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Collective Action for Technology Diffusion**

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Collective Action for Technology Diffusion***

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ABSTRACT

This paper analyzes the structure and functions of suppliers' associations (*kyoryokukai*) in the automobile industry in Japan. The bilateral assembler-supplier relationship has received much attention recently as a source of Japanese industrial competitiveness. However, this paper argues that the hitherto neglected area of inter-supplier coordination in technology diffusion is at least as important as the bilateral assembler-supplier relationship in accounting for the overall performance of the Japanese automotive industry. On the basis of company visits and a large-scale survey of first-tier suppliers conducted by the author, the paper analyzes the reasons why suppliers' associations were established, why they continue to exist today, and their effects on economic performance.

Journal of Economic Literature Classification: L14, L22, L23, L62, N65, O32

Introduction

The Japanese economy is often described as a 'network economy', with some distinctions made between enterprise groups and networks (Imai 1994), or between inter-market and vertical *keiretsu* (Gerlach 1992). A decade ago, when Italian industrial districts were rediscovered as a source of innovation and local economic regeneration (Piore and Sabel 1984), scholars looked for equivalents in Japan and found that the same principles underlying flexible specialisation operated in large decentralised multinational firms (Sabel 1989) as in a machine tooling district of Sakaki (Friedman 1988) (which incidentally is just one of the 549 industrial districts in Japan) (SMEA 1989, p.117).

The suppliers' association (known generically as *kyoryokukai*), the focus of this paper, is a highly relevant type of network in this context. In particular, such associations exist at all eleven Japanese vehicle manufacturers except Honda. In addition, over 300 primary parts suppliers, many of which are members of vehicle manufacturers' associations, have their own associations of suppliers (Dodwell 1986, as cited in Smitka 1991). The suppliers' association therefore is an institution with a significant and long-standing presence in the Japanese automotive industry.

Despite this, suppliers' associations, their origins and their *raison d'etre*, have been relatively understudied in recent years because the main paradigm for analyzing the leading sector of the Japanese economy does not allow for a network-like analysis. Traditionally, the suppliers' association featured in scholarly inquiries among Japanese Marxist economists as a tangible institution for large firms (monopoly capital) to exercise unilateral control over their smaller subcontracting firms. More recently, however, the Marxist paradigm has been superseded by mainstream economic theory which conceives transactions as decomposable into bilateral contracts (Grossman and Hart 1986, Williamson 1985). In this framework, Japanese car industry has a competitive edge because the assembler has forged a long-term and recurrent

relationship with each of its core suppliers. The stability of the assembler-supplier relationship enables the supplier to contribute to design and development, to make investments and to accumulate know-how which may be useful only to that relationship. Such 'relationship-specific skills' (Asanuma 1989) are a major source of superior performance. This analysis of the bilateral relationship has tended to underestimate the significance of horizontal coordination among suppliers. Inter-supplier rivalry is certainly promoted by some Japanese assemblers' practice of making public the ranking of their core suppliers according to performance (see Wada 1991, p.9 for Toyota). Relative ranking creates an incentive to engage in continuous improvement (Aoki 1988). But this technique in managing the supply chain can be implemented without a suppliers' association.

The above paradigm may, in part, account for a view that the suppliers' association is a redundant institution whose existence has far surpassed its utility. Until the 1970s, most assemblers were engaged in disseminating technical and organisational practices such as total quality control (TQC), value analysis or engineering (VA.VE), and Just-in-Time (JIT). The suppliers' association was a convenient forum to exploit economies of scale in providing technical assistance, while minimizing the spill-over of benefits from such assistance to competing assemblers. There were, therefore, significant 'association-specific rents' as well as bilateral relationship-specific rents. However, with slower and less assured growth in the 1970s and 1980s, more suppliers started to diversify their risk by trading with several assemblers in the late 1970s and 1980s, so that benefits from association activities could no longer be made exclusive to one assembler. Moreover, assemblers began to undertake less top-down technical assistance as more technologically capable suppliers emerged over time. According to this view, suppliers' associations continue to exist out of inertia, and do not contribute much to the overall efficiency of the Japanese automobile industry today. Associations are more like social clubs with little economic consequences, because companies' real business lies in bilateral transactions, unrelated to the suppliers' association activities.

A view which goes beyond asserting the declining utility of suppliers' associations is based on the Adam Smithian notion of businessmen's conspiracy against the public interest. This was most recently expressed during the US-Japan Structural Impediments Initiative (SII) discussions. Here, suppliers' association was cited, along with horizontal enterprise groups, as a case of *keiretsu*, a group of firms like a cartel which exists to protect its monopoly profit by excluding outsiders. According to this view, the suppliers' association constitutes an unfair trading barrier which ought to be dismantled. Such criticism led Nissan, in 1991, to merge its two associations (Takarakai and Hoshokai) into one (Nisshokai), to which non-Japanese suppliers are increasingly admitted. Also, most of the Japanese assemblers have endeavoured to make the criteria for becoming association members more explicit and transparent than in the past. But the Japanese government's response, and its official line spelt out in recent Economic White Papers (EPA 1990, p.196ff; EPA 1992, p.276ff), have been in terms of the bilateral relationship paradigm only. They have thus far failed to investigate whether the suppliers' association itself has any significant economic impact or not.

From the above, it is clear that a study of suppliers' associations is needed in order to clarify how they function and what their effects are. This is in anticipation of an increased interest in suppliers' associations from the following angles. First, *keiretsu* critics would wish to know: are the associations indeed exclusionary with strict boundaries, and ought to be dismantled? Second, as more non-Japanese firms are admitted into suppliers' association in Japan, potential overseas suppliers would need to have a good understanding of what association membership entails.¹ Third, is the suppliers' association a method of managing suppliers which would work only in Japan (as Womack et al (1990) seem to imply)? Alternatively, is it an organisational form worthy of emulation by Japanese and non-Japanese assemblers located in North America² or Europe?³ Or is it a historical anachronism which would eventually wither away with the globalisation of the car industry?

In contrast to the three prevailing views in the literature spelt out above, it is shown in this paper (a) that suppliers value mutual learning from other suppliers just as much as learning from their assembler-customer; (b) that the majority of first-tier suppliers do not consider suppliers' associations to be of less use now than in the past; and (c) that association members have lower pre-tax profitability than non-members, a piece of evidence which undermines the view of the association as a cartel-like entity. The empirical analysis will be based on data collected by the author through (i) company visits and interviews of purchasing departments and suppliers' association offices of all Japanese assemblers in 1992 and 1993, and (ii) a large-scale survey of first-tier parts suppliers conducted by the author in July 1993.

This paper is structured as follows. The first section provides an overview of the membership structure, growth and turnover. This is followed by a brief account of the historical development in Section 2. Section 3 examines the contemporary functions of the suppliers' association and their effects.

1. Suppliers' association as a Japanese Business Network

An Overview of Association Membership

Considerable variations exist from association to association in its characteristics. First, as shown in Table 1, the number of member suppliers per assembler varied from as few as 97 at Suzuki to 362 at Mitsubishi Motors. But relative to assemblers' production levels, Toyota has a concentrated membership (17,839 vehicles produced per annum per member supplier) while smaller assemblers have dispersed membership (only 379 vehicles per member supplier in the case of Hino). A relatively large assembler, Mitsubishi Motors, also has a dispersed membership, with 3883 vehicles produced per member supplier.

* INSERT TABLE 1 ABOUT HERE *

Perhaps the most significant reason for the varying degree of concentration or dispersion of membership lies in the location of assemblers' plants. At one extreme, Toyota had, until very recently, located all of its plants in and around Toyota City, where a majority of its suppliers are also located. Toyota plants in the same locality have shared their supplier base. At the other extreme, Mitsubishi Motors have plants which are geographically dispersed, in Tokyo, Nagoya, Kyoto and Mizushima. Each developed its own local supplier network. Even after the four plants were incorporated into the newly independent Mitsubishi Motor Corporation in 1970, the scope for consolidating the supplier base was limited. This limitation was aggravated by Mitsubishi's wide product variety, ranging from large trucks and buses to small passenger cars.

Membership is Encompassing to a Varying Degree

Automotive suppliers may be broadly classified into three categories: parts suppliers, raw materials suppliers, and suppliers of equipment and tools. Most assemblers have an association exclusively for parts suppliers, while some assemblers have separate associations for different types of suppliers. This paper concentrates on the associations of parts suppliers as they are numerically the most significant. In general, association members take up a large proportion -- around 80 or 90 per cent -- of each assembler's expenditure on purchasing parts. However, the degree to which the association is encompassing varies slightly from assembler to assembler. The most encompassing association was Kyohokai, whose 183 members, out of a total of 350 parts suppliers, accounted for nearly all (98 per cent) of Toyota's total purchasing expenditure on parts. In the same year, Nissan was also said to be trading with a total of 350 parts suppliers, of which the 191 association members accounted for 90 per cent of Nissan's total purchasing expenditure (see Table 2).

*** INSERT TABLE 2 ABOUT HERE***

Membership is Broader than Keiretsu

Suppliers' association members include both suppliers which are considered by the assembler to be part of its *keiretsu* group and other suppliers which are not. Unlike vertically integrated firms, vertical *keiretsu* groups (Gerlach 1992) have blurred boundaries to the extent that the business community defines itself as a *keiretsu* group by virtue of having overlapping and multiplex ties in shareholding, personnel and trading. But it is clear that whatever definition is adopted, suppliers' association membership captures a broader segment of the parts supplier industry than implied by the term *keiretsu*.

For instance, in the case of Toyota's Kyohokai association, members may be classified broadly into three categories. First, there are 10 member companies which Toyota itself defines as part of the so-called Toyota Group (for example, Nippondenso, Toyota Auto Body and Aisin Seiki). The Group firms are linked through a complex reciprocal shareholding pattern, with around a quarter of the Group firms' total shares being held within the Group. Besides the 10 Group companies, there are 25 Kyohokai members whose largest shareholder is Toyota Motors. Thus, around a fifth of the total 183 Kyohokai members are part of the core vertical *keiretsu* group.

Second, there are around 40 locally based sub-contractors which tend to be independent in shareholding and personnel aspects, but are heavily dependent on orders placed by Toyota (Ueda 1989, p.15-6). Their businesses are mainly in mechanical engineering such as metal pressing, casting and forging. They have a long history of trading with Toyota, from which they have received technical and managerial assistance. If unions are recognised at these firms, they tend to belong to the All Toyota Federation of Enterprise Unions. These links, both managerial and labour, may warrant grouping these firms as part of the Toyota *keiretsu* group.

But this leaves us with just over a half of Kyohokai members in the third category, consisting of mainly medium-sized independent firms, such as Akebono Brake, which do not

owe allegiance to any particular assembler for their origin and growth, and some large corporations such as Toshiba and Dunlop Japan. These so-called independents constitute a non-negligible proportion of the other assemblers' association membership. Some assemblers' association members are easily categorizable into relatively dependent sub-contractors and larger independent suppliers. For example, Nissan, before the 1991 reorganisation of its association, had made the clearest distinction by having two separate organisations. Takarakai with 104 members in 1990 was for smaller suppliers who tended to be heavily dependent on Nissan's business, and Shohokai with 70 members was for larger independent suppliers. Other assemblers' associations have been making this same distinction informally by having regional branches within a single suppliers' association. For example, Toyota's Tokai Kyohokai and Mazda's Western Japan (Hiroshima area) section of its Yokokai are for locally based suppliers in the main.

Growing Overlap in Membership

Once it is established that suppliers' association membership encompasses groupings which are broader than keiretsu groupings, it is perhaps not surprising to discover significant overlaps in membership. Even arch rivals, Toyota and Nissan, shared 44 suppliers in their respective associations in 1985 (Ueda 1989, p.11). Moreover, this is not just a recent phenomenon, as 32 suppliers belonged to both Toyota's association and one of Nissan's associations as early as in 1967 (Miwa 1990). In 1992, there were 191 members of Nissan's Nisshokai, of which 55 were also members of Toyota's Kyohokai (the author's calculation based on Auto Trade Journal and JAPIA 1992). These companies were predominantly manufacturers of tires and rubber parts, glass, paint, batteries, electronic parts, bearings and brake systems. By contrast, suppliers which have remained members of a single association tended to be in mechanical engineering.

Over time, there has been a growth in multiple membership of suppliers' associations. In particular, the number of parts suppliers which participated in five or more suppliers'

association associations increased from 67 in 1980, to 81 in 1985 and 93 in 1990 (See Table 3). Of the 93 in 1990, 20 firms were members of eight major associations (i.e. Toyota, Nissan, Mitsubishi, Mazda, Isuzu, Fuji, Daihatsu, Hino) and were also main suppliers to Honda. These companies are producers of brake systems, bearings, springs, spark plugs, tires, belting, and batteries. They tend to play a leading role in association activities, by taking on chairmanship and executive positions in association committees and meetings. Thus, instead of regarding the automotive industry as consisting of eleven overlapping keiretsu groups each headed by an assembler, the industry may be better characterized as a network with the 20 or so core primary suppliers transmitting information from one association to another. Assemblers with a relatively new suppliers' association, such as Mitsubishi and Mazda, have learnt the know-how in running the association from these core suppliers, rather than from competitor assemblers.

* INSERT TABLE 3 ABOUT HERE *

Why has multiple membership of suppliers' association increased over time? Possible candidates for major causes of multiple membership are: (a) slower growth after the 1973 oil crisis which led some suppliers to diversify their customer outlets, (b) the electronification of the automotive technology which led assemblers to source from non-traditional sources (Ikeda 1989) and from sources possessing technological expertise which the assembler had little hope of being able to match in the short run, and (c) the globalisation of the Japanese automotive industry. Examples of the latter two factors abound, but do not fully account for the growth in multiple membership. In 1989, Nissan started purchasing electric fuel pumps from Nippondenso for use at Nissan Motor Manufacturing Co. in the USA (*Nikkei Shinbun* 4 September 1990). In 1990, Tachi-S, a Nissan affiliated seat manufacturer, obtained an order for Toyota's new compact car model (*Nikkei Shinbun* 15 January 1990). Similarly, Hitachi, a Nissan supplier, started trading with Toyota (*Nikkei Shinbun* 9 February 1993), while Zexel whose major business has been with Nissan and Isuzu also started supplying Toyota. But

neither Hitachi nor Zexel nor Tachi-S are members of Toyota's Kyohokai. Nor is Nippondenso a member of Nissan's Nisshokai. Trading embodying strategic technology is evidently possible without an association membership.

Membership Growth and Turnover

The trend towards overlapping membership was accompanied by an increase in the total number of members over time. As one might expect, such increases tended to be greater among smaller manufacturers such as Hino, Fuji, and Mazda, than at larger firms, such as Toyota, Nissan and Mitsubishi, which held a more or less constant membership during 1971-1990.

Small changes in the total number of association members, of course, do not preclude high turnover, with new entrants replacing those that exit. In fact, an impression that suppliers' association membership is stable is more accurate for some assemblers than for others (see Table 4). In the 1970s, Nissan's associations had the lowest turnover, but by the 1980s, Toyota's association emerged as the one with the lowest rates of quits and entry, while membership has been quite unstable at Mitsubishi Motors and Fuji Heavy Industries. At Toyota, the Tokai Kyohokai had 105 members in 1963. By 1971, there were 120 members; only 5 of the old members had been dropped, while 20 were added (Smitka 1991, p.85). During 1971-81, 21 new suppliers joined, while only 3 left; and during 1981-92, 8 joined while 2 left the Tokai Kyohokai.

* INSERT TABLE 4 ABOUT HERE *

By contrast, at Mitsubishi Motors, 84 firms entered while 83 firms exited the Kashiwakai during 1971-81, and 73 entered while 46 exited during 1981-90. Thus, on a rough count, of the 358 members in 1990, only about a half remained members over the entire twenty year period (see also Smitka 1991, p.85-7).

What factors account for the differences in turnover rates among associations? One reason appears to be differences in the assemblers' product strategy. In the Japanese automobile industry, it is well known that the implicit supplier contract is for the duration of a model cycle. This implies that the possible occasions for the assembler to switch suppliers, and hence for potential entry and exit of association members, are more numerous the greater the product variety and the shorter the model cycle. Given that the length of the model cycle is more or less the same across assemblers, the greater variety of vehicles manufactured by Mitsubishi Motors, as compared to Toyota, perhaps accounts in part for the higher turnover rate in Mitsubishi's Kashiwakai membership than in Toyota's.

Product or marketing strategy may affect the scope for continuous sourcing in another way. In particular, a contrast may be drawn between two broad types of marketing. On the one hand, some assemblers, such as Toyota, pursue full-line marketing with an emphasis on the continuum in the spectrum of models from low to high price. On the other hand, other assemblers, such as Honda and Nissan to an extent, pursue a segmented market strategy with an emphasis on bringing out discrete 'hits' targetted at specific customer groups (Itami et al 1988 chapter 5). The former can take better advantage of common styling and parts over model cycles as well as across existing models than the latter. Therefore, supplier relationships can be expected to be more continuous at full-line strategy assemblers like Toyota than at segmented strategy assemblers like Honda.

Another factor which may account for differential membership turnover rates is the assemblers' timing of entry into the car industry. Early entrants, such as Isuzu, Toyota and Nissan, needed to nurture their own supplier base. Late entrants like Honda could buy in parts from suppliers nurtured by other assemblers. There is a presumption here that some of the suppliers which received much technical assistance earlier started diversifying their customer outlets without compromising on loyal trading with the older assemblers.

2. Historical Origins and Contemporary Context

The suppliers' association (*kyoryokukai*) literally translates as a 'cooperation association'. It is generally a voluntary association with their own rules and regulations. Its aim is generally said to be to enhance member suppliers' cooperation with the assembler and with each other. Most of the assembler's associations have a name which signifies cooperation, friendship, or prosperity. Some suppliers' associations, just like Japanese companies, are described as a 'community of fate' (*unmei kyodotai*). Tracing the historical origins and the evolution of suppliers' association assists us in understanding these sentiments.

Historical Evolution

The oldest of the supplier associations is Toyota's Kyohokai which may be traced back to a gathering in 1939 (Kyohokai 1967, p.10), although a formal association was not launched until 1943. As part of the wartime control regime, the Japanese government at the time imposed a regulation for nominating small and medium sized firms to supply to large firms in order to control industrial production for the war effort. Non-designated firms were left to perish due to lack of funds and materials (Nakamura 1986, p.124-5). Kyohokai was founded at the request of Toyota's suppliers (referred to as cooperating factories (*kyoryoku kojo*)) in order to ensure that they could survive this period of hardship. A central task of the Kyohokai, not surprisingly, was to channel raw materials and funds, which only Toyota Motors could secure through the ration system, to member suppliers.

With the end of the Second World War, Kyohokai's central task shifted towards making improvements in technological and managerial capabilities of member firms. The original members, who formed the Tokai (region) Kyohokai in 1947, were joined by newly formed Tokyo Kyohokai and Kansai Kyohokai members. The latter members tended to be

larger specialist component suppliers, which developed independently of Toyota and were considered more capable managerially. This new group of suppliers aroused eagerness among the original members to strengthen their management system.

The first opportunity to make improvements collectively presented itself in 1953, when the prefectural authorities offered a free factory benchmarking service (*kojo shindan*) to Kyohokai members (Kyohokai 1967, p.24; Wada 1991). This service was part of the post-war government policy to rationalize and modernize small and medium sized enterprises (SMEs). Because of large numbers, the Japanese SME Agency chose the keiretsu group (and the industrial district) as units of diagnosis, thus endorsing the existence of suppliers' associations. The public consultancy offered concrete solutions to establishing managerial objectives and production plans, and to improving productivity and quality at each of the supplier firms. Kyoyokai members' effort in implementing the solutions bore fruit in the form of the launch of Toyopet Crown in 1955.

Government policy also encouraged SMEs to form themselves into groups in a more explicit manner, through the SME Cooperative Association Law (*Chusho Kigyoto Kyodo Kumiai Ho*) of 1949. Cooperatives, once approved and registered publicly, can take out investment loans from government financial institutions, and receive government subsidies for a variety of activities, such as employee training and joint research in recent years. Around 47,000 formally registered cooperatives existed in Japan in 1991 (SMEA 1992, p.106). They are regionally based associations, and do not normally have a focus around a common customer among their members. Cooperatives in the auto industry are exceptions to this convention. The 1950s saw the formation of a number of cooperatives in the car industry, by local suppliers to Mazda, Daihatsu, Hino, and Nissan Diesel. At these assemblers, cooperatives continue to exist, with an overlapping membership with the suppliers' association associations which were founded subsequently.

A major cooperative association in the car industry which is in effect a suppliers' association at the same time is the Suzuki Motors Cooperative Association. It was founded in 1957 when the Shizuoka prefectural office approached Suzuki Motors with details of recently enacted laws concerning SMEs. Suzuki cashed in on the financial facilities offered by these laws to create its suppliers' association in the form of a cooperative. The Cooperative Law requires that the cooperative membership be restricted to SMEs. But except for this requirement, the reasoning behind setting up the Suzuki Cooperative was rather similar to that for founding suppliers' associations in general. A document "The Intent to Establish the Suzuki Cooperative Association" states:

"With a rapid progress in society, every company is facing increasingly tough competition over improvements in product performance and the expansion of production. Our cooperating factories must adapt to both the economic and technological aspects of this situation. As one measure, a policy shall be hereby implemented, which will promote the welfare of every cooperating factory through friendship and mutual help. We intend to promote a higher level of cooperation, and to achieve co-prosperity with Suzuki Motor Company as our parent factory."

Around the same time in 1958, Nissan's plant level supplier associations at the Yokohama and Yoshiwara factories, founded a few years earlier, were consolidated into Takarakai. Takarakai was essentially a gathering of small and medium sized firms, whose technological and managerial capabilities Nissan deemed necessary to strengthen. The concerted effort to improve industrial engineering and to adopt quality control methods culminated in Nissan's receipt of the Deming Award, the very first in the Japanese auto industry, in June 1960. This spurred Toyota suppliers to do better. From 1961, Toyota Motors started to take a greater lead in Kyohokai activities, centred around the diffusion of Total Quality Control and Value Engineering to the top management of core suppliers (Wada

1984, p.88). Domestic rivalry was thus a significant factor in intensifying the effort poured on association activities.

However, the 1960s presented an added challenge, namely the liberalisation of international trade and capital markets. In anticipation of open trade, Japanese assemblers made a concerted effort to improve quality and cost efficiency. There was widespread fear that if nothing was done, dismantling the protection would severely undermine the domestic automotive industry. Some suppliers' association associations, such as Nissan's Shohokai and Isuzu Kyowakai, were formed specifically to meet this challenge of internationalisation.

To summarize, suppliers' associations spread in the Japanese car industry in three waves. The first was the years leading up to the Second World War, when the assembler and suppliers attempted to forge organisational solidarity to cope with the war effort; materials shortages posed a problem to be overcome. The second wave was in the 1950s, when cooperatives as well as suppliers' associations were formed; cooperatives were the channel for interest-reduced equipment modernisation loans to members, as well as for financial help in setting up common services for members. The third wave in the 1960s was associated with the prospect of the liberalisation of capital markets and international trade, and the perceived need to make a leap in international competitiveness. The associations in the post-war period were mainly private sector initiatives, but favourable government policies towards SMEs also facilitated them.

Suppliers' Association Activities in the 1990s

Today, every association has its own rules and regulations which spell out the bureaucratic machinery that supports the association activities. In the case of Toyota's Tokai Kyohokai, an Administrative Board (kanjikai), which meets every two months, is in charge of deciding the basic policy of the association, and of drafting a plan of activities for the forthcoming year. Such a plan is approved at the Annual General Meeting (AGM), which is

attended by top managers of all member companies. They listen intently to the keynote speech delivered by Toyota's chief executive for clues on Toyota's strategic thinking and future direction. At least a dozen more Toyota managers also attend this AGM. After an award ceremony for best quality or VA.VE suggestions for member suppliers, the day closes with a dinner party. More detailed information on Toyota's purchasing policy, production schedules and sales trends is communicated to member suppliers via the Discussion Meetings (kondankai) (which meets 8 times a year) and an occasional lecture or two by Toyota managers.

The activity plan is implemented by sectoral groups and functional committees. Most of the assembler's associations have this dual structure, although the number of groups and committees vary from association to association. Tokai Kyohokai has three sectors grouped according to the type of parts that members produce. Each group meets once a month, typically to visit a member supplier's factory, and to learn from the member's presentation about problems and achievements at his company the following month. Tokai Kyohokai has three functional committees, on quality, cost, and health and safety. Each meets at least once every two months to study ways of improving the performance of member companies. The committees may conduct a questionnaire survey of members, and write reports and manuals on best practice examples based on members' own experience. The cost committee also organises VE seminars, and the health and safety committee runs technical and safety courses for employees of member companies. Lastly, there are a monthly newsletter, and baseball and golf tournaments for members.

The above organisation structure is well suited to dealing with the staple diet issues of quality, cost, and health and safety. In fact, although slightly different emphases may be put on various aspects of an issue, the themes typically chosen by the suppliers' associations tend to be focused around improving member companies' shopfloor efficiency. This bias is partly because both assemblers and suppliers have felt thus far that gains can be made most by

concentrating their efforts on incremental process innovation rather than product innovation. This was dictated by the timing of the Japanese assemblers' entry into the auto industry (Wada 1984, p.97). Another reason for why association activities remain focused around process technology is the need to find themes which are of wide and common interest to the members. Recently, some suppliers' associations, including at Toyota and Daihatsu, held meetings to discuss how to reduce parts variety. Suppliers may make good suggestions. But the spirit of open and frank information exchange may be undermined if there is too much shift towards design and development issues which touch on confidentiality in bilateral trading.

What's in it for Assemblers? A Trade-off between Control and Autonomy

The historical overview above noted why suppliers' association associations were started. Do the same reasons for their founding explain why they persist? What are the incentives of assemblers to continue sponsoring their association? Are there disadvantages, as well as advantages, of having an association from the assembler's viewpoint? Answers to these questions differ again from company to company within the Japanese car industry.

At one extreme, Honda, as mentioned earlier, does not have any association even today. One possible explanation for the absence is that Honda's late entry into the four wheel business made it possible to free ride on other manufacturers' effort at improving their suppliers. However, late entry does not appear to be a sufficient explanation for the absence of an association, as some assemblers have established their own associations subsequently, Mazda being the most recent case in 1981.

Honda continues not to have its suppliers' association because of a different perspective backed up by its purchasing philosophy which puts much emphasis on competition and equality of trading. To Honda, suppliers' association seems too old fashioned and imbued with an undesirable image of top-down control of suppliers. According to a Honda purchasing

manager, an association is not necessary *as long as there is close bilateral exchange of information* (*Nikkei Sangyo Shinbun* 11 June 1991). Besides, it has been argued by Honda managers that since suppliers' association is largely an association for suppliers, Honda cannot initiate something which suppliers thus far have not demanded.

The other assemblers which have an association continue to retain much control over the activities of the association. For instance, first, the association is typically financed mostly by membership subscription, but is not fully autonomous as the assembler provides a small subsidy out of the purchasing department's budget. Second, the association's secretariat office may exist in a separate building from the assembler's purchasing department as at Toyota, but the secretary-general (*jimu kyokuchō*) is typically a retiree from the assembler. Third, although less common today, many of the associations required the assembler's recommendation, as well as the approval of, the association's Administrative Board, for members to enter and exit the association.

But there are also some moves towards giving more autonomy to suppliers' associations. Association activities remain focused around the assembler whose presence is felt at all the association meetings; no formal meeting takes place without the presence of at least one representative from the assembler. For example, although the purchasing department remains the point of contact for the suppliers' association, functional committee meetings are attended by the assembler's personnel in the relevant functional department (e.g. the quality committee attended by the assembler's quality control manager). Precisely what the role these managers play has a different nuance from assembler to assembler. Mazda and Nissan, both with recent reorganisations in their suppliers' association, define their managers' role at these meetings as coordinators, who may steer discussions and be instrumental in setting themes. Ultimately, the chosen themes and activities must be useful to the assembler. By contrast, the Purchasing Department of Toyota conveyed their wish to withdraw into a supporting and

advisory role, as member suppliers are considered more capable of taking greater initiatives now than in the past.

But whether leading or advisory, providing support for the suppliers' association is expensive in managerial time, judging from the frequency of meetings. Weighed against this cost are the benefits which were most frequently cited by respondents at company visits by the author, (a) of being able to communicate about production plans en masse, and (b) of soliciting good suggestions for common problems, such as common parts and the environment. The lateral communication and mutual learning among suppliers through association activities were also considered to have benefits which outweighed the potential danger of cartelisation or bargaining by groups of suppliers.

3. Assessing the Role of Suppliers' Associations: Survey Evidence

Having examined the historical and contemporary functions of suppliers' association from the assembler's viewpoint, this section turns to the analysis of the reasons why Japanese suppliers participate in association activities. In particular, the key questions are:-

- (i) What do suppliers regard as the most important benefits of belonging to a suppliers' association? In particular, how important is lateral inter-supplier learning as compared to bilateral assembler-supplier linkages?
- (ii) How do the benefits of belonging to suppliers' association vary according to the assembler and supplier characteristics?
- (iii) What are the performance outcomes of association membership?

The rest of this paper reports on suppliers' views about the above according to the results of a large-scale survey.

Survey Data Description

In July 1993, the author conducted a survey of around 1500 automotive parts suppliers in Japan, sponsored by MIT's International Motor Vehicle Program. The sample was drawn from a comprehensive list of all first-tier suppliers of components for cars and trucks in Japan (Auto Trade Journal and JAPIA 1993). Surveys were sent to sales and marketing directors, who were asked to answer the survey for a typical product provided to their most important customer. 473 usable responses were received, constituting a 30 per cent response rate.

As shown in Table 5, 83.9 per cent of the survey respondents are members of the association of the customer for which the survey was answered. Since the survey did not ask about multiple membership, 'non-members' may be members of other customers' association. But to the extent that respondents were asked to answer the survey for their most important customer, the member/ non-member distinction should capture a major difference among first-tier suppliers. Among the non-member respondents, 44% were suppliers to Honda, 27% were suppliers to Toyota and the rest suppliers to other assemblers.

*** INSERT TABLE 5 ABOUT HERE ***

In this sample, members were not significantly more likely than non-members to be owned by a car assembler. Nor was the number of customers per supplier significantly different between members and non-members. Moreover, the number of other firms supplying the same part to the same customer was actually greater -- 2.3 companies -- for members than for non-members -- 1.8 companies.

The most significant difference between members and non-members lay in the record of long-term trading with their customer to date: over 50% of the members have traded with the customer for 20 years or longer, as compared to 38% for non-members. Moreover, members'

perception of commitment by the customer into the future was much more long-term than non-members'. This tallies with the earlier evidence in Section 1 that the membership turnover of suppliers' associations is generally quite low.

Benefits of membership

The majority of the survey respondents are association members. But there is evidence of a significant variation in the incentives for belonging to a suppliers' association. The questionnaire asked respondents to rank the five most important benefits of belonging to an association. The options given were the five listed in Table 6, derived from semi-structured interviews with both assemblers and suppliers and the pilot testing of the survey.

*** INSERT TABLE 6 ABOUT HERE ***

Dealing with overall averages first, the most popular benefit of belonging to an association was better informational access to the customer. Next, 'learning from other members through exchange of technical information' -- lateral inter-supplier learning -- was considered the second most important benefit, and more important than the receipt of technical assistance from the customer. Many members apparently regard fellow member suppliers as a more important source of technical know-how than their customer. This lends support to what Fruin and Nishiguchi (1993) call a 'network model' or a 'learning model', in contrast to the bilateral or dualistic model. These top three reasons were followed by the benefit of receiving stable orders from the customer, and the benefit of being able to monitor the customer's behaviour. The rank ordering of these five reasons remain the same for various sub-samples considered below, but the following distinctions may be noted.

Suppliers were asked in the survey about the process of product development. Those suppliers who jointly developed with their customer or took entire responsibility for design

tended to value the first reason -- access to information about the customer -- more than suppliers whose products were developed by their customer. Thus, the type of customer information which is valued by members appears to be about design and development for the next model, rather than, for instance, about the certainty of production scheduling.

Suppliers were also asked to assess their own technological capability. Those which considered their product design engineering capability to be above average valued access to customer information through the association more than those with average or below average capability. By contrast, the second most popular reason -- mutual inter-supplier learning -- was cited less by the above average respondents than by those with average or below average design capability. Moreover, the opportunity to receive technical assistance from the customer -- the third benefit --- was less of a concern for suppliers developed their products jointly with their customer or on their own.

These findings might lead one to expect that suppliers' associations continue to be of greater utility for members with below average technical capability than for those with superior skills. However, that is not the case. In fact, suppliers with superior design capability disagreed more with both the statements, 'Benefits of association activities have declined recently' and 'Association is no longer central in our dealings with this customer', than suppliers with average or inferior skills. This might be because technically superior suppliers are engaged in informal know-how trading among themselves (von Hippel 1987), while suppliers who have little to offer to others in terms of technical know-how are not getting less useful information from other suppliers.

Table 6 shows a clear distinction in the magnitude of benefits between members who feel that the suppliers' association is of declining use and those who do not. As compared to those who saw no decline in the usefulness of suppliers' association, the suppliers which agreed with the statement "Benefits of association activities have declined recently" value both

technical assistance and inter-supplier learning less, fear leakage of know-how to other members more, and value the receipt of stable orders from the customer more. Moreover, the function of the suppliers' association as a forum for monitoring whether their customer behaves and acts fairly was more highly rated by suppliers experiencing a decline in the usefulness of the association.

Lastly, the magnitude of benefits differed according to which assembler's association the respondents belonged to. As shown in Table 6, members of the Toyota association tended to regard the association as still central in their dealings with Toyota, not least because Toyota members perceived greater benefits in technical assistance from the customer than members of other assemblers' associations. It bears out the impression that Toyota's association, with its long-standing history and its concerted effort to diffuse the Toyota Production System, is different both in the magnitude of benefits it brings to its members and the function it fulfills.

Performance outcomes of association membership

The paper began by posing three (not necessarily mutually exclusive) points of view concerning the function of the suppliers' association. The first was an economic theory focus on bilateral contracts which renders supplier associations irrelevant (the Bilateral Contracting Case). A second view was that associations had been useful for improving supplier efficiency in the past but not any longer today (the Declining Utility Case). A third perspective regarded suppliers' association as like an exclusionary *keiretsu* or a cartel (the Cartel Case).

We would expect the relative economic performance of association members and non-members to be different in each of the three perspectives. In the Declining Utility Case, we would expect members to be no different from, or even performing worse than, non-members. In the Cartel Case, we would expect members to be reaping monopoly profit, and possibly

better performing in other respects, as compared to non-members. The Bilateral Contracting Case remains silent on this issue.

As shown in Table 7, the overall picture of the link between membership and performance is mixed. First, pre-tax profitability was lower for members than for non-members. This profitability result refutes a claim that supplier associations might be acting like a cartel reaping monopoly profit. Second, members saw a faster growth of sales to the customer than non-members. Third, R&D as a percent of sales was lower for members than for non-members. This may be because there are 'network externalities' among members who can achieve high sales growth without R&D spending. This may also indicate that there is a group of suppliers who do not wish to belong to an association as they would do better by appropriating benefits from intense R&D without fear of leakage to competitors. Fourth, members were not significantly better at achieving cost reduction nor in reducing production and delivery batch sizes, according to the survey data.

*** INSERT TABLE 7 ABOUT HERE ***

Does performance vary with different incentives for belonging to an association? The only significant distinction was between members which agreed and those which disagreed with the statement that benefits of the association declined recently. Those perceiving a decline in the usefulness of the association experienced slower growth in both sales to the customer and market share, while their costs rose more on average during 1988-92.

4. Conclusions

This paper presented an analysis of the structure and the functions of suppliers' associations in the Japanese car industry. The underlying set of questions in the paper were:

- i. why did the suppliers' association associations start;
- ii. why do they persist; and
- iii. what are their effects?

The major empirical contribution of the research reported here is in its reliance on the result of a large scale survey of nearly 500 parts suppliers to all the eleven Japanese assemblers. This data has enabled the analysis of not only the structure of the association, but of the suppliers' perspectives on the role of these associations. The diversity in their function from association to association is borne out by survey evidence which complements the case studies carried out on Toyota (Wada 1984) and on Mitsubishi (Smitka 1991).

One of the important findings of this study with an implication for theory is that lateral communication and learning between suppliers in the same association is just as valued by members as technical assistance from the assembler. This finding calls for some modification to the analytical framework which has recently become focused on bilateral contracting between the assembler and the supplier.

The survey provided evidence that the suppliers' association associations continue to exist in Japan not merely out of inertia but because it is serving a useful function in delivering benefits to both the assembler and member suppliers. Those suppliers who found the association of declining utility were not in the majority, and were less likely among members of Toyota's Kyohokai than among members of other assemblers' associations. Moreover, those members who find it of declining importance or utility tended to be worse in their performance than other members.

The analysis in the paper indicates that on the whole, the suppliers' association contributes towards increasing the informational efficiency of the industry-wide network, in which the core nodes are increasingly not the assemblers, but the twenty or so major component suppliers which serve several assemblers at once. The suppliers associations with overlapping membership have provided a strong mechanism for the rapid diffusion of innovations within the Japanese automotive sector (e.g. Lieberman 1994 for the more rapid diffusion of JIT in Japan than in the USA). This network for technology diffusion appears to be as important as the close bilateral assembler-supplier relationship in accounting for the overall performance of the Japanese automotive industry.

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Table 1: Membership of Suppliers' Associations 1990

Auto Makers' Association	Founding Year	Total Members (A)	Vehicle Production (units) (B)	Ratio (B)/(A)
Toyota Tokai Kyohokai Kanto Kyohokai Kansai Kyohokai	1939/43 1947 1947	229* 141 63 25	4,085,081	17,839
Nissan Takarakai Shohokai	1954 1966	174* 104 70	2,330,943	13,396
Mitsubishi Kashiwakai	1971	262	1,405,647	3,883
Mazda Yokokai West Japan Kanto Kansai	1981	180* 62 62 56	1,385,941	7,700
Isuzu Kyowakai	1962	284	470,950	1,658
Fuji Heavy Industries Subaru Yuhikai	1986	218	528,333	2,424
Daihatsu Kyoyukai	1969	168	670,481	3,991
Suzuki Motors Cooperative	1957	97	858,268	3,693
Hino Suppliers' association	1962	238	90,269	379
Nissan Diesel Yayoikai	1960	57	60,529	1,062
Honda* *	n.a.	297	1,358,415	4,574

N.B. * Some multi-plant supplier companies may belong to more than one of the regionally based associations of an assembler. The numbers shown in this table include such double-counting.

** Honda does not have any association. The suppliers refer to those listed as 'main suppliers' in the first source.

Sources: Auto Trade Journal and JAPIA (1990) *Nihon no Jidosha Buhin Kogyo* ;
Japan Motor Manufacturers Association (1991) *Nihon no Jidosha Kogyo*

Table 2: Members of Suppliers' Associations as a Proportion of Total Suppliers 1992

Auto Makers	Association Members			Total Number of Parts Suppliers	% of Total Parts Purchasing Cost taken up by Members
	P	M	E		
Toyota	183	0	65	350	98%
Nissan	191	0	0	350	90%
Mitsubishi	376	0	0	600	85%
Mazda	198	0	0	350	86%
Isuzu	217	41	40	427	90-95%
Fuji	168	0	0	246	96%
Daihatsu	175	68	17	260	90%
Suzuki	104	0	0	186	31%
Hino	190	0	57	500	80%
Nissan Diesel	147	0	0	300	85%

N.B. P=parts suppliers; M=materials suppliers; E=equipment (including tool and jig) suppliers.

Source: Company visits and interviews by the author in 1992 and 1993.

Table 3: Multiple Membership in Supplier Associations 1975-1990

	Toyota	Nissan	Mitsub.	Mazda	Isuzu	Fuji	Daihat.	Suzuki	Hino	ND	Honda
Aishin Seiki											
ASMO											
Atsugi Unisia											
Aisan Kogyo											
Akebono Brake											
Asahi Glass											
Inoac Corp.											
Ishikawajima H.											
Ishikawa Tekko											
Izumi Motor											
Ichiko Industr.											
Imasen Electric											
Usui Kokusai S.											
NOK											
NTN											
Ohtsui Tire											
Kayaba Indust.											
Kyosan Denki											
Kyokuto Kaih.											
Clarion											
Koito Mfrig											
Koyo Seiko											
Saga Tekkohsh.											
Sanoh Indusry											
Shiroki											
Jeco											
Jatoco											
Jidosha Kiki											
Shin-kobe El.											
Stanley Elect.											
Sumitomo Elec.											
Zexel											
Takata Corp.											
Tachi-S											
Taiho Kogyo											
Daikin Mfring											
Daido Metal											
Daido											
Chuo Spring											
Tsubakimoto C.											
TRWSI											
Teikoku Piston											
Topura											
Tokico											
Topy Industries											
Tokai Rubber											
Tokai Rika											
Tokyo Roki											
Table 3 Continued											

	Toyota	Nissan	Mitsub.	Mazda	Isuzu	Fuji	Daihat.	Suzuki	Hino	ND	Honda
Toyo Rubber											
Toyo Radiator											
Toyoda Gosei											
Niles Parts											
Nifco											
Nishikawa Rub.											
Nisshin Kogyo											
Nittan Valve											
Nippon St. Glas											
Nippon Air Br.											
Nippon Cable S.											
Nippon Seiko											
Dunlop Japan											
Nippondenso											
Jap. Stor. Batt.											
Nihon Power S.											
NHK Spring											
Nip. Piston R.											
Nihon Michelin											
Bando Chem.											
Hayashi Telem.											
NGK Spark Pl.											
Hitachi Kasei											
Hitachi Kinz.											
Hitachi Seisaku											
Bridgestone											
Nachi-Fujikoshi											
Fuji Bellows											
Fuji Valve											
Furukawa Elec.											
Furukawa Batt.											
Marui Industrial											
Matsushita El.											
Maruko Keiho.											
Mitsui Kinzoku											
Mitsuba Electr.											
Mitsubishi Ste.											
Mitsuboshi Bel.											
Muro Corp.											
Murata Spring											
Meiwa Industry											
Yazaki Corp.											
Yuasa Battery											
Yokahama Rub.											
Riken Corp.											
	- 1975		- 1980		- 1985		- 1990				
N.B. Shades indicate membership in that year.											

Source : As for Table 4.

Table 4: Entrants and Leavers of Suppliers' Associations 1971-90

SUPPLIERS' ASSOCIATION		1971/2 - 1980/1		1981/2-1989/90	
		Entrants	Leavers	Entrants	Leavers
Toyota	Total	47	39	20	13
	Turnover*	2.1	1.7	1.0	0.6
Nissan	Total	16	14	30	15
	Turnover	1.0	0.9	2.0	1.0
Mitsubishi	Total	84	83	73	46
	Turnover	2.5	2.5	3.3	2.1
Mazda	Total	44	59	22	17
	Turnover	3.4	4.5	1.4	1.1
Isuzu	Total	96	33	49	44
	Turnover	3.9	1.3	1.9	1.7
Fuji	Total	95	43	80	76
	Turnover	5.1	2.3	4.1	3.9
Daihatsu	Total	33	50	32	7
	Turnover	2.2	3.4	2.3	0.5
Suzuki	Total	42	18	19	24
	Turnover	4.6	2.0	2.1	3.0
Hino	Total	132	43	21	27
	Turnover	6.5	2.1	1.0	1.3
Nissan Diesel	Total	12	17	5	7
	Turnover	2.0	2.8	1.0	1.4
Honda	Total	n.a.	n.a.	195	239
	Turnover			6.7	8.2

N.B. Thanks to Toshiko Iwase and Arisa Ouchi for assistance in compiling this table.

* Average turnover rate per annum = $\frac{\text{Average number of entrants or leavers per annum}}{(\text{Members in initial year} + \text{Members in end year})/2}$

Source: Author's own calculations based on the data in Auto Trade Journal and JAPIA *Nihon no Jidosha Buhin Kogyo*, various years.

Table 5: Descriptive Statistics of Association Members in the Survey (N=473)

	Members	Non-members
TOTALSAMPLE	83.9%	16.1%
OWNERSHIP % of suppliers who are wholly or partially owned by the assembler	34.5%	29.3%
EXCLUSIVE SUPPLY Number of customers per suppliers Number of other firms supplying the same product to the same customer *	4.1 2.3	3.8 1.8
LENGTH OF TRADING Number of years of trading to date (% of suppliers with 20 years or longer) *** Customer commitment in future (in years) **	55.9% 27 years	38.4% 16 years

Difference between members and non-members is significant according to the t-test at:-

- * 10% level
- ** 5% level
- *** 1% level

Table 6: Benefits of Belonging to a Suppliers' Association

	All Members				Design Capability	Product Development	Decline in Benefits
Obtain better information about the customer from the customer more quickly	3.98	Above average 4.14**	Joint or supplier-led 4.08**	3.94			
Learn from other members through exchange of technical information	3.52	3.31**	3.52	3.39*			
Receive useful technical assistance from the customer through the association	3.32	3.35	3.21**	3.03***			
Receive stable orders from the customer	2.65	2.78	2.61	2.90***			
Monitor whether the customer behaves and acts fairly	1.59	1.51	1.63	1.79***			
"We fear that our know-how would leak to other members through association activities."	2.49	2.60	2.50	2.77***			
"Benefits of association activities have declined recently. We are not very enthusiastic."	2.42	2.24***	2.44	n.a.			
"Association is no longer central in our dealings with this customer."	2.28	2.16*	2.29	n.a.			

Note: Mean scores of the top 5 statements in order of importance (5=most important; 4=second most important; 3=third most important; 2=fourth most important; 1=least important). Mean score for the bottom 3 statements of (5=strongly agree; 4=agree; 3=neither agree nor disagree; 2=disagree; 1=strongly disagree).
 Difference in means between the binary categories in each column (not shown in the table are Col.2: average or below average design capability; Col.3: customer-led product development; Col.4: No decline in benefits of the association) is significant at * 10%, ** 5%, and *** 1%, according to t-test. Pearson's chi-square tests were also performed on the 1-5 scale, which gave similar results of significance.

Table 6: Benefits of Belonging to a Suppliers' Association (Continued)

	All Members	Toyota Members	Nissan Members	Mitsubishi Members	All (except Toyota)
Obtain better information about the customer from the customer more quickly	3.98	4.00	4.23	3.95	3.99
Learn from other members through exchange of technical information	3.52	3.59	3.43	3.59	3.50
Receive useful technical assistance from the customer through the association	3.32	3.54	3.06**	3.06***	3.28*
Receive stable orders from the customer	2.65	2.58	2.80	3.02*	2.68
Monitor whether the customer behaves and acts fairly	1.59	1.42	1.59	1.71*	1.59
"We fear that our know-how would leak to other members through association activities."	2.49	2.62	2.56	2.39	2.48
"Benefits of association activities have declined recently. We are not very enthusiastic."	2.42	2.12	2.65***	2.41**	2.49**
"Association is no longer central in our dealings with this customer."	2.28	1.96	2.60***	2.20*	2.37**

Note: Mean scores of the top 5 statements in order of importance (5=most important; 4=second most important; 3=third most important; 2=fourth most important; 1=least important). Mean score for the bottom 3 statements of (5=strongly agree; 4=agree; 3=neither agree nor disagree; 2=disagree; 1=strongly disagree).
 Difference in means with Toyota members is significant at * 10%, ** 5%, and *** 1%, according to t-test. Pearson's chi-square tests were also performed on the 1-5 scale, which gave similar results of significance.

Table 7: Performance Outcomes of Association Membership: Survey Evidence

	Members	Non-members
Pre-tax profits as % of sales ***	2.6%	3.5%
R&D as % of sales ***	1.7%	2.6%
Percent of sales in new products since 4 years ago	17%	15%
% change in sales to the customer 1988-1992 **	7.8%	4.1%
Percentage point (pp) change in the Japanese market share 1988-1992	0.8pp	1.1pp

N.B. Percentage point change measures the difference between one rate and another rate. For example, the change from a 4% margin to a 6% margin is 2 percentage points.

Difference between members and non-members is significant according to the t-test at:-

- * 10% level
- ** 5% level
- *** 1% level

ENDNOTES

1. As of September 1992, 18 members of Mitsubishi's Kashiwakai were non-Japanese, including Bosch, GM Japan Allison, and Simpson Industries (*Nikkan Kogyo Shinbun* 11 September 1992). Nissan's Nisshokai had 9 non-Japanese members, including Goodyear Tire and Rubber (*Nikkei Sangyo Shinbun* 4 August 1992).
2. Of the 130 or so North American parts and materials suppliers of Toyota Motor Manufacturing in Kentucky, sixteen suppliers formed a suppliers' association called BAMA in 1991 (*Nikkei Sangyo Shinbun* 19 August 1991) (see Hines 1994 pp.241-247) for subsequent developments). Also, GAMA was formed in 1993 by nine suppliers to NUMMI in California.
3. Hines (1992, 1994) reports the case of Llanelli Radiators Supplier Association which was established with the advice of the Welsh Development Agency (WDA). WDA was also an initiator of a group of Welsh-based suppliers to Toyota Motor UK and another group supplying to Rover. Such public sector consultancy and support were indispensable in Japan also, at the time when supplier associations were still in their nascent stage in the 1950s (see Section 2 of this paper). Also, Andersen Consulting (1993) recommends that the top management of European companies 'build shared destiny relationships with your suppliers - through establishing supplier clubs' (p.5). See also Lamming (1993).