC 1997). Ford and GM recently announced the U.S. version, which required a $350 million government subsidy to develop with no production before 2003.

the current condition of the engine, motor, generator, battery, and other components, and controls them accurately in real time." It also uses an "intelligent power module to increase reliability." All this is not so easy to do or emulate as indicated by the fact that Ford and GM have just announced their versions will be ready after 2003 and $350 million in U.S. government funding. Meanwhile Toyota will start selling its car in the U.S. in August 2000. Given TMC's two year design and production cycle combined with its target costing, this means Toyota globally will be in its third generation model with the associated technology upgrades and cost improvements due to learning and scale effects before the Americans sell their first mass-produced hybrid vehicle. Already TMC is learning a lot about the new power system. For example, one result from the new engine design is its very light weight so that the car does not require a conventional transmission. In turn, lightening the vehicle through special steels is a complementary strategy with TMC's increased cooperation with NSC to receive customized steel production on a just-in-time basis (Rapp 2000).

Intelligent Transportation System [25] (ITS)[26]

[25] Even in 1993 Toyota (1993) could summarize its evolving smart car approach as responding "to the needs of our information oriented society" in which "automobiles are now increasingly equipped with navigation systems and sophisticated communication devices. Cars are gradually becoming 'intelligent vehicles.' Toyota is developing and introducing car electronics to enhance communication between people, automobiles, and society. Also, out of concern for the natural environment, we are developing clean, fuel economical engines."

[26] According to Mr. Ohe, Manager of Toyota's ITS project, Toyota has worked on this system for 25 years and he has been involved all that time. As of 1998, TMC had spent over $1 billion on the project. The idea has been to develop a packaged system that will be sold. It has two elements, the on-board computer inside the car and the external system that controls road traffic and each car through its on-board computer. Matsushita and NEC are involved in building the electronics and computer systems for the project such as the on-board navigation system that is part of the on-board computer. NRI (Nomura Research Institute) and Mitsubishi Research Institute are involved in the software development. The idea was to first develop a system for Japan that TMC and Nikko Research indicated would be piloted as a second Tomei expressway between Tokyo and Osaka. This system would then be adapted and sold to other countries. However, this timetable has been changed due to objections from the National Police Agency regarding responsibility for accidents; the system, the car or the driver? Now, the initial test will be at Tsukuba in December 2000 with a full demonstration ready for Expo 2005 in Nagoya. Full introduction will then depend on negotiations with the NPA but could take several years. For this reason, Toyota may introduce the integrated system overseas first since it will be technologically complete and tested by 2005. See Exhibits 1 and 3 for Toyota's projected evolution of ITS through 2015 (TMC 1999a).

Toyota has been exploring the development and use of ITS since the 1970s, but it is only in the last few years that ITS, as a set of commercial products, has become full-blown through a combined use of embedded software and external guidance systems. There are currently two pillars to ITS. One is a multimedia system for managing the car and the other is an external computerized traffic management system. Toyota and many outside analysts see ITS as offering a tremendous boost to customer satisfaction as well as being helpful to the environment and health by reducing traffic jams and accidents. In Japan, ITS is organized around VERTIS (Vehicle, Road and Traffic Intelligence Society), set up by the government, companies and universities in 1994. The estimate is that "intelligent transport could reduce traffic congestion 50% in 10 years and 80% in 20 years. That would help achieve huge reductions in emissions of pollutants and greenhouse gases" (Toyota 1997). Further the potential market for ITS related business could exceed 2 trillion yen by 2005 (Toyota 1997). Some of this potential is already realized through the sale of on-board information terminals that include high-level navigation systems. TMC has developed these in conjunction with Japan's Vehicle Information and Communication System (VICS), another joint public and private effort. In addition, Toyota has been a leader from the beginning in this too, and even in 1997 it had a 45% market share of Japan's two million installed navigation systems (Brogan 1997) that by April 2000 had grown to 5 million units.

TMC has stated its strategic goals and mission for ITS very clearly. Indeed it "does not regard ITS simply as a sideline to its main business, but as an opportunity to introduce new systems for the 21st Century that will manage problems created by traffic."

Further, by 2015, it expects the Japanese market for ITS related products and services alone to exceed 60 trillion yen with the worldwide market a multiple of that. Thus over the next several years Toyota will be working to realize its vision of ITS enterprises that will support a more integrated mobile transportation system. To make this vision a reality, it has divided ITS into five basic work areas. The first is the Intelligent Car, where the car incorporates more sophisticated and complex systems and functions. This view then supports and is the foundation for the other areas (Exhibit 2).

The second area is multimedia for the automobile or the "Internet on Wheels", which represents a new arena for mobile communications. The third area covers support facilities that will achieve smoother traffic flow by coordinating vehicles and the transportation infrastructure. The fourth is business and organizational logistics where TMC will work with other firms to develop a comprehensive set of tools that will support the more efficient transportation of goods and services through improved utilization of the existing road system. The fifth area is new or radically improved transport where TMC will work to develop transport systems for the next generation. By coordinating and managing the interactive relationships among these five work areas, Toyota intends to achieve growth and development as a "Total Mobility Company."

"In the medium-to-long term, we are working to realize our vision of ITS enterprises as a way to build a more integrated mobile society. To make that vision a concrete reality, we have divided our ITS endeavors into five basic fields. The first is the Intelligent Car, where the car itself is invested with higher functionality. This concept is central to all the other areas. Second is the Car Multimedia, a new field of mobile communications. In the third area, Facilities, we aim for smoother traffic flow by harmonizing vehicles and infrastructure. Under the fourth heading, Logistics, we seek to build a comprehensive, efficient transport system. Activities in the last area, Transport, are directed at the development of transport systems for the next generation. Through comprehensive and organic interaction among these different fields, Toyota is striving for Harmonious Growth in the twenty-first century as a Total Mobility Company," (Toyota 1998a).

To the extent TMC is successful in not only meeting but leading the way to these objectives, it will transform the nature of driving and the automobile as well as control how the industry and vehicles evolve during the coming decades. This is because it will be incorporating next generation ITS systems into vehicle development from the design stage to support multiple driving systems that will transcend advanced navigation systems to include automated driving and coordination with the transportation infrastructure (Toyota 1998a). A key driver in pursuing this strategy is TMC's belief that "advances in traffic management will be accompanied at each stage by an expansion of functions in the car itself," (Toyota 1998a), an approach that includes "the fusion of automobiles and information communications," (Toyota 1998a). This is one reason TMC became an investor in DDI, which when combined with IDO and KDD will form one of Japan's new digital telephone systems, KDDI. It is also why the system it is developing even for automatic toll-collection is a two-way system as opposed to the one-way systems used in the U.S. such as EZ-Pass. Toyota wants to establish from the beginning a transportation infrastructure through which the highway can sense and communicate with each vehicle. It will then be easier to introduce more advanced functions as they are developed or as permission is obtained from the government to use them. TMC's smart design and smart production will in turn support this strategy through the ability to speed model design and production to rapidly incorporate such new technologies and functions. So smart design and production are integral aspects of TMC's overall strategy for ITS.

Under the current and widely used navigation system in Japan, traffic data is obtained from the National and Local police, this data then goes to VICS (Vehicle Information) for editing and is subsequently relayed to a car's navigation system. This system has been operating very successfully since 1996 and most new cars in Japan come with this feature. Indeed, there were about 5 million such systems in operation in the spring of 2000 compared to 100,000 in the U.S. and about 50,000 in Germany. Using this system, drivers can avoid congestion and take alternate routes. In addition to saving customers time and frustration, the system has environmental benefits by reducing the pollution from cars creeping for hours over congested highways, often near urban areas. Socially, it will save on fuel for similar reasons. These impacts are why the Japanese government has supported this effort by contributing to the public corporation responsible for implementing the system and to which Toyota and its corporate partners are selling their software and hardware. Toyota's own proprietary system it is developing for Japan is called Nihon ITS.

While planning began in 1990, the government's plan was initiated in 1996, and it envisions lots of technology and business spin-offs, the current proliferation of car navigation systems being the most visible example. After it is working in Japan, TMC plans to proceed outside Japan, and again the first manifestation appears to be car navigation systems with Toyota agreeing to join GM's North American geo-positioning consortium. Now Toyota is in the process of introducing a "new generation traffic system

‘ITS’ (including navigation systems like VICS and automatic highway bill system)” that can be extended beyond the highway to include automatic account debiting for gas and roadside services. Further it sees aggressive entry into ITS as part of its strategy to establishing its base as a general vehicle company in the 21st Century while contributing to social development. This effort includes making cars more “intelligent” through driver supervision, visual information support, distance-control from other vehicles, transport services and automatic driving (Exhibits1 and 3, TMC 1999a).

One part of making this system work is a direct extension of the car-related multimedia business such as supplying traffic and travel information via in-car terminals and telecommunications. These on-board systems will be coupled with facilities and systems related businesses that will include automatic money charging systems and parking control systems. There will also be value-added businesses related to improved logistics via operational control systems for distribution and delivery. One example of these latter systems has already been described in terms of Toyota’s own parts delivery system. But in addition TMC’s ITS group is working with Coca-Cola on a similar project to optimize Coke’s urban deliveries. Related to these concepts are transport service businesses and comprehensive transportation services such as the pilot project with Toyota City taxis or dual mode buses in Australia.

Toyota also sees multiple business interfaces. One is that TMC will be setting the standard for the car and related transportation for the future -- effectively becoming the Microsoft of the automobile, the way Sony is becoming the Microsoft of video games. This system was memorialized in 1996 in the Transportation Efficiency Act in Japan. There was a similar act in the U.S. called ISTEA that allocated $60 million a year for six years. The idea was that each country would do its own R&D and system research and would then meet to exchange information on the status of their projects. A key aspect of this R&D from Toyota's perspective was the development of the on-board computer.

In current motor vehicles, each feature has its own controller or mini-computer. Thus, brakes are controlled separately from fuel injection, and the navigation system, telephone and radio have their own controllers. Therefore, if the car is going to be controlled as a whole, there needs to be a single computer directly managing all aspects of the vehicle. Under Toyota's ITS, therefore, there would be a single PC for the vehicle directly linked to the servos or small electromechanical switching devices that monitor and control the vehicle's various functions from braking to navigation to entertainment. This PC's operating system will be externally based, supported and controlled by an Internet platform that Toyota is developing. The computer of course will have the capability of not only controlling the car but also of displaying all this information to the "driver" and the passengers. Higashi Fuji is currently working with Toyota to develop the software to manage this car and communicate via the Internet while Nippon Denso will manufacture the on-board computer to Toyota's specifications. Toyota is building the controllers that will dot the highways using its two-way communication system. In developing the operating systems, though, Toyota has not started from scratch but is borrowing from existing operating systems. But TMC is then modifying these to make its own system based on its knowledge of the car in terms of both mechanics and electronics.

However, TMC has found that the people in Japan who are able to develop such software are limited. So it has had to go to Asia and the U.S. to get the actual software programs written once TMC itself had developed the basic idea of what it needed to have done along with the basic system. Nevertheless, TMC believes that other countries and producers are way behind it in developing the on-board computer and the Internet-based control and communication system, though Daimler-Chrysler is the closest. One illustration of a possible three-year lead is in the sales of navigation systems. Whereas in the spring of 2000 the U.S. had about 100,000 systems installed and Germany about 50,000, Japan had over five million, or over 90% of the global market. In addition, during 1999, Toyota and its partners launched a new much more sophisticated second-generation system that even includes visual data on gas stations, convenience stores, and other facility locations in addition to traffic and weather data. The next new and improved version is being developed but to complete this phase will require the integrated on-board computer described above and two-way communication.[27] This is why TMC is working hard in these areas and on its three major pieces, the Internet Application Package, the on-board computer's operating system, and the hardware in the car.[28] The group that is managing the process works in the same way as any other major TMC project since there

[27] For the 1st and 2d generation systems the traffic data is collected by the police and transferred to VICS on a real time basis. Planning for the first system began in 1990 and the government allocated 370 billion yen to infrastructure investment. The system uses an integrated radio wave and infrared beacon receiver and was first introduced in the Central part of Japan in eight prefectures (Tokyo, Saitama, Chiba, Kanagawa, Aichi, Kyoto, Osaka and Kobe) in 1996 with another 15 added in 1999. Since early 2000 all of Japan has been included and one can drive from one end of Japan to the other and the navigation system will track the vehicle's progress and display it on an interactive map with geographic, road and local site information. The navigation system or "nav" has also been combined with a cellular phone that gives audio information in addition to the visual data displayed on its display panel. One can also ask for information on near-by restaurants, etc. from "MONET" or Mobile Network Real-time time travel information on navigation screens. Toyota sells the hardware for this system both in its new cars and on a dealer installation basis. An affiliate, Toyota Media station, which also provides the interactive MONET request service, is developing the software. This latter company was only founded in the last five years. TMC also believes it and Japan lead in developing and selling this kind of system, though Daimler-Chrysler was the first to have one in operation in Germany called ITGS. The U.S. is relatively limited to a "help-me" or emergency call system such as GM's Northstar system and Ford's rescue system. Also, Opel, VW and Daimler-Chrysler in Europe all have such emergency road service. But these systems do not have the customer-oriented features of Japan's current version nor are they building the basis for a full-fledged ITS using a multiple-function two-way road communication system. Thus, while, Toyota's system has "Mayday" features, which include emergency road service and even health and accident alerts, it goes well beyond what the competition currently offers.

[28] Another reason for the on-board computer is the new hybrid powertrain or CNG that involves integrating an electrical motor with a small gasoline or diesel engine and requires the on-board computer to manage the system through sophisticated control technology. In this way ITS and CNG are actually converging.

is someone from each application group or area assigned to the working group, and it is presently pursuing two avenues.

The first approach is based on ISO (International Standards Organization) discussions for harmonization of traffic control (TC 204). This is composed of 15 working groups, and Japan is working to get a common international standard in cooperation with ITS America and Europe (ERITCO). TMC's other avenue is a more flexible approach since there are differences between countries on whether a real time system such as Japan's or a request version such as in the U.S. is appropriate. Also, the U.S. situation is complicated by the fact that traffic and automobile related issues are primarily handled by states on a state-by-state basis. So Toyota is designing its system and strategy to work even if there are multiple standards.[29] In addition, like Microsoft,

Toyota believes if it has a system that works and can be introduced anywhere, it has a good chance to become the de facto global standard, which as Mr. Matsushima at Nikko Research notes is part of TMC's long term strategy. In this way, Toyota products including its cars will become part of a total delivery system, and its marketing approach

[29] TMC noted that the hardware is being designed so that it can easily be adapted to U.S. telecommunication frequencies and the applications are also being designed with American adaptation and adoption in mind. That is, the working group knows what the standard will be in each country, and it will develop connector interfaces as required to meet standards according to the particular country in which the car and its navigation system will operate. In Japan, of

will be to sell the system not just the cars! Further, customer service is embedded into the final product and continues after the actual sale.

Part of the next generations of ITS and navigation systems will be AHS (Advanced Cruise-Assist Highway Systems) and TMC's automatic driver. These systems will help guide or actually take drivers to their destination via the shortest or if there is congestion fastest route (Exhibits 1, 2 and 3). It knows how to go and can help the car get there more safely and more quickly through such features as automatic sensing and adjustment for distance between cars. In fact, AHS is an intermediate stage towards automated driving where "vehicle operation is automated through interaction with the road infrastructure, so that braking and acceleration are done automatically for safe and smooth driving." It uses magnetic markers in the road and magnetic sensors in the car to control steering while on-board radar detects and avoids obstacles (TMC 1999a). This illustrates why TMC has planned to introduce a two-way system from the start. Similarly, it is developing "intelligent intersections" that alert "drivers and pedestrians to approaching vehicles and gives road information and instructions using programmable display panels."

Toyota has already piloted some of the ITS features such as best route guidance in Toyota city with local taxis and has used it to solve its own logistical problem for timely parts delivery. It has also sold a similar system to the Coke bottlers in Nagoya, vastly improving delivery times and driver productivity. The latter is a single system involving 140 vehicles and 600 vendors (customers). Once it has been piloted, the system can then be extended to either other Coke bottlers in other cities or to vendors such as convenience

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course, the group has developed the map navigation system, and TMC has a cross shareholding in the company producing it.

stores in other locations. In summary, TMC's "Total Delivery System" "establishes a communications network among shops, convenience stores, vending machine, trucks, logistics centers, etc., and provides comprehensive management of the distribution of goods." [30] TMC's "Total Delivery System" can thus establish a communications network among shops, convenience stores, vending machine, trucks, and logistics centers that provides total management of goods distribution. The result is improved operating efficiency and better inventory control in ordering and receiving including the goods in the trucks.

Ultimately this can lead to computer-controlled driving or "automated vehicle and highway systems" (Exhibits 1 to 3, Toyota 1999 & 1998a, Matsushima 1998). While such systems are not widespread, they do exist and will be increasingly demonstrated such as at the Nagoya 2005 Expo. One automatic driver system is currently being piloted in Australia and another in Essen, Germany. In these cases, the cities have Dual-Mode Buses that have their own special road and are automatically driven. Then when the buses need to be driven off the special road, they convert back to driving as a normal bus. Toyota calls this is the kind of system an "Intelligent Multimode Transit System (IMTS)" that "combines the advantages of trains and buses." It includes the platooning of commercial vehicles[31] and is what TMC would like to introduce later in this decade in terms of a second Tomei expressway that would be a special track along the existing road. TMC does not expect building this special lane to be physically or technologically

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[30] Expanding this potentially important business channel may be one reason behind TMC's 10% investment in the "e-retsu" group being formed around Family Mart's over 5000 convenience stores. In May 2000, Family Mart (50.5%), C. Itoh (14.5%), NTT Data (10%), Toyota (10%), Dai Nippon Printing (5%), JTB (5%) and Pia (5%) formed a new "e-retsu" company, famima.com. It will operate websites and place terminals in Family Mart stores and offer tens of thousands of goods through the chain's on-line markets.

[31] A similar use is the "intelligent parking lot" that provides data on parking availability, guides the vehicles to spaces, and collects fees automatically.

difficult, given the Japanese government's commitment to the project and current interest in promoting public works. However, there are legal obstacles due to the issue of responsibility in the case of accidents (footnote 26). Still, its development seems only a question of time, while installation of the two-way interactive driver-assist system can gradually evolve into a fully automated driving system on a large scale. This will give Toyota a big jump on other producers, especially compared to the U.S. where such efforts would involve state and Federal legislation (Matsushima 1998).[32] In addition, Nikko Research (Matsushima 1998) claimed that the system was "almost perfect," and that Yamato Transport, the package delivery service, was planning to use the technology for its inter-city trucks once it was available.

Information Technology Infrastructure and Project Selection[33]

Toyota's basic information system is a typical Japanese "three-tier" mainframe system similar to most other large Japanese companies (Rapp 1995).[34] The mainframes

[32] "Intelligent Transportation Systems, Applications," (ATIP00.013, 3/99) provides an overview of Japan's Intelligent Transportation System (ITS), and several associated applications that are being developed. The associated website is http://www.atip.org/public/atip.reports.00/atip00.013.pdf

[33] The data in this section is based on a meeting with Mr. Nagane, General Manager of Systems Planning Division, and Mr. Kida on 7/28/98 in Toyota City to discuss TMC's systems operations and plans, also Fujimoto (1999).

[34] The mainframes control servers that control the networking system and communicate with the plants and their equipment as well as dealers and suppliers. The mainframes have the task of scheduling production and just in time parts delivery as well as tracking orders. TMC uses a client server system but the client servers are mostly mainframes, though physically the mainframes are getting smaller as is the disc-storage space. TMC's system has hundreds of million lines of code. So this is a huge system. Yet in 1998 there was no direct link between information embedded in the car and its on-board computer and the data or systems used in the factories and offices, though this may evolve.

manage a series of servers that manage the PCs and workstations. In addition, because it is a real time on-line system, it has been totally integrated with TMC's own business operations, as is typical of most large Japanese firms. It is completely managed and maintained by Toyota's internal systems group. Internal communication depends on TMC's own fiber optic system and its own customized middleware that provides the interface or bridge between different users within TMC.

These systems and communications are in turn critical to order processing and tracking as well as to JIT production since parts must be ordered and delivered in a synchronized manner with the production schedule. The clear objectives of better communication, improved plant productivity, and increased client satisfaction (i.e. better quality at a lower price) have in turn enabled TMC to select, develop and use the IT required for each function and to integrate it into the total support system. This is because Toyota can measure whether these objectives have been achieved. Except for the operating systems, TMC has generally developed its own software and IT systems.

TMC now has about 1000 servers throughout Toyota, which tie various pieces of the corporation together, including the 30,000 PCs that it bought for every office worker in 1996. The basic IT strategy is to use systems to enhance existing strategies and organizational structures. Indeed, since Toyota is processing 200 times 10,000 general pieces of mail a day paper use is starting to come down. At the same time, Toyota does not plan to increase the number of PCs. Conversely, the number of CAD/CAMs is 3000, and TMC would buy more or upgrade them if it could increase the speed at which its engineers could work or if Toyota hires more engineers.

In 1998 Mr. Nagane was approached by Peoplesoft to buy an enterprise management (EMS) package covering accounting, finance, and personnel. This was the first time he considered buying such an outside package, and he began using it from 1999. The reason was because it was cheap and would allow Toyota to create a global standard because as it has globalized, the company has seen the need for a global system in these areas. Thus globalization is what pushed this consideration. But for the production system (Total Production Factory or Toyota Production System), TMC continues to use only customized software since this is the core of its operation, whereas accounting, finance and personnel are secondary since the systems are just keeping track of cash.

The firm's on-line parts ordering system is now also global, but it is not yet on a 24-hour basis. Furthermore, TMC still uses batch-processing for parts ordering once the production schedule it set. In Japan, this ordering is done daily, whereas internationally it is done weekly; so TMC must carry some inventory as a result. The way the system works is that the parts' orders for tomorrow's production are set. That is, the central computer specifies the car ID numbers that are going to be produced. The server also decides which location is best to have that car produced. Once that has been decided, the server notifies the parts makers who are on-line 3 hours before as to where the parts should be delivered. This is the type of assembly control TMC currently has. The central main computer decides the cars to be produced and the specifications and sends a message to the servers that communicate with the major parts makers who are now on-line and have similar systems, and can notify their suppliers in similar ways. TMC's production IT group has regular meetings with parts makers to make sure the system is working right up and down the parts-supply chain.

The group also meets with computer makers regularly. These are Fujitsu and IBM for mainframes and Tandem as a fault tolerant back-up support since Toyota cannot afford to have the system go down. This would disrupt the entire assembly process, which is unacceptable. They also meet with DEC, Sun, and HP for CAD/CAM and engineering workstations. On PCs, TMC uses IBM, HP, Compaq, and DEC with a Unix operating system. If the UNIX system did not to work for some reason as the system evolves, then Mr. Nagane would recommend a switch to Windows, but not yet.

TMC's overseas operations are still independent with respect to their IT systems, though as noted above Toyota is trying to introduce a global standard for at least some software. However, the company may end up dividing the operation into inside and outside Japan systems. So for example, outside Japan TMC uses almost 100% HP, whereas inside Japan it does not use HP so much. Globalization is one area Mr. Nagane's group is working on since it is often a problem getting domestic and overseas systems to communicate. The Network in Asia, called the "Kikan System", for instance is working reasonably well except in India where the communication infrastructure is really bad.

Mr. Nagane also acknowledged that Toyota's use and interest in IT had expanded dramatically since 1994, and some requirements were highly specialized. TMC thus decided to reorganize software development and as part of the reorganization (Rapp 1995), they spun off five software development subsidiaries (footnote 22), which are all Toyota majority-owned. The first is for telecommunications, including what happens inside the car. The second is CAE (Computer Aided Engineering), which includes simulations. The third is pure software development, a joint venture with Fujitsu. The fourth is a CAD/CAM joint venture with Unix, which is now part of Novell. The fifth is TSI, which is a joint venture with IBM and Toshiba. In addition, TMC has an ownership interest in IDC telecommunications (now sold to Cable and Wireless) that is supporting Motorola's cellular system in Japan. Finally, Toyota has a major software effort related to ITS (Intelligent Transportation System) that is a special organization formed about 5 years ago, though the research has been going on for over 25 years as explained above. This group also handles development of the Multi-Media Station inside the car as well as taxi navigation since the systems use related technology based on a centralized car computer.

To support just in time and assembly functions, the systems group in the company maintains an extensive database for parts, which contains all the parts for the cars TMC is producing or has produced, for both current production and replacement part requirements. This data not only includes specifications but which company produced the part and for which cars. Thus, in addition to knowing who is producing current production by model Toyota can also trace particular parts in terms of warranty, insurance claims, etc. This serves several functions in terms of after-sales service as well as design and production improvements. Similarly, Toyota has a database for completed cars that again is related to warranty claims, repairs and marketing but this also has implications for design and production changes needed to improve reliability and quality. These assembled cars are cross-referenced by factory and assembly. PCs are used to access this database, which is why every employee has one. This procedure has created various security problems as well as issues related to determining how different information is being used. But since information sharing is critical to the company's success, it sees no alternative. Nevertheless, while the network is live and on-line, materials purchasing is still cumulated and done on a batch basis.

As of 1998, most of the software used by Toyota has been developed by Toyota, or developed via captive subsidiaries (except for accounting where it is using a package it has adapted to its system as well as one to keep track of temporary or hourly workers). The overseas factories also have their own systems, some of which are packages. These latter systems are basically separate, i.e. not integrated, but the subs are connected via a global network the company has developed. So TMC communicates data on distribution and the total global supply chain by sending data back and forth in a preprogrammed format. For example, TMC would send information concerning production of certain cars to the dealer network in the U.S.; so those dealers would then know when those cars had been produced and were going to be delivered. Or Toyota would send orders to overseas suppliers for parts. So it uses IT to manage both the sales and production of its global system. Global marketing particularly is a primary function of e-mail in addition to global intercommunication and coordination among various units, subsidiaries, and suppliers.

As Mr. Nagane explained, the purpose of IT is not to change the system or operation strategy, which works very well, but to enhance it. It does this by speeding the transmission of information and especially by eliminating the paper chain that is basically costly and more subject to human error or lost orders. Thus the Kanban system, which originally had been paper-based, is now IT based and uses computers and CRTs. Though Toyota has considered using the Internet for allowing customers to purchase cars, it has found this does not yet work well. In addition to dealer complaints, it found there was just too much that had to be done in terms of registering the car and meeting various regulations, especially in Japan. However, what TMC has introduced is an interactive website and database particularly oriented at younger people, where these potential customers can introduce their own ideas for cars or design their own car on-line. This completed car can then be priced, etc., and the customer referred to a nearby dealer. In addition, Toyota can track the kinds of cars or features that appeal to young people.

It can then use this data to design cars that are more appealing to the next generation, one of its prime strategic marketing programs. So it is using the web globally for direct marketing but not yet for sales in Japan. Further, in the U.S. once you want to buy the car, you can communicate with a local dealer directly and then just pick up the car once payment and/or financing is arranged on line. These websites, including the one in Japan, operate on a real time basis. The data can be accessed using e-mail. Because all employees have their own PCs, they can also access this data as well as communicate. However, it has taken time to get executives to change their habits and to actually use e-mail to communicate rather than phone or call direct meetings. Change is coming.

In terms of buying new PC operating systems, i.e. upgrading, TMC upgrades about every 5-6 years in terms of hardware and software, even though the software producers are making upgrades about every 18 months. This is in keeping with Toyota's philosophy of using the simplistic least expensive way to achieve an objective and to implement what works. Its experience is that it can get the functionality it wants based on a 5-6 year cycle. Also, this insures reliability and usage since people are not constantly changing their operating system or having to learn about added features, which most do not use. Indeed, most people use the PCs for e-mail and word processing; so the existing

PCs, operating systems, and software work fine. Also not buying the latest technology for its own sake saves lots of money, not only in installing and debugging the latest software, but in outright expense. A new PC plus software can run $2000 in direct costs. At 30,000 PCs, that is a $60 million purchase decision. In fact Mr. Nagane estimates each time TMC upgrades its PCs the total all-in cost of each new system, including indirect costs related to system integration, training, and support is 700,000 yen per PC or between $6000 and $7000 each, raising the total corporate expenditure to about $200 million.

However, if there is some reason employees need an upgrade or a special computer, they can always request it, and the request is evaluated on its merits. Further, the same upgrade cycle does not apply to workstations and the CAD/CAM engineering systems needed for design and engineering where upgrades are more frequent, though such changes and software purchases are based on an engineering group's actual requirements. Thus the IT group must also work with Toyota's parts suppliers to ensure compatibility, so that designs and engineering data can be easily exchanged.

Software selection in all these cases is very pragmatic and hinges on the question of the software's contribution to the overall value of the car or the cost of designing and producing a car versus the cost of the software whether purchased or developed. Thus develop versus buy decisions are not made automatically but case-by-case based on evolutionary learning. This is the same routine TMC uses to decide between designing-in and ordering customized or standard parts for a car. It is also the decision process that led it to reduced "fat design" (Fujimoto 1999), in terms of the number of options TMC would offer customers for items such as steering wheels, when it discovered replacement part inventories were becoming too high. Therefore, it represents Toyota's normal strategic routine for introducing new technologies whether organizationally or in the car.

Summary - Controlling the Future

The effects on Japan's automobile industry of the Asian Financial Crisis and the after-effects of Japan's Bubble's collapse have polarized the industry into two groups, Honda and Toyota, and everyone else. This reality has been reflected in the performance of auto producers' stock prices as well as their relative financial performance during the 1990s (Appendix II). Indeed, this polarization is fundamental to the industry's likely evolution since the weaker companies have been forced to restructure, reduce production, and close plants. This general consolidation of their operations is thus gradually reducing Japan's excess production capacity of 3-4 million units (Keller 1997), but not sufficiently to prevent the weaker firms from being propelled into the arms of the various international auto groupings. So during 1999 and 2000 the remaining independent firms, other than Toyota and Honda, were acquired by the groupings centered on large U.S. and European manufacturers such as GM, Ford, Daimler-Chrysler, Renault and Volkswagen. It is these foreign firms that will be determining their Japanese affiliates' future strategies.

Given these changes, Toyota's market success and accumulated wealth have helped it to build a strategic advantage in Japanese and Asian markets. This is because it can afford to invest in geographic, product, and technology expansions that give it newer more profitable products. These help it to further extend its lead in these areas relative to Japanese competitors, while those competitors, except for Honda, find it difficult to respond, putting them under additional competitive pressure. The result has been more restructuring and dependence on the new global groupings. Though this situation may have been beneficial for TMC in the short-run, in the longer run the large global groupings and their Japanese affiliates pose a serious and long-term competitive challenge. Given their greater financial resources and global reach, these reconfigured groups can effectively challenge Toyota both in Japan and overseas markets. Further, given different production locations, swings in exchange rates can affect competition in various key markets.

Overlaying these Japanese industry considerations are various global industry developments. Advanced country demand is fairly saturated, particularly the booming U.S. market (Brogan 1997). Yet, within the U.S. and other advanced country markets, there have been significant and rapid demand shifts. This situation puts a premium on a firm's ability to quickly design, develop and produce new models that incorporate new technologies, especially electronics, and have a fresher look (Fujimoto 1999). On the other hand, rapid emulation by competitors can lead to rapid profit deterioration even in initially attractive segments such as minivans and light trucks (Brogan 1997).

Another important strategic consideration is that the industry expects the largest growth in demand to be in the developing countries with Brazil, China, and India particularly targeted. Further, since these emerging countries are interested in the technology spin-offs and development externalities from having an auto industry as part their industrial base there are complex policy-related issues to efficiently meeting this anticipated demand. While the Japanese industry would clearly prefer to export, this option has been constrained (Appendix II) and FDI is the accepted option. At the same time, the form of the FDI, the type of car produced, and parts sourcing are all important aspects of how this should be done and require sophisticated IT to support this strategy.

As described above, Toyota's response to these various strategic considerations has been a multi-faceted approach incorporating both product and organizational aspects in which information systems are an important competitive tool. This approach has included smart design, smart production and the smart car. Further, to reduce potential emulation and to own the industry's future evolution, it is working hard to establish a global industry standard for smart cars such as the hybrid car in terms of environmental standards or ITS for driving and transportation systems. This is a fundamental part of TMC's strategy. In terms of the smart design component, the company is very customer-focused and is using IT and the Internet to capture ideas from its customers. However, this approach is an evolutionary extension of its smart marketing and sales strategy where orders from customers and the dealers are fed directly by computer into the production and assembly process. The production software system in turn is designed to support this demand by producing cars to order.

In their study "Information Technology, Work Practices, and Wages," Larry Hunter and John Lafkas (H & L 1998) note two approaches to using IT in the workplace. One automates existing practices to reduce skills needed to perform a task, "deskilling". The other enhances employees' existing skills, extending capabilities and making them more productive, "upskilling". This is because H & L indicate that IT systems that generate information as opposed to just automating existing tasks tend to be "skill-biased" and support high performance work practices. They are "upskilling", and such "upskilling" usually improves existing skills, creates new ones, and leads to greater worker autonomy. Under these conditions, the IT system usually evolves and changes with the job so there is a co-evolution of technology and work practices. As such development is based on the firm's original choices, it supports an evolutionary understanding of IT's use and how certain firms achieve best practice (Nelson and Winter 1982 and Fujimoto 1999). Further, since H&L correlate upskilling with higher wages and strategy solutions, this approach should be preferred when possible.

From this perspective, one can see TMC has selected mostly upskilling IT in developing its smart design, smart production and smart product IT systems to solve its strategic problem due to improved plant use, productivity increases and more sophisticated products. In addition, the smart car will change many competitive aspects of the automobile industry. To differentiate its "smart" strategy from its competitors, TMC's management is depending on three basic elements. The first is its design, plant and personnel infrastructure, including its proprietary IT systems; second is its smart car and environmentally based product strategy; and third is its management's evaluation of their customers' increasingly sophisticated and specialized transportation requirements.

Though difficult, TMC systematically collects, manages and analyzes the data needed to link these elements together and to integrate that information directly with its own sophisticated design and production scheduling systems. Tracking, marketing, and delivering these products on a timely cost effective basis is a key aspect of TMC's success in implementing this strategy. At the same time, it must assure that product development evolves in ways that are responsive to changes in customer requirements and the technology within the car as well as in the technology used to design and produce cars, parts and material inputs. This process therefore includes the IT used to control the overall process from order to delivery as well as the software embedded in the automobile. In turn, TMC is constantly modifying these systems based on its understanding of how they are working and could be improved as well as the feedback from plants, dealers and customers. In this way TMC is constantly offering new and old customers products tailored to their changing vehicle demands while the mechanisms to design, produce and market these products quickly is also being adapted to changes in IT technology, such as web-based ordering.

By getting the customer acquainted with TMC’s automated and customized ordering system at an early date and by constantly and rapidly increasing the number and quality of its services and products, TMC has improved customer contact, reduced customer migration and kept costs low. The new smart cars will take this to another level. Toyota is thus using IT to influence customer behavior and expectations and tie them to TMC on an interactive basis, since the competition looks less advanced and sophisticated. But for the strategy to work, TMC must efficiently gather and manage a wide range of information about its client base and its changing demand for vehicles and transportation so it can offer products in a customized and direct manner while constantly improving the operation and its products’ client appeal. However, TMC does seem good at doing this as well as at improving and managing the related organizational and customer complexity needed to manage the technical complexities for cars and IT. As explained by Toyota, trained personnel who understand auto production, automobiles and IT are critical to the success of TMC’s strategy since all three technical streams are needed to develop new cars, new car production technologies, and supporting IT systems.

For example, to more efficiently meet customers' order demands in as little as five days, TMC has recently linked several processes that now enable the auto chassis and the body to flow in parallel directly within the assembly plant (Fujimoto 1999) while still using JIT parts supply. This effort helps reduce assembly time and in-process inventories, but it requires combining auto-making expertise with IT system controls. This close integration of organization, personnel and technology is very important since it is well known that when conflicts arise among managers and employees in goal setting, employees can sabotage the system and productivity improvements become limited (H&L 1998; Fujimoto 1999). TMC's approach of making the design engineers, assembly plants and suppliers the users and stakeholders in the IT system's development and evolution therefore seems sound. This is complemented by simple, easily understood measurable goals such as reducing production costs that are part of IT's strategic development and implementation.

As with other leaders in using IT, establishing *beneficial* IT loops with articulated goals and outcomes is part of TMC's IT utilization process. For example, using IT to monitor customer requirements in terms of products (customization) and delivery (JIT and replacement part inventories) keeps the information loop of orders, products and delivery focused on the customer and repeat business. Such repetition for customized vehicle orders and JIT delivery stabilizes revenues and increases TMC's user base both in terms of products and customers. This then reduces the fixed cost per vehicle while enhancing the demand for high value added and smart products less subject to price pressures. This justifies more IT investment to improve and expand the smart system, including sales to other producers further building revenues while lowering fixed system costs. One clear case of this involves TMC's tying of telecommunications and embedded software in the smart car. The customer gains by taking less time to get from A to B, while TMC gains since producers who cannot offer such vehicles cannot compete.

Further, with "smart" supply capability order success is likely to be greater. This reinforces dealer, supplier, and customer acceptance of the system and the smart design, production and product concept. In turn, Toyota is building the basis for its own business success, including client, geographic and product diversification. This helps to maintain and expand its earnings and asset base. Given current economic and competitive conditions domestically and globally, such developments are critical for its competitive position compared to other producers. Further, to the extent that its smart cars or ITS become a global standard, TMC will benefit from the fact such systems, software or IT are protected by copyright. In addition, it can realize increasing economies due to user base economics (Rapp 1998) where high development costs per unit are continuously reduced by adding users (customers, employees, or suppliers), since the cost of the software is mostly in the development, not in the reproduction. Combining intellectual property protection with increasing returns then begins to emulate a Microsoft competitive model with high returns protected from rapid emulation. A beneficial loop thus emerges such that expansion and usage lowers unit costs, which can increase market share and user-benefits, and thus expand the user base, which lowers costs. This results in a strong company that finds it easier to retain customer and market confidence in an uncertain environment.

There are powerful benefits to such a strategy, especially for a capital-intensive industry that is particularly vulnerable to diminishing returns due to rapid product emulation and economic fluctuations. Furthermore, TMC's integrated IT strategy extends the various important criteria for success in the auto industry explained by Womack et al (1990) or Fujimoto (1999). This is because each IT investment decision relates to a focused market strategy and fits within the totality of the firm's investments including links to auto design and production technology as well as the employees' knowledge base. TMC's managers understand this and take advantage of the interlocking nature of investments in machines, IT, employee skills, HR practices, and organization as well as their complementary relationships (Fujimoto 1999).

This view includes recognizing that technology and human organization must be linked in their development because they need to evolve and improve together. Thus, the company as whole has demonstrated the capacity to learn on an evolutionary basis, which Fujimoto calls organizational evolutionary learning in which strategy and implementation are aligned so they support each other and improvement is continuous, kaizen (Imai 1986 and Fujimoto 1999). In turn, this evolution is based on TMC's vision of how it sees global automobile and transportation systems markets developing while it recognizes that at the same time it must continue to raise the bar in terms of product quality and technology, as well as efficient production. This perspective includes the conviction of TMC's chairman, Mr. Okuda. Furthermore, the emphasis at TMC along with the other leading IT users is on effective use of automation to gain quality or productivity advantage as opposed to being on automation's cutting edge for its own sake (Fujimoto 1999). Indeed, automation for its own sake was found to be inefficient at other auto firms due to frequent line stoppages combined with the high cost of maintenance personnel. However, TMC can be on the IT technological frontier when it is necessary to improve its long-term competitive position as demonstrated by its work on ITS (Exhibits 1 & 2).

In this way one can see that TMC is using IT to control every aspect of its business, from sourcing to delivery to after-sales support and even the very nature of the product's future development and how it will be used. Further, management, including top management, now can view customer relations even more as an extended relationship rather than as a set of transactions for a product with a known price. TMC is thus using IT to impact its competitive environment by changing the way its customers look at automobile requirements so as to favor TMC's business strategy. At the same time, this approach would appear to take TMC beyond a mere extension of the lean design and production strategic model posed by Womack et al (1990). This is because smart cars combined with smart design and production have already absorbed and moved beyond the frontier explained in that study, though Womack et al's view is still correct in noting the competitive importance of TMC's attention and commitment to ongoing improvements in productivity and quality.

As explained above, the driver for TMC's smart strategy has been its need to raise the efficiency and emulation bar for its global group competitors, whose cost cutting and market share goals have increased competitive pressures in all markets. Thus TMC's strategy has been to reduce the ease with such competitors can emulate its strategic, technical and product advances with "me-too" responses using benchmarking and reverse engineering. But by creating and implementing a new initiative that couples auto making and organizational skills with proprietary IT systems, including embedded software, TMC has moved a long way in this direction since competitors do not have access to the IT element. This would seem to be a well-developed, though still evolving, "Controlled Production" paradigm (Rapp 1998a and 1999a), an approach several leading Sloan study

IT firms appear to use. That is, these firms including TMC are using IT not only to control all aspects of their businesses, but also to directly influence the external environment to their strategic advantage. Because TMC is especially good at this, the interactive process should reinforce its analysts' ratings as the world's top auto company in business and IT strategy and thus its future leadership position.

Exhibit 1

Promotion Plan for Intelligent Transportation System

Exhibit 2

Toyota's ITS Businesses and R&D

Exhibit 3

ITS Evolutionary Development

APPENDIX I

Summary Answers to Questions for Toyota – Auto Strategy & Operations

General Management and Corporate Strategy	Yes	No
Has the firm integrated IT into their management and production strategy, including using it to institutionalize organizational strengths and capture tacit knowledge on an iterative basis?	**x**	
Has the firm succeeded solely on the basis of its software strategy?		**x**
Does firm believe some customized IT and its close organizational integration enables it to capture and perpetuate on a more consistent basis tacit knowledge and unique corporate features, i.e. core competencies, that account for its continued success in the market with reliability and repetition important elements in its thinking?	**x**	
Is firm's IT strategy successful because it is well managed and introduces IT innovation when it serves corporate goals for enhancing productivity or customer relations within its industry?	**x**	
Does the division generally meet established criteria as a quality organization such as: effective organizational self assessment, use of project and especially cross functional teams, improving quality outcomes through reducing uncertainty, rapidly diffusing learning throughout the organization including the use of software and information technology, effective implementation of organizational and technical change, facilitating change via evolution rather than revolution or reengineering[35], emphasizing participatory management, having process excellence, using value added analysis, actively doing benchmarking, constant organizational improvement, commitment to concrete realistic goals, effectively managing a dynamic iterative experimental process through goal setting, training and constant consultation?	**x**	
Does the firm plan in detail for operational excellence including the contribution of IT to the allocation of resources?	**x**	
Do planning systems enable management to make better business, operating and resource allocation decisions, including IT?	Yes **x**	No
Do projects focus on small number of IT goals, usually 3 or fewer, with a well-defined system reaching from the commitment of senior management to the department level with associated metrics?	**x,** Not clear	

[35] MIT Systems Dynamics Group in 9/97 presentation estimated 70% of reengineering efforts fail.

Is the firm a "high performance" workplace for services?	**?**	
Is there a heavy emphasis on improving process through IT?	**x**	
Industry Related Are industry economics & competition important strategic drivers for firm's IT use in that IT is adapted to its competitive situation?	**x**	
Are there industry paradoxes: falling stock prices, production improvements that create product improvement difficulties, or employees' active product use that retards improvements?		**x**
Competition Is IT a significant successful input into the firm's competitiveness?	**x**	
Does the firm explicitly and consciously perceive implications of IT strategies and use on its competitiveness and business success?	**x**	
Are there direct links from IT strategies to overall management goals?	**x**	
Do customers, affiliates, competitors, industry analysts, government officials, industry associations and suppliers perceive the competitive benefits or impact of the firm's use of IT?	**x**	
Has the firm gained first mover advantages through successfully introducing software-related innovations?	**x,** Hybrid Car, ITS	
IT Strategy	Yes	No
Is firm a sophisticated software user that consciously designs and implements an IT strategy to achieve competitive advantage?	**x**	
Does firm combine several types of IT to achieve an advantage?	**x**	
Does firm's system rapidly uncover implementation barriers, including using new or better IT, while generating cross-functional and hierarchical consensus so measured goals are achieved?	**x,** culture	
Is leadership at different levels actively involved in IT planning, assessment and deployment with regular progress reviews that link plans, goals, metrics, milestones, resources and responsibilities?	**x,** varies project	

Does system allow for flexibility and innovation plus change and individual efforts if goals, planning and metric criteria are met?	**x**	
Is there a clear vision making project and new software selection straightforward and closely related to strategic goals and processes?	**x**	
Does firm's IT strategy involve conscious clearly defined reliance on customized and semi-customized software in addition to packaged software with specific criteria and goals for selecting each type, and does it have ways to measure this so the firm knows customized software achieves functional or market gains that justify the added expense, including related costs of integrating customized and non-customized software into a single information system?	**x**	
Does firm use option valuation methods to manage uncertain random outcomes, since this approach even among very well managed companies is at IT implementation frontiers?[36]		**x**
Does strategy include more use, development, integration of firm specific and industry vertical application IT and embedded SW in production & delivery processes to improve competitiveness?	**x,** ITS, Hybrid Car	
If firm has embedded SW strategy, is it integrated or interactive with other IT and business strategy in ways affecting delivery, product design or service that improve quality and costs long term?	Yes **x** coop NSC on steel parts	No
Does firm favor increased outsourcing of software design and development?	**x,** some non TPS, vehicle	
Does firm believe large-scale outsourcing by many US companies assumes those firms' IT systems development need not be integrated with their business organization and that they view their IT systems as generic products best developed by outside vendors who can achieve low cost through economies of scale? That is, do they feel these firms' approach focuses on software costs and such firms do not see differences in systems used by competitors?	**x,** not clear most large J firms customize	
Does it believe this is a mistake by competitors that gives it a long-term and sustainable advantage over such companies because it believes outsourcing surrenders firm's strategic IT options as systems service companies tend to develop increasingly	**x,** view on ANX	

36 Easton, G. S. and S. L. Jarrell, "Using Strategic Quality Planning More Effectively: Lessons Learned from NSF Project Research," Columbia Business School conference presentation, September 1997

standardized products one step removed from company's customers and business?		
Has the firm established a software strategy that is open and interactive with its customers and/or suppliers?	**x,** auto project, on-line supply	
Has this enabled it to capture information or cost competitive externalities?	**x**	
<u>IT Operations</u> Do participants own goals and are then committed to implementation strategies?	**x**, user driven IT	
Does firm embed software into its production and delivery processes with competitive market implications?	**x**, ITS	
Is IT technology tied to high speed telecommunications technology, allowing the firm to track, receive and deliver shipments or services directly or on-line without further handling or processing?	Yes **x,** have optic VAN	No
Does it manage potential risks in the extensive IT use or open systems?	**x,** but concerns	
Does it work to ensure consistency and reduce programming errors?	**x**	
Is informal interaction key aspect of planning and implementation?	**x**	
Is firm's IT system institutionalized and self-reinforcing with good communication and consensus building while IT plays a role, including preventing retrospective goals or target reduction?	**x**, inter-active	
<u>Human Resource and Organizational Issues</u> Does firm pay close attention to systems training and organizational integration for all employees, reducing errors through improved consistency and staffing efficiencies across the firm since software can confound even routine operations?	**x**, culture	
Does certain software require special HR competencies or education?	**x,** ITS, hybrid, CAD/CAM	

Does the firm try to change human behavior to use software?		**x**
<u>Parameter Metrics - Inventory, Cycle Times and Cost Reduction</u> Are goals linked regularly reviewed metrics with inputs coming from all levels, often cross-functional affecting large parts of the company: cycle times, timely delivery, and customer satisfaction?	**x,** HO reviews regularly	
Does the firm have standard agreed ways to explicitly organize or manage this IT selection process?	**x**, form teams	
Does the firm have agreed ways to measure and evaluate success in using software to promote objectives such as lower costs, contract time, market share, product development times, or system support?	Yes **x,** cost or function	No
Are IT costs balanced against overall long-term productivity or revenue gains?	**x**	
Does the firm have methods to ensure increased customization costs result in lower costs downstream so developing and using customized software makes sense?	**x**	
Has the firm created large interactive databases to allow automatic feedback between stages or players in the production and delivery process? And are these databases constantly being refined and updated on an interactive basis with actual performance results in a real time global environment?	**x,** parts production histories	
Are there competitive and metric impacts such as reducing inventory costs and wastage while improving the quality of customer service?	**x**	
Has the firm used IT to create beneficial feedback cycles that increase productivity, reduce cycle times and errors, and integrate product and delivery?	**x**	
Do other firms or analysts have alternative measures of competitiveness or views on the appropriate industry strategy?		**x,** Not noted
Has firm achieved better than industry growth, superior delivery, improved control, reduced down-time or changeover problems, reduced product or process errors, fewer complaints, an improved product development process, and/or any other definite and measurable progress relative to competitors?	**x,** leader	

Do the firm's metrics go beyond financial to areas like customer satisfaction, operational performance, and human resources?	**x,** surveys	
Does firm's evaluation system apply to new product development and significant projects as well as to continuous operations?	Yes **x**	No

Summary and Conclusions

<u>Conclusions and Results</u>	Yes	No
Can you summarize mission statement on the role and impact of IT as a tool of competitive advantage for this firm in this industry?	**x,** stated vision	
Is it consistent with strategies identified as successful or appropriate in competitiveness research from Sloan's industry study center?	**x**, 1990 book	
Are there important business or IT situations requiring further research?	**x,** follow-up	
Are intellectual property issues important in explaining firm's successful and sustainable use of IT to achieve competitive advantage?	**x,** ITS and hybrid	
Are beneficial cost impacts generally an important consequence of this firm's successful software strategy?	**x**	
Does this company fit a profile where IT seems most likely to contribute to enhanced competitiveness?	**x**	
Based on this study is the market for vertical application and embedded software growing?	**x**	
Since Japanese competitors normally do not outsource, do Japanese firms see themselves as benefiting from this US trend?	**x,** possibly, e.g. ANX	
Does this leading U.S. firm assign positive value to improved integration and enhanced control through selective customization?	**x**	
Do general measures such as decreased costs evidenced by reduced account servicing expenses reflect benefits successful IT strategy?	**x**	

	Yes	No
Are the benefits of a successful software strategy also reflected in specific industry standards such as an expanded customer base?	**x,** intent, hybrid car	
Does this leading IT user have explicit criteria for selecting package versus customized software and for semi-customizing IT packages?	**x**, cost or function	
Does this firm closely integrate or couple its IT and business strategies beyond mere alignment?	**x,** integral	
Does it closely integrate its organizational and HR policies with its IT systems?	**x**	
Have they reorganized to use software and information technology?		**x** but created 5 subs
Has IT codified or built on existing organizational strengths or core competencies, including HR alignment business and IT strategies?	**x**	
Have they embraced and integrated IT as part of their business strategies and core competencies?	**x**	
Is MIS function integrated with the rest of consumer bank in terms of organization and decision making?	**x**	

APPENDIX II

SOME INDUSTRY AND FIRM DATA

Table 1 -Toyota's Position within the Japanese Auto Industry 1983-1998

(Millions of Vehicles)

Year	Toyota Japan Production			Industry	Toyota	Industry	Toyota
	Cars	Truck/Bus	Total	Total	Exports	Exports	Global Sales (O)
1983	2.4	0.9	3.3	11.1	1.7	5.7	3.3 (1.7)
1984	2.4	1.0	3.4	11.5	1.8	6.1	3.4 (1.8)
1985	2.6	1.1	3.7	12.3	2.0	6.7	3.8 (2.1)
1986	2.7	1.0	3.7	12.3	1.9	6.6	3.9 (2.1)
1987	2.7	0.9	3.6	12.2	1.8	6.3	3.9 (2.1)
1988	3.0	1.0	4.0	12.7	1.8	6.1	4.4 (2.2)
1989	3.1	0.9	4.0	13.0	1.7	5.9	4.4 (2.1)
1990	3.3	0.9	4.2	13.5	1.7	5.8	4.9 (2.4)
1991	3.2	0.9	4.1	13.2	1.7	5.8	4.7 (2.4)
1992	3.2	0.8	3.9	12.5	1.7	5.7	4.6 (2.4)
1993	2.9	0.7	3.6	10.6	1.5	4.6	4.5 (2.4)
1994	2.8	0.7	3.5	10.6	1.5	4.4	4.5 (2.5)
1995	2.6	0.6	3.2	10.2	1.1	3.6	4.6 (2.5)
1996	2.8	0.6	3.4	10.3	1.3	3.8	4.8 (2.6)
1997	2.9	0.6	3.5	11.0	1.5	3.7	4.8 (2.8)
1998	2.7	0.5	3.2	10.0	1.5	3.3	4.6 (2.9)

Source: TMC 1994 and 1999 and Brogan (1997); in 1998, Toyota's market share of 29.1% was about twice Nissan's (15.4%) and almost three times Honda's and Mitsubishi's. If Hino and Daihatsu are included, the group's share rises to 37%. Also between 1989 and 1998, overseas production, mostly in North America, grew from 472,000 to 1.5 million.

Table 2 - Toyota's Japanese Market Share 1989-98 (TMC 1999)

Year	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	
Share	31.8	32.2	31.3	32.1	31.9	31.3	30.0	30.2	29.8	29.1	**(%)**

Table 3: 1986-1998E- The Global Light Vehicle Outlook – (Million Units)

Company/Year	**1986**	**1988**	**1990**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998E**
U.S. Passenger Car Sales										
Big 3	7.85	6.91	5.82	5.10	5.45	5.73	5.51	5.40	5.20	5.00
Transplants	0.37	0.64	1.08	1.18	1.28	1.45	1.62	1.75	1.85	1.95
Total Domestic Cars	8.21	7.54	6.90	6.28	6.73	7.18	7.13	7.15	7.05	6.95
Imports	3.19	3.00	2.40	1.94	1.78	1.81	1.51	1.45	1.35	1.25
U.S. Light Truck Sales										
Big 3	3.66	4.17	3.81	3.98	4.63	5.20	5.30	5.60	5.75	5.50
Transplants	0.10	0.05	0.15	0.27	0.37	0.49	0.44	0.50	0.55	0.70
Total Domestic	3.76	4.22	3.96	4.25	5.00	5.69	5.74	6.10	6.30	6.20
Imports	0.89	0.61	0.60	0.40	0.38	0.40	0.39	0.40	0.40	0.40
Total U.S.	4.65	4.83	4.56	4.65	5.38	6.09	6.13	6.50	6.70	6.60
U.S. Light Vehicle Sales										
Big 3	11.51	11.08	9.63	9.08	10.08	10.93	10.81	11.00	10.95	10.50
Transplants	0.47	0.69	1.23	1.45	1.65	1.94	2.06	2.25	2.40	2.65
Total Domestic	11.97	11.76	10.85	10.52	11.74	12.87	12.87	13.25	13.35	13.15
Imports	4.08	3.61	3.00	2.34	2.16	2.21	1.90	1.85	1.75	1.65
Total U.S.	16.05	15.37	13.86	12.86	13.90	15.08	14.77	15.10	15.10	14.80
N.A. Production	13.28	13.45	12.29	12.56	13.86	15.24	15.03	15.18	15.35	14.95
Western Europe										
U.K.	1.88	2.22	2.01	1.59	1.59	1.78	1.91	2.03	2.12	2.13
Germany	2.83	2.81	3.04	3.93	3.19	3.21	3.31	3.51	3.65	3.80
France	1.91	2.22	2.31	2.11	1.72	1.97	1.93	2.13	1.96	2.04
Italy	1.83	2.18	2.35	2.37	1.69	1.68	1.73	1.74	1.98	2.02
Other Europe	3.24	3.58	3.53	3.49	2.88	3.17	3.10	3.42	3.48	3.67
Car Sales	11.68	13.00	13.23	13.50	11.26	11.94	12.02	12.82	13.19	13.66
Light Commercial	1.21	1.43	1.52	1.42	1.15	1.19	1.26	1.30	1.35	1.43
Total Sales	12.90	14.43	14.75	14.91	12.41	13.13	13.28	14.12	14.54	15.09
Total Production	12.15	13.51	13.66	14.03	11.82	13.27	13.91	14.35	14.75	15.30
Japan										
Mini Vehicle Sales	1.63	1.77	1.90	1.61	1.58	1.64	1.73	1.73	1.66	1.74
Other Vehicle Sales	4.12	4.98	5.90	5.27	4.81	5.06	5.17	5.50	5.54	5.61
All Domestic Sales	5.75	6.75	7.80	6.88	6.39	6.70	6.90	7.22	7.20	7.35
Exports	6.59	6.19	5.82	5.66	4.62	4.35	3.62	3.75	3.70	3.30
Total Production	12.27	12.82	13.59	12.33	10.85	10.62	10.09	10.54	10.44	10.13

Source: Salomon Brothers (Brogan 1997)

Table 4: 1993-2001E- Auto Firms Sales, Earnings and Profits (Unconsolidated) – (¥ Billions)

Company/Year	**FY93**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999E**	**2000E**	**2001E**
Toyota's Revenues	9031	8154	6164	7957	9104	7769	7480	7520	7500
% Cars	71.0	69.0	67.0	67.0	65.4	63.7	-	-	-
% Trucks	28.7	30.8	32.8	32.8	34.4	36.1	-	-	-
% Buses	0.2	0.2	0.2	0.2	0.2	0.2	-	-	-
Japan Production	3460	3502	3174	3501	3422	(1000 units) **peak 4223 1990**			
Net Profit	116	111	111	183	303	365	255	311	340
Nissan Revenues	3897	3583	3408	3518	3690	3546	3430	3320	3300
% Cars	74.6	75.3	74.7	74.4	71.6	73.4	-	-	-
% Trucks	25.2	24.6	25.1	25.4	28.2	26.5	-	-	-
% Buses	0.2	0.2	0.2	0.2	0.2	0.2	-	-	-
Japan Production	1750	1589	1677	1663	1672	-	**peak 2380 1990**		
Net Profit	-15.1	7.6	-61.0	3.6	51.3	16.5	-20.0	15.0	50.0
Honda Revenues	2695	2505	2469	2448	2846	3077	2890	2730	2690
% Cars	98.5	98.1	98.7	98.3	98.3	98.3	-	-	-
% Trucks	1.5	1.3	1.2	1.2	1.3	1.7	-	-	-
% Buses	-	-	-	-	-	-	-	-	-
Japan Production	1127	982	956	1153	1328	-	**peak 1375 1990**		
Net Profit	30.1	14.3	21.6	26.5	90.3	128.0	127.0	105.0	112.0
Mitsubishi Revenues	2616	2456	2653	2523	2586	2501	2310	2270	2250
% Cars	51.1	48.9	45.8	46.0	53.0	61.9	-	-	-
% Trucks	47.7	50.0	53.1	52.9	45.7	36.4	-	-	-
% Buses	1.2	1.1	1.1	1.1	1.3	1.7	-	-	-
Japan Production	1325	1350	1284	1221	1175	-	**peak 1408 1991**		
Net Profit	20.2	16.0	18.8	20.5	15.0	-25.7	-46.0	-26.0	17.0
Mazda Revenues	2191	1769	1700	1443	1427	1512	1520	1470	1450
% Cars	66.3	66.8	53.8	59.8	68.4	72.9	-	-	-
% Trucks	33.7	33.2	46.2	40.2	31.6	27.1	-	-	-
% Buses	-	-	-	-	-	-	-	-	-
Japan Production	982	931	771	781	873	-	**peak 1435 1990**		
Net Profit	2.6	-44.2	-35.8	0.4	6.1	11.5	17.0	17.0	17.0

Source: Nikko Research Center (Matsushima 1998) – Assumes Yen at 130.

Table 5: 1994-1998E- Auto Firms' Capital and R&D Expenditures (Unconsolidated)

Company/Year	FY	1994	1995	1996	1997	1998E – (¥ Billions)
Toyota's Capital Expenses		227	293	313	344	360
R&D		400	450	438	428	440
Nissan Capital Expenses		109	64	74	106	130
R&D		154	162	168	208	220
Honda Capital Expenses		43	48	54	73	95
R&D		195	209	241	281	303
Mitsubishi Capital Expenses		83	87	102	78	50
R&D		112	106	120	126	131
Mazda Capital Expenses		27	16	22	34	50
R&D		54	51	59	70	80

Source: Nikko Research Center (Matsushima 1998)

Table 6: 1991-2000E- Auto Firms' Operating Profit Margin and ROE (Consolidated) – (%)

Company/Year	FY1991	1992	1993	1994	1995	1996	1997	1998	1999E
Toyota's Revenues	-	-	10211	9363	8121	10719	12244	11678	11400
OP Margin	5.07	2.15	1.78	1.45	3.15	3.25	5.43	6.68	4.56
ROE	9.79	5.12	3.72	2.62	3.57	4.97	7.02	7.77	5.31
Nissan Revenues	-	-	6198	5801	5834	6039	6658	6564	6300
OP Margin	2.11	2.28	-0.12	-2.48	-1.81	0.68	2.95	1.28	1.27
ROE	2.75	5.64	-3.17	-5.27	-11.0	-6.35	5.73	-1.06	-3.51
Honda Revenues	-	-	4132	3863	3966	4252	5293	6000	6150
OP Margin	3.41	3.49	2.63	2.03	2.72	3.38	7.58	7.71	8.13
ROE	7.02	5.47	3.49	2.37	6.20	6.55	17.5	17.4	17.3
Mitsubishi Revenues	-	-	3180	2947	3414	3537	3672	3735	3520
OP Margin	3.21	2.81	2.42	1.38	2.81	2.03	1.24	0.09	0.00
ROE	7.45	7.98	6.59	1.38	2.84	2.65	2.39	-24.4	-19.2
Mazda Revenues	-	-	2593	2188	2204	1842	1894	2041	2020
OP Margin	2.73	1.54	1.11	-1.65	-1.14	-0.45	0.01	1.62	2.23
ROE	6.63	2.24	0.31	-12.7	-12.1	-3.53	-5.37	-1.99	3.25

Source: Nikko Research Center (Matsushima 1998). Forecast assumes Yen at 130.

Table 7: 1990-1996- Per Unit Labor Costs – (Yen 1000)

Company/Year	FY1990	1991	1992	1993	1994	1995	1996
Toyota	13.3	14.2	16.0	15.7	16.2	18.1	18.7
Nissan	17.5	17.9	18.7	20.3	21.3	20.1	19.8
Honda	17.6	18.9	21.7	23.1	26.3	28.0	26.2
Mitsubishi	12.9	13.6	13.7	14.1	13.9	14.9	15.6
Mazda	13.5	14.7	15.6	17.3	17.4	19.6	19.4

Source: Nikko Research Center (Matsushima 1998)

Table 8: 1994-98- Firms Domestic, Overseas Vehicle Sales & Production – (1000s units)

Company/Year	FY94	1995	1996	1997	1998
Toyota's Domestic Sales	2063	2084	2232	2006	**1711**
Exports	1441	1141	1312	1494	**1463**
Japan Production	3502	3174	3501	3502	**3166**
Overseas Production	1120	1283	1379	1388	**1468**
Nissan Domestic Sales	1049	1141	1135	1060	
Exports	611	594	594	690	
Japan Production	1589	1677	1663	1720	
Overseas Production	1090	1055	1080	1091	
Honda Domestic Sales	579	657	783	800	
Exports	494	383	410	540	
Japan Production	983	955	1153	1320	
Overseas Production	824	904	1057	1070	
Mitsubishi Domestic Sales	786	824	772	685	
Exports	555	490	481	575	
Japan Production	1350	1284	1221	1220	
Overseas Production	633	671	763	810	
Mazda Domestic Sales	410	391	377	380	
Exports	574	420	445	560	
Japan Production	931	790	781	900	
Overseas Production	197	169	148	137	
Total Japanese Production	10610	10080	10640	10780	10500 **peak was 13591 in 1990**

Source: Nikko Research Center (Matsushima 1998) – Assumes Yen at 130. Forecast for 1999 and 2000 is domestic production under 10 million vehicles.

Table 9: Sources of Efficiency and Operating Profit Improvement 1994-97 (Billion Yen)

Company (Parent)	Better Design & Production	Rationalization (Cost Cutting)	Sales Increase	Yen Depreciation	Total Up
Toyota	760	60	285	430	1501
Nissan	20	713	55	150	940
Honda	94	254	96	115	595
Mitsubishi	-	270	85	95	446
Mazda	-	419	-	49	481
	Sales Decrease	**Yen Appreciation**	**Net R&D Increase**		**Total Down**
Toyota	160	360	180		762
Nissan	365	270	18		704
Honda	110	155	107		377
Mitsubishi	237	187	12		446
Mazda	246	226	3		475

Source: Adapted from Nikko Research Center (Matsushima 1998)

Net Improvement Period: Toyota – 739; **Nissan –** 238; **Honda –** 218; **Mitsubishi –** 0; **Mazda –** 6

% Parent Revenues: Toyota – 2.3%; **Nissan –** 1.7; **Honda –** 2.1; **Mitsubishi –** 0; **Mazda –** 0.1

Table 10: Firms' Consolidated Yen Sensitivity - 1997 (Billion Yen)

Company	Overseas Revenues % Revenues FY 95	Change Pretax Profit per ¥1/$ FY97	% U.S. Sales from N.A. Production CY96
Toyota	45.2	16.0	64%
Nissan	48.2	7.0	60%
Honda	63.8	6.9	82%
Mitsubishi	43.9	3.2	67%
Mazda	55.7	2.8	54%

Source: Salomon Brothers (Brogan 1997)

Table 11: Key Firm Data – Toyota Motor Corporation (Parent only)

	6/93	3/99 (TMC 1999)
FY Revenues (Billion Yen)	9030.9	7525.5
Net Income (Billion Yen)	115.5	267.2
Vehicle Production (1000s)*	4820.0	4634.1
Domestic	3931.3	3165.8
Overseas	888.7	1468.2
Vehicle Sales (1000s)	3927.1	4641.0
Domestic Sales	2228.9	1711.0
Exports	1698.2	1462.8
Overseas Sales	2586.9	2930.0
Total Capital	260.5	397.0
Employees	71000	68000
Return on Capital (%)	44.3	67.3

Source: Toyota (1994 and 1999). In calendar 1992, Toyota's domestic auto production was roughly 3.2 million cars with 1.3 million exported. This production was up from 2.4 million in 1983. Their domestic market share was 32% in 1992 compared to 29.7% in 1983

<u>Firm Data</u> (billions of ¥en – Consolidated))	**1997 (3/97)**	**1998 (3/98)**	**1999 (3/99)**
ASSETS & LIABILITIES			
Cash and Short-term Money Claims	1855	1769	1980
Receivables	1480	1377	1359
Inventories	562	727	765
Other Current Assets	1943	1556	1595
Fixed Assets	4094	4682	4862
Land	653	682	828
Construction in Progress	235	232	329
Other Assets	2771	4711	5182
Total Assets	**12705**	**14822**	**15847**
Automotive	6070	6934	7427
Finance	3404	4215	4446

Liabilities	**7028**	**8275**	**9189**
Equity	**5677**	**6547**	**6658**

Source: (TMC - Annual Reports 1997, 98, 99)

Table 12: Toyota's Japanese Auto Market Share 1994 – 98E (Excluding Mini Cars)

Year	**1994**	**1995**	**1996**	**1997**	**1998E (%)**
Toyota	41.4	39.4	39.2	38.9	38.7
Honda	6.4	7.5	10.0	10.9	10.4
Nissan	20.7	21.3	20.4	20.2	21.4
Mitsubishi	10.0	9.7	8.9	8.2	8.3
Mazda	6.8	6.0	5.3	5.7	6.5
Imports	6.1	7.5	8.0	7.1	6.1
Large Cars		28.9	30.9	25.7	22.7

Source: Nikko Equity Research (Matsushima 1998)

Table 13: Forecast Japanese Automobile Unit (1000s) Sales 1992 – 2000E

Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998E**	**1999E**	**2000E**
Domestic Sales	4427	4154	4304	4466	4852	4190	4315	4270	4383
Exports	4415	3568	3268	2761	2968	3722	3660	3360	3280

Source: Nikko Equity Research (Matsushima 1998)

BIBLIOGRAPHY AND REFERENCES

1. Ahmadjian, Christina, "Japanese Auto Parts Supply Networks and the Governance of Interfirm Exchange," Center on Japanese Economy and Business Working Paper, No. 129, Columbia, NY, 1997

2. Ahmadjian, Christina, "Network Affiliation and Supplier Performance in the Japanese Automotive Industry," Center on Japanese Economy and Business Working Paper, No. 138, Columbia, NY, 1997a

3. Ahmadjian, Christina, and James Lincoln "Changing Firm Boundaries In Japanese Auto Parts Supply Networks," Center on Japanese Economy and Business Working Paper, No. 137, Columbia, NY, 1997

4. Amari, H., W. Rapp, & H. Patrick, "Sustaining Long Term Advantage through Information Technology, Pharmaceuticals: Takeda," in Information Processing as a Competitive Advantage of Japanese Firms, H. Albach, U. Goertzen, & R. Zobel, ed., WZB, Berlin

5. Brogan, Edward, "Global Automotive Digest," Salomon Brothers, New York, 1997

6. Brogan, Edward, "Japan Auto Monitor," Salomon Brothers Japanese Equity Research, Tokyo, 1997a

7. Burmeister, Robert A., "Intelligent Transportation Systems in Japan," Presentation University of Victoria, Victoria, B.C., 1996

8. Cogan, Ron, "Smart Cars," Fortune, New York, 1995

9. Dazai, Takeo, and Toyoshi Maruyama "Practical Research of the Steel Products EC," CALS Expo International 1997, CALS, Tokyo 1997

10. Easton, George S. and Sherry L. Jarrell, "Using Strategic Quality Planning More Effectively: Lessons Learned from NSF Project Research," presentation at Columbia Business School Conference on Quality, New York, September 1997

11. ENICOM, "Nippon Steel & Information Systems for Strategy of Business," Steel Making Systems Division, presentation, Tokyo, 1998a

12. Evans, Philip and Thomas Wurster, Blown to Bits: How the New Economics of Information Transforms Strategy, Harvard Business School Press, Boston, 1999

13. Fujimoto, Takahiro, The Evolution of a Manufacturing System at Toyota, Oxford Press, NY 1999

14. Hunter, Larry W. and John J. Lafkas, "Information Technology, Work Practices, and Wages" Working Paper 98-02, Wharton, Financial Institutions Center, 1998

15. Imai, M., Kaizen: The Key to Japanese Competitiveness Success, Random House Business Division, New York, 1986

16. Keller, Maryann, "International Automobile Production: How Will Firms Compete in the 21st Century," Occasional Paper Series, No. 34, Center on Japanese Economy and Business, Columbia, New York, 1997

17. MacKnight, Susan, "Asia: The Next Automotive Proving Ground," JEI Report, Japan Economic Institute, Washington, D.C., 1997

18. Matsushima, Noriyuki, "Automotive Industry in Japan," The Nikko Research Center, Ltd., Tokyo 1998

19. Matsushima, Noriyuki, "Automobile Sector, Trends in Corporate Earnings and Stock Price," The Nikko Research Center, Ltd., Tokyo 1998a

20. Matsushima, Noriyuki, "Automotive Industry," The Nikko Research Center, Ltd., Tokyo 1998b

21. Nelson, Richard and Sidney Winter, An Evolutionary Theory of Economic Change, Cambridge, MA, Harvard University Press, 1982

22. Nippon Steel, Basic Facts About Nippon Steel 1997, NSC, Japan, 1997

23. Nippon Steel, "Japan's Steel Industry and the Kimitsu Works," NSC, Japan, 1998

24. Okuda, Hiroshi, "When the Ground Rules Change," Presentation Yale University, New Haven, 1998

25. Rapp, William V. and Thomas Hout, "Competitive Development of the Japanese Automobile Industry," in Jerome Cohen, ed., Pacific Partnership: United States-Japan Trade, D.C. Heath, Lexington, MA., 1972

26. Rapp, William V., The Future Evolution of Japanese-U.S. Competition in Software: Policy Challenges and Strategic Prospects, Final Report Japan-U.S. Friendship Commission, Columbia Center on Japanese Economy and Business, 1995

27. Rapp, William V., "Gaining and Sustaining Long-term Advantage Through Information Technology: The Emergence of Controlled Production," Center on Japanese Economy and Business Working Paper, Columbia, New York, 1998.

28. Rapp, William V., "Gaining and Sustaining Long-term Advantage Using Information Technology: Emergence of Controlled Production," Best Papers Proceedings, Association of Japanese Business Studies, Salt Lake City, UT, 1999.

29. Rapp, William V., "Nippon Steel's E-commerce and Customized Casting Strategy: An Example of Controlled Production," Association of Japanese Business Studies, Keio University, Japan, 2000.

30. Sealy, Michael, "The Global Design Strategy of Japanese Automobile Manufacturers," Seminar Paper, Columbia, NY 1991

31. Smitka, Michael, “The Decline of the Japanese Auto Industry: Domestic and International Implications,” A Japan Economic Seminar Paper, 1993

32. Sobek, Durward K., “Integrating Manufacturing Process Design and Product Design: The Toyota and Chrysler Models,” AJBS Conference Paper, 1997

33. Toyota Media Station, “MONET,” Toyota, Nagoya, 1998

34. Toyota Motor Corporation, “Outline of Toyota”, TMC, Toyota City 1999

35. Toyota Motor Corporation, “Outline of Toyota”, TMC, Toyota City 1994

36. Toyota Motor Corporation, Annual Report 1997, Toyota City, 1997

37. Toyota Motor Corporation, “Toyota’s Approaches to ITS, Peoples, Vehicles, Society,” Toyota City, 1998a

38. Wold, Geoffrey H. and Robert F. Shriver, Strategic Systems Planning for Financial Institutions, Probus, Chicago 1993

39. Womack, J. P., D. T. Jones, and D. Roos, The Machine that Changed the World, Rawson Associates, New York, N.Y., 1990