The Japanese Transplants in North America: Production Organization, Location and R&D

RICHARD FLORIDA
H. John Heinz III Professor of Economic Development
Director, Center for Economic Development
H. John Heinz III School of Public Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213
Fax: (412)268-5161
E-mail: rlflorida@aol.com

DAVIS JENKINS
Faculty Fellow, Great Cities Institute
Research Ast. Professor, College of Urban Planning and Public Affairs
University of Illinois at Chicago
322 S. Green Street, Suite 108
Chicago, IL 60607
Tel: (312)996-8059
Fax: (312)996-8933
E-mail: davis@uic.edu

DON SMITH
Co-Director, Center for Economic Development
H. John Heinz III School of Public Policy and Management
Carnegie Mellon University
Pittsburgh, PA 15213
Fax: (412)268-5161
E mail: ds2i@andrew.cmu.edu

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Introduction

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, electronics and other industries and, more generally, as the foundation for a new and superior form of capitalist industrial organization (Lazonick 1990; Abo 1993; Kenney and Florida 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 manufacturing facilities in the U.S. increased more than fivefold from 240 to 1,380 plants, and the number of American workers employed by Japanese manufacturing plants increased from 52,339 to 340,000. This wave of investment focused attention on whether Japanese companies were transferring innovative production work systems to their U.S. transplant operations.

Florida and Kenney (1991a, 1991b; Kenney and Florida 1993) found that Japanese automotive transplants effectively transferred core elements of Japanese production organization, human resources systems 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 in the U.S. of an integrated Japanese-style just-in-time production complex of automobile assembly and automotive component parts (Mair, Florida and Kenney 1988). The MIT International Motor Vehicle Program noted that Japanese automotive transplants represent important models of lean production that could provide learning opportunities for U.S. firms (Krafcik 1986; Womack, Jones and Roos 1990). Numerous case studies of the automotive transplants documented the successful transfer of elements of the Japanese production systems 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 of Japanese innovations is by and large not taking place outside of a few well-publicized cases.

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

This chapter examines the experience of the Japanese transplants in the United States across industrial sectors. It reports findings from a decade-long research project at Carnegie Mellon University on the transfer and adoption of innovative production work practices by the transplants, on their location decisions, and on the transfer and establishment of research and development laboratories by Japanese industrial corporations in North America.

Research methodology: transplant database, field research and survey

To shed light on these issues, the project constructed a comprehensive database of all Japanese-affiliated manufacturing establishments 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, JETRO, the Japanese Automobile Manufacturers Association, the Japanese Economic Institute, and others confirm that this database is the most comprehensive listing of Japanese-affiliated 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 automobile manufacturing establishments in the U.S.

Field research was conducted at a selected sample of Japanese transplants and plants of U.S.- owned manufacturers that supply the transplants. 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. A second component of the field research consisted of site visits to and interviews with two economic development agencies. A third component of the field research examined the capabilities of Japanese R&D and production 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.

Finally, a national survey of Japanese transplants was conducted. The survey obtained extensive information on production work organization, supplier relations, plant characteristics and performance of Japanese manufacturing transplants and a selected sample of U.S.-owned manufacturing plants that serve as the suppliers to the Japanese transplant automobile assemblers.

The sample of Japanese transplants was based on the 1,695 transplant establishments in the 1993 Japan External Trade Organization (JETRO) database. The Carnegie Mellon 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 complied by the Japan Economic Institute (MacKnight 1992); directories of Japanese-affiliated companies operating in the U.S., such as Toyo Keizai, 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 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 sample frame, resulting in a frame of 1,195 Japanese transplants and 338 U.S. suppliers to the transplants. The survey achieved an unadjusted response rate of 40 percent.

Adoption of Innovative Production Work Practices by Japanese Transplants

This aspect of the research was designed to overcome the limitations of previous research and to shed new light on the pattern of practice among the transplants in the wide range of industries in which Japanese manufacturers have a significant presence in the U.S. Specifically, this research examined the following questions:

- What is the pattern of adoption of innovative approaches to managing production work among Japanese transplant establishments?
- How does this compare to the pattern of adoption by U.S. manufacturers?

- How does the adoption of innovative work systems by the transplants vary by industry?
- What factors explain this variation?

Generally speaking, the results of the survey indicate that a sizeable proportion of the Japanese transplants have adopted innovative production work practices such as production worker teams, job rotation, total quality management, statistical process control and other innovative production work practices. More than half of transplants have made a no-layoff pledge to their workers, nearly half offer profit sharing plans and more than 45 percent pay workers for the skills and knowledge they acquire.

U.S. manufacturers differ

Our analysis compared the adoption of innovative work practices by the transplants to that of U.S. manufacturers, using data from our 1994 survey of the Japanese transplants and a 1992 survey of work organization in U.S. plants by Paul Osterman of MIT.[1]

As Table 1 shows, the transplants exhibit a somewhat higher rate of adoption of innovative production work practices. Twenty seven percent of transplants had adopted a combination of self-directed teams, job rotation and quality circles, compared to 19 percent of U.S.-owned manufacturing plants. 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 production work organization with a

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[1]Osterman's sample was limited to establishments with more than 50 employees. Restricting the sample to larger plants had the effect of eliminating the "tail" of the many smaller and presumably less innovative plants in the U.S. This explains why Osterman's U.S. plants seem surprisingly innovative compared to our sample of Japanese transplants.

supportive work or human resources 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 accumulate. That said, U.S. manufacturers are in general surprisingly innovative, and, in some cases, more likely to adopt innovative production work practices than the transplants. For example, U.S. manufacturers 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. Even so, this is perhaps not so surprising given that self-directed teams are more of an American or Western invention, though they reflect Japanese ideas of worker involvement (see Cole 1989).

Our analysis also explored differences in the adoption of innovative production work practices for the transplants and U.S. manufacturers on an industry by industry basis. Table 2 shows the distribution of practices by industry for the transplants (based on the Carnegie Mellon survey sample) while Table 3 shows the industry distribution for U.S. plants (from Osterman's sample). Among the transplants, four industry sectors—primary metals and glass, industrial machinery, electrical equipment, and transportation equipment—are relatively high adopters of innovative production work practices. Of these sectors, however, metals and glass and industrial machinery, show the highest rates of penetration of the use of innovative work practices in combination with one another. Japanese transplants in the instruments sector have a very low rate of adoption of clusters of innovative work practices.

As Table 3 shows, among the U.S. plants, transportation equipment was far and away the highest adopter 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. plants in this industry had a remarkable 68 percent rate of adoption of the cluster of practices consisting of self-directed teams, rotation, and quality circles, compared with less than 36 percent among transplants in that industry. The propensity of U.S. manufacturers in the automotive sector to adopt innovative work practices was confirmed by further analysis of data from our 1994 survey, which was also administered to U.S.-owned manufacturers that supply the Japanese transplant automobile assemblers. U.S. plants in the instruments and industrial machinery industries were also more likely than their Japanese counterparts to adopt innovative production work practices, while transplants in basic metals and glass were more innovative on the whole than U.S. plants in those industries. U.S. and Japanese transplants in the fabricated metal and electric equipment industries were about equally likely to adopt innovative production work practices.

Diffusion of innovative practices

We were particularly interested in seeing whether or not the transplants had deepened their use of innovative production work practices over time. To shed light on this issue, we compared the findings for the automotive-related transplants in our 1994 survey to the findings of the 1988 survey of Japanese automotive-related transplants conducted by Florida and Kenney. As Table 4 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 used quality circles but if they planned to do so. A substantial proportion of these plants were new and just starting production, and so they 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). The proportion of plants using these practices in combination with one another increased somewhat from 1988 to 1994. About a third of Japanese auto parts 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, a smaller proportion of plants in the 1994 survey used none of the innovative 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, Mixed and Innovative

Our field research revealed that highly innovative companies, such as Toyota and Nippondenso, see individual work practices in terms of their contribution to an integrated system of practices. Recent studies by MacDuffie (1994) and Ichniowski and Shaw (1995) have found that individual work practices have a more beneficial impact on organizational performance when used together as part of a broader "worker system."

This aspect of the research examined the distribution among the Japanese transplants of different approaches to managing production work, or what we refer to as "work system regimes." To do so, we developed a theoretically based model of a system of production work practices that promote organizational learning and knowledge mobilization, and then used confirmatory factor analysis to validate the model and cluster analysis to determine which plants fit that model and which plants fit other less innovative models. The basic characteristics of innovative work system regimes compared with more traditional Taylorist regimes are outlined in Table 5.

This analysis addressed the following questions.

- What are the bundles of practices that comprise various work systems regimes (e.g. Taylorist vs. Innovative)?
- How are these work system regimes distributed among the Japanese transplants? How does this vary by industry, and why?
- Are innovative regimes associated with higher levels of organizational innovation and performance?

Until rather recently, research on new forms of work 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 are used together as interrelated systems referred to variously as "transformed," "flexible," "high commitment" and "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 exploratory factor analysis to select practices for analysis and clustering techniques to classify systems of such practices into particular types.

MacDuffie (1994) 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 system practices) and those that reflect plant- or firm-level human resource policies affecting employees at all levels (human resource management or HRM policies). MacDuffie's findings provide strong empirical support for taking a systems perspective in attempting to understand the connection between innovative work organization and organizational performance. Additional support is provided in a study by Ichniowski and Shaw (1995) that 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 and Shaw 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 explore these issues using data from our survey of the Japanese transplants, we developed a model of an innovative work system. Our basic theory is that the defining characteristic of the new work system regimes is their ability to promote knowledge mobilization and organizational learning. The model consists of three dimensions—teamwork, worker involvement and training—each of which comprises a set of practices that contribute to organizational learning. We estimated this model empirically using a structural equations method that makes it possible to test hypotheses concerning not only which practices should be included in the model but also what are their interrelations. The results of the model confirmed our hypotheses. In our sample of plants, the three interrelated dimensions of the overall system of production work are found to be linked to the scale and scope of manufacturing process improvement activity—an important source of organizational learning. Figure 1 shows the results of the structural equations analysis. Efforts to involve workers by sharing information with them and giving them responsibility for quality control and job design were found to have the strongest link to manufacturing process improvement.

Following MacDuffie (1994), we used cluster analysis to group plants in the sample according to various work system regimes. Five clustering techniques were used to group our sample of transplants according to their use of the innovative work system practices validated using the structural equations analysis described above. Table 6 shows the means of the work practice variables for the three-cluster solution produced by Ward's method. Note that all variables have been standardized by transformation to z-scores to facilitate comparison among them. Three work system regimes emerged from this analysis, ranging from Taylorist to innovative. In the middle is a cluster of "mixed" approach 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 and worker involvement in shop floor quality control and job design.

A basic conclusion of this analysis is that plants in the innovative cluster do it all. They use a whole set of best practice approaches to organizing and managing work inside and outside the plant. In addition, they make use of concurrent engineering, engage in electronic data interchange with their customers and suppliers and design products to minimize adverse impact on the environment. Compared to plants in the other work regime clusters, innovative plants are more capital intensive and have better educated workers. Management in the innovative group of 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 steps to ensure job security for these workers. Automotive-related plants were most likely to be in the innovative cluster.

Plants in the "mixed" group tend to be large unionized that pay comparatively high wages. Older transplants in the electronics, chemicals, and rubber and plastics parts industries fall into this cluster. These plants are likely to have experienced recent restructuring or downsizing and to have experienced greater turnover of production workers. The mixed group of plants is distinguished by a heavy emphasis they place on training. These plants tend to view individual workers, rather than the overall system of production work, as the source of change, 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. Others among these plants may be using training as a means of "transitioning" workers toward a more innovative form of work organization.

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.

We also examined the performance impacts of different work system types. The results of this analysis were inconclusive. Part of the problem here is getting a systematic and comparable measure of performance across industries. We did however find a strong evidence of a connection between innovative work systems and a high level of production processes innovation, a key source of overall organizational performance.

Customer Supplier Relations and Work System Innovation

Customer supplier relations are increasingly seen as a potential mechanism for the diffusion of innovative production work organization (see Nishiguchi 1994). Japanese transplants like Honda and Toyota take considerable efforts to assist suppliers in the adoption of new and innovative production work systems. Florida and Kenney (1991a, 1991b) provided evidence that there is an elective affinity between innovative internal and external relationships among the Japanese transplant automotive parts suppliers they surveyed. 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 end user and supplier manufacturers in the adoption and diffusion of innovative production work systems, focusing on the following key questions.

- How do industrial networks of end users and suppliers affect the adoption and diffusion of innovative approaches to managing production work?
- Are plants that are high adopters of innovative production work practices also participants in innovative customer - supplier relationships?

These questions were 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 field research revealed that, among the transplants, both OEM manufacturers and first-tier suppliers are actively engaged in efforts to diffuse innovative production work organization through supplier networks. Toyota, for example, provides technical assistance to its suppliers, and has set up a semi-independent entity, the Toyota Supplier Support Center, to work with U.S.-owned suppliers that are interested in learning about the Toyota Production System. Toyota has also established the Bluegrass Automotive Manufacturers' Association, a supplier association, in an effort to accelerate the adoption and diffusion of innovative production work systems among suppliers to its Georgetown, Kentucky assembly complex. Nippondenso, a first-tier supplier to Toyota and other automobile makers, works closely with its suppliers to promote the adoption of innovative approaches to managing production work.

We conducted a series of analyses of our survey data to examine the connection between innovative work systems inside the plant and innovative customer supplier relations. Table 7 shows the hypothesized symmetry between internal and external relations. To test this relationship, we used a structural equations model and data from our 1994 survey. The findings here indicate that there is a strong connection between innovative work organization within the plant and close cooperation and communication with the plant's most important customer. As Table 8 shows, plants that adopted innovative work systems were more likely to engage in cooperative relationships with their suppliers. Put another way, the use of teamwork, worker involvement and training to achieve manufacturing process improvement within the plant is linked to a propensity to work closely with suppliers to improve product design, quality, delivery and cost. This suggests that customer and supplier relationships can reinforce innovative work systems and provide a mechanism for diffusing innovative production work organization through the supply chain.

Learning by U.S. Suppliers to the Transplants

In a influential 1993 study 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 production methods that generate improved productivity can be implemented with local workforces. Third, and most importantly, transplant producers transfer knowledge of best practice production work 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) 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. In a survey of purchasing managers at Japanese auto assembly transplants, 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 Japanese-affiliated and U.S.-owned, to meet Japanese standards for quality and pricing. However, they concluded that the overall high quality performance of suppliers to the transplant assemblers resulted more from the relocation of Japanese suppliers to the U.S. than improvement in the capacity of U.S.-owned suppliers through the transfer of managerial skills to those firms.

This aspect of the study examined the diffusion of innovative production work organization among U.S.-owned auto 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 addition 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 partners and/or customers?

The findings suggest that, in the automotive sector at least, U.S.-owned suppliers to the transplants are quite innovative in their approach to managing production work. However, no evidence was found that U.S.-owned manufacturers on a wide scale are adopting these innovations because of direct learning from their Japanese transplant customers.

There is very little difference in adoption of innovative production work systems between Japanese-affiliated and U.S.- owned suppliers of components to the transplant automotive assemblers. In fact, a slightly higher proportion of U.S.-owned auto parts suppliers have adopted an innovative approach to managing production work, although this difference is not statistically significant. U.S.-owned auto parts suppliers are also more likely than their Japanese counterparts to use Taylorist methods in managing production work. And, those that are older brownfield plants are significantly more likely to adopt Taylorist forms of work organization.

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 to the transplants. This plant has learned a great deal about new systems of production work organization from Toyota, and has made considerable progress in terms of both work systems and performance in the past five years.

On the other hand, the survey data provide no evidence of widespread direct learning between the transplants and their suppliers, whether Japanese-affiliated or U.S.-owned. We conducted econometric analyses of the factors that account for the adoption of innovative production work 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 production work practices. These analyses showed that supplier plants that have a close cooperative relationship with their main customer manufacturer are more likely to adopt innovative work methods than are plants that have arms' length customer relations. However, plants whose main customer was Japanese-affiliated were no more likely than other plants to adopt innovative production work systems.

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 between 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 and 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.

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 been misguided by at least four myths.

The first is that Japanese automotive-related industries 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 repel 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, including 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 (Sheard 1983; Asanuma 1985a, 1985b, 1989; Aoki 1988, 1990; Sako 1992; Dore 1983; Odaka et al. 1988). 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 with their suppliers 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 U.S. 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 automotive 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 (1,000) of the roughly 3,100 counties in the United States.

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 automotive-related 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 that 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 home in Japan. Others argue that Japanese companies are opening up state-of-the- art facilities in Silicon Valley, California, 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 (1989) 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. Our 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 in the U.S.

The past decade has seen an outpouring of geographic and 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 (see, e.g., Reich 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; 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; 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.

Our research indicates that Japanese R&D investment in the U.S. has grown substantially in recent years, increasing fourfold from $292 million in 1986 to $1.2 billion in 1990. Japanese companies currently operate 174 research, design and development facilities in the United States. Japanese R&D investment is concentrated in electronics and automobiles, which are the same sectors in which the bulk of Japanese manufacturing in the U.S. is concentrated. These are also industries in which Japanese manufacturers have in some cases achieved competitive advantage over U.S. producers. Japanese R&D investment in the biotechnology and the pharmaceutics 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 location pattern with R&D establishments located either in close proximity to manufacturing plants or close to leading U.S. technology centers. On one hand, the majority of investments are applied research and product development facilities located at or near existing Japanese-affiliated manufacturing sites. Such locations have been chosen to provide technical support to manufacturing facilities, design and develop products for the U.S. and North American regional markets, and enhance interaction between the factory and the R&D laboratory. On the other hand, a smaller number of facilities dedicated to scientifically-oriented basic R&D are located near major U.S. universities and scientific research centers such as Cambridge, Princeton, and Silicon Valley. The purpose of these investments is to gain access to multinational scientific and technical talent as a source of new knowledge which can reinforce existing corporate technological capabilities.

The globalization of innovation 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 location 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 have 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 that allocates different economic functions and capabilities to different physical locations. Our research 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 R&D and "innovation-mediated production" embedded in spatially concentrated networks of producers, suppliers and researchers. 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 itself with the shift to a virtually seamless system of innovation and production. The establishment of offshore R&D units functions to mobilize and harness the knowledge, ideas and social capability embedded in regionally based networks of innovation and production. As each firm in the network faces 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 networks of producers, suppliers and researchers. As such, they function to harness and integrate knowledge and intelligence in ways that reinforce these multiple dimensions of innovative and production activity.

Summary of Findings

The main findings of our 10-year study of the Japanese transplants in the United States are as follows. Based on a 1994 survey of the population of the Japanese-affiliated manufacturers in the U.S., we conclude that a substantial proportion of the Japanese transplants have adopted innovative production work practices such as work teams, quality circles and job rotation. However, the use of innovative work practices by the Japanese transplants varies considerably by industry. Transplants in primary metals and glass, industrial machinery, electrical equipment and transportation equipment tend to be adopters of innovative practices. In contrast, transplants in the instrument sector are not very likely to use such practices.

In general, the Japanese transplants are more likely to use innovative production work practices than U.S. manufacturers in the same industries. There are some notable exceptions. U.S. plants in transportation equipment were considerably more likely to adopt such practices than were their Japanese transplant counterparts. The transplants are more likely to reinforce innovative production work practices 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 on-the-job.

Comparing the results of the 1994 survey with those of our 1988 survey of the automotive-related transplants, we find that, at least in the automotive sector, the Japanese transplants have basically stuck with the practices and systems originally transferred to the United States. The proportion of plants using innovative practices such as teams, job rotation and small numbers of job classifications changed little between 1988 and 1994.

The approaches taken by the Japanese transplants to managing production work can be grouped into three work system types or "regimes:" innovative, mixed and Taylorist. Plants in the innovative group make use of a set of approaches to the management of work within the plant and relations with outside customers and suppliers that enhance organizational and inter-organizational learning. Transplants in the "mixed" work system group place a heavy emphasis upon training, but take a traditional or Taylorist approach to managing work on the factory floor. Some of these plants seem to view the individual worker, rather than the overall system of production work, as the source of obstacles to organizational improvement, and thus may see training as a means of improving organizational performance by improving the capability of individual workers. Others of these plants seem to use training as a vehicle for transitioning workers toward a more innovative work organization. Taylorist transplants, which are prevalent in the instruments industry, take a very traditional approach to managing relations both inside and outside of the plant.

Customer and supplier relations can be a catalyst for the adoption of innovative production work systems within the plant. Transplants that have adopted innovative work systems are more likely to engage in cooperative relationships with their customers and suppliers aimed at improving product design, quality, delivery and cost. Japanese automobile assemblers in particular are actively engaged in efforts to diffuse innovative production work systems through supplier networks. Toyota, for example, provides considerable technical assistance to its suppliers, and has set up a supplier support center and supplier associations for this purpose.

U.S.-owned suppliers to the automotive transplants are comparatively high adopters of innovative production work organization. It is unclear, however, to what extent these plants are learning about these practices from their transplant customers. While some U.S. suppliers, such as Johnson Controls, have learned a considerable amount from their transplant customers, there is no evidence from our survey research that, in general, having a Japanese manufacturer as a plant's most important customer increases the likelihood of direct learning from such customers.

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. The most important factor in the location decision of Japanese automotive-related transplants is the need to be near the plants of their key customers to facilitate just-in-time production.

Japanese transplants have supplemented their manufacturing investments with more recent investments in research, product design and development. Japanese R&D investment in the U.S. is geographically concentrated 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 location pattern with R&D establishments located either in close proximity to manufacturing plants or close to leading U.S. technology centers. The majority of investments are applied research and product development facilities located at or near existing Japanese-affiliated manufacturing sites. Such locations have been chosen to provide technical support to manufacturing facilities, design and develop products for the U.S. and North American regional markets, and enhance interaction between the factory and the R&D laboratory. A smaller number of facilities dedicated to scientifically-oriented basic R&D are located near major U.S. universities and scientific research centers such as Cambridge, Princeton, and Silicon Valley. 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.

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, in contrast to U.S. and European multinationals, which have tended to separate R&D from off shore branch plants, Japanese companies are developing integrated innovation and production capabilities in major markets outside Japan.

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Table 1
Adoption of Innovative Work Practices
by Japanese Transplants and U.S. Manufacturing Plants

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: % of Plants	27.1	19.3
S.D. Teams and Job Rotation and Quality: % 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.
[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 sample 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 each sample that use the given practice.
"% Participation" indicates the percentage of production workers in a plant who participate in the given practice.

Table 2
Adoption of Innovative Work Practices by Japanese Transplants by Industry

	Japanese-Affiliated Manufacturing Plants in the U.S. (1994)[1]									
	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

[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.
"≥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.

Table 3
Adoption of Innovative Work Practices by U.S. Manufacturers by Industry

	Manufacturing Plants in the U.S. (1992)[1]									
	All	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 of MIT and published in Osterman (1994).
"≥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.

Table 4
Comparison of Two Surveys
Adoption of Innovative Work Practices by Japanese Transplants

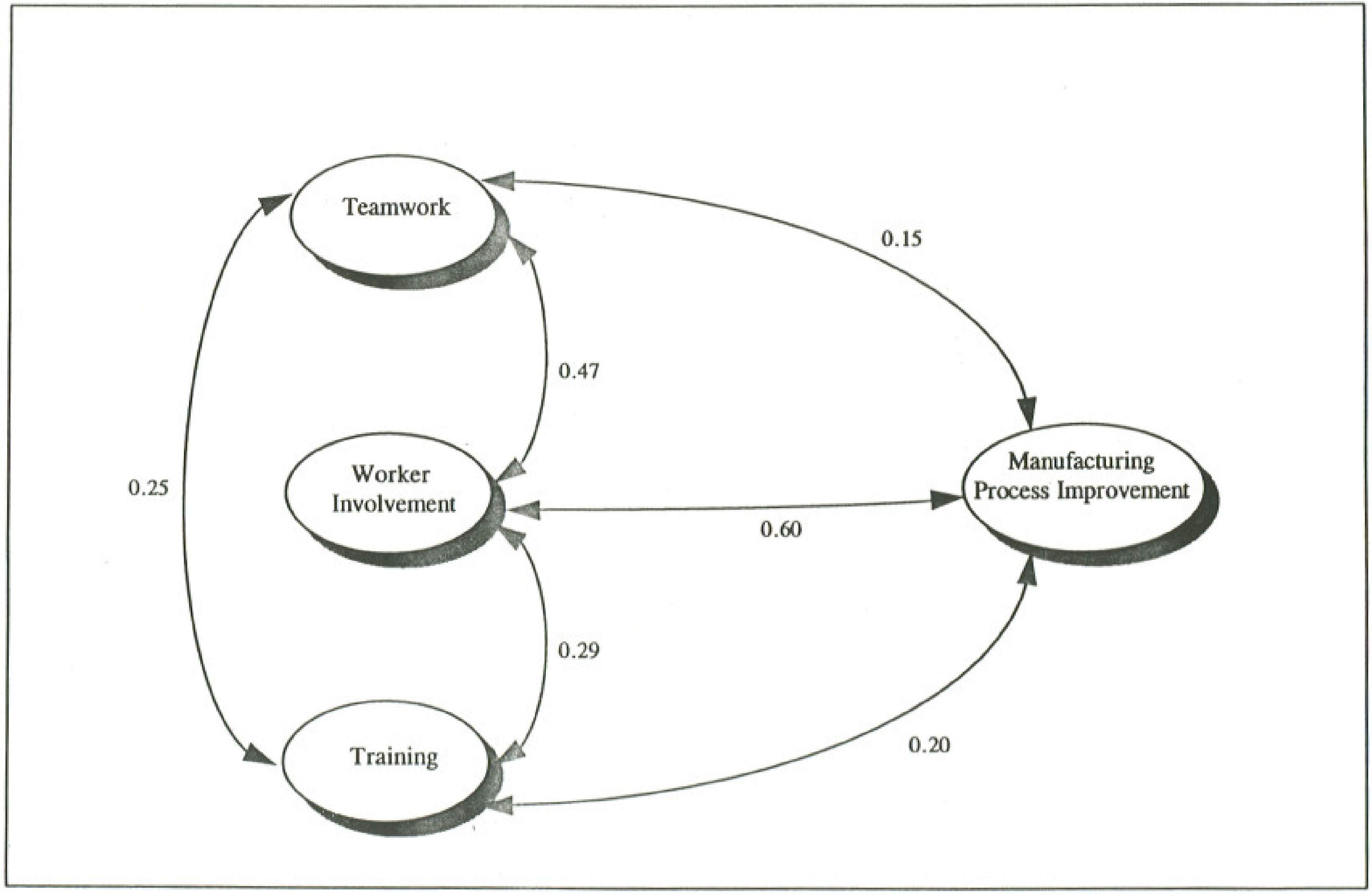
	Florida and Kenney 1988	Florida and Jenkins 1994	Florida and Jenkins 1994[1]
Any Teams	76.7	75.3	72.2
Any Self-Directed Teams	71.2	48.4	33.3
Job Rotation Between Work Groups	61.6	65.2	66.7
Any Quality Circles	44.4	85.7	83.3
1-2 Job Classifications for Production Workers	43.0	34.7	58.3
Teams+Rotation+QCs	22.2	33.9	16.7
Teams+Rotation+QCs+ Few Job Classifcations	15.9	14.7	16.7

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.

Table 5
Characteristics of Taylorist vs. Innovative Work Systems

	Taylorist	Innovative
Teamwork		
Production management	Closely supervised, narrowly defined tasks	Worker-led teams
Quality circles	No	Yes
Pay	Tied to job classification and/or seniority	Based on group performance
Worker Involvement		
Information sharing with workers	Limited	Extensive
Control of job design	Industrial engineers and supervisors	Production workers
Responsibility for quality control	Quality specialists	Production workers
Suggestion systems	No	Yes
Training		
Training of production workers	Limited	Extensive
Training of managers	Moderate	Extensive

Figure 1 Covariance Structure Model of an Innovative Production Work System
Covariances Among Latent Work System Dimensions
U.S.-based Japanese Transplants



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

Table 6

Means of Work System Variables by Plant Cluster
Three-Cluster Solution by Ward's Method for Pooled Sample of Plants

Work System Dimension Work practice	Cluster 1 (Taylorist)	Cluster 2 (Mixed)	Cluster 3 (Innovative)
Teamwork			
% of Prod. Workers in Teams	-0.37	-0.93	0.64
Worker Team Authority Scale	-0.47	-0.87	0.71
% of Prod. Workers in QCs	-0.32	-0.27	0.38
Group Pay Scale	-0.23	-0.15	0.26
Worker Empowerment			
Information Sharing with Production Workers	-0.27	-0.18	0.31
Extent of Prod. Worker Control over Work Methods	-0.48	-0.05	0.45
% of Workers Who Use SPC	-0.42	-0.12	0.41
Extent of Prod. Worker Involvement in Quality Control	-0.60	-0.13	0.39
Rate of Suggests from Workers	-0.23	-0.01	0.22
Skill Development			
% of Prod. Workers Trained	-0.64	0.84	0.31
Scope of Prod. Worker Training	-0.61	0.25	0.47
% of Managers Trained	-0.62	0.78	0.31
N	210	76	231

Note:
All variables have been standardized using the z-score transformation.

Table 7
Symmetry Between Innovative Relations Within the Plant and With Outside Suppliers

	Within the Plant	With Outside Suppliers
Selection	Rigorous screening of applicants with aim of hiring workers with initiative and problem-solving ability.	Screening and certification aimed at finding suppliers able to contribute to product design and quality control.
Information Sharing/ Communications	Workers informed about performance of products they produce.	Suppliers asked to provide detailed information on quality and cost of production (Cost Engineering approach).
Contact	Managers and support staff work closely with production workers on the shop floor.	Frequent visits to suppliers for relationships building, certification and technical assistance.
Skill/Capacity Building	Extensive training of workers in quality control and problem-solving as well as technical skills.	Technical assistance to suppliers on manufacturing process improvement, human resources management, etc.
Cooperation in Design	Workers play active role in designing and improving work methods.	Suppliers cooperate in product design.

Table 8

Customer and Supplier Relations by Work System Regime

Characteristic	Work System Regime Taylorist (Cluster 1)	 Mixed (Cluster 2)	 Innovative (Cluster 3)
Relations with Customers and Suppliers	Arm's Length	nss	Cooperative
Place in Supply Chain	Finished Equipment or Goods Producer	nss	Components Supplier
EDI with Customers and Suppliers	No	nss	Yes
Customer Certifies Plant as Supplier	No (U.S. Auto Suppliers)	nss	Yes (U.S. Auto Suppliers)
Plant Certifies its Suppliers	No (U.S. Auto Suppliers)	Yes (U.S. Auto Suppliers)	Yes (U.S. Auto Suppliers)
Major Customer is Japanese-affiliated	nss	nss	nss

"nss" indicates that there is no statistically significant association between the given characteristic and work system regime at $p < .01$.