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The Toyota Production System

——Its Organizational Definition in Japan——

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There is now overwhelming evidence that Toyota Production System (TPS) represents the world's best practice for the manufacture of motor vehicles[1], but there is also underwhelming agreement concerning why the TPS became so efficient and how it works with regard to the organizational dynamics, institutional requirements, and economic conditions that frame the famed production system. While a sizeable literature has appeared on some of these topics relating the postwar motor vehicle industry in Japan to industrial structure, industrial relations, and economic performance, including studies on the history of the automobile industry, quality control circles, worker multi-skilling, supplier networks, product development capabilities, marketing-manufacturing feedback loops, and so on, very little integration has been assayed between these themes in light of the unparalleled performance of the TPS[2]. This essay attempts to pull together some of these separate threads of inquiry and presents an evolutionary model of how the TPS developed during the past four or five decades.

For the moment, therefore, it may be premature to assert that the TPS is replacing the traditional Fordist or American model of manufacturing as the leading paradigm for achieving high productivity and product variety in manufacturing; our understanding of the institutional interrelations and interconnections securing Japan's postwar economic performance is still partial and limited. So while the TPS is important, even epochal, in the history of manufacturing, there is surprisingly little agreement regarding what the TPS is and why it works[3]. The definitional problem leads to a related concern : it is not as easy as it might seem to trace the diffusion of the TPS and to evaluate its impact in Japan or elsewhere on manufacturing practices. In short, there is surprisingly little agreement as to how the TPS should be characterized and how far it has diffused[4].

The Problem of Definition

Japanese government data highlight the ambiguity. According to a Ministry of International Trade and Industry (MITI) census of the division of labor supporting the auto industry in 1977, 47, 308 independent, bookkeeping entities supply Toyota Motor Corporation (TMC) with parts, components, subassemblies, and services. Adjusting for double-counting drops the total to 36, 468. Depending on how one counts, therefore, between 36,000 and 47,000 organizations supply TMC with about 70 percent of the manufacturing cost of Toyota brand name motor vehicles[5].

As a practical matter, it may be possible to begin our exploration of the TPS at this juncture. How is it possible to coordinate and mobilize resources in 36,000 to 47,000 suppliers and still be, by far, the world's lowest cost producer? Conventionally, there are two answers to

Figure 1 Division of Labor in the Automobile Industry

〈Toyota Motors' Suppliers by Level〉

	First-level	Second-level	Third-level	Total
Engine Parts	25	912	4,960	5,897
Electronical/ Electronics	1	34	352	387
Transmission, Gears, Steering	31	609	7,354	7,994
Brakes, Suspension	18	792	6,204	7,014
Brake & Suspension Parts	18	926	5,936	6,880
Chassis & Parts	3	27	85	115
Body & Pressing	41	1,213	8,221	9,475
Other	31	924	8,591	9,546
Totals	168	5,437	41,703	47,308

Source: Small- and Medium-Sized Enterprise Agency, MITI, "An Investigation into the Current Level of the Division of Labor(Automobiles)," mimeographed, 1977. Also cited by Shiomi. p. 81.

such a paradox[6]. Internalize the factors of production, promote an internal division of labor, coordinate, allocate, and plan effectively within unified and consistent corporate boundaries; this is the transaction cost economizing solution. But a network of 40,000 suppliers suggests that TMC is not pursuing a transaction cost economizing strategy, unless one assumes that the 40,000 independent organizational entities identified by MITI are *not* really independent. So, one answer to Toyota's manufacturing efficiency may be found in the high degree of vertical integration or quasi-integration, assuming a lack of strategic independence on the part of Toyota's thousands of suppliers.

Otherwise, TMC may be pursuing a buy rather than make strategy, maximizing the logic of market choice and price flexibility. On average, TMC buys 70 percent of the value of the motor vehicles it assembles; the comparable figures for General Motors, Ford, and Chrysler are 30, 50, and 60 persent[7]. So, Toyota buys anywhere from 75 to 17 percent more of the value of its motor vehicles than does the American Big Three yet TMC is not only the lowest cost producer, but also the fastest to market.

Transaction cost economies and economies of speed are hard to effect with "pure" buy rather than make strategies because information is never perfect and it is often asymmetrical and impacted. Human nature is no more perfect with opportunism and finite choice the result. The more one relies on market-based information, therefore, response times are likely to be slower, especially when purchased items are not highly standardized as is often the case in the motor vehicle industry. Yet TMC boasts the shortest product development cycles, lowest inventory levels, quickest turnaround times in a global sample of representative motor vehicle companies[8]. In short, Toyota excels at cost- as well as time-based competition.

Hence, neither market nor hierarchy in their unadulterated forms seems to explain TMC's competitive position. Perhaps something in between, say financial power linking TMC to its key suppliers, may provide an explanation. Certainly, TMC has financial leverage over some of its key suppliers but not so many of them. According to 1986 data, among seventy-seven of TMC's largest, first-tier suppliers, the average level of TMC'S shareholding in affiliated, first-tier suppliers was 20.7 percent[9]. Excluding the fifteen largest of these, either firms controlled directly by Toyota or firms that were spun-out of TMC, drops the figure to 13.7 percent. Moving outside the group of the largest 77 suppliers, TMC's financial involvement falls dramatically and progressively to a point of insignificance.

One reason for the progressive decline is the sheer number of suppliers, and outside of first-tier suppliers, Toyota Motor rarely holds shares in suppliers. If

some 40,000 suppliers are used as the denominator, then the *average* level of Toyota Motor shareholding in suppliers quickly drops below 1 percent. Indirectly, it could be argued that Toyota surrogates, namely the largest first-tier suppliers and affiliates, control lower-tier suppliers, so that financial power does in fact organize the system. But this interpretation is rather problematic. To be persuasive, one has to assume an extremely dominant Toyota, rather passive suppliers, and an informal conspiracy uniting the bunch of them.

In contrast, the approach presented here argues for a dynamic and strategic, technology-based, organizational evolution of the TPS binding Toyota Motor to its many suppliers by mutually negotiated and beneficial, long-term contracting. Reciprocity, profit sharing, organizational learning and interdependence are outcomes of the fully evolved TPS. Nonetheless, this interpretation allows that at earlier times an extremely dominant Toyota and passive suppliers may have characterized the TPS.

This is not to dismiss the financial argument, indeed it appears to be one key to understanding the TPS but only up to a point. Since it is unclear to T. Boone Pickens and many others exactly how much financial involvement in the form of interfirm shareholding is needed to demonstrate control, the point is moot. Thus, financial relationships are part of the complex nature of assembler-supplier relations found in the TPS (and more generally in assembly industries in Japan) and they should be factored into an understanding of the TPS.

Notwithstanding the actual degree of financial involvement between Toyota and its suppliers, the fundamental question is this: given the exceedingly large number of TMC suppliers, how can the exacting cost, quality, and delivery standards of the TPS be exercised? Just-in-Time (JIT) purchase, delivery of manufacture is one thing with a finite number of suppliers, and quite another with suppliers in the large numbers supporting TMC today. As a consequence, confusion with regard to a definition of the TPS in the context of diffuse, extended and decentralized organizational characteristics and capabilities may be warranted. Indeed, to our knowledge, no one has yet attempted to define the TPS in this way.

The Boundaries of Definition

Traditionally, the TPS has been assigned the following single-site characteristics in contrast to the Mass Production System (MPS). Instead of push production control under a master plan, TPS operates by a pull production system that flexibly adapts to changing market needs and manufacturing process requirements. Instead of a rigidly specialized workforce and dedicated equipment (e. g. 200 job classifications and a large number of transfer machines at a typical U. S. assembly plant), TPS seeks operational flexibility through multi-skilled workers, running a limited number of machines, in an autonomous fashion (e. g. 3-4 job classifications with workers responsible for the maintenance, inspection, and operation of perhaps a half-dozen machines where man/machine systems incorporate "judgment" functions, such as auto-stoppers checking for abnormals.)

JIT operations with minimum stock levels throughout the manufacturing process are in sharp contrast to Just-in-Case (JIC) operations of the MPS. Small-lot, ultimately one-piece-at-a-time, production with fast changeover times permits a large variety of goods to be

manufactured in small volumes. Large-lot production with long changeover times is typical of MPS. Zero defects are the target of the TPS, and evidence suggests that its most successful performers are achieving 30～40 PPM (parts per million) defects today, whereas several percent "acceptable" defects are characteristic of the MPS.

Finally, in its ultimate expression, the MPS may seek to eliminate workers from the shopfloor because they are perceived to be a basic source of production problems. The TPS considers workers to be a source of problem solving, an infinite and irreplacable reservoir of *kaizen* or continuous improvement, if their input can be effectively translated into organizational learning[10].

While a standard definition of the TPS hinges largely on the hardware-dependent factors as given above, there remain some puzzling areas of inquiry. If TPS represents "best practice" and if its hardware-based features are well understood, why is there so much variation in the degree of successful implementation? Why should TPS be a benefit to one manufacturer and a bane to another?

This paper probes these issues by presenting two organizational models of the TPS: a dualist model and a network model. In addition, an especially dynamic variation on the network model, a so-called learning model, is also explored. The key concepts underlying these models are a transition from residual to transaction-specific rights in the supply function, from uni-directional to multilateral flow of information and learning, and from reciprocity (to equity) to distributive justice in an interorganizational model of the TPS. A definition of the TPS in the context of these organizational characteristics and capabilities suggests that contrary to general belief the TPS is not so widely diffused even in Japan.

As a result, the competitive advantages associated with the TPS seem less country-specific than organization-specific. Nonetheless, the principles and practices of the TPS are extremely well understood in Japan and, as a result, the TPS may be becoming a model of how best to organize in industries characterized by high volume production, multiple year product life-cycles, and considerable product variety. In these industries, the spread of TPS-like production management systems may be culminating in country-specific competitive advantages.

However, we actually argue that the TPS is something more than an organization-specific advantage. We hypothesize that the TPS is a system-specific advantage embedded in an *inter-organizational* matrix with certain behavioral, institutional, and performance characteristics. We believe that very few manufacturing systems can boast of TPS-like, system-wide advanteges. If and when they begin to acquire them, they will do so in conjunction with large numbers of other organizations, and hence an inter-organizational model of the TPS necessarily implies certain system-wide, organization-specific characteristics. For now, these appear most advanced in Japan and best illustrated by the TPS.

Thus, this paper seeks to reduce the ambiguity surrounding a number of important issues: what is the TPS, what are its key characteristics from an organizational point of view, and what has been its impact in Japan on technology and the organization of work?

What is the TPS: 2 Different Models

The Dualistic Model

Very often, the TPS is presented as a

dualist model of organization where the Toyota Motor Company (TMC) induces its many agents to adopt certain organizational forms and practices. In this, TMC as a principal represents the interests of owners, managers, and shareholders against those of agents, either its non-managerial employees of other individuals and organizations cooperating with TMC in the execution of the TPS[11]. The argument runs as follows.

1. Structures and processes associated with the TPS include Just-in-Time (JIT) operations, small group activities, such as QC circles, training in statistical quality controls for supervisors and rank-and-file, training in multiple machine tool mastery (multiskilling), general flexibility in the use of plant, equipment, and personnel, reduction of waste (of energy, time, labor, resources in general), small lot manufacturing, and use of *kanban* and *andon*.

2. Structures and processes such as these were generally worked out, evaluated, improved and implemented within TMC first and then transmitted to firms cooperating closely with TMC[12]. In short, performance standards and parameters originated with TMC.

3. The assumptions of this model are :

a) managerial perogatives (what may be called residual rights of ownership of the physical equipment of production as well as rights to operate the plant and equipment) lie in the hands of TMC managers and are exercised exclusively by them ;

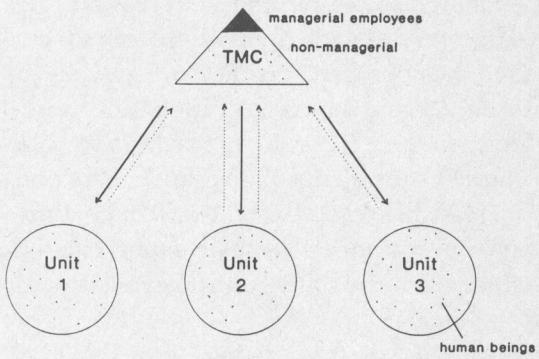
b) the flow of information about the structures and processes of the TPS is largely one-way, namely from TMC management outward and downward ;

c) regardless of the number and configuration of the organizational units in the TPS, the flow and control of transactions is predictable and managed ;

d) power, rights, and information in the TPS are characterized by discrete, step-like functions, that is by bilateral asymmetry ;

e) the assumptions of the dualist model may be illustrated in the following manner :

Figure 2 Dualist Model



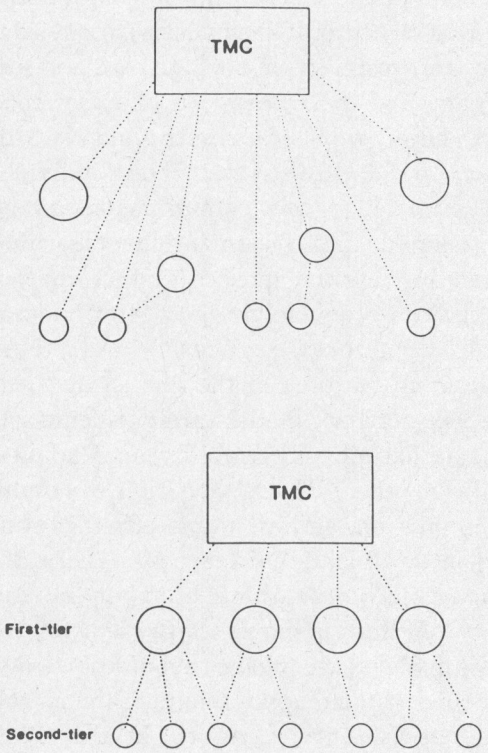
The Network Model

More recently, the TPS has been presented as a network model of organization where the overall size, configuration, and nature of interactions between many parts of an interconnected system are emphasized. Managerial rights are not stressed and instead of a dualistic model of asymmetrical, bilateral relations, a more symmetrical, multi-lateral model of reciprocal relations among TMC and its many suppliers is offered[13]. In addition, in network models where large numbers of organizational units are involved (hundreds instead of dozens), the network may be analyzed in terms of its organizational sub-systems[14]. Within these separate subsystems, interactions may tend toward more asymmetrical, bi-lateral relations as in the dualist model even as other subsystems are characterized by more symmetrical, multi-lateral relations.

1. Structures and processes of the earlier dualist model are not neglected. But they are viewed in light of an emerging multi-lateral system (the network as a whole) and its many bilateral parts.

2. Credit for originating and improving structures and processes are not interpreted uni-laterally and, instead, systemic features that give rise to, sustain, and enhance those structures and processes are stressed. Symmetrical, bi-lateral dynamics characterized by reciprocity define the system. Nevertheless, as just mentioned, within sub-systems of the whole, particularly within what Nishiguchi calls "clusters," a more bilateral than multi-lateral dynamic may operate. Clustering refers to the organizing of sub-systems of the whole around key, lower-tier suppliers to TMC. Instead of TMC organizing second or third-tier suppliers, this task in left to first-tier suppliers. Clustering may be illustrated as below.

Figure 3 Clustered Control



3. Mutuality of interests within the context of the network is emphasized, leading to an ethos of bi-lateral, reciprocal, collaborative bargaining, what is often termed coexistence and co-prosperity (*kyozon kyoei*) in Japanese[15]. Mutuality of interests can be traced in the expanding volume and velocity of information (transactions), its multi-directional flows, and a large number of organizations (points, nodes) in the network.

4. The assumptions of this model are:

a) specificities in transaction rights are separable from residual rights of ownership[16]. Specificity in transaction rights refer to an expectation of and perhaps a guarantee to a portion of the revenue stream generated by a product, process, or service over which one does not have final market power.

Specificities in transaction rights may be both ex ante and ex post in that the product, process, or service has to be tailored ex ante to specifications fitting an intermediate or final market and ex post in light of the subsequent acceptance, grading, and adaptation of that product, process, and service. In neither case, however, does the product, process, or service have much value independent of the specific market for which it is tailored. While contracts may be written to cover the many contingencies of small numbers bargaining; contracts cannot be written flexibly and frequently enough to cover all the design, development and production change orders necessary to stay competitive in the Japanese auto industry.

In Japan, full-model changes come every four or five years and substantial

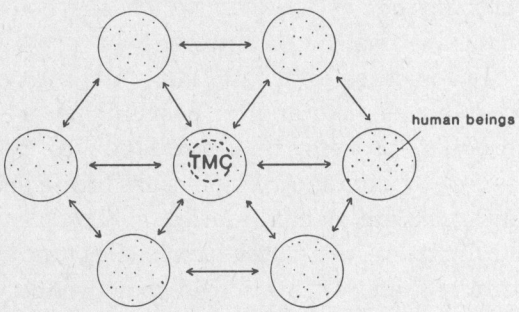
face lifting may occur every year. In these circumstances, transaction specific rights of ownership provide suppliers with the credible commitments needed to guarantee that their considerable investments in design, development and production to meet the specifications of final assemblers will be rewarded.

b) system features, like directional flow, velocity, frequency, and intensity of transactions, may be becoming more important than characteristics associated with bi-lateral relations;

c) important behavioral and institutional characteristics of the TPS are more continuous than discrete in terms of their frequency and distribution within the network.

d) the assumptions of the network model may be illustrated as follows:

Figure 4 Network Model



The Learning Model: An Extension of the Network Model

Most recently, the TPS has been seen as a form of manufacturing that embodies high degrees of system-specific learning[17]. We call this the learning model of the TPS and feel that it represents a potentiality associated with the network model when certain crucial conditions are realized. Among these, the most important would be the full separation of transaction-specific ownership rights from residual rights of ownership and the further development of reciprocity and bi-lateral symmetry in information flow and exchange. The limited diffusion of the TPS in its fullest sense hinges on the attainment of these conditions and the incentives affecting them.

Learning comes from many sources but, most importantly, from the human beings involved in the TPS. Learning is of two sorts: (a) the accumulated efforts of many individuals to improve, and (b) the enhanced capability of the organization to harness (institutionalize) that improvement. In this perspective, neither ownership and managerial rights nor bilateral, multi-lateral, and systemic trans actions alone account for the advantages of the TPS. Instead, experience —— thoughtful, accumulated experience on the part of everyone engaged in the TPS, a behavioral transformation congruent with a strong shift in emphasis from residual to transaction-specific ownership rights, and the translation of experience into better ways of assessing and rewarding work——are stressed. Thus, individual experience and commitment can be translated into organizational learning and this learning pushes system characteristics to new heights of performance.

1. Structural, process, and transactional features of the dualist and less robust network models are not denied.

2. Flexibility, variability, and adaptability of the TPS are the result of human imagination, ambition, and effort captured in organizational learning. There are many kinds of learning, both general and local. What distinguishes the learning of this model is the higher rate of knowledge acquisition and application within as well as between organizations in the TPS. Higher levels of learning, more fully

captured and exploited, result in qualitative changes in employee attitudes, performance, and commitment.

3. Continuous improvements of the TPS depend on the accumulated efforts and insights of all the stakeholders in the TPS. Those efforts and insights are released by experiences of equity and distributive justice in the allotment of rewards and benefits derived from the TPS. Equity and distributive justice come to characterize economic relations in the TPS as there is a shift toward notions of transaction-specific rights of ownership and of diffuse rather than discrete bilateral relations (mutuality of interests). These notions include an expectation that organizations and individuals without residual rights of ownership will benefit in some direct proportion to the contributions they bring to the TPS.

4. The assumptions of this extended network model are:

a) rights, interests, and inputs of stakeholders in the TPS are not separable (neither residual rights of ownership nor specific transaction rights); being inseparable, the benefits of lowering marginal costs are distributed equitably.

b) people are trustworthy (or can become so) and they are essential for continuous improvement of the TPS;

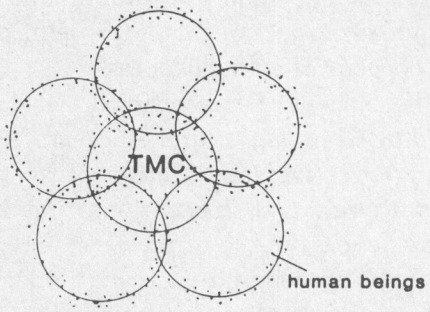
c) learning is more continuous than discontinuous, more diffused than concentrated;

d) learning is organic, self-reinforcing, growing from within and between rather than being transplanted from without;

e) organizational entities in the TPS are interdependent rather than independent; learning occurs within a highly integrated, interconnected context.

f) the learning model of the TPS may be represented as follows; the dots in the illustration are meant to suggest human beings and their increasingly important role in the TPS:

Figure 5 Learning Model



How to Reconcile Different Views of the TPS?

Either no reconciliation is possible or reconciliation may be attempted in a historical interpretation. In the former view, the models are different representations of the same phenomenon, seen differently (because you see what you're looking for, you're not necessarily looking at different phenomena). In the latter case, a historical or evolutionary model captures the temporal development of the TPS, highlighting changes in structure and function over time.

While some features of the two basic models represent different views, perspectives and features of the same reality, such as an agreement on what hardware best characterizes the TPS, other features of the two models concentrate on definitional differences, such as issues of ownership or managerial rights, the logic or dynamic of the TPS, and whether or not behavioral and performance attributes are discrete or continuous.

An evolutionary treatment of the TPS, however, allows for some features of the two models to be emphasized at certain

times and for others at different times. Presumably, the timing and sequencing of these features in a developmental model would be particularly crucial. In other words, the temporal pattern with which features unfolded is important. A significant aspect of this interpretation is the concept of embeddedness.

The concept of embeddedness, as developed by Granovetter and others, refers to the progressive interrelation of persons, institutions, and institutional environments over time. Granovetter "stresses the role of concrete personal relations and structures of such relations in generating trust and discouraging malfeasance."[18] Three aspects of this adaptation, evolution or embeddedness may be especially important for understanding the nature of the TPS: (1) the sequence of adaptation (in what order the steps occurred), (2) when the steps occurred, (3) when the effects were observed.

1. The dualist model appears most appropriate during the earliest days of experimentation and institutionalization of the TPS. Taiichi Ohno writes that trials having workers handle two or more machines in order to catch up with the larger output of American factories began in 1947 in the Number Two Machine Works in Toyota City, and that suppliers began to adopt JIT techniques in their deliveries with Toyota Motor Company (TMC) in 1963[19]. So, during the period 1947-1963/64, major changes in the arrangement, use, and management of the physical assets associated with the TPS occurred.

a) during this period, major changes in the TPS were initiated on the perogative and power of top management within TMC.

b) between TMC and its principal suppliers, the main elements of the hardware dependent definition of the TPS began to be transferred toward the mid-1960s, again on the initiatives of the TMC.

c) the transfer of the TPS to first-tier suppliers, therefore, was largely conducted within the framework of the dualist model characterized by unequal rights, bi-lateral asymmetrical relations, and the one-way transfer of knowhow.

2. The network or interorganizational model seems most appropriate during a period from 1965 to 1985 or so. The network model focuses on a shift toward reciprocal, multi-lateral relations and toward a concern with specific rights of transaction rather than residual rights of ownership. So, this model assumes a fairly large number of organizational entities (at least hundreds if not thousands), all cooperating in the implementation of the TPS.

a) the network model assumes a period of transitional learning when the TPS was transferred outside the TMC, so sometime after 1963/64 when Taiichi Ohno says suppliers began to adopt JIT deliveries.

b) more generally, the high volume of transactions associated with a network view of the TPS coincides with a phenomenal increase in output of Toyota brandnama vehicles. Production, in fact, quintupled in a seven year period—— from just 200,000 vehicles in 1961 to over 1,000,000 in 1968, and *doubled again* between 1968 and 1972!

c) an increase in output associated with the transfer of the TPS to first-tier suppliers assumes a further organization and expansion of second-and third-tier suppliers to secure the inputs and outputs of first-tier suppliers.

3. A learning model, as an extension of the network model, seems most appropriate for the two decades since the mid-

1970s when, in the first instance, the oil crises forced TMC to cope with a much more demanding technical market for automobile design and manufacture in terms of fuel efficiency, environmental protection, safety, price and quality, and when, in the second instance, a much more rigorous financial market with the dramatic reevaluation of the yen in 1985 and constant political pressure affected export market pricing and penetration strategies.

At the same time, the maturation (not saturation) of the motor vehicle industry in Japan led consumers to demand variety, choice, and style in the purchase of automobiles[20]. The consecutive, nearly simultaneous, occurrence of these developments (increasing technical requirements, financial discipline, and consumer demand) largely shifted the burden for product development, flexible manufacturing, and market responsiveness away from TMC as the primary party responsible for the organization and management of the TPS. Time to market shortened, product variety increased, technical complexity climbed, and financial exposure widened. TMC was forced to rely increasingly and in notably more interdependent ways on those firms to which it had diffused the TPS. A learning emphasis infused the network of suppliers.

During the 1970s, in effect, TMC became a large firm and an efficient firm by buying rather than by making. That is, the success of TMC became tied to its success in diffusing the TPS. But Toyota's success was not rooted in the simple buying of more and cheaper parts but in the complex buying of higher value-added parts. The nature of the asset specificity embodied in the buying of high value-added, supplier (or jointly) designed parts, components, and subassemblies is rather different from that of sourcing one-party/TMC designed parts from subcontractors.

The asset specificity of make or buy decisions hinges largely on who bears most of the design, development, and production costs associated with those things of value purchased by TMC. If the costs of product development and, therefore, of the related, underlying asset specificity of the transaction lie more with one side than the other, that party has clear ownership rights and may elect to sell or to retain them. But, if the value of the product hinges largely on its purchase by a party other than the one responsible for its design and development, then ownership rights become clouded. The cost of the product is borne by one party but the value of the product lies in its purchase by the other party. How should profits gained in such transactions be distributed?

In the shift from the dualist model of the TPS to the network model, there is an emerging shift the burden and nature of asset specificity. The transition is from an emphasis on residual rights of ownership toward an emphasis on rights of transaction specific ownership. This parallels a shift from bi-lateral asymmetry to bi-lateral and multi-lateral symmetry in information flow. A corresponding shift from uni-lateral to bi-lateral purchasing agreements seems to follow. (Figure 5 below)

Finally, a further shift to collaborative product development and self-developed technologies becomes possible when transaction-specific rights associated with high asset specificity in network-dependent transactions become recognized and rewarded. (Figure 6) Such developments occurred in Japan, particu-

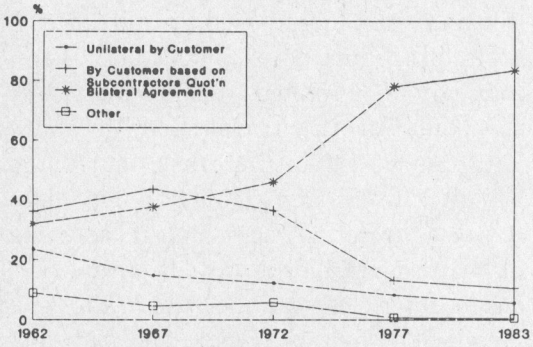
larly among TMC suppliers, from the late 1960s and early 1970s, as Nishiguchi's data show.

a) if the learning model as an extension of the network model implies a certain degree of spontaneity, randomness, and mutuality as to when, where, and how improvements to the TPS occur, then it is quite obvious that the learning model of the TPS must come after the dualist model, that is the hard-edged definition of the TPS that had been transferred to suppliers.

b) what is less clear is the developmental relationship between the network model of TPS and its extension, the learning model. Perhaps an emphasis on building good bi-lateral relations within the network model is key. This requires the appearance of a new organizational culture, interpreting culture as "learned ways of coping with experience," and this would undoubtedly take time[21]. There is an argument in the organizational learning literature which asserts a progression from reciprocity to equity to distributive justice, and this is congruent with a shift in behavioral emphasis from control to commitment[22]. But for a new organizational culture to coalesce, emerge, and grow around the themes of equity, commitment, trust and distributive justice, perhaps a decade or longer was needed.

It is just this sort of a progression that would allow improvements to occur more spontaneously, autonomously, and randomly, in the TPS. Furthermore, as TPS moved to a less centralized system of ownership rights, a tendency to favor mutual problem solving would lead to a situation where reciprocity and equity become principles of diffuse, reciprocal and multilateral transactions. In short, the combined shift from (a) bi-lateral asymmetry to multi-lateral symmetry, and from (b) residual rights of ownership to transaction specific rights of ownership creates a organizational system where localized learning is enhanced and shared,

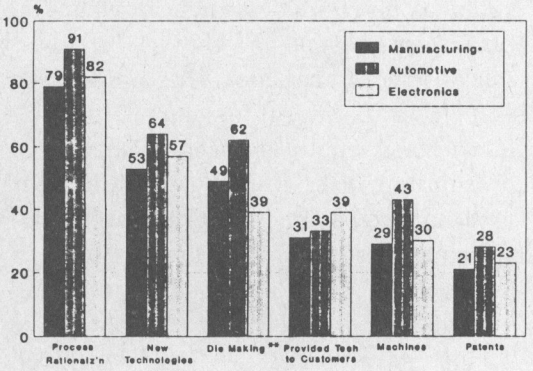
Figure 6 Price Determination Patterns in Japanese Manufacturing Industries



Compiled by Toshihiro Nishiguchi

Sources: Ikeda, 1975: 32; Central Bank for Commercial and Industrial Cooperatives, Survey Department, 1977: 36 & 1983: 37. Original Source: SMEA (1972), *Shitauke Chusho Kigyo Choki Doko Chosa* (Survey on Long-Term Trends of Small and Medium Enterprises), quoted in Ikeda, ibid.

Figure 7 Percentages of Subcontractors Who Possessed Self-Developed Technologies in Use and Who Provided Them to Customers in Japanese Manufacturing Industries (1983)



* Sample size-1, 592 subcontractors.

** Percentages of those who were using self-made dies among those whose processes included the use of dies.

Source: Central Bank for Commercial and Industrial Cooperatives, Survey Department, 1983: 61-8

Compiled by Toshihiro Nishiguchi

organizational boundaries became overlapped, and the system-wide quantity and quality of transactions are transformed.

Thus, what we call the 'multiplier effect' distinguishes the learning from the network model. Learning and profit sharing diffuse rapidly in the TPS because organizations sustaining the TPS have had the experience of co-existence and co-prosperity within a context of multilateral, future-oriented, collaborative activity. Learning and reward are multiplied throughout the system by the creation of a nearly infinite number of pathways for enhancing the performance attributes of the TPS without an attendant requirement that these pathways culminate in or even intersect the TMC.

c) in order to move to a full-fledged learning model, however, there has to be a role shift for TMC within the TPS. Co-existence and co-prosperity imply that TMC assumes more of a coordinating than leading function in the TPS. In the learning model, comparatively speaking, TMC becomes more of a strategic than operational hub of the TPS.

Conclusion

This paper has sought to define the organizational features of the TPS. Our proposed definition is a two-part one, identifying a number of interrelated physical characteristics of the plant and equipment supporting the TPS on one hand, and highlighting a range of behavioral, organizational, and economic features within the TMC and its affiliates on the other. The most important of these features fully expressed include a large number of interdependent organizational entities, multilateral symmetry in information flows, the separation of residual rights of ownership from transaction-specific rights of ownership in relation to interdependent investments characterized by high asset-specificity, a progression from simple reciprocity in bi-lateral and multi-lateral relations to equity and distributive justice among transacting members of an organizational network.

The full elaboration of these features in the case of the TMC and the first-tier of suppliers or the Toyota Transaction Group (TTG) transpired over a forty year period from 1947 to 1987 or so, during which time the Japanese automobile industry and general economy grew enormously, more rapidly, in fact, than have ever been experienced perviously in world history. We would like to emphasize the coincidence of the micro- and macro-organizational conditions leading to the appearance of the TPS.

In general, we find that the TPS in its organizationally embedded, fully elaborated sense has not spread very far in Japan. Nevertheless, the "success" of the TPS is evident, much studied and discussed in Japan and elsewhere[23]. Paradoxically, therefore, even without a clearcut organizational definition and understanding of the TPS in Japan, the TPS has become an example, inspiration, and vision of what is possible in the world of production organization and management. Japanese workers, engineers, managers and academics can attest to the workings of that vision.

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Endnotes

1) Daniel Roos, Daniel Jones, and James Womack, *The Machine that Changed the World :*

the Triumph of Lean Production, forthcoming 1990.

2) Some of the representative works from these various lines of inquiry include Kim B. Clark, W. Bruce Chew, and Takahiro Fujimoto, "Product Development in the World Auto Industry," *Brookings Papers on Economic Activity* 3 (1987): 729-771; Robert Cole, *Strategies for Learning*, Berkeley: University of California Press, 1989; Michael A. Cusumano, *The Japanese Automobile Industry*, Cambridge: Harvard East Asian Council, 1985; Takahiro Fujimoto, "Jidosha no Seihin Kaihatsu Soshiki to Sekkei Hinshitsu," *Soshiki Kagaku* ("Product Development Organization and Design Quality of the Automobile," *Organizational Science*), 22-1 (1988): 2-20; Robert H. Hayes and Kim B. Clark, "Exploring the Sources of Productivity Differences," in Kim B. Clark, Robert H. Hayes, and Christopher Lorenz, eds., *The Uneasy Alliance*, Boston: Harvard Business School Press, 1985; Ken'ichi Imai, Ikujiro Nonaka, and Hirotaka Takeuchi, "Managing the New Product Development Process: How Japanese Companies Learn and Unlearn," in Kim B. Clark et. al. above; Johny K. Johansson and Ikujiro Nonaka, "Market Research the Japanese Way," Harvard Business Review (May-June 1987): 16-22; Yasuhiro Monden, *Toyota Production System*, Atlanta: Institute of Industrial Engineers, 1983; Richard J. Schonberger, *Japanese Manufacturing Techniques*, New York: The Free Press, 1982; Moriaki Tsuchiya, ed., *Gijutsu Kakushin to Keiei Senryaku* (Technical Innovation and Business Strategy), Tokyo: Nihon Keizai Shimbunsha, 1986.

3) While anecdotal, a good story can be told concerning the TPS and its acknowledged founder, Mr. Taiichi Ohno. Mark Fruin recalls a conversation with Mr. Norihiko Shimizu, Former Director of he Boston Consulting Group in Japan. On a number of occasions, Shimizu sat on panels or participated in workshops with Ohno. Shimizu reports that Ohno once said, "We know that the TPS works but we don't know why it works so well."

4) A general treatment of the post-Fordist debate but without too much attention to the Toyota Production System can be found in Mark J. Elam, "Puzzling Out the Post-Fordist Debate: Technology, Markets and Institutions," *Economic and Industrial Democracy*, Vol. 11 (1990): 9-37.

5) The MITI study included single proprietorships, companies, and separate plants within multiplant firms in the category of independent, bookkeeping entities. However, there are problems with the MITI data. First, there are more than three tiers of suppliers. Some Japanese researchers report fourth-and fifth-tiers. Second, the MITI numbers recorded at each tier do not always make sense. For example, one firm, presumably Nippondenso, is shown as the sole supplier of electrical and electronic parts. But what about NGK sparkplugs, Yuasa batteries, Fujiten sound systems, and Sumitomo Denso wire harnesses, to name but a few of the suppliers providing electrical/electronic parts and components sourced by Toyota? In spite of some puzzling issues, the MITI data are suggestive of the overall large size and complexity of the interfirm network supplying Toyota Motor Corporation.

6) As early as 1972 and some would say even earlier, beginning with R. H. Coase's seminar article, "The Nature of the Firm," *Economica*, 1937: 386-405, economists have chafed and belabored the dichotomy between markets and hierarchies in economic relations. A 1972 article that pivots on this issue is G. B. Richardson, "The Organization of Industry," *Economic Journal* (Sept. 1972): 883-896.

7) Interview with John Eby, Director of Strategic Planning, Ford Motor Company, Detroit, August 10, 1990.

8) This assertion can be sustained on the basis of the data published in the forthcoming *The Machine That Changed the World*, cited in endnote number 1. The background data for this book as well as other materials will be published by members of the International Motor Vehicle Program in the future, and they will document beyond a doubt the greater efficiency and speed of the Toyota Production System. For a paper reaching a similar cunclusion but written by researchers entirely unrelated to the International Motor Vehicle Program, see Marvin B. Lieberman, Lawrence J. Lau, and Mark D. Williams, Firm-Level Productivity and Management Influence: A Comparison of US and Japanese Automobile Producers, *Management Science*, 36-10 (October 1990): 1-21.

9) Industry Research System, *Toyota Jidosha*, Nagoya: Industry Research System, 1986: 25-29.

10) There is a vast literature that deals with the traditional and production management notions of the TPS. Among the most useful are Ohno (1978; 1988), Monden (1983; 1985), Schonberger (1982), and Cusumano (1985).

11) The dualist argument when applied in the extreme can result in treatments that are highly critical of the TMC, such as Satoshi Kamata's, *Japan in the Passing Lane*, Penguin: 1982.

12) Michael A. Cusumano argues that the history of innovations supporting the development of the TPS was one of moving from an emphasis on process improvement to product improvement within the TMC and then transferring these improvements to suppliers. "Manufacturing Innova-

tion: Lessons from the Japanese Auto Industry," *Sloan Management Review*, 29 (Fall 1988): 29-39.

13) This is the model of the TPS explored in W. Mark Fruin, *The Japanese Enterprise System-Competitive Strategies and Cooperative Structures*, Oxford: Oxford University Press, forthcoming 1991.

14) Toshihiro Nishiguchi, "*Strategic Dualism : An Alternative in Industrial Sosieties*," D. Phil. Thesis, University of Oxford, 1989 : 194-198.

15) The characters for this phrase can be read equally correctly in two ways: *kyozon kyoei* or *kyoson kyoei*.

16) For more on this distinction, see Sanford J. Grossman and Oliver D. Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy*, 94 (Aug. 1986): 691-719.

17) Robert H. Hayes, Steven C. Wheelwright, and Kim B. Clark, *Dynamic Manufacturing*, The Free Press, 1988, Chapters 9 & 12.

18) Mark Granovetter, "Economic Action and Social Structure: The Problem of Embeddedness," *American Journal of Sociology*, 91 (Nov. 1985): 491.

19) Taiichi Ohno, *Toyota Seisan Hoshiki* (The Toyota Production System), Tokyo: Daiyamondo, 1978 : 20, 60.

20) There is a major interpretative difference between maturation and saturation of markets. Maturation of markets, the more common term, refers to the matching of demand with available products. Saturation, on the other hand, implies a surfeit of products relative to demand. Is you like, maturation is "demand-driven" and saturation is "supply-driven". The best known recent statement of the saturation thesis relative to modern production is Michael Piore and Charles Sabel, *The Second Industrial Divide*, New York: Basic Books, 1984.

21) The definition of culture employed here is Kathleen L. Gregory's "learned ways of coping with experience," in "Native-View Paradigms: Multiple Cultures and Culture Conflicts in organizations," *Administrative Science Quarterly*, 28 (1983): 364.

22) The organizational learning argument is found in Peter Smith Ring and Andrew H. Van de ven, "Structures and Processes of Transaction," Discussion Paper 86, May 1988, Strategic Management Research Center, University of Minnesota. Otherwise, see Richard E. Walton, "From Control to Commitment: Transforming Work Force Management in the United States," in Kim B. Clark, Robert H. Hayes, and Christopher Lorenz, *The Uneasy Alliance*, Boston: Harvard Business Shool, 1985.

23) Comparative data gathered and analyzed by Toshihiro Nishiguchi and John Krafcik document the considerable differences found in motor vehicle production facilities worldwide. See, for example, John Krafcik and James P. Womack, "Comparative Manufacturing Practice: Imbalances and Implications," paper presented at the First Policy Forum, International Motor Vehicle Program, M. I. T., May 1987 and Toshihiro Nishiguchi, "Competing Systems of Automotive Components Supply," paper presented at the First Policy Forum, International Motor Vehicle Program, M. I. T., May 1987.