The Japanese Transplants Project

Final Report to the Alfred P. Sloan Foundation

June 1995

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EXECUTIVE SUMMARY

This report summarizes the key findings of a study of Japanese manufacturing transplants conducted by Richard Florida and a team of Carnegie Mellon University researchers and funded by the Alfred P. Sloan Foundation. The research examined the adoption of innovative approaches to managing production work by Japanese transplants and by U.S. suppliers to the transplants. In doing so, it explored the cross-national transfer of new and innovative work systems, the diffusion of such practices through industrial networks, and the potential for learning by U.S. suppliers to transplant manufacturers.

The study was organized around six sets of questions.

> To what extent are Japanese-affiliated manufacturers using innovative methods of managing production work in their U.S. transplant operations? In what ways are Japanese transplants transferring or adapting Japanese production methods to the U.S. manufacturing environment? How does this vary across industries and why? How does this compare to the adoption of innovative work systems by U.S. manufacturers?
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> To what extent are U.S.-owned companies that supply the transplants *learning* about innovative work methods from their transplant customers? Are these U.S.-owned suppliers adopting similar work system innovations?
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> Can we identify distinct systems or *regimes* of work organization among the approaches to managing production work used by Japanese transplant manufacturers and their U.S. suppliers? What are the specific practices associated with the various approaches? What are the key factors associated with the adoption of different work system regimes?
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> How do industrial networks of OEM manufacturers and their suppliers affect the adoption and diffusion of innovative work systems? Are plants that adopt innovative work systems also participants in innovative customer-supplier relationships?
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> What are the key factors that affect the location and economic geography of Japanese transplants? How important is regional clustering of OEM manufacturers and suppliers? How important are central *hub* organizations to these clusters?
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> To what extent are Japanese manufacturing firms establishing research, product design and product development capabilities in the U.S.? To what degree does this reflect strategy of *global localization*. i.e., the development of integrated innovation-production complexes? To what extent is transplant R&D a strategy to gain access to U.S. scientific and technological capabilities?

To answer these questions, the study conducted systematic field research consisting of factory visits and personal interviews with transplant industrial complexes comprised of OEM manufacturers and first and second tier suppliers, and surveyed virtually the entire population of Japanese transplants in the U.S. as well as a selected sample of U.S.-owned suppliers to the automotive transplants. The use of multiple research methodologies was designed to limit the biases inherent in any one.

The main findings of the study lead to the following major conclusions.

Japanese transplants exhibit a high rate of adoption of innovative work practices, such as work teams, quality circles and job rotation. The use of innovative work practices by the transplants differs considerably by industry. The automotive-related sectors have the highest rate of adoption of innovative forms of work organization. The use of such innovations is least prevalent among transplants in the instruments sector.

In general, the transplants are more likely than U.S.-owned manufacturers in the same industries to have adopted innovative work practices. Twenty-seven percent of the transplants use a combination of self-directed teams, job rotation and quality circles, compared to 19 percent of U.S.-owned manufacturing plants. However, U.S. plants in the transportation equipment industry are more likely to adopt innovative work practices than their Japanese transplant counterparts in that sector.

The transplants are more likely to reinforce innovative work systems with a supportive human resources environment. The transplants are much more likely than their U.S. counterparts to provide a *no-layoff* pledge to their production workforce and remunerate workers for the skills and knowledge they acquire. More than half of transplants provide a no-layoff pledge to their workers, nearly half offer profit-sharing to production workers, and more than 45 percent pay workers for the skills and knowledge they acquire on the job.

Three broad approaches to managing production work or "work system regimes" were identified among the Japanese-affiliated and U.S.-owned plants surveyed: taylorist, transitional and highly innovative or "learning-intensive." Taylorist plants follow a traditional approach to organizing production in the plant and in their relations with outside customers and suppliers. Transitional plants tend to be large, unionized plants which pay high wages, and have invested considerably in off-the-job training of workers, but have not adopted innovations related to the organization of work on the factory floor such as worker teams, worker empowerment, and shop floor quality control. Some transitional plants place a heavy emphasis upon training, as a vehicle for *transitioning* workers toward a more learning-intensive work organization, while for others this approach seems to represent more of a permanent strategy. Learning-intensive plants do it all, making use of a whole set of highly-innovative best-practice approaches to quality improvement. We find that plants that organize work as a learning-intensive system of practices exhibit significantly higher rates of manufacturing process innovation than do plants that rely on taylorist or transitional approaches to managing production work. Such plants also tend to work more closely with their customers and suppliers to improve product quality, delivery and cost.

Customer-supplier relations can serve as a catalyst for the adoption of innovative work and production systems. Transplants with highly innovative approaches to organizing work and production are much more likely to engage in cooperative relationships with customers and suppliers, certify suppliers, and engage in electronic information exchange with their customer and suppliers. Furthermore, Japanese automotive assemblers are actively engaged in efforts to diffuse innovative work and production practices through supplier networks. Toyota, for example, provides considerable technical assistance to its suppliers, and has set up a supplier support center and a supplier federation for this purpose.

U.S. suppliers to the Japanese automotive transplants are remarkably innovative in their approach to managing production work. It is unclear, however, to what extent these plants are learning about innovative practices from their transplant customers. While some U.S.

suppliers, such as Johnson Controls, have learned a considerable amount from their transplants customers, in general U.S. manufacturers tend to be selected as suppliers to the transplants because they are *already* advanced in this regard.

The adoption of innovative work practices is a recent phenomenon for both the Japanese transplants and U.S.-owned manufacturers. Most plants have been using these practices for only three-and-a-half to five years on average. The years 1989-1991 were the peak period for adoption of innovative work practices for the manufacturing plants surveyed.

The automotive-related transplants have basically stuck with the practices and systems originally transferred to the United States. The proportion of plants using teams, job rotation and small numbers of job classifications was mostly unchanged between 1988 and 1994. About one third of Japanese auto supplier transplants used teams, quality circles and job rotation in combination in 1994, compared with just over one-fifth (22.2 percent) in 1988.

While Japanese companies have come under fire for locating their U.S. plants outside traditional manufacturing areas where wages and the concentration of minorities are high, the empirical evidence indicates that Japanese automotive-related producers do not avoid minorities and high wages; rather they tend to locate their plants in established manufacturing areas where levels of education are higher. Japanese automotive-related transplant suppliers locate their production facilities near the plants of their key customers to facilitate just-in-time production. The location of Japanese automotive-related transplants is distinguished by regional clustering and the development of integrated regional industrial complexes.

Japanese transplants have complemented their manufacturing investments in the U.S. with more recent investments in research, product design and development. Japanese companies operate 174 research, design and development facilities in the United States, increasing their U.S. R&D spending from $292 million in 1986 to $1.2 billion in 1990. The majority of transplant R&D centers are applied research and product development facilities located at or near existing Japanese-owned manufacturing sites. These centers support a strategy of global localization. A smaller number are scientifically-oriented basic R&D facilities, located near major U.S. universities and scientific research centers.

OVERVIEW

This report summarizes the key findings of a study of Japanese manufacturing transplants conducted by Richard Florida and a team of Carnegie Mellon University researchers and funded by the Alfred P. Sloan Foundation. The research examined the adoption of innovative approaches to managing production work by Japanese transplants and by U.S. suppliers to the transplants. In doing so, it explored the cross-national transfer of new forms of work organization, the diffusion of such practices through industrial networks, and the potential for learning by U.S. suppliers to transplant manufacturers.

The overall research project included studies of:

- the location and economic geography of Japanese transplant manufacturers across industries (Smith and Florida 1994a, 1994b, Smith 1994, Smith and Florida in process),
- the transfer and adaptation of innovative work systems in transplant facilities across industries (Jenkins 1993, 1994a, 1994b, 1995a, 1995b; Florida and Jenkins in process),
- the effects of transplants on learning and the adoption of innovative work systems by U.S. suppliers (Jenkins 1995a, 1995b, Florida and Jenkins in process),
- the role of customer-supplier networks in the adoption and diffusion of innovative work practices (Jenkins 1994a, 1995a, 1995b, Florida and Jenkins in process),
- the movement of Japanese transplant research and product development capabilities to the U.S. and their implications for the U.S. innovation system (Florida and Kenney 1994; Florida 1995a).

The project's findings will be summarized in a book-length monograph by Florida and Jenkins as well as a series of academic journal articles, trade journal articles, and opinion editorials to be completed during 1995.

The study was designed to shed light on six sets of questions.

> To what extent are Japanese-affiliated manufacturers using innovative methods of managing production work in their U.S. transplant operations? In what ways are Japanese transplants transferring or adapting Japanese production methods to the U.S. manufacturing environment? How does this vary across industries and why? How does this compare to the adoption of innovative work systems by U.S. manufacturers?
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To what extent are Japanese manufacturing firms establishing research, product design and product development capabilities in the U.S.? To what degree does this reflect strategy of *global localization*. i.e., the development of integrated innovation-production complexes? To what extent is transplant R&D a strategy to gain access to U.S. scientific and technological capabilities?

To answer these questions, the study conducted systematic field research consisting of factory visits and personal interviews with transplant industrial complexes comprised of OEM manufacturers and first and second tier suppliers, and surveyed virtually the entire population of Japanese transplants in the U.S. as well as a selected sample of U.S.-owned suppliers to the automotive transplants. The use of multiple research methodologies was designed to limit the biases inherent in any one.

RESEARCH TASKS AND METHODS

Japanese Transplant Database

The project created a unique database of all Japanese-affiliated manufacturing establishments currently operating in the United States. This database contains information on the location, year of establishment, size and principal products of some 1,800 Japanese manufacturing plants in the U.S. Cross checks of this database against lists developed by the U.S. Department of Commerce, the Japanese External Trade Organization (JETRO), the Japanese Automobile Manufacturers Association (JAMA), the Japanese Economic Institute, and other sources confirm that this database is the most comprehensive listing of Japanese-operated manufacturing establishments in the U.S. available anywhere. The transplant database was used to develop the sampling frame for the survey (described below) and also to examine the factors that influence the location of Japanese automotive manufacturing establishments in the U.S. (Smith and Florida 1994; Smith 1994).

A related database of Japanese R&D facilities in the United States was also developed with funding from the Sloan Foundation and other sources. This database was used to examine the factors that account for the economic geography of Japanese R&D in the U.S., specifically to explore whether transplant R&D facilities cluster around manufacturing complexes (global localization), or are located in established high-technology complexes such as Silicon Valley, the Boston-Cambridge area, the greater Princeton area (see Florida and Kenney 1994; Florida 1995). This aspect of the research is ongoing and will include a survey of all foreign-affiliated laboratories in the U.S. to be carried out in summer 1995.

Field Research

Field research was conducted at a selected sample of Japanese transplants and plants of U.S.-owned manufacturers that supply the transplants. The objective was to examine the adoption and diffusion of innovative work systems across the supply chain or industrial network. A central thrust of the field research explored the supplier system for Toyota's Georgetown, Kentucky plant, and thus consisted of field research at the main Toyota assembly plant in Georgetown, Kentucky, key first-tier Toyota suppliers such as Nippondenso and Johnson Controls, and second-tier suppliers. Field research was also carried out at a series of Sony plants in the United States and Mexico and at selected Sony suppliers. At each manufacturing establishment, members of the research team conducted semi-structured interviews with Japanese and American managers, engineers and staff in production, purchasing and human resources. The research team also observed production in process at each site, where possible talking with workers on the production floor. This element of the field research played a central role in development of the survey research instrument and in guiding the questions raised in this study. A second component of the field research consisted of site visits to and interviews with two economic development agencies (the Georgetown Chamber of Commerce and Battle Creek Unlimited) that focused on efforts to recruit Japanese transplants to the U.S. and the effects of transplant manufacturing on regional economic development. A third component of the field research examined the capabilities of Japanese R&D and product design and development facilities in the U.S. through site visits and interviews with the transplant automotive design cluster of southern California and Japanese electronics R&D facilities in the U.S. The following plants and organizations were the sites of field research. (The field research instruments are attached in Appendix A).

Toyota Motor Manufacturing, U.S.A., Inc. - Toyota's Georgetown, Kentucky automobile assembly complex.

Toyota Supplier Support Center - An organization set up by Toyota to help selected Toyota suppliers in North America adopt the Toyota Production System.

Johnson Controls - A U.S.-owned and operated manufacturer of car seats that is a just-in-time supplier to Toyota, Georgetown.

Nippondenso Manufacturing U.S.A. Inc. - The largest Japanese-owned supplier of auto parts.

Koyo Corporation - A small Japanese-owned producer that supplies Nippondenso with auto air conditioner and heating parts.

I.I. Stanley Co. - A Japanese-owned manufacturer of LED lighting equipment and automotive lights.

Sony Corp. - The research team conducted site visits and interviews at Sony facilities making televisions in Westmoreland, PA, San Diego, CA, and Tijuana, Mexico.

Georgetown Chamber of Commerce - The primary economic development agency in the Georgetown, Kentucky area.

Battle Creek Unlimited - A public-private economic partnership that has been successful in attracting Japanese and other foreign manufacturers to an industrial park in Battle Creek, Michigan.

Calty - Toyota's, Long Beach, California automotive design studio.

NDI - Nissan's San Diego, California automotive design studio.

Honda R&D North America - Honda's Torrance, California, automotive design and engineering center.

Mitsubishi Design Center - Mitsubishi's Torrance, California automotive design studio.

Mitsubishi Electric Research Laboratory - Mitsubishi's basic research lab in Cambridge.

NEC Research Institute - NEC's basic research facility in Princeton, New Jersey.

Canon Information Systems Laboratory - Canon's information system's lab in Palo Alto.

Survey Research

A national survey of Japanese transplants was conducted. The survey obtained information on the work and production organization, labor force, customer and supplier relations and performance of Japanese manufacturing transplants and a selected sample of U.S.-affiliated manufacturing plants that serve as suppliers to the Japanese automotive-related transplants. (Appendix B presents a fuller discussion of the survey methodology).

The sample of Japanese transplants was based on the 1,695 transplant establishments listed in the 1993 Japan External Trade Organization (JETRO) database. JETRO is a Japanese government agency that conducts annual surveys of Japanese-affiliated manufacturing plants in the United States, and has access to proprietary information including the base notification data of the Ministry of Finance, to which Japanese companies planning to make investments outside of Japan are required to report. The CMU research team supplemented the JETRO list with data on Japanese investment in U.S. manufacturing from other sources, including: the list of Japanese-affiliated plants in the U.S. as of 1990 compiled by the Japan Economic Institute (MacKnight 1992); directories of Japanese-affiliated companies operating in the U.S., such as Toyo Keizai (1993); and various newsletters, news articles and other publications, resulting in a database of 1,768 transplant manufacturing establishments. Excluding 359 transplants involved in food processing and related industries resulted in a total sample size of 1,409 Japanese transplant manufacturing establishments. The sample includes large numbers of plants in the transportation equipment, chemical, electronics, and industrial machinery industries. Other industries that are represented in the sample include: rubber and plastics, primary metals, fabricated metals, instruments and glass products. (The breakdown of Japanese-affiliated plants in the sample by industry is shown in Table 1).

The base list of U.S. suppliers, purchased from ELM International, Inc., a market research firm, includes information about plant ownership and customer base, making it possible to extract a list of plants owned by U.S. companies that supply Japanese auto assembly operations in the U.S. The research team supplemented the ELM list of U.S.-affiliated suppliers to the transplants using information on U.S. auto parts suppliers that sell to Japanese automobile manufacturers that was provided by the Japanese Automobile Manufacturers Association (JAMA) to the U.S. Department of Commerce in accordance with the MOSS talks on Transportation Machinery between the U.S. and Japanese governments. In total, this list includes 388 plants, of which 41 are owned by the U.S. Big Three automobile manufacturers and 347 are independently-owned.

The survey was administered to plant managers in these establishments by the Center for Survey Research (CSR) of the University of Massachusetts, Boston. The survey was implemented in 1994 in two phases: the first involving a mail survey and the second relying on telephone interviews. Based on an initial screening, 238 additional plants were eliminated from the sampling frame, resulting in a sampling frame of 1,195 Japanese transplants and 338 U.S. suppliers to the transplants.

A copy of the survey instrument is attached. Respondents were asked for detailed information about their plant's products, its labor force, the organization of production work within the plant and relations with outside customer and supplier organizations. The survey achieved an unadjusted response rate of 40.1 percent. The results of the Japanese transplant survey were compared on an industry-by-industry basis to those of a survey of U.S. manufacturing plants conducted by Paul Osterman of MIT (who made his database available to us). As noted above, field research at a selected sample of plants was conducted to inform the development of the survey and aid in the interpretation of results.

MAIN FINDINGS AND CONCLUSIONS

This section provides a brief summary of the main findings of the research. More detailed discussions on many of these issues are contained in the articles, papers and dissertations produced by members of the project team (attached). A more complete discussion of the study, its design and major findings will be contained in a forthcoming book monograph by Florida and Jenkins (1995).

Adoption of Innovative Work and Production Practices by Japanese Transplants

For more than a decade, there has been growing interest in the methods developed by Japanese manufacturers to organize and manage production work on the factory floor. Such work systems are seen as a source of competitive advantage for Japanese companies in automobiles and electronics especially and, more generally, as the foundation for a new and superior form of capitalist industrial organization (Lazonick 1990; University of Tokyo 1990; Florida and Kenney 1993). Interest in Japanese work practices was intensified by the high level of Japanese direct investment in manufacturing in the U.S during the 1980s. Between 1980 and 1990, the number of Japanese-affiliated manufacturing facilities in the U.S. increased more than five-fold from 240 to 1,380 plants; and the number of American workers employed by Japanese manufacturing plants increased from 52,339 to 340,000 (Japan Economic Institute, 1991). This wave of investment focused attention on whether Japanese companies were transferring innovative work and production systems to their U.S. transplant operations.

Florida and Kenney (1991; Kenney and Florida 1993) found that Japanese automotive transplants are transferring core elements of Japanese production organization, human resources practices and supplier linkages to the U.S. Such efforts have been remarkably successful, despite what some believed was a hostile environment. Their research further documents the emergence of an integrated Japanese-style just-in-time production complex of automobile assembly and automotive component parts supply (Mair, Florida and Kenney 1988). The MIT International Motor Vehicle Program found that Japanese automotive transplants were important models of *lean production* which provide a learning opportunity for U.S. firms that supply them (Krafcik 1989; Womack, Jones and Roos 1990). Numerous case studies of the automotive transplants documented the successful transfer of elements of the Japanese production system to the U.S. (Krafcik 1986; Adler 1991). A study by the University of Tokyo's Institute of Social Science (1990) found evidence of significantly greater transfer of Japanese organizational techniques and production methodology in the automotive sector than in electronics. Other researchers (e.g., Milkman 1991; Howes 1993) argue that the transfer is not taking place. (See Appendix C for a more detailed review of the literature.)

Previous research on the Japanese transplants has focused mainly on the automotive sector. While the research literature has covered the automotive assembly transplants in considerable detail, there has been little systematic research on the Japanese manufacturing transplants in other important industrial sectors. The automotive assembly transplants comprise a relatively small and, to some extent, unique sample that may not be representative of the broader transplant experience, and from which it may be misleading to generalize.

The survey aspect of the study was designed to overcome these limitations. The results of our survey of Japanese transplants cover virtually the entire population of Japanese transplants across manufacturing industries. Furthermore, we compare our survey results to those of a survey by Osterman (1994) of innovative work practices in U.S. manufacturing establishments on both an aggregate and industry-by-industry basis. The survey research addressed the following four questions.

> What is the pattern of adoption of work system innovations among Japanese transplant establishments in the U.S.?
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> How does this compare to the pattern of adoption by U.S.-owned manufacturers?
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> How does the adoption of innovative work systems by the transplants vary by industry? What factors explain this variation?
>
> Are certain types of work systems more appropriate to certain industries or particular types of production processes?

Generally speaking, the results of our survey indicate that Japanese transplants are relatively high adopters of innovative work and production systems. The transplants have a high rate of adoption of work teams, job rotation, statistical process control and innovative work practices. More than half of transplants have made a no-layoff pledge to their workers, nearly half offer their workers profit-sharing plans, and more than 45 percent pay workers for the skills and knowledge they acquire on the job. To shed further light on this issue, we also examined the use of innovative work and production practices in combination with one another--that is, as a *system* of highly innovative practices. More than a quarter (27.1 percent) of transplants use self-directed teams, quality circles and job rotation in combination with one another, while 12 percent exhibit a high rate of penetration of these core practices, meaning that they involve more than 50 percent of their workforce in their use.

The adoption of innovative approaches to managing production work differs considerably by industry. Generally speaking, the automotive-related sectors have the highest rate of adoption. Table 2 provides the industry-level detail on the adoption of innovative work practices by the transplants. Four industries, transportation equipment, electrical equipment, metals and glass, and industrial machinery, are relatively high adopters of a core system of innovative work practices. Of these industries, however, metals and glass, and industrial machinery, show the highest rates of penetration of this core system. Japanese transplants in the instruments sector have a very low rate of adoption of the core set of practices

How does the pattern of adoption of innovative work organization by the transplants compare to that of U.S. manufacturers? Are the transplants more or less innovative than their U.S. counterparts? Our analysis compared the adoption of innovative work practices by the transplants to that of U.S. manufacturers, using data from a survey of work system innovation in U.S. plants made available to us by Paul Osterman of MIT. As Table 3 shows, the transplants exhibit a higher rate of adoption of the system of innovative work and production organization. Twenty-seven percent of transplants use self-directed teams, job rotation and quality circles in combination, compared to 19 percent of U.S. manufacturing plants generally. The transplants had higher rates of adoption of job rotation, quality circles, total quality management, and statistical process control. Moreover, the transplants were more likely to reinforce innovative work and production organization with a supportive human resources policy environment. The transplants were much more likely than their U.S. counterparts to provide a *no-layoff* pledge to their production workforce and remunerate workers for the skills and knowledge they acquire on the job. That said, there is little doubt that U.S. manufacturers are also quite innovative; and in some cases, more likely to adopt innovative forms of work organization than the transplants. U.S. manufacturers, for example, have a higher rate of adoption of self-directed work teams. It is important to note, however, that our survey used more restrictive definitions of both teams and job rotation than did the Osterman survey.

Our analysis also explored differences in the adoption of innovative work practices for the transplants and U.S. manufacturers on an industry-by-industry basis. As Table 4 shows, among the U.S. plants, those in transportation equipment were far and away the highest adopters of innovative practices. In fact, U.S. plants in the transportation equipment sector were considerably more likely than their Japanese transplant counterparts to adopt innovative work practices. U.S. transportation equipment manufacturers had the highest rates of adoption of teams, job rotation, quality circles, and statistical process control. Sixty-eight percent of U.S. plants in this sector used a core cluster of teams, rotation, and quality circles in combination. U.S. plants in the instruments and industrial machinery industries were also more likely than their Japanese counterparts to adopt innovative work and production organization. U.S. and Japanese transplants in the fabricated metal and electric equipment industries were equally likely to adopt innovative approaches to managing production work.

We were especially interested to see whether or not the transplants have deepened their use of innovative work practices over time. To shed light on this issue, we compared the findings for the automotive-related transplants in our 1994 survey with the findings of the 1988 survey of Japanese automotive-related transplants conducted by Florida and Kenney. As Table 5 shows, there has not been a great deal of change over this six year period. The proportion of plants using teams, job rotation and few job classifications was relatively stable between 1988 and 1994, although the proportion using quality circles is much higher. Here, it is important to note that the 1988 survey asked respondents not only if they currently use quality circles but if they planned to do so. A substantial proportion of these plants were just starting up production at the time, and many had not yet fully implemented a human resource management system. The proportion in the 1988 sample that either used quality circles currently or planned to do so in the near future (73.6 percent) was much closer to the 1994 result (85.7 percent). Interestingly, the proportion of plants using these practices in combination with one another also remained virtually unchanged. About a third of Japanese auto supplier transplants used teams, rotation and quality circles in combination, compared with just over one-fifth (22.2 percent) in 1988. A large part of this difference comes from the higher use of quality circles. Furthermore, there was a smaller proportion of plants in the 1994 survey that used none of the practices, providing some limited evidence of increased diffusion and learning. One explanation is that Japanese automotive transplants originally implanted a fairly advanced set of work practices and have basically stuck with those practices over time, making little refinement or revision. It is also important to note that our survey documents the level of adoption of practices, but not worker behavior under those practices. The field research findings suggest that workers have become more involved in and adept at continuous improvement activities over time

Japanese Transplants and Work System Regimes: Taylorist, Transitional and Learning-Intensive

It is well-known that different manufacturing plants and different manufacturing industries are characterized by different approaches to managing production. The field research indicates that highly innovative companies, such as Toyota or Nippondenso, see individual practices in terms of their contribution to an integrated system. Recent studies by MacDuffie (1994) and Ichniowski, Shaw and Prennushi (1993) found that individual work practices have a more beneficial impact on organizational performance when used together as part of a broader system.

This aspect of the research examined the distribution of Japanese transplants across different approaches to work organizations or what we refer to as *work system regimes*. To do so, we developed a theoretically-based model of a system of *learning-intensive* practices that promote organizational learning and knowledge mobilization. This model was validated using a structural equations methodology that makes it possible to test hypotheses about which practices are indeed used together as a system in practice. We then used cluster analysis to determine which plants fit that model, and which plants fit other less innovative models. The basic characteristics of highly-innovative or *learning intensive work system regimes* and more traditional taylorist regimes are outlined in Table 6.

This analysis addressed the following questions.

> What are the bundles of practices that comprise various work systems regimes?
>
> How are Japanese transplants distributed across the continuum of work system regimes? How does this vary by industry, and why?
>
> Are learning-intensive regimes associated with higher levels of organizational innovation and performance?

Until rather recently, research on new forms of work and production organization has focused on individual practices such as the use of teams, job rotation, job classifications and so forth. However, recent work suggests that such practices are most effective when they work together as interrelated systems referred to variously as *transformed*, *flexible*, and *high commitment* or *high-performance* work systems (see Bailey 1993 for a review). Because they are interested in collections or systems of practices, these studies tend to use factor analysis to select practices for analysis and clustering techniques to classify systems of such practices into particular types. MacDuffie (1994a) examined the relationship between the human resource practices and production system performance in automobile assembly plants. MacDuffie distinguished between practices that govern the way work tasks are carried out on the factory floor (or work systems practices) and those that reflect plant or firm-level human resource policies affecting employees at all levels (human resource management, HRM, policies). MacDuffie's findings provide strong empirical support for taking a *systems perspective* in attempting to understand the connection between innovative work practices and organizational performance. Additional support is provided in a study by Ichniowski, Shaw and Prennushi (1993) which examined the impact of human resource management practices on productivity among a sample of steel finishing lines. Using a panel data set of monthly observations of the work practices and productivity, Ichniowski et al. found that combinations of human resource management practices had a greater effect on productivity improvement over time than did the sum of component effects due to individual practices.

To further probe these issues, we developed a model of a system of innovative work practices. Our basic theory is that the fundamental aspect of new and innovative work systems is their ability to promote knowledge mobilization and organizational learning; thus we refer to them as *learning-intensive work systems*. We include in our model only those practices that contribute to knowledge mobilization and organizational learning (see Table 7). Figure 1 shows the hypothesized relationships among the dimensions of this model, which include teamwork, worker involvement in quality control, information sharing and empowerment of workers and investment in worker training and skill development. We validated this model using our survey data and a structural equations method that makes it possible to examine which practices are used together as a system in practice and what are the interrelations among these practices. The results of the model confirmed our hypotheses. The four interrelated dimensions of the overall system of work and production--teamwork, shop floor quality control, empowerment and training--are found to be linked to the scale and scope of manufacturing process improvement activity in our sample of plants. In other words, plants that organize production work as a learning-intensive system of practices exhibit significantly higher rates of manufacturing process improvement. Efforts to empower workers by sharing information with them and giving them responsibility for job design were found to have the strongest link to continuous improvement (see Figure 2).

We then used cluster analysis to group the plants in our sample according to their approach to managing production work. Five work system *regimes* emerged from this analysis, ranging from *highly taylorist* to *highly learning-intensive*. In the middle was a cluster of *transitional* plants that invest a great deal in off-the-job training of workers, but have not adopted innovations related to the organization of work on the factory floor such as work teams, worker empowerment, and shop floor quality control. Table 8 summarizes the characteristics of plants in the three broad classes of plants: taylorist, transitional and learning intensive plants.

A basic conclusion of this analysis is that learning-intensive plants do it all. They use a whole set of best-practice approaches to organizing and managing work inside and outside the plant, including innovative approaches to work organization, production management, and customer-supplier relations. In addition to this, they make use of concurrent engineering, engage in electronic data interchange with their customers and suppliers and adhere to green design in the development of new products. Management in learning-intensive plants is also more likely to make assurances to production workers that their jobs will be secure in the face of productivity improvements and to take active steps to ensure job security for these workers. Learning-intensive work organization is most prevalent among transplants in the automobile sector, although it is evident in other industries as well.

Transitional plants tend to be large, unionized plants that pay high wages. These plants are likely to have experienced recent restructuring or downsizing, and to have experienced greater turnover of production workers. Transitional plants are distinguished by the heavy emphasis they place on training. For some of these plants, there is evidence that training is used as a means of *transitioning* workers toward a more learning-intensive work organization; while for others, it represents more of a permanent strategy. These latter set of plants tend to view individual workers, rather than the overall work and production system as the source of problems, and thus may see training as a mechanism to improve organizational performance. Training may in some cases represent an effort to persuade workers and their unions that management is concerned about their well-being and development. Older plants in the electronics, chemicals, and rubber and plastics are more likely to follow a transitional approach to managing production work.

Taylorist plants have a very traditional approach to work organization both inside and outside the plant. They do not use work teams, have large numbers of job classifications and so forth. Transplants in the instruments and industrial machinery sectors dominate this cluster.

Performance Impacts of Quality Practices by Industry

We also examined the performance impacts of different work system types. Previous studies of the automotive industry (Womack, Jones and Roos 1991; MacDuffie 1994) and the steel finishing industry (Ichniowski et al 1993; Ichniowski and Shaw 1995) have found significant performance gains associated with the adoption of systems of quality-related practices. Still, others contend that the introduction of such practices, particularly the use of worker participation and employee involvement schemes, does not necessarily pay off in terms of improved organizational performance (this debate is summarized in Blinder 1990).

Table 9 compares the productivity of manufacturing plants (measured as sales per employee) grouped into three groups according to their approach to managing production work: taylorist, transitional and learning-intensive. The results of the aggregate analysis indicate that while there is no overall relationship between the methods of managing production work and plant performance for manufacturing industries as a whole, adoption of quality practices has a significant impact on performance in particular industries. As Table 9 shows, there is evidence of significant performance paybacks to the adoption of work practices designed to improve quality for plants in the transportation equipment, primary metals, electronics and chemicals industries. There is no significant performance payback of adoption of quality-related practices in the other industries examined. In the transportation equipment industry, for example, quality-oriented, learning-intensive plants averaged twice the annual sales per employee as taylorist plants in that industry. There was little difference between different types of plants in the fabricated metals, rubber and plastics and electronics industries. The instruments industry exhibits a negative return to quality, with taylorist plants outperforming quality-oriented, learning-intensive plants by a two-to-one margin.

Customer-Supplier Relations and Work System Innovation

Customer-supplier relations are increasingly seen as a potential mechanism for the diffusion of innovative work and production practices. Japanese transplants like Honda and Toyota take considerable efforts to assist suppliers in the adoption of new approaches to managing production. Nishiguchi (1994) suggests that customer-supplier relations are a powerful mechanism for diffusion of innovative work systems and practices. Florida and Kenney (1991) found evidence that there is an elective affinity between innovative internal and external relationships. However, using data from a 1993 survey of first-tier auto parts supplier plants in the U.S., Helper and Levine (1993) found no evidence that having a Japanese customer predicts the presence of employee participation within the plant.

This aspect of the research examined the role of linkages between OEM manufacturers and their suppliers in the adoption and diffusion of innovative work and production systems, focusing on the following key questions.

How do industrial networks of OEM manufacturers and their suppliers affect the adoption and diffusion of innovative work and production systems?

Are plants that have adopted innovative work systems also participants in innovative customer-supplier relationships?

This aspect of the research was probed through a combination of survey and field research. The field research was explicitly designed to examine the role of hub companies and first tier suppliers in the adoption and diffusion of innovative work practices and regimes.

The main finding for this aspect of the research is that customer-supplier relations can serve as a catalyst and mechanism in the diffusion of innovative work systems. The field research indicates that both OEM manufacturers and first-tier supplier are actively engaged in efforts to diffuse innovative organization through supplier networks. Toyota, for example, provides technical assistance to its suppliers through its purchasing departments, and has set up a semi-independent operation, the Toyota Supplier Support Center, to work with U.S.-owned suppliers that are committed to adopting core values and practices of the Toyota Production System. Toyota has also established two U.S.-based supplier associations--associated with its Georgetown, Kentucky and Van Nuys, California (NUMMI) operations, respectively--to accelerate the adoption and diffusion of innovative work systems among its suppliers.

We conducted a number of analyses to examine the relationship between innovative work systems inside the plant and innovative customer-supplier relations. Table 10 shows the hypothesized symmetries between internal and external relations. We used a structural equations model to examine the relationships between close customer and supplier relations and the adoption of innovative work systems. The findings here indicate that there is a strong connection between learning-intensive work organization within the plant and close cooperation and communication with the plant's most important customer (see Figure 3). As Table 11 shows, plants that organize production work within the plant as a learning-intensive system were more likely to engage in cooperative relationships with customers and suppliers. For plants in the auto supply sector, the adoption of these practices within the plant was linked to a propensity to work closely with suppliers to improve product quality, delivery and cost. This suggests that customer-supplier relationships reinforce innovative work systems and, in the automobile sector at least, provide a mechanism for diffusing innovative work and production organization throughout a tightly-linked customer-supplier network.

We also examined the effect of certain aspects of customer-supplier relations (such as supplier certification and electronic data interchange) on the adoption of innovative work systems. Here, we found that certification by customer is associated with a greater likelihood of adopting innovative work systems only for U.S.-affiliated auto suppliers. Similarly, U.S.-owned auto supplier plants that certify their suppliers are significantly more likely to adopt innovative work systems. It seems that U.S. auto supplier plants have figured out how to integrate supplier certification activities into a strategy that includes the adoption of innovative work systems within the plant. Japanese automotive suppliers are more likely to use electronic data interchange (EDI); furthermore, EDI is associated with the tendency to adopt innovative work systems only for the Japanese-affiliated auto parts suppliers. Toyota, for example, orders its seats from Johnson Controls via computer, placing orders for seat subassemblies as its cars start down the assembly line. Japanese-affiliated auto supplier plants that have EDI with their customers are significantly more likely to adopt a highly learning-intensive approach to managing production work. Japanese-affiliated auto suppliers appear better able to integrate electronic data interchange into a production system that both emphasizes information-sharing within the factory and rich communications and cooperation with supplier and customer organizations.

Learning by U.S. Suppliers to the Transplants

In an influential 1993 study of the sources of manufacturing productivity, the McKinsey Global Institute (1993) outlined three ways in which transplant companies contribute to domestic productivity. First, transplant producers contribute directly to domestic productivity, pulling up the overall average with the higher levels of productivity they are able to achieve. Second, transplant producers put competitive pressure on other domestic producers and provide a powerful demonstration effect that leading edge work and production organization can be implemented with local workforces and generate improved productivity. Third and most importantly, transplant producers transfer knowledge of best-practice work and production organization to domestic producers. This occurs both through the interaction of lead manufacturers with their domestic suppliers and perhaps also through the movement of personnel between firms.

Japanese automotive assembly transplants have expressed a desire to help U.S. suppliers improve manufacturing performance and have established programs to provide technical assistance to suppliers. The Japanese Automobile Manufacturers Association (JAMA, 1993) notes: "As Japanese automakers expand their U.S. manufacturing operations, they are seeking to incorporate U.S. suppliers in their design-in process. Japanese automakers are now engaged in strenuous efforts to forge lasting partnerships with U.S. suppliers." Kenney and Florida (1993) highlighted a number of efforts made by Japanese automotive transplants to provide assistance to domestic suppliers. Cusumano and Takeishi (1991) found some evidence that these firms have managed to help or at least persuade their suppliers in the U.S., both U.S.-affiliated and Japanese-affiliated, to meet Japanese standards for quality and pricing in a survey of purchasing managers at Japanese auto assembly transplants. However, they concluded that the overall high quality performance of suppliers to the transplant assemblers reflects more the transfer of Japanese suppliers to the U.S. than improvement in the capacity of U.S.-affiliated suppliers through the transfer of managerial skills to those firms.

This aspect of the study examined the diffusion of innovative work practices among U.S.-affiliated automobile parts plants that serve as first-tier suppliers to Japanese transplant auto assemblers, focusing on two key questions:

> Are there differences between the transplants and U.S.-affiliated establishments in the rates of and reasons for adoption of work system innovations?
>
> Are U.S. suppliers to the transplants learning to implement more effective ways of organizing and managing production work from their Japanese joint venture partners or their Japanese-affiliated customers?

The findings suggest that U.S. suppliers to the transplants are quite innovative. However, the findings also indicate that, in general, U.S. suppliers are more likely to be selected because they are already advanced, as opposed to learning about new work systems from their transplant customers.

First, there is very little difference in adoption of innovative work systems between Japanese-affiliated and U.S.-owned suppliers to the Japanese transplant automobile assemblers. In fact, a slightly higher proportion of U.S.-owned suppliers use learning-intensive work methods, although this difference is not statistically significant. U.S.-owned suppliers are also more likely than their Japanese counterparts to use taylorist methods in managing production work. And, U.S.-owned plants that are older brownfield plants are significantly more likely to be highly taylorist.

We looked closely at the ways through which U.S. plants may be learning from the transplants. Here, the evidence is mixed. On the one hand, our field research on Johnson Controls, a highly innovative U.S. supplier, provides clear-cut evidence of learning by a U.S. supplier. This plant has learned a great deal about new systems of work and production organization from Toyota, and has made considerable progress in terms of plant performance in the past five years.

On the other hand, the survey data tends to support a *selection effect* over a *learning* explanation for U.S. suppliers. We conducted econometric analyses (multinomial probit models) of the factors that account for the adoption of innovative work and production practices by U.S. automotive suppliers to the transplants and their Japanese counterparts. We explored the effects of employment size, capital intensity, wages, education levels, unionization, customer (transplant versus Big Three), and supplier relations on the adoption of innovative work and production practices. The results of this analysis suggest that, for the U.S.-owned automobile suppliers, having a Japanese transplant assembler as a plant's most important customer, is not by itself associated with a greater likelihood that the plant will adopt innovative work system practices.

Furthermore, we looked at the timing of adoption of innovative work and production systems for U.S.-owned and transplant suppliers. The results indicate that U.S.-owned suppliers have on average been at these practices longer than Japanese-affiliated plants--by at least a year for each practice (see Table 12). This suggests that Japanese-affiliated plants were not first movers in the use of innovative practices. These findings support the *selection effect* explanation, where the most innovative U.S.-owned suppliers were selected as suppliers by Japanese automotive transplants.

In general, we were struck by how recent the adoption of innovative work and production organization is across our sample of manufacturing plants, whether Japanese-affiliated or U.S.-owned. The average time that plants have been involved with such practices is only 3.5- 5 years, with 1989-1991 being the peak period for adoption. In general, plants in the sample have been involved with teams the longest on average, followed by quality circles and then TQM. The only exception is U.S. plants, which have used quality circles for an average of six years compared to only three-and-a-half years for Japanese-affiliated auto suppliers. We examined the relation of experience with innovative work practices and work system innovation, and found no statistically significant relationship between the length of time a plant has been using teams, quality circles and TQM, on the one hand, and its propensity to adopt a learning-intensive *system* of work practices.

Location and Economic Geography of the Transplants

Japanese companies have come under increasing fire for locating their U.S. plants outside traditional manufacturing areas where wages and the concentration of minorities are high. There is a general consensus in both academic studies and the conventional wisdom that Japanese transplant manufacturers choose their locations to avoid trade unions and racial minorities, and that they tend to select primarily rural, greenfield locations characterized by docile and malleable workforces, lower wages and relatively small concentrations of manufacturing plants. However, these claims are based mostly on anecdotal evidence or incomplete data.

In a much-cited 1988 study, Cole and Deskins (1988) explored the location and hiring practices of automotive transplants and came to the conclusion that Japanese transplants, on average, located in areas with lower minority population percentages than areas with domestic Big Three automotive producers (also see Cole 1989). They also found that the Japanese transplants frequently employed a lower percentage of minority workers than the proportion in the surrounding labor pool.

Cole and Deskins (1988) concluded that: "Japanese firms can stay within Equal Employment Opportunity guidelines and still hire very few blacks. By placing their plants in areas with very low black populations, they in effect exclude blacks from potential employment." In a study of the location of a broader sample of Japanese transplants, Woodward (1992) concluded that Japanese-affiliated manufacturers prefer areas with relatively low levels of minority population and unionization.

This aspect of the research examined the location decisions of Japanese transplants in the United States. Specifically, we examined the effect of demographic and economic factors such as race, wages, unionization, population size, and manufacturing intensity on the location of Japanese transplant manufacturers. We also looked at the role of just-in-time supplier relations on the location and geographic organization of Japanese automotive-related transplants (Sheard 1983; Asanuma 1985a, 1985b, 1989; Sako 1989; Odaka et al. 1988).

The findings here provide strong statistical evidence that, contrary to the popular view, Japanese automotive-related producers do not avoid minorities and high wages; rather they tend to locate their plants in established manufacturing areas where levels of education are higher. Another key finding is that there is a very strong tendency among Japanese automotive supplier companies to locate their production facilities near the plants of their key customers in order to facilitate just-in-time production. In fact, these findings suggest that the academic literature as well as the conventional wisdom have given rise to several myths.

The first myth is that Japanese automotive-related transplants avoid minorities. Our findings suggest that Japanese manufacturers do not avoid areas with higher minority populations. If anything, Japanese transplant manufacturing is more concentrated in areas with moderately high minority populations.

The second myth is that Japanese automotive-related manufacturers choose their locations to avoid unions. The findings indicate that there is little or no pattern of union avoidance on the part of transplant manufacturers. This is not to suggest that trade unions are a positive factor in transplant location, or that Japanese manufacturers are more likely to have unionized workforces. Rather, it is to simply say that the locations with relatively high levels of unions neither attract nor dissuade Japanese automotive-related transplants.

The third myth is that Japanese transplants prefer low wage areas. Against this, our findings suggest that Japanese manufacturers are concentrated in relatively high wage areas. Transplant manufacturers are willing to pay a premium for qualified workers who are acclimated to a manufacturing environment and will remain with the company.

The fourth myth is that Japanese automotive-related plants locate primarily in rural, greenfield areas. The findings provide little support for this hypothesis. On any of a variety of measures -- size of population, whether places are urban or rural, and the level of manufacturing -- the evidence demonstrates that Japanese direct manufacturing investment goes more often to relatively urbanized areas, with larger populations, and more established manufacturing bases.

The role of just-in-time supply and delivery in the Japanese production system is well known (Aoki 1988, 1990; Dore 1983; Sheard 1983; Sako 1989). This system is characterized by short, tight delivery schedules and highly interdependent customer-supplier relationships. Geographic clustering allows Japanese manufacturers to capitalize on agglomeration economies, minimize their transaction costs, interact frequently in design, development and production, and share information and knowledge. The best example of a just-in-time production complex is Toyota City, outside

Nagoya, which is home to Toyota's main production complex and thousands of its suppliers (Cusamano 1985).

In light of this, we advanced the hypothesis that Japanese automotive-related industries are oriented by the strong centripetal force of the just-in-time system of production. To examine this hypothesis, we collected data on the distribution of Japanese automotive-related establishments in counties that constitute a potential just-in-time automotive production complex. We defined this complex by drawing a 250 mile straight-line radius (one day's delivery time) around each of the transplant assemblers. We then connected the points (in a semi-smooth fashion) to form a region or complex. The complex is comprised of just under one-third (1000) of the roughly 3100 counties in the United States.

The results of this analysis indicate that Japanese direct investment in automotive-related industries is highly agglomerated, with 73 percent of transplants (300 establishments) located in just a six-state area. Japanese automotive-related manufacturing is disproportionally concentrated within this potential just-in-time production complex.

We next estimated a series of econometric models for the location of Japanese automotive-related transplants in the United States. The results of these models accord well with the findings presented above. At the state level, proximity to transplant assemblers is the most important factor in the location of automotive-related transplants, such as automotive component suppliers, steel makers, and tire producers. Other factors consistently associated with higher levels of Japanese manufacturing included: higher population density, higher wages, and higher manufacturing intensity. Unionization and minority population were not found to be of statistical significance in the overwhelming majority of cases.

The models were also estimated at the county level. Here, the results were even stronger. Proximity was again, far and away, the most powerful influence on location. A positive relationship was found between minority population and the number of transplant establishments--areas with higher levels of minority population actually attracted higher numbers of transplants. Japanese transplants were also attracted to high wage locations, manufacturing areas, and larger places. Unionization was seldom a statistically significant indicator, but in the cases where it was significant, the net effect was positive. These findings provide additional support for the view that Japanese transplant manufacturers do not avoid areas with high minority concentrations, trade unions or high wages, nor do they necessarily favor rural, *greenfield* locations. Rather the driving force in their location is the proximity required for just-in-time production. The findings indicate that the main organizing principle in the location of transplant manufacturers is the proximity required for efficient operation of the Japanese just-in-time system of supply and delivery. Japanese transplants are highly concentrated in a well-defined complex which includes roughly one-third of all U.S. counties. Such a location pattern means that the suppliers of important inputs are able to make the frequent and regular deliveries to automotive assembly plants as required for just-in-time production.

Research and Development by the Transplants

This aspect of the research examined the transfer of Japanese R&D and product development activity to the United States. Some argue that Japanese companies are making little R&D investment in the United States, keeping such knowledge-based activities at homes. Others argue that Japanese companies are opening up state-of-the-art facilities in Silicon Valley, Cambridge, Massachusetts, Princeton, New Jersey, and similar areas to *steal away* America's top scientists and engineers. Based on a highly aggregate analysis, Graham and Krugman (1992) suggest that even though Japanese companies invest roughly the same amount per employee in R&D as do U.S. firms, there is a *headquarters effect,* which means that the most advanced R&D activities tend to be kept in the home country. Sloan-funded research examined the capabilities of Japanese R&D and production development facilities in the U.S. through field research on the automotive design cluster of southern California and Japanese electronics R&D facilities throughout the U.S..

The past decade has seen an outpouring of social science research on the role and function of innovation in advanced economies (see Nelson 1993) and a growing body of research on the globalization of economic activity (Reich 1990, 1991; Porter 1986, 1990; Ohmae 1993). Economic geographers note that industrial R&D is concentrated in a few major regional centers in the advanced industrial nations, and that R&D laboratories cluster in central locations in large metropolitan areas where scientific and technical talent is readily available (Malecki 1980a, 1980b; Malecki and Bradbury 1992; Howells 1984, 1990). While the business and management literatures traditionally suggested that R&D is concentrated in *home base* locations (Vernon 1966, 1977; Porter 1986), recent studies identify a trend toward the internationalization of R&D activities through the establishment of offshore R&D facilities (Ronstadt 1977, 1978; Cantwell 1989; Mowery and Teece 1992; 1993; Howells 1990; Howells and Wood 1993; Westney 1990, 1992). Such internationalization results from four factors: (1) the increasing level of foreign direct investment and the attendant globalization of economic activity, (2) the increasing pace of technological change, (3) the emergence of new centers of technological innovation and knowledge-based production, and (4) the growing importance of linkages and interaction between the sites of innovation and production.

The findings indicate that Japanese R&D investment in the U.S. has grown substantially, particularly over the past five years, increasing four-fold from $292 million in 1986 to $1.2 billion in 1990. Japanese R&D investment is concentrated in sectors such as electronics and automotive--the same sectors as those in which the bulk of Japanese manufacturing in the U.S. is concentrated. These are also sectors in which Japanese manufacturers have achieved considerable competitive advantage over U.S. producers. Japanese R&D investment in the biotechnology and the pharmaceutical sectors is dwarfed by European investments which even dominate overall U.S. R&D investment in these sectors.

Japanese R&D investment in the U.S. is geographically concentrated with primary locations on the East and West Coasts and in the Midwest transplant automotive corridor. Japanese R&D investment in the U.S. follows a two-dimensional locational pattern with R&D establishments located either in close proximity to manufacturing plants or close to leading U.S. technology centers (see Figure 4). On one hand, the majority of investments are applied research and product development facilities located at or near existing Japanese-owned manufacturing sites. Such locations have been chosen to provide technical support to manufacturing facilities, to design and develop products for the U.S. and North American regional markets, and to enhance interaction between the factory and the R&D laboratory, reflecting a more general strategy of *global localization*. On the other hand, a smaller number of investments in scientifically-oriented basic R&D facilities are located near major U.S. universities and scientific research centers such as Cambridge, Massachusetts; Princeton, New Jersey; and Silicon Valley, California. The purpose of these investments is to gain access to multinational scientific and technical talent as a source of new knowledge that can reinforce existing corporate technological capabilities.

The globalization of innovation and of R&D by leading Japanese corporations reflects Japan's rise as a world leader in a growing number of technological fields, and the development of business and locational strategies designed to develop successful commercial products tailored to regional markets. Japanese firms have located R&D operations overseas to meet the needs of customers in major markets of the world by developing close linkages between the sites of innovation and production. To some extent then, Japanese companies are using a strategy originally developed by U.S. multinational corporations like IBM that have long operated global R&D facilities. However, Japanese companies appear to have advanced further in this path than U.S. or European multinationals. In contrast to U.S. and European multinationals, which tended to separate R&D from off-shore branch plants, Japanese companies are developing integrated innovation and production capabilities in major markets outside Japan.

Economic geographers have long noted that the innovation process is characterized by a distinct *spatial division of labor* which allocates different economic functions and capabilities to different physical locations. The findings suggest that this division of labor is dynamic. At the international scale, innovation is characterized by decentralization of the sort brought on by globalization and the establishment of international R&D units. At the regional scale, there is the development of integrated complexes of innovation and/or innovation-mediated production embedded in spatially-constituted networks of producers, suppliers, R&D facilities, and innovative activity. As product life cycles become shorter and new generations of products emerge at an ever increasing pace, innovation has become an inseparable component of production, leading to the emergence of a virtually seamless innovation-production system. The establishment of off-shore R&D units serves to mobilize and harness the knowledge, ideas and social capability embedded in regionally-based centers of innovation and production. These networks of ideas and knowledge mobilize knowledge and intellectual labor on a collective or social basis providing a powerful dynamic of innovation. As each firm in the network feels increased economic and social pressure to improve, the network becomes a powerful source of collective innovation and continuous improvement. Japanese R&D investments in the U.S. can thus be understood as a process of building capable networks of producers, suppliers, R&D and innovation on a world scale. As such, they function to harness and integrate knowledge and intelligence in ways that reinforce these multiple dimensions of innovative and production activity.

NEXT STEPS

Over the course of the summer, members of the project team will complete a series of academic journal and magazine articles and opinion editorials on various aspects of the research described here. Florida and Jenkins will complete a book length monograph summarizing the key findings and contributions of the study. This book is envisioned as an academic book with a considerable spill-over trade audience. Oxford University Press has already expressed considerable interest in this book. The Principal Investigator is involved in the development of a series of PBS documentaries on manufacturing, production globalization and jobs, and has and will continue to use television as a venue to disseminate the key findings of the study.

Two immediate extensions of the project are planned. The research on transplant R&D is being extended to include a survey of all foreign-affiliated R&D establishments in the U.S. with additional funding from the Japan Science and Technology Management Program and the Carnegie Bosch Institute. The Principal Investigator has initiated a project proposal for the Sloan Foundation with Kenneth Oye, Paul Osterman and others to examine the employment impacts of work system innovation and production globalization in the automotive sector.

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APPENDIX A: FIELD RESEARCH INSTRUMENTS

Manufacturing Site Visits: List of Key Questions

Work and Production Systems

To what extent does this plant follow Japanese-style management practices, for example, in the use of: production teams and quality circles, job rotation and multi-skilling, formal training in company-specific technical knowledge, *kaizen*, careful selection of and employment security for core workers, just-in-time inventory control, close cooperation with suppliers, etc.

If your plant is owned (wholly or in part) by a Japanese company, how is production managed differently at this plant compared to sister plants in Japan? (We are especially interested in differences in the selection, training, promotion and pay systems for production workers and managers.)

In what ways has your plant had to adapt its management practices to the North American economic environment?

What are the main obstacles to improving the performance of production systems at your plant?

Which segment of your plant's workforce (e.g., top management, middle management, engineering staff, production workers, etc.) poses the biggest challenge to such efforts?

What are the recent trends at this plant in productivity, quality and other measures of plant performance? How do these compare to trends in your industry generally?

What is your plant's strategy for dealing with fluctuations in market demand, particularly through its human resource policies?

What are your priorities with respect to labor force management over the next five years?

Relations with Suppliers and Customers

What criteria do you use to select your suppliers?

Do you exchange personnel with your suppliers or customers? For what purposes?

Do you cooperate with your suppliers/customers on the design and development of products or production systems?

Where and by whom is this R&D work conducted? In what other ways does your plant cooperate with its suppliers/customers?

What are the key differences in your relations with American suppliers/customers and Japanese (or joint venture) suppliers/customers?

R&D Site Visits: List of Key Questions

The following are examples of the types of questions we would like to cover in our visit to your facility.

What is the main purpose of your R&D at this facility?

What are the major areas of R&D you conduct?

What role does the R&D you conduct play in your larger parent company?

<u>Location Choices</u>

Why did you choose to locate in the U.S.?

Why did you locate in this particular site?

What were the major considerations in your choice of this location?

What are the strengths and weaknesses of conducting R&D in the United States versus Japan?

<u>Organization of R&D</u>

What is the breakdown of your work force?

Would you say your facility is organized more like one in Japan or is it more American in style?

<u>Linkages and Technology Transfer</u>

How is your facility linked to and interact with other facilities of your parent company in the U.S. and Japan?

What are the main mechanisms you use to transfer your technology? Which of these are the most effective?

Do you interact with your parent company's manufacturing transplants in the U.S.? If so, how?

Do people from your facility visit other units of your parent company in the U.S. and Japan? How often do researchers and executives from other units of your parent company visit your facility? What are the main mechanisms through which you exchange information with your parent company: mail, e-mail, faxes, telephone, etc.?

Do you have joint projects and/or other forms of collaboration with suppliers, other R&D labs, or universities in the United States and Japan? If so, what are the main mechanisms for doing so?

Has anyone ever created a spin-off company from your facility?

R&D Site Visits: Key Information Checklist

We would very much appreciate it if you could provide answers to the following questions and return this form to us at the time of our visit.

How would you describe your facility?
- a newly constructed facility_____
- a purchase of an existing facility______
- a facility on a university campus______
- other____

What year was this facility established? _____

What percentage of your activity is devoted to:
- Basic R&D _______ %
- Applied R&D _______ %
- Product/process development _______ %
- other (please describe) _______ %

What is the main technological or industrial focus of your facility? ____________________________ ________

What is the total annual R&D expenditure of the parent company as of 1993? _________

What is the total annual R&D expenditure of this facility as of 1993? __________

What is the total amount of investment in this facility? _________

What is the total number of employees at your facility as of 1993? _____________

Please provide a breakdown of the number employees in your facility by category
- Scientists and engineers engaged in basic R&D ________
- Scientists and engineers engaged in applied R&D ________
- Product development engineers ________
- Managers ________
- Clerical and administrative ________
- Other ________

What percentage of the researchers in your facility hold the following degrees?
- Ph.D. ______
- M.S./ M.A. ______
- B.S./ B.A. ______

Is there anyone else at your company in the United States or Japan that you would suggest we visit to discuss issues related to the globalization of R&D?

Could you please provide us with copies of your company's annual report, materials describing the overall R&D efforts of your company, and/or a brochure describing your facility, or other pertinent information?

APPENDIX B: SURVEY RESEARCH DESIGN

One set of data used in this study was collected through a survey of manufacturing plants conducted in the summer and fall of 1994. The establishments surveyed were of two types: Japanese-affiliated manufacturing plants operating in the U.S.--so-called Japanese "transplants"--and U.S.-affiliated manufacturing plants that serve as the suppliers to the transplants. The survey was administered to plant managers in these establishments via a combination of mail and telephone instruments. In both cases, the respondents were asked for detailed information about their plant's products, its labor force, the organization of production work within the plant and relations with outside customer and supplier organizations. The survey achieved a response rate (unadjusted) of 40.1 percent.

This appendix provides details on the composition of the survey sampling frame and the methods used to administer the survey. It also outlines the steps taken to analyze the responses to the survey for possible response bias.

Survey Sample Frame

The sampling frame for the survey consists of two types of manufacturing plants:

1) Japanese-affiliated manufacturing plants in selected industries operating in the contiguous 48 states in the summer of 1994.

2) U.S.-affiliated manufacturing plants that serve as first-tier suppliers to the Japanese transplant automobile assemblers.

The list of Japanese-affiliated plants operating in the U.S. was compiled over the past several years by a team of researchers at Carnegie Mellon University under the direction of Professor Richard Florida. The base list of plants comes from the Japan External Trade Organization (JETRO), a Japanese government agency that since 1981 has conducted an annual survey of Japanese-affiliated manufacturing plants in the United States JETRO defines a plant as Japanese-affiliated if the plant is owned at least 20 percent by a company based in Japan, or its subsidiary. Therefore, its listing includes plants that are joint ventures with companies based in the U.S. or other countries as well as those owned entirely by Japanese companies or their subsidiaries. We have updated our database to include the 1,695 transplants involved in JETRO's 1993 survey, the latest available. The JETRO list is considered to be quite authoritative, since part of JETRO's mission is to keep up-to-date information on Japanese investment in foreign countries. JETRO invests considerable care and resources toward this end, using its regional offices in the U.S. as well as outside market research organizations to track the overseas activities of Japanese companies. JETRO also has access to proprietary information from the Japanese government on Japanese foreign direct investment, including the base notification data of the Ministry of Finance, to which Japanese companies planning to make investments outside of Japan are required by law to report. Our research team here at Carnegie Mellon supplemented the JETRO list with data on Japanese investment in U.S. manufacturing from other sources, including: the list of Japanese-affiliated plants in the U.S. as of 1990 complied by the Japan Economic Institute (MacKnight 1992); directories of Japanese-affiliated companies operating in the U.S., such as JETRO (1993) and Toyo Keizai (1993); and various newsletters, news articles and other publications.

Given the objectives of the study, it made sense to confine the sample frame of Japanese-affiliated establishments to plants in sectors in which Japanese manufacturers have a sizeable presence in this country. Therefore, the research team decided to exclude plants in industries where the number of Japanese transplants operating in the U.S. is too small to allow one to draw statistical inferences at the industry level. The nearly 200 Japanese transplants involved in food-related industries were also excluded because the manufacturing processes involved in food production are so distinctive as to prevent useful comparison with other industries. In addition, the eight Japanese-affiliated automotive assembly complexes in the U.S. were removed from the sample frame because they have been extensively studied in other research (including previous studies conducted by members of our research team). Thus, from the original database of 1,768 U.S.-based, Japanese-affiliated manufacturing plants, 359 were excluded, leaving a total of 1,409 in the sampling frame.

In creating the sampling frame of U.S.-affiliated plants, we were guided by two objectives: first, to select a set of U.S.-affiliated plants whose production practices could be compared to plants in our sample of Japanese-affiliated plants; and, second, to include U.S.-affiliated establishments in which there has been a potential for direct learning from Japanese-affiliated manufacturers. Therefore, our sampling frame of U.S.-affiliated plants is drawn from establishments that serve as first-tier suppliers to one or more of the eight Japanese-affiliated transplant auto assembly complexes in the U.S.

The base list of such plants came from ELM International, Inc., a market research firm in East Lansing, Michigan, that specializes in the automobile industry. In particular, we made use of the *ELM Guide*, a computerized database containing profiles of the North American plants of companies involved in automobile assembly as well as of first-tier OEM automotive supply. The ELM data has been used for analysis of Japanese foreign direct investment by the U.S. Department of Commerce and the Office of Technology Assessment. (See, e.g., OTA 1994, p. 147). Helper also used the ELM listing in creating the sampling frame for her recent survey of supplier relations in the U.S. automobile industry. This database, which is updated quarterly, includes information about plant ownership and customer base, making it possible for us to extract a list of plants owned by U.S. companies that supply Japanese auto assembly operations in the U.S. Our research team supplemented the ELM list of U.S.-affiliated suppliers to the transplants using information on U.S. auto parts suppliers that sell to Japanese automobile manufacturers that was given by the Japanese Automobile Manufacturers Association (JAMA) to the U.S. Department of Commerce in accordance with the MOSS talks on Transportation Machinery between the U.S. and Japanese governments. In total, the list includes 388 plants, of which 41 are owned by the U.S. Big Three automobile manufacturers and 347 are independently-owned.

Our lists of Japanese-affiliated and U.S.-affiliated plants (which included the mailing address for each establishment) were screened by the Center for Survey Research (CSR), a research institute at the University of Massachusetts, Boston, that was contracted to assist in carrying out the survey work for this study. The purpose of this screening was to verify each plant's address, ensure that the facility at that location was currently engaged in manufacturing, and obtain the name of the person who would be best positioned to provide the information requested by our survey (typically, the plant manager). Through the screening process, 238 additional plants were eliminated from the sample. Establishments were considered not eligible for inclusion in the sampling frame if no manufacturing was conducted at the given address. Typically such sites were being used for sales, administration or R&D. This left 1,559 plants in the sample frame, of which 1,195 were Japanese-affiliated and 388 were U.S. affiliated.

Survey Methods

The survey instrument was developed by Davis Jenkins and Richard Florida over the year beginning in Spring 1993. The process included an extensive review of survey instruments that have been developed by other researchers for use in studies of innovations in work organization and human resource management.

Draft versions of the instrument were sent out to both scholars and practitioners who are knowledgeable about new forms of work organization for review. Revisions were made on the basis of their comments. Finally, a near-final draft of the instrument was field-tested. Based on the feedback from the field test, the instrument was again revised and the final 12-page version was prepared for printing.

The survey was administered by the Center for Survey Research (CSR) of the University of Massachusetts, Boston. CSR was selected from among several prominent survey organizations because of its experience in conducting establishment surveys, which differ in important respects from the more common household surveys. CSR has done the survey work for a number of well-regarded establishment-level studies in recent years, including the 1987 and 1991 studies of machine tool use in manufacturing plants by Kelley and Brooks, Bailey's study of employer-sponsored training in U.S. textile plants, and Osterman's study of human resource practices and policies in a nationally representative sample of establishments. The survey was administered between June and November of 1994 in two phases: the first involving a mail survey and the second involving telephone interviews.

Phase 1: Mail Survey. The mail survey was carried out according to the following timetable:

7/11	Full questionnaire mailed to entire sample frame.
7/25	Post card reminders sent to entire sample frame.
8/12	Reminder copy of full questionnaire sent to all non-respondents.
8/15	Fax reminder sent to all non-respondents.
8/29 -9/9	Non-respondents telephoned by CSR to urge them to complete and return the survey.

By mid-September, two months after the first mailing, this process had yielded just over 300 completed questionnaires, or about 20 percent of the sample frame. To increase the response rate and lessen the demand on respondents' time, we decided to conduct telephone interviews of non-respondents to date using a subset of questions from the mail survey. About half of the items on the mail survey instrument were included in the telephone survey interview. A sample of 300 plants were selected at random from the pool of non-respondents to the mail survey. On September 19, a fax was sent to the plant managers of these establishments indicating that they had been selected to take part in the telephone survey and informing them of the procedures. Following that, telephone interviewers from CSR took to the phones in an effort to encourage plant managers in the sample to complete the 25-minute interview. The interviewers were quite successful, obtaining interviews from nearly 70 percent of those contacted. By mid-November, nearly 300 interviews were completed by telephone, bringing the total number of responses to either the mail or telephone surveys to more than 600, or over 40 percent of the sample frame.

Beginning in late November, a response bias survey was conducted with a small number of plants selected at random from the remaining non-respondents. These plants received a two-page fax with a few key questions about their plant: age, size, sales, ownership, union status and customer base. The purpose of this survey was to determine whether, on these key variables at least, the respondents to the mail and telephone surveys were representative of the non-respondents to the survey. To ensure a high response rate, CSR interviewers followed up the faxes with telephone calls prompting plant managers to complete the short questionnaire.

Analysis of Survey Responses

In the course of telephoning plant managers to encourage them to complete the mail or telephone surveys, CSR interviewers found that an additional 59 plants were ineligible for the survey, because: they were not (or were no longer) Japanese-affiliated; or they did not currently supply any of the Japanese transplant auto assembly complexes; or (in a handful of cases) the plant had closed. This left a total of 1,500 eligible cases in the sample frame.

As was indicated above, the mail and telephone surveys had each generated over 300 completed instruments, for a total of more than 600 responses, or about 40 percent of the sample frame. The responses to the mail and telephone surveys were compared to determine if there was evidence of bias in the responses generated by the two survey modes. Further analysis of response bias was conducted using the information available for each plant in the sampling frame (national affiliation, product or industry and geographic location) as well as the results of the response bias survey. These analyses revealed no significant evidence of response bias.

A study such as this one, which is based on an analysis of data collected through a cross-sectional survey, would be remiss if it failed to describe the particular economic conditions of the period in which the survey was conducted.

The five months in 1994 during which our survey was administered was a period in which many U.S.-based manufacturers were running at full tilt in an effort to keep up with rising demand for their products amid the prevailing economic expansion in the U.S. Brisk sales of automobiles and other consumer durables during the period resulted in high capacity utilization in steel, auto parts, electronics and other sectors. In autos and construction equipment, unionized workers were threatening to disrupt production because they were being required to work too many overtime hours. Although some factories were hiring new workers (thereby increasing manufacturing payrolls during the period) most manufacturers were very reluctant to hire new full-time workers, often relying instead on temporary workers or automation to meet temporary spikes in demand. In this, they were heeding the harsh lessons of the 1980s, in which U.S. manufacturing industries were battered by foreign competition and manufacturing employment suffered a long decline amid companies' efforts to cut costs. The recession of 1991-92 provided yet another reminder of the risks of bringing on too many new workers too fast.

Indeed, the central challenge facing manufacturers in the U.S. during the survey period was how to meet rising short-term demand while at the same time continuing efforts to cut costs over the long run. For Japanese transplant manufacturers in the U.S., the imperative to continue cost-cutting was perhaps even greater, in part because of the soaring value of the yen, or *endaka*, which increased the cost of components imported from Japan. Japanese corporate parents were placing enormous pressure on overseas subsidiaries to cut costs, not only just in response to the *endaka*, but because of the disappointing profitability record of Japanese investment in the U.S. In its 1993 survey, the Japan External Trade Organization (JETRO) found that 53 percent of Japanese manufacturing facilities in the U.S. were losing money. The recession in Japan only made matters worse. The collapse of the bubble economy and cheap money era in Japan meant that few funds were available to cover losses in the U.S.

All of these factors, combined with the recession in the U.S., contributed to a sharp decline in the level of investment by Japanese manufacturers in U.S. operations in the early 1990s. The 1993 JETRO survey recorded the first reduction in the number of Japanese-affiliated manufacturing plants in the U.S. since JETRO began doing the survey in 1981. The level of new investment in the U.S. by Japanese manufacturers during the early 1990s was especially small compared with the heady days of the 1980s. The 1993 JETRO survey found that Japanese manufacturers opened only 17 new factories in the U.S. in 1992, down from 169 in 1988, the peak year.

Japanese manufacturers are not pulling out of the U.S., however. On the contrary, in autos and other sectors, Japanese manufacturers are increasing production in their U.S. operations, partly in response to the current expansion in the U.S. and partly in response to political pressures to increase the local content of products produced in the U.S. Still, the tendency is to expand production by streamlining and upgrading existing facilities rather than by opening new ones. The 1993 JETRO survey found that more than 70 percent of respondents said that their company had invested earnings to expand, modernize or rationalize their plants since their inception of operations in the U.S. A similar percentage of respondents said they had plans for re-investment in the future. The comparable figure for the 1992 survey was 68.2 percent. Fewer than one in thirty manufacturers, or 3.2 percent, said that they had reduced their operations since coming to the United States, and an even smaller percentage, 1.8 percent, said they planned to reduce their U.S. operations or withdraw from the U.S. market entirely. This trend is reflected in the 1993 JETRO survey, which found a sharp drop in average employment among the transplants in 1993 compared with the year before. The principal reason given by respondent plant managers for this drop was restructuring efforts aimed at cutting costs and increasing profits. This orientation toward restructuring is supported by fact (again, according to the 1993 JETRO survey) that in U.S. manufacturing plants *acquired* by Japanese manufacturing firms, the average number of employees dropped 36 percent, from 369 to 239, while in newly established or greenfield sites average employment actually increased, from 214 to 220.

In summary then, the period in which the survey from which the data used in this study were drawn was a time in which doing more with less was an imperative for both U.S.-affiliated and Japanese-affiliated manufacturers in the U.S. One would expect, therefore, that these firms would have been eager to adopt new approaches to organizing and managing work and other innovations that promise to enhance productivity and market responsiveness while cutting costs.

APPENDIX C: RESEARCH ON WORK SYSTEM INNOVATIONS AND THE JAPANESE TRANSPLANTS

Most of the research on the adoption of work system innovations by Japanese manufacturers operating in the U.S. has relied on case studies, with much of this work focused on a single case: New United Motors Manufacturing Inc., or NUMMI, the Toyota - GM joint venture based in Fremont, California (Krafcik 1986; Brown and Reich 1989; Adler 1993; Wilms et al. forthcoming). What makes NUMMI such a magnet for research on work systems is that it represents an experiment by the largest Japanese auto manufacturer designed to test the feasibility of implementing the Toyota Production System, and especially its core of innovative work practices, with American managers and a unionized American work force. The case study research on NUMMI has concluded that Japanese-style work methods can be used successfully with a U.S. work force and in the presence of an American union. Whereas the former GM Fremont plant in which NUMMI is housed had been the site of some of the worst labor-management strife and productivity problems in the U.S. auto industry, under NUMMI, labor-management relations have been characterized by an extraordinary level of cooperation, and the plant's productivity has rivaled that of Toyota plants in Japan (Womack et al. 1990, p. 83). A key lesson of NUMMI, therefore, is that Japanese work practices are not bound by Japanese culture and can be transplanted into a foreign labor environment, if there is the will to do so.

Based on preliminary results of the International Motor Vehicle Program's Round Two International Assembly Plant Study, which involved surveys and site visits to nearly every assembly plant in the world, John Paul MacDuffie reported that U.S.-owned plants in North America are adopting Japanese-style lean production methods, but less quickly than are European automakers. For example, the study revealed that European companies and unions have embraced the team concept or group work very rapidly, whereas U.S.-owned plants in North America have the lowest average percentage of teams of all regions. (IMVP Research Briefing Meeting, Berlin Germany, June 22, 1994.)

Other case study research has examined whether innovative work practices of the sort in use at NUMMI and the seven other Japanese-affiliated auto assembly operations in the U.S. are also evident in the many other Japanese-affiliated manufacturing transplants that have been established in the U.S. in the past three decades. In a study of Japanese manufacturing plants in Southern California, Milkman (1991) found little evidence that the plants she studied have adopted methods of work organization or management of the sort used at NUMMI. Instead, most of the plants in her sample resemble American-owned, non-union plants in the way they organize and manage production work on the shop floor. According to Milkman,

> Few have teams or quality circles; in many cases their managers are not even familiar with Japanese work organization or management techniques. Like their American-owned counterparts in California, most of the Japanese-owned plants rely heavily on low-wage immigrant labor, and in their management practices as well they conform to the patterns established by non-union American manufacturing firms in the past few decades. (Milkman 1991, p. xiv)

Milkman concludes that high expectations for Japanese direct investment in U.S. manufacturing are misguided, and that the tendency of these plants to imitate American non-union models of work practice may in fact erode U.S. competitiveness and labor standards. However, as MacDuffie points out in a review of Milkman's study (MacDuffie 1993), despite Milkman's important finding that by no means all Japanese factories in the United States are run like NUMMI, the scope of Milkman's study is too limited to warrant the sweeping conclusions she draws about the character of Japanese manufacturing investment in the U.S. generally. For one, although Milkman administered a mail survey to 50 Japanese plants throughout the state, her conclusions are based largely on interviews conducted during visits to just 20 plants. All of the plants she visited are in Southern California, which, as MacDuffie notes, "presumably excludes those suppliers of NUMMI farther north that might be expected to adopt Japanese manufacturing techniques" (MacDuffie 1993, p. 133). Moreover, many of these plants were established in the 1970s and early 1980s--before the major wave of Japanese investment of the mid-to-late 1980s. MacDuffie questions whether the plants Milkman studied are representative of more recent developments. He hypothesizes that, more recently, as more Japanese companies have come to view a U.S. production base as important to their global manufacturing strategies, they may be more likely to adopt the sort of innovative work systems found at NUMMI.

The hypothesis that Japanese companies that have established manufacturing operations in the U.S. in recent years may be more likely to use innovative work systems than those that set up plants here earlier on is advanced in an impressive piece of case study research conducted by Joel Cutcher-Gershenfeld and his graduate students at Michigan State University (Cutcher-Gershenfeld et al. 1993). Like Milkman's research, the Michigan State study undermines any tendency to believe that there is a universally-applied Japanese way of organizing work among Japanese-affiliated manufacturers in the U.S. by describing in rich detail the diversity of teams found in eight Japanese transplants. The eight plants involved in the Michigan State study included: NUMMI and the Auto Alliance International (Mazda-Ford) plant in Flat Rock, Michigan; the Battle Creek Michigan plant of Nippondenso, a large Japanese auto parts supplier; I/N TEK and I/N KOTE, two steel plants in South Bend, Indiana operated by an Inland / Nippon Steel joint venture; the Michigan-based plants of Coil Center Corporation and Ogihara, two metal stamping operations, and Hitachi Magnetics Corporation and Yamaha Musical Products, two producers of electronic devices.

The study identifies three distinct types of teams among the eight plants: 1) lean production teams, which are characterized by a strong production worker team leader and which operate in the context of lean production systems as characterized by the MIT International Motor Vehicle Project (Womack et al. 1990); 2) socio-technical systems teams, which are highly autonomous groups, driven more by group process than by a team leader; and 3) traditional teams, defined as quality circles or other problem-solving groups that workers participate in apart from regular production work, which in such plants tends not to be carried out by production workers working in teams.

In attempting to account for the diversity in the forms and uses of teams by the eight Japanese transplants it studied, the Michigan State research team suggests that the timing of Japanese investment in North America may be a factor. Based on the small sample of plants it studied intensively, the Michigan State team speculates that there have been at least two periods of Japanese investment in U.S. manufacturing: the first, prior to 1980, which did not involve the transfer to the U.S. of Japanese work systems, and a later period, in which Japanese work systems were more likely to be transplanted. The plants established in the earlier period tended to be low value-added operations. Some of these were brownfield sites, that is, they were acquired from a previous owner. In purchasing these plants, argues the Michigan State team, Japanese companies tended to retain the methods of management and work organization used by the former owner, which typically followed an American model, instead of imposing Japanese methods. This explanation was supported by the Michigan State researchers' interviews with Japanese executives at the plants they studied who indicated that Japanese firms were not as confident in the 1970s as they are now about the merits of their work systems (Cutcher-Gershenfeld 1993, p. 20). Still, only two of the eight plants in the Michigan State sample are from the pre-1980 period. The team categorizes both of these pre-1980 plants as representing the traditional use of teams more characteristic of American manufacturers. Interestingly, the Michigan State study found that both of these plants established in the 1970s have been plagued by labor unrest and in recent years have faced diminishing productivity and profitability -- the sorts of problems that some have attributed to the dependence by U.S. firms on taylorist work methods (Lazonick 1990). Indeed, the Hitachi plant has been motivated by its problems with flagging quality and productivity to begin to experiment with Japanese-style work methods (Cutcher-Gershenfeld et al, 1993, p. 16).

The Michigan State researchers point to two other factors to explain the diversity of teams among the transplants they studied: ownership structure and production technology. With respect to the first factor, they conclude that the adoption of socio-technical systems teams is characteristic of U.S.-Japanese joint ventures where there is a strong influence by the U.S. partner on work system choices. With respect to the second factor, the researchers found evidence that assembly operations lend themselves to lean teams, continuous process operations lend themselves to socio-technical teams and batch production can be organized either way. This latter finding supports the notion that particular production technologies or processes may be more or less appropriate for use with particular forms of work organization. Yet, while the Michigan State study raises some intriguing hypotheses for explaining the adoption of work system innovations by the transplants, it does not provide conclusive evidence that these explanations hold for the hundreds of Japanese transplant establishments not included in their sample.

Certainly the most extensive case study research on the transfer by Japanese manufacturers of work system innovations outside of Japan is the series of studies conducted under the direction of Tetsuo Abo of the University of Tokyo (University of Tokyo 1990; Abo 1994). These studies address two questions: 1) To what extent do Japanese multinational companies, in setting up manufacturing operations outside of Japan, apply Japanese management methods as opposed to adapting the local management methods of the countries in which the operations are located? and, 2) What are the means by which the transfer of Japanese management systems takes place--by direct transfer of Japanese technology and personnel or by building local capacity to implement Japanese methods?

To ensure comparability of results from their field research in plants around the world, Abo and colleagues developed an *application vs. adaptation* model of the transfer of Japanese-style production organization and management. The model consists of six dimensions, with Work Organization/ Management as the core dimension. The other dimensions include: Team Sense, Labor Relations, Procurement of Parts (supplier relations), Linkages with the Parent Company, and Involvement with the Local Community. Thus, Abo et al. see the organization of work on the factory floor as the heart of a larger system of interlocking practices that define the overall approach to production. Each dimension of the model is defined by a number of elements. For example, the Work Organization/Management dimension includes the use of worker-led teams in production, simplified job classifications to encourage greater flexibility and adaptability in work groups and systematic job rotation to promote multi-skilling of workers. Closely-related are the small group activities of the Team Sense dimension, which include the use of quality circles or problem-solving groups as channels for feedback between front-line workers and managers.

Using a 5-point scale that indicates the extent of application (or, conversely, adaptation) of each element of the model, Abo and his colleagues have systematically measured the extent of transfer of Japanese production systems in scores of plants affiliated with Japanese multinationals in the U.S., Europe and Asia. In the U.S., they used the framework in site visits during the fall of 1986 by a team of Japanese and American researchers to 14 plants of 13 companies in auto assembly, auto parts, consumer electronics and semiconductors and again, during 1989, in visits to a total of 45 Japanese, Korean and American plants in those same industries.

As one would imagine, this prodigious research effort has produced a plethora of fine-grained typologies of the diverse forms in which Japanese multinationals have applied or adapted Japanese production methods in their overseas operations. The main finding of this research with respect to Japanese transplants in the U.S. is that the application or transfer of Japanese production systems has been most thorough-going among auto assembly and auto parts plants, whereas Japanese consumer electronics plants exhibit a strong pattern of adapting or conforming to a U.S. model of production organization and management. Japanese transplants in semi-conductors represent a middle ground between the greater transfer of auto-related establishments and greater adaptation of consumer electronics plants.

Given their exhaustive analysis of the patterns of work organization and management among Japanese transplants in the U.S. (and other countries as well), Abo and his colleagues offer surprisingly little explanation of the factors underlying the diversity of forms they document. They do, however, provide added support to the hypothesis that the timing of Japanese investment in the U.S. is a factor by observing that, the longer a plant has been in operation in the U.S. and the greater the number of employees, the less likely that Japanese methods of production--with their core of shop floor organization and management practices-- have been transplanted (University of Tokyo 1990, p. 136). They also find evidence that Japanese companies have had difficulty implementing Japanese-style production methods in brownfield sites (University of Tokyo 1990: 136). These findings are consistent with those of other case study research described above, but all of these findings are based on selected cases that are not necessarily representative of other transplants. Therefore, one is hesitant to make generalizations based on these results about patterns of use and underlying reasons for adoption across the nearly 2,000 Japanese-affiliated manufacturing establishments in the U.S.

The first and, until the survey conducted in this study, the most comprehensive effort to collect data on patterns of transfer of Japanese organizational forms and practices across a representative sample of Japanese manufacturing establishments in the U.S. was the 1988 survey by Florida and Kenney of the 299 Japanese-affiliated auto parts supplier plants known to have begun production in the U.S. by that time. Florida and Kenney designed their survey around a model of Japanese production organization and management, the keystone of which is the use of teams in production, job rotation and other forms of shop floor work organization that serve to "harness the intelligence of workers on the shop floor" (Florida and Kenney 1991). Like Abo and his colleagues, Florida and Kenney see the Japanese approach to organizing work on the shop floor as embedded in a larger system of production. Florida and Kenney's conception of this production system encompasses not only structures internal to the establishment or firm, but also inter-organizational forms as well, in particular, the just-in-time system of supplier and customer relations. In their view, the Japanese production system is characterized by a high degree of functional integration both inside the factory, through the breaking down of functional specialization and integration of workers' minds with physical labor, and between factories, through the creation of tightly networked production complexes involving customers and suppliers in close interaction, and, ideally, in close proximity with one another (Florida and Kenney 1991: 395). Florida and Kenney set this, admittedly stylized, model of the Japanese production system against a model of the production organization characteristic of traditional U.S. manufacturing.

Based on the findings from their survey and extensive site visits to transplant establishments in auto parts supply and assembly, Florida and Kenney conclude that Japanese transplants have been successful in transferring to the U.S. essential elements of the Japanese production system model. At the same time, their data show considerable diversity in the specific forms in which this transfer has taken place. As with Milkman's study, Florida and Kenney's research suggests that there is no monolithic model of practice followed by all or even most Japanese manufacturers in the U.S.

Because their focus was on the question of whether the transfer of Japanese production systems to a foreign culture and economic environment is possible, Florida and Kenney did not attempt to account for this diversity. This was a key question addressed by the research described in this report.

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BIOGRAPHIC MATERIAL FOR THE RESEARCH TEAM

Richard Florida served as Principal Investigator on this study. He is Director of the Center for Economic Development and Professor of Management and Public Policy and Carnegie Mellon University. He is the co-author (with Martin Kenney) of *Beyond Mass Production: The Japanese System and Its Transfer to the United States* (Oxford University Press, 1993), and *The Breakthrough Illusion: Corporate America's Failure to Move from Innovation to Mass Production*, (Basic Books, 1990). Florida has written more than 75 articles. He earned his Bachelor's degree from Rutgers College, did advanced graduate work at MIT, and received his Ph.D. from Columbia University.

Davis Jenkins served as Research Director for the study, responsible for survey-based research on work and production system innovation in Japanese transplants and their U.S. suppliers. Jenkins is currently completing his doctoral dissertation, entitled, *Japanese Transplants and the Work System Revolution in the United States* at Carnegie Mellon University. Formerly, Jenkins was a research associate at the University of Pittsburgh's Learning Research and Development Center, where he directed the Applied Learning initiative of the New Standards Project, a multi-state partnership seeking to better prepare school-age young people for the workplace of the future by creating a system of high standards and assessments of student performance in relation to those standards. Jenkins spent eight years with the Academy for Educational Development, an international consulting firm, providing technical assistance to manufacturers and community colleges throughout the U.S. on the development of "total quality" approaches to training for advanced production systems. He holds a BA in Religion and Philosophy from Princeton University.

Donald F. Smith Jr. served as research associate and later as research consultant on the project. Smith is currently Executive Director of the CMU Center for Economic Development, and was previously a member of the RAND Corporation Critical Technologies Institute in Washington, DC. Smith carried out the research on the economic geography of the Japanese transplants and completed his doctoral dissertation titled *The Economic Geography of Japanese-Affiliated Manufacturing Establishments in the U.S.: An Econometric Analysis of the Role of Industrial Organization, Production Organization and Regional Specialization* at CMU.

Mitsumasa Motoya served as a research assistant on the project during 1993-1994, when he was a student in the joint Masters Collaborative Program in Public and Private Management at CMU. He played a central role in analysis and translation of Japanese language documents and data and was instrumental in helping secure Japanese-language data on direct investment and in serving as liaison for the group with Japanese managers, scholars and government officials in the U.S. and Japan. Motoya is a graduate of the University of Tokyo, where he received a Bachelor of Law, and currently a manager with the West Japan Railway Company.

Martin Kenney, Professor of Applied Behavioral Science at the University of California at Davis, served as a consultant during the initial phases of the project providing advice on the development of the survey and field research instruments.

Table 1

**Japanese Transplants Sampling Frame
by Industry**

Industry (SIC code)	No. of Plants
Transportation Equipment (37)	265
Chemicals (28)	226
Electronics (36)	226
Industrial Machinery (35)	216
Rubber and Plastics (30)	136
Instruments (38)	92
Primary Metals (33)	89
Fabricated Metals (34)	83
Glass (32)	39
Other/Unclassified	37
TOTAL	1,409

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Table 2

Adoption of Innovative Work Practices by Japanese Transplants by Industry

	All	Chem.	Rubber/ Plastic	Metals/ Glass	Fabr. Metal Prods.	Indus. Mach.	Electric Equip	Electron-ic Equip	Transport Equip	Instrum-ents
Self-Directed Teams: Any	43.7	41.5	45.8	59.5	42.1	51.9	54.6	37.4	44.2	24.9
Self-Directed Teams: ≥50%	33.0	36.5	23.2	47.6	34.2	42.6	34.7	28.0	38.4	10.0
Job Rota.: Any	63.1	64.3	53.6	66.4	65.8	69.0	69.3	61.5	68.3	50.0
Job Rota.: ≥50%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
QCs: Any	77.5	76.0	91.0	79.7	77.3	68.3	90.7	77.8	89.1	30.3
QCs: ≥50%	40.5	51.9	41.6	39.1	40.3	39.6	28.0	38.9	31.7	31.0
S.D.Teams+Rotation+QCs: Any	27.1	26.2	23.8	35.7	27.3	34.1	38.6	22.9	35.8	5.0
S.D.Teams+Rotation+QCs: ≥50%	11.9	16.6	13.6	19.6	10.7	15.5	9.3	8.4	5.0	3.8
TQM: Any	62.1	60.6	69.0	72.6	56.4	54.2	56.0	68.4	76.6	34.0
TQM: ≥50%	40.2	41.5	41.7	40.5	37.1	41.8	30.7	46.5	49.9	19.0
SPC: Any	70.1	51.9	88.6	69.9	74.1	55.1	85.3	79.2	79.1	43.9
SPC: ≥50%	29.8	22.4	35.8	28.0	44.2	14.0	28.0	33.8	25.9	15.0

Data for Japanese-affiliated manufacturing plants in the U.S. are from a 1994 survey by Richard Florida and Davis Jenkins of Carnegie Mellon University.
"≥50%" indicates that at least 50% of production workers in a plant participate in the given practice.
Observations have been weighted to produce estimates for the entire population of plants sampled in each case.

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Table 3

Adoption of Innovative Work Practices
by Japanese Transplants and U.S. Manufacturers

Practice	Japanese Transplants[1]	U.S. Manufacturing Plants [2]
Self-directed Teams: % of Plants	43.7	50.0
Self-directed Teams: % Participation	31.5	34.9
Job Rotation: % of Plants	63.1	52.0
Job Rotation: % Participation	NA	33.9
Quality Circles: % of Plants	77.5	50.7
Quality Circles: % Participation	41.7	34.1
S.D. Teams and Job Rotation and Quality Circles: % of Plants	27.1	19.3
S.D. Teams and Job Rotation and Quality Circles: ≥ 50% Participation	11.1	9.7
TQM: % of Plants	62.1	47.6
TQM: % Participation	40.1	34.9
Statistical Process Control: % of Plants	70.1	52.3
Statistical Process Control: % Participat.	30.8	28.6
Off-the-job Training for Production Workers: % of Plants	79.2	70.9
Off-the-job Training for Production Workers: % Participation	39.7	27.8
No layoff pledge to production workers?	52.1	40.2
Group incentive compensation (e.g. gain sharing) for production workers: % of Plants	13.4	12.4
Pay for skills for production workers: % of Plants	45.6	36.9
Profit sharing for production workers: % of Plants	50.3	42.1

[1] Data for Japanese-affiliated manufacturing plants in the U.S. are from a 1994 survey by Richard Florida and Davis Jenkins of Carnegie Mellon University.
[2] Data for U.S. manufacturing plants are from a 1992 survey by Paul Osterman and published in Osterman (1994). Only data for plants in industries comparable to those in the Florida and Jenkins survey are reported here.
Observations have been weighted to produce estimates for the entire population of plants sampled in each case.
"% of Plants" indicates the percentage of plants in the given sample that use the given practice. "% Participation" indicates the percentage of production workers in a plant who are involved in the given practice.

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Table 4

Adoption of Innovative Work Practices by U.S. Manufacturers by Industry

	Manufacturing Plants in the U.S. (1994)[1]									
	All[2]	Chem.	Rubber/ Plastic	Metals/ Glass	Fabr. Metal Prods.	Indus. Mach.	Electric Equip	Electron-ic Equip	Transport Equip	Instrum-ents
Self-Directed Teams: Any	50.0	23.2	37.6	32.5	52.8	65.5	63.5	57.3	76.8	85.7
Self-Directed Teams: ≥50%	35.8	17.0	25.9	13.1	38.4	57.0	45.0	28.0	59.9	61.8
Job Rota.: Any	52.0	52.7	88.3	55.1	50.4	27.1	39.2	36.8	87.6	70.7
Job Rota.: ≥50%	34.4	33.7	80.6	15.6	32.0	19.3	3.4	25.5	69.5	61.8
QCs: Any	50.7	42.2	66.5	27.8	58.7	40.9	72.8	51.8	92.3	30.1
QCs: ≥50%	32.9	37.3	28.9	22.5	38.1	33.1	39.0	11.3	72.6	21.9
S.D.Teams+Rotation+QCs: Any	19.3	10.3	30.6	3.0	21.8	16.6	38.8	10.3	68.3	13.7
S.D.Teams+Rotation+QCs: ≥50%	9.7	7.9	12.5	0.4	8.2	16.5	3.0	0.3	51.0	8.9
TQM: Any	47.6	33.1	54.5	27.5	54.4	63.3	67.4	22.0	40.9	48.7
TQM: ≥50%	33.6	28.0	18.6	22.6	35.9	48.3	55.7	19.3	25.1	44.6
SPC: Any	52.3	44.7	66.4	72.0	60.3	36.3	41.7	39.7	91.2	28.0
SPC: ≥50%	30.3	35.4	46.6	36.1	31.5	22.9	16.5	28.3	13.9	13.1

[1] Data for U.S. manufacturing plants are from a 1992 survey by Paul Osterman and published in Osterman (1994).
[2] This column gives the averages for the manufacturing industries listed in the other columns. This does not include plants in other manufacturing industries such as food, lumber, etc..
"≥50%" indicates that at least 50% of production workers in a plant participate in the given practice.
Observations have been weighted to produce estimates for the entire population of plants sampled in each case.

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Table 5

Adoption of Innovative Work Practices by Japanese-Affiliated Auto Supplier Transplants, 1988 and 1994

	Florida and Kenney 1988	Florida and Jenkins 1994	Florida and Jenkins 1994[1]
Any Teams	76.7	75.3	72.2
Any Self-Directed Teams	71.2	48.4	33.3
Job Rotation Between Work Groups	61.6	65.2	66.7
Any Quality Circles	44.4	85.7	83.3
2 or Fewer Job Classifcations	43.0	34.7	58.3
Teams+Rotation+ QCs=3	22.2	33.9	16.7
Teams+Rotation+QCs+ Few Job Classifcations =0	9.5	1.8	0.0
=1	15.9	22.4	25.0
=2	27.0	28.6	25.0
=3	31.8	32.6	33.3
=4	15.9	14.7	16.7
CLUSTER3 "Taylorist"	NA	29.2	35.7
"Transitional"	NA	18.4	17.9
"Learning-Intensive"	NA	52.4	46.4
CLUSTER5 "Highly Taylorist"	NA	4.2	3.6
"Taylorist"	NA	25.0	32.1
"Transitional"	NA	18.4	17.9
"Learning-Intensive"	NA	24.5	21.4
"Highly Learning-Intensive"	NA	27.8	25.0

All figures are expressed as the percentage of establishments using the practices indicated.
[1]These figures are for the 36 plants in the 1994 survey sample that also responded to the 1988 survey by Forida and Kenney.

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Table 6

Taylorist vs. Learning-Intensive Work Systems

	Taylorist	Learning-Intensive
Organization of Production Work	Production work carried out by individuals as narrowly defined, often repetitive, tasks Production work supervised by managers	Production work carried out by teams with broad authority Teams supervised by production worker "team leaders"
Problem-Solving Groups	Workers generally not given time apart from production duties to discuss problems with the production system and work environment	Quality circles give workers time away from production duties to work together in identifying and solving problems
Compensation	Hourly pay based on job classifications tied to seniority Pay for performance only based on "piece rate"	Pay contingent upon group or organizational performance as well as seniority, and bonuses given for skills learned
Locus of Quality Control	Quality control carried out and enforced by specialists	Production workers responsible for quality of work in process
Suggestion Systems	Workers not asked to contribute ideas for improvement	Suggestion systems established to solicit and act on workers ideas for improvement
Hiring	Little screening of applicants for production jobs. Hiring criteria emphasize previous experience in similar jobs	Rigorous screening of applicants. Hiring criteria emphasize problem solving, teamwork and ability to learn
Information Sharing	Management does not usually share information on costs and plant and firm performance with workers	Management regularly shares information with workers about costs, financial performance, plans for new product introductions, etc.
Control of Job Design	Work methods defined by industrial engineers and supervisors	Production workers are actively involved in setting and improving work methods
Training	Formal, off-the-job training offered primarily to mangers and other professional employees. Training for production workers confined to safety, machine operation and company policies	Extensive, regular training of employees at all levels. Production workers trained in problem solving and quality control as well as technical skills, machine operation, safety and company policies

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project*, Center for Economic Development, Carnegie Mellon University, May 1995).

Table 7

Dimensions of a Learning-Intensive Work System

Dimension Element	**Motivates Initiative/Commitment**	**Develops Skill/Knowledge**	**Enhances Authority/ Opportunity**
Teamwork			
Worker Teams	X	X	X
Problem-Solving Groups	X	X	?
Compensation Tied to Group Performance	X		
Low Status Differentiation	X		
Shop Floor Quality Control			
Training in Quality Methods	X	X	
Decentralization of Quality-Related Tasks	X	X	X
Suggestion System	X	X	?
Empowerment and Trust			
Rigorous Screening of New Hires	X	X	
Information Sharing	X	X	
Low Functional Specialization	X	X	X
Workers Define Work Methods	X	X	X
Skill Development			
Training	X	X	
Training of Supervisors and Managers	X	X	
Job Rotation	X	X	X
Promotion from Within	X	X	X

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Figure 1

Elements of a Learning-Intensive Work System

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

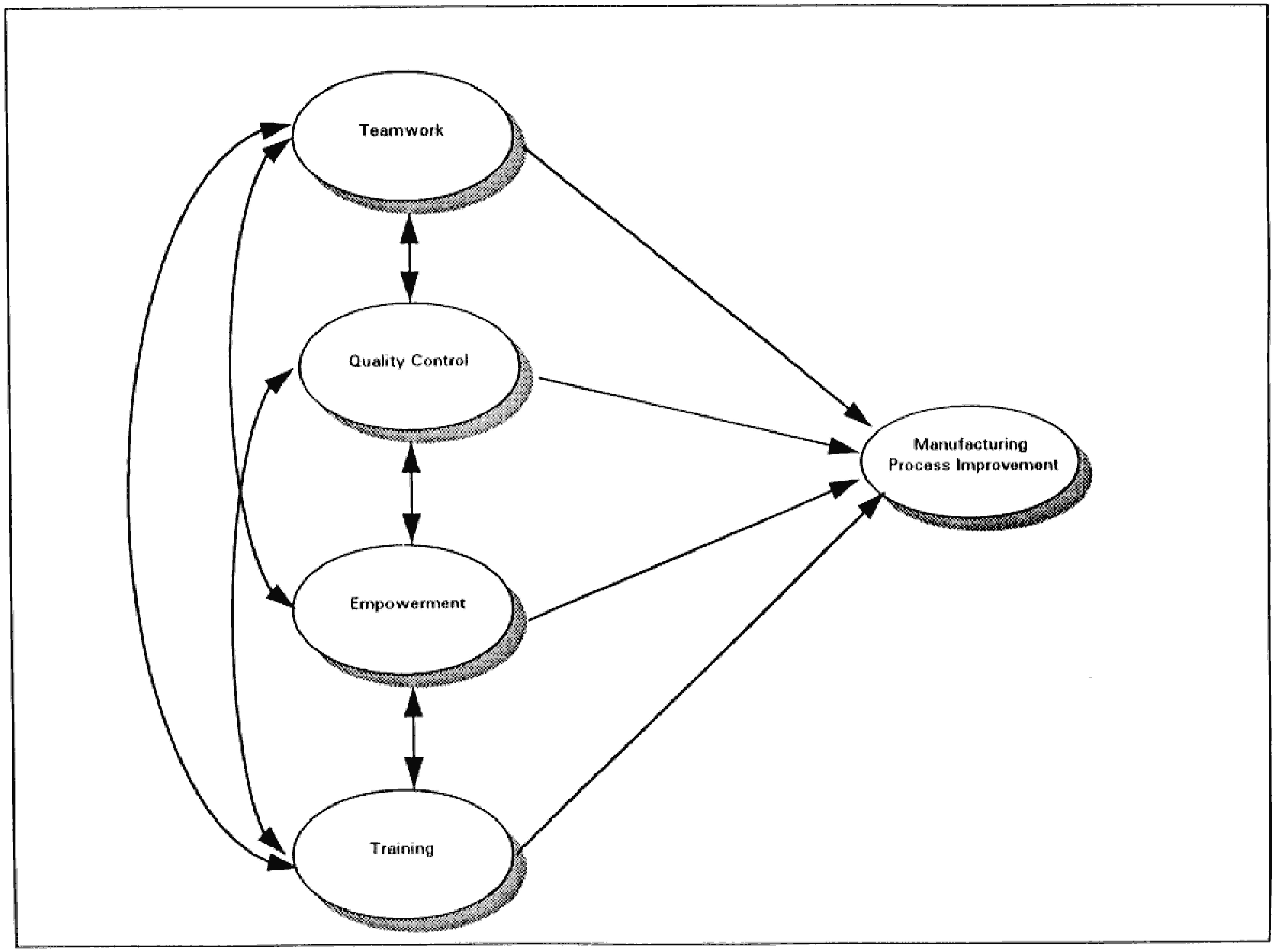
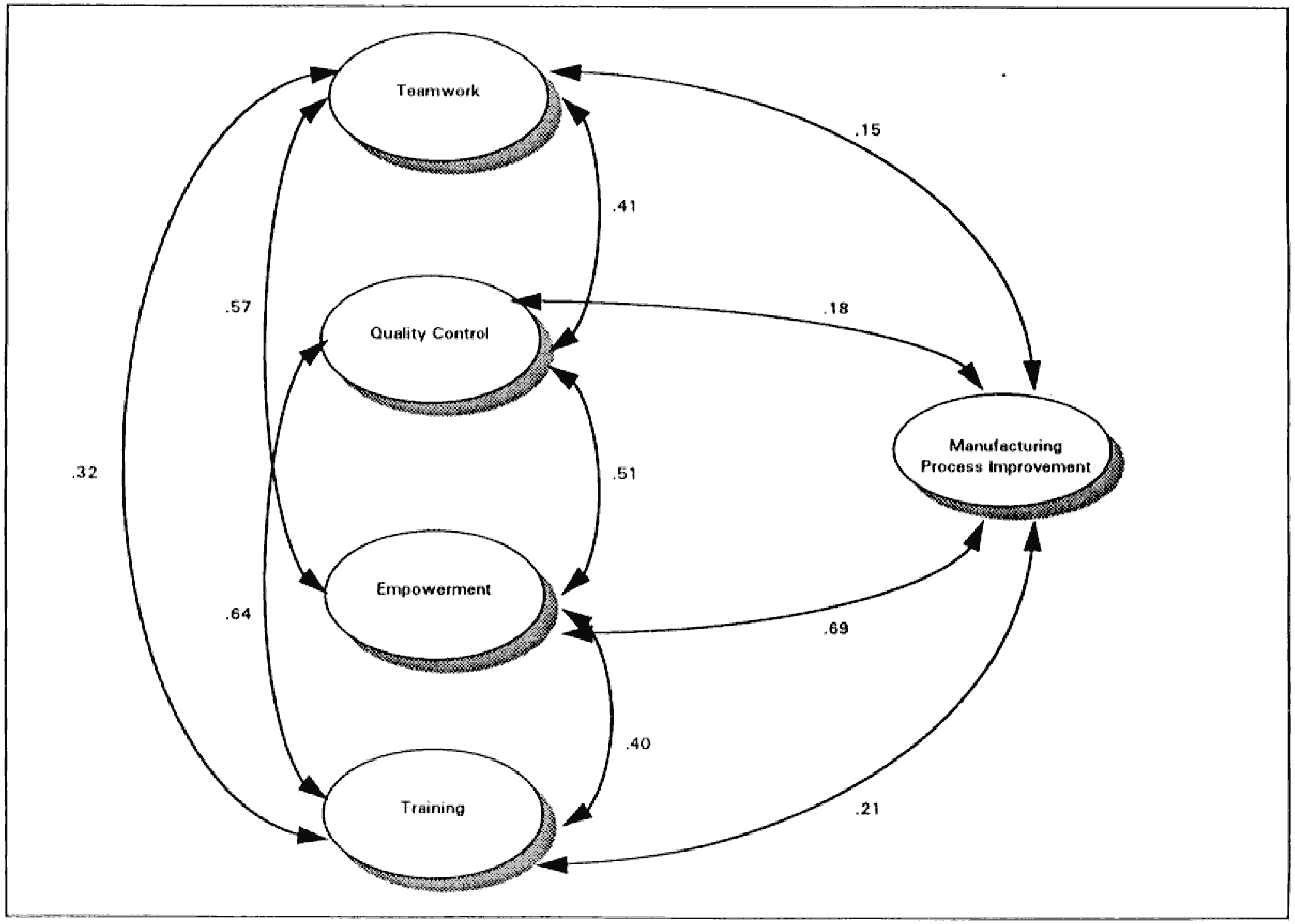


Figure 2

Dynamic among Elements of a Learning-Intensive Work System: Results of a Structural Equations Model

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).



Note: All covariances are statistically significant at the $p < 0.01$ level.

Table 8

Key Characteristics of Taylorist, Transitional, and Learning-Intensive Plants

Plant Characteristic	Work System Regimes		
	Taylorist (Clusters 1 and 2)	**Transitional (Cluster 3)**	**Learning-Intensive (Clusters 4 and 5)**
Industry	Instruments Industrial Machinery	Chemicals Transportation Equipment, Electronics	Metal/Glass Fabrication Fabricated Metal Products
Supplies Auto Industry?	No	ns	Yes
% of Output Exported	ns	ns	ns
Age of Plant	ns	Oldest	ns
Tenure of Management Regime	Short	Long	ns
Brownfield (vs. Greenfield)	ns	ns	ns
Employment Size	Small	Large	Mid-sized
Capital Intensity	Low	ns	High
Wages	Low	High	Mid-range
Union	No	Yes	ns
% Workers Who Are H.S. Graduates	Lower	ns	Higher
% Workers w/ At Least Some College	ns	ns	ns
Hiring Criteria: Production Workers	Experience in Similar Job	ns	Team Work, Problem-Solving Skills, Technical Training
No Layoff Pledge to Workers	No	ns	Yes
Active Efforts to Avoid Layoffs	Limited	Extensive	Extensive
Recent Down-sizing?	ns	Yes	ns
Turnover rate	ns	High	ns
Obstacles to Performance Improvement	ns	"Inadequate skills of prod. workers" "Programs still new"	"Programs still new"

"ns" indicates that there is no statistically significant relation between the given characteristic and work system type at the $p < .01$ level.

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Table 9

Productivity (Sales per Employee) by Work System Regime and Industry
Japanese-affiliated Manufacturing Plants in the U.S.

	Plants Grouped by Work System Regime		
Industry	Taylorist	Transitional	Learning-Intensive
Transportation Equipment	198.8	287.0	407.3
Chemicals	289.1	366.3	430.4
Primary Metals/Glass	237.5	131.4	362.9
Electronics	239.7	159.7	282.2
Rubber/Plastic Prods.	131.9	290.5	158.5
Fabricated Metal Prods.	165.1	170.1	153.0
Electrical Prods	187.6	238.3	179.4
Industrial Machinery	343.8	185.6	212.2
Instruments	353.0	114.1	165.4

Note: All figures are in thousands of dollars.
Source: Richard Florida and Davis Jenkins, *Survey of Japanese-affiliated Manufacturers in the U.S.*, Carnegie Mellon University, 1994.

Table 10

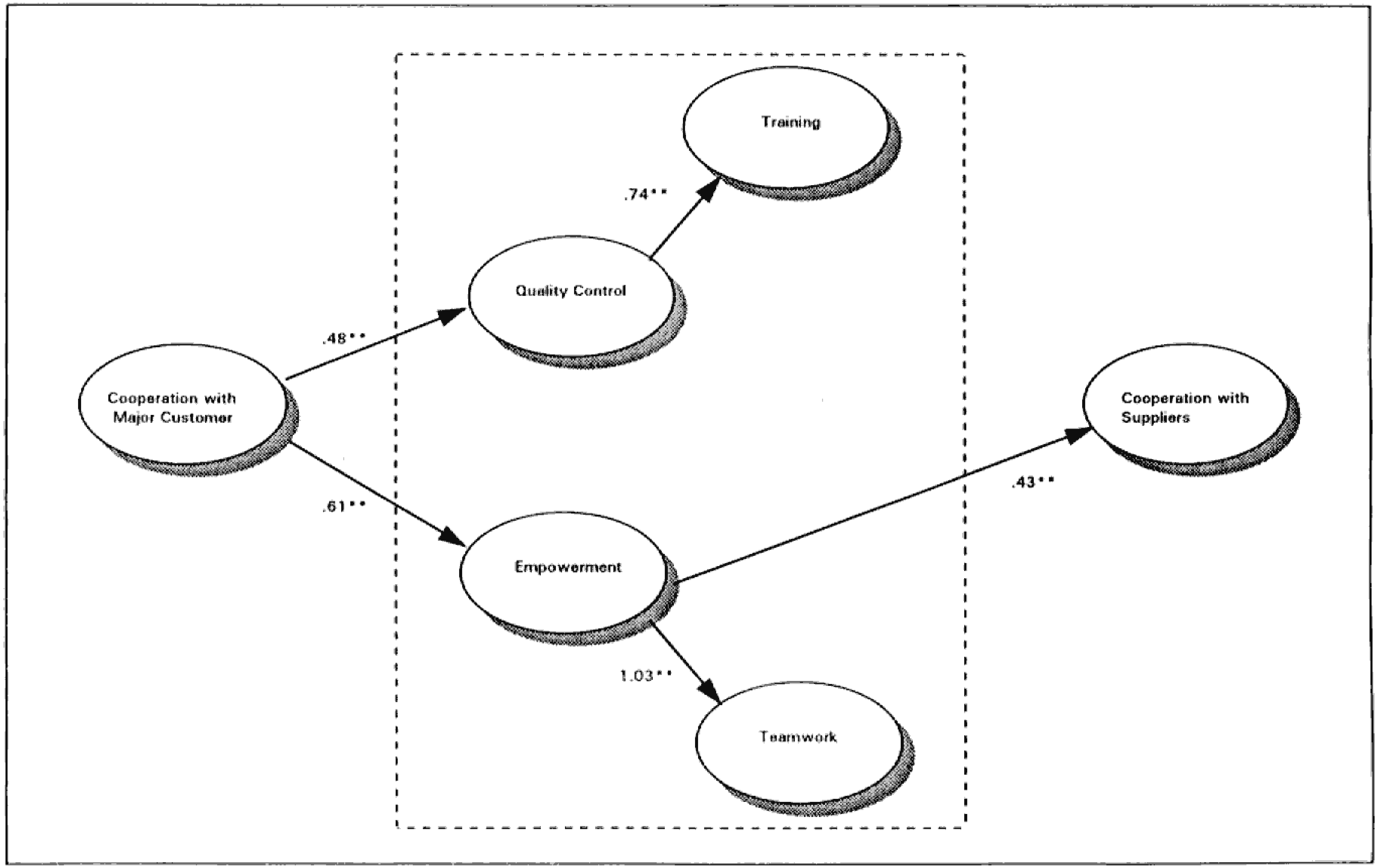
Innovative Work Systems and Customer-Supplier Relations

	Production Workers	Suppliers
Careful Selection	Rigorous screening of appplicants with a view to hire workers with initiative and problem-solving ability	Supplier screening and certification aimed at finding suppliers willing and able to contribute to product design and quality control.
Information Sharing/ Communication	Workers informed about performance of products they produce	Suppliers asked to provide detailed information on the quality and costs of production. (Cost engineering approach.)
Person-to-person Contact	Managers and other support staff closely with production workers on the shop floor	Frequent visits to suppliers for relationship building, certification and technical assistance
Skill/Capacity Building	Training of workers in quality control and problem-solving as well as technical skills and knowledge	Technical assistance to suppliers on manufacturing process improvement, human resource management, etc.
Cooperation in Design	Workers play active role in designing and revising work methods in cooperation with managers and engineers	Suppliers cooperate with customer in product design, eventually taking primary responsibility for it

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

Figure 3
Customer-Supplier Relations and Innovative Work Systems: Results of a Structural Equations Model

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).



Note: Only paths for statistically significant coefficients are shown.
*$p < .05$ **$p < .01$

Table 11

Customer and Supplier Relations by Work System Regime

Plant Characteristic	**Work System Regimes**		
	Taylorist (Clusters 1 and 2)	**Transitional (Cluster 3)**	**Learning-Intensive (Clusters 4 and 5)**
Relations w/ Customers and Suppliers	Arm's Length	ns	Cooperative
Place in Supply Chain	Finished Equipment or Goods Producer	ns	Components Supplier
EDI with Customer and Suppliers	No (all plants) No (Auto Suppliers)	ns	Yes (all plants) Yes (Auto Suppliers)
Customer Certifies Plant as Supplier	No (all plants) No (U.S. Auto Suppliers)	Yes (all plants) ns (U.S. Auto Suppliers)	ns (all plants) Yes (U.S. Auto Suppliers)
Plant Certifies Its Suppliers	ns (all plants) No (U.S. Auto Suppliers)	ns (all plants) Yes (U.S. Auto Supliers)	ns (all plants) Yes (U.S. Auto Suppliers)
Major Customer is Japanese-affiliated	ns	ns	ns

"ns" indicates that there is no statistically significant relation between the given characteristic and work system type at the $p < .01$ level.

Source: Richard Florida and Davis Jenkins, *Japanese Transplant Project* (Center for Economic Development, Carnegie Mellon University, May 1995).

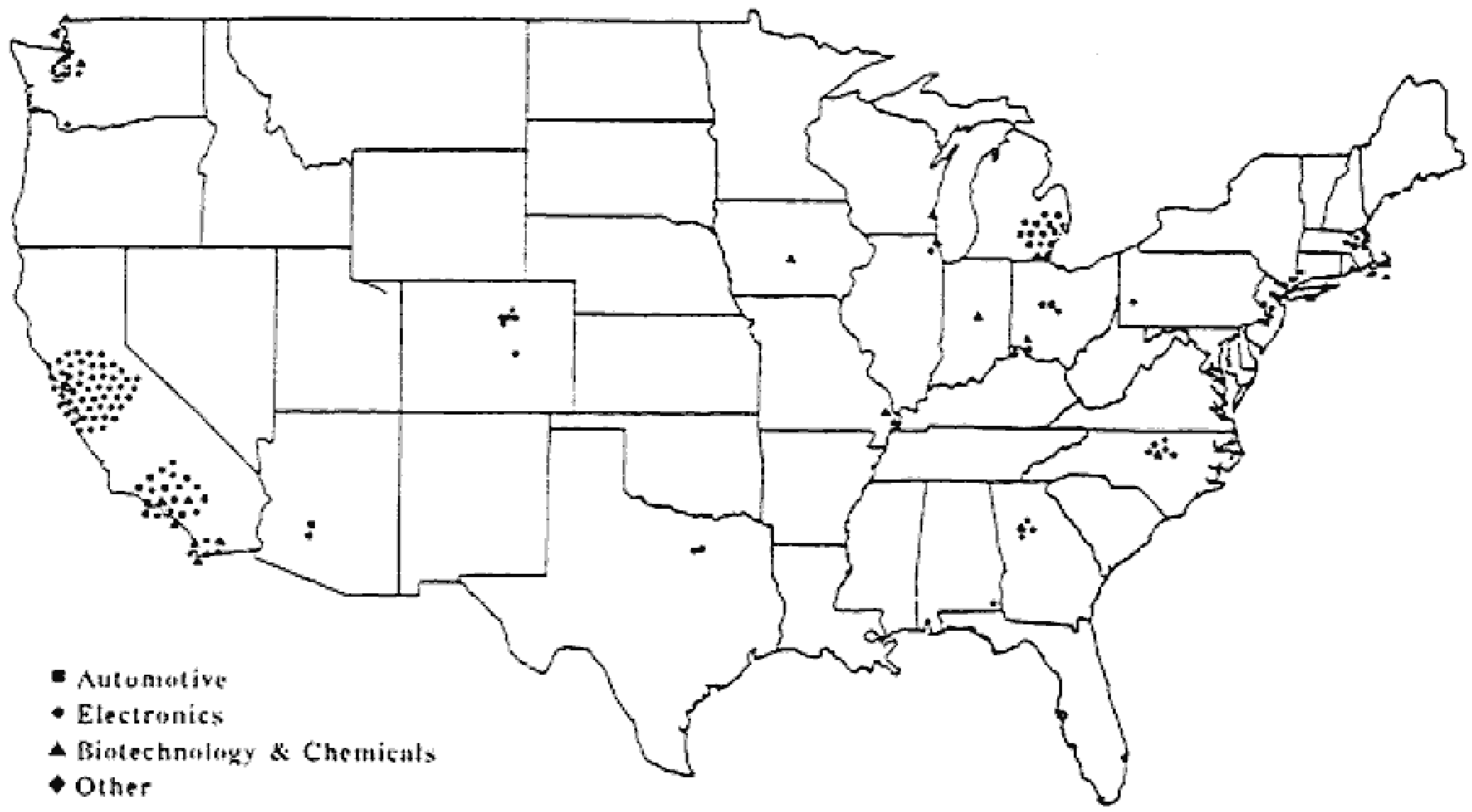
Table 12

Peak Year for the Adoption of Innovative Work Practices
Manufacturing Plants in the U.S.

Practice	U.S. Manufacturing Plants[1]	Japanese-affiliated Transplants[2]
Job Rotation	1983	NA
Self-directed Teams	1986	1989
SPC	1987	NA
Quality Circles	1988	1989
TQM	1989	1990

[1] Estimate based on data on manufacturing plants in the U.S. from a 1992 survey by Paul Osterman and published in Osterman (1994).
[2] Estimate based on data on Japanese-affiliated manufacturing plants in the U.S. from a 1994 survey by Richard Florida and Davis Jenkins of Carnegie Mellon University.

Figure 4
Japanese R&D Facilities in the U.S.



Source: Author's data base compiled from Japan Economic Institute (various years), *Directory of American Research and Technology* (various years), Dalton and Serapio (1993).