Restructuring in Place: Japanese Investment, Production Organization, and the Geography of Steel*

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Abstract: Japanese investment has set in motion a restructuring of the U.S. steel industry. This restructuring is occurring on three related geographic scales. At the global scale, Japanese investment in U.S. steel reflects a more general shift in the center of steel production technology and accumulation from the U.S. and western Europe to Japan. Japanese advances are now diffusing back to the U.S. via Japanese direct investment and organizational restructuring. At the national level, within the U.S., Japanese investment reinforces a westward shift in the center of steel production from the traditional Pittsburgh region to Ohio, Michigan, and Indiana. This spatial redirection stems from the high fixed costs of integrated steel production, the importance of the automobile industry as a user of steel, and the particular requirement of supplying steel to the automotive transplants and their suppliers on a just-in-time basis. At the plant or organizational level, Japanese direct investment has set in motion a process of "in situ restructuring" or restructuring in place. This process has resulted in the remaking of preexisting social relations in the factory.

Key Words: steel, Japanese direct investment, restructuring, production organization.

The process of industrial development has an important geographic dimension, and the process of industrial location is in turn conditioned by underlying technological, economic, and organizational factors. Indeed, firms decide to locate and relocate within the context of strong orienting forces such as technological change, underlying modes of production organization, and existing industrial landscapes. The short-term decisions of putative individual actors are thus informed by interconnected structural forces. Such factors may make it difficult or unnecessary to abandon existing geographies. Landscapes may be either abandoned or rebuilt and transformed to harness a new technological and industrial trajectory and the new underlying model of production organization upon which it is based.

Theories of spatial and industrial restructuring have neglected the way that

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production organization influences geographic patterns. Prevailing theories conceptualize restructuring mainly in terms of the relocation of economic activity, with firms abandoning old regions and establishing new production systems in new places. Harvey's (1982; 1985a; 1985b) theory of the "spatial fix" views the development of new regions for accumulation as the fundamental element of the restructuring process. Storper and Walker (1989) emphasize the interaction between technical and spatial fixes and suggest that the restructuring of labor relations and interfirm networks is intrinsically linked with technical and spatial restructuring as part of a broader process of geographic industrialization. Despite these and other important contributions, current geographic theory for the most part fails to specify the deeper transformations at the point of production inside the factory that underpin the current epoch of technological, organizational, and spatial restructuring.

We focus on the tension between changing modes of production organization and spatial restructuring, particularly the restructuring of production in existing places. We advance a concept of "in situ restructuring," by which we mean restructuring that occurs when the existing geography remains fixed, but what occurs on and in that geography is fundamentally transformed. In situ restructuring involves not only the restructuring of the organizational forms and institutional structures that comprise the objective content of the production and labor process, but the remaking of human social relations at the micro-scale or everyday level and the reorientation of human behavior. Thus, the human labor force is the focal point of in situ restructuring. This human side of the restructuring process—what can be thought of as the restructuring of human labor power—is sorely neglected by both geographic scholarship and the corpus of social science theory, which focus on observable changes in regional and/or organizational forms and patterns and, for the most part, ignore the actual human behavior that occurs within those forms.

We explore the nexus of production organization and spatial restructuring through an empirical analysis of Japanese steel investment in the United States. We organize our argument around three main points. Our first point concerns the nature and scope of Japanese direct investment in the U.S. steel industry. Japanese investment in U.S. steel production is extensive and has set in motion significant restructuring of U.S. steel. Japanese direct investment in U.S. steel totals roughly $6.9 billion and involves major integrated steel mills, state-of-the-art steel galvanizing and finishing lines, and a significant number of smaller steel processing centers. This restructuring of U.S. steel production by the Japanese companies contrasts markedly with prevailing theories, which predicted an inexorable decline of integrated steel production in the U.S. and a secular trend toward disinvestment and deindustrialization of U.S. steel.

Our second point concerns the location of Japanese steel investment in the U.S. Japanese investment in U.S. steel is mainly concentrated on the preexisting terrain of the U.S. steel industry—the old core region of the industrial Midwest (see Meyer 1983; Page and Walker 1991). This stands in sharp contrast to recent geographic theories that predicted a geographic shift of steelmaking from the Midwest to newer "mini-mill" forms of production in the South and West and to the newly industrializing countries. Japanese steel production in the U.S. has taken the form of a spatially articulated production chain linking integrated steel producers and the automotive assembly transplant plants. Integrated steel production is concentrated at a small number of existing U.S. steel facilities; galvanizing and finishing lines, the next link in the chain, are located both at integrated mill sites and closer to automotive assemblers; and the steel processors are located close to the transplant automotive assemblers and component parts suppliers to facilitate just-in-time delivery, close interaction, and information-sharing. Japanese investment in U.S. integrated steel production has reinforced an ongoing locational shift from the Monongahela Valley toward automobile-related steel production in Ohio, Michigan, and Indiana. This spatial pattern is the result of two intersecting forces. On the one hand, Japanese steel production in the U.S. was motivated by transplant automotive production and thus is part of a broader process of backward integration and industrial complex formation with automobile production at its core. On the other hand, the tremendous fixed capital required for integrated steel production restricted Japanese producers to existing U.S. integrated facilities and thus to joint ventures with established U.S. producers.

Third and most fundamentally, Japanese investment is driving a deep technological and organizational restructuring of the U.S. steel industry. Japanese steel production organization is based upon functional integration of tasks, continuous improvement, just-in-time production and supply, and a synthesis of intellectual and physical labor (Kenney and Florida 1993). The Japanese steel firms are now striving to transfer this model to the U.S. This transfer is occurring both at new greenfield plant sites and, more importantly, at a series of existing, large, integrated steel facilities. The transfer process is transforming production organization, changing the objective content of work, and restructuring the role of human labor. This dynamic of the transfer of this new model is driving the geographic restructuring of U.S. steel.

The steel industry is a particularly appropriate industry in which to examine the intersection of production organization and geographic restructuring. The production of iron and steel has been an essential human activity since the Iron Age. The processes of industrialization and urbanization were undergirded by the rise of modern steel production. Steel was a focal point for crucial technological, organizational, industrial, and commercial advances that propelled the growth of advanced capitalist economies. Both the steam engine and the railroad required iron and steel. Even Western military power and imperialism depended upon superior armaments made from iron and steel. To this day, iron and steel remain crucial inputs to a wide range of industrial activities. The steel industry has been an important indicator of the growth and decline of major industrial nations. The decline of the British economy was reflected in the decline of its steel output relative to the U.S. and Germany during the 1890s. The U.S. steel industry was a bellwether of both U.S. growth and later disinvestment, deindustrialization, and general economic decline. Finally, Japan's postwar success in steel provided one of the crucial inputs to and drivers of its rise to economic strength.

The research presented here is based upon the results of a long-term research project examining the development of Japanese industry and its global expansion. We compiled firm-level data from the following sources: the Japan Economic Institute, JETRO, the Japan Iron and Steel Federation, the Japan Iron and Steel Exporter's Association, U.S. Department of Commerce, U.S. International Trade Commission, Wharton Econometric Forecasting Associates, and a large number of trade journal reports. The field research comprised site visits to and personal interviews with American and Japanese executives and managers of Japanese-U.S. steel ventures, representatives of the International United Steel Workers Union, relevant local union branches, and factory workers conducted by Richard Florida during the period 1989-1991. Field research consisting of site visits and personal interviews with Japanese steel executives, managers, government officials, unionists, and bankers was conducted in Japan by Richard Florida during October-November, 1991.

The Theory of Industrial Location of Steel

Steel, perhaps more than any other industrial sector, has occupied a central position in the study of industrial and economic geography, providing the empirical referent for a number of leading theories. Studies of steel represented the quintessential application of classical Weberian location theory in demonstrating the importance of transportation costs between resources and markets (see Walker 1989 for a review). Classical theory, however, neglected the underlying technological and organizational dynamics of steel production and the way in which trajectories of production organization and technological developments could fundamentally redefine resources, costs, and location at various junctures in the development of the steel industry. As Warren's (1973) geographical study of the history of U.S. steel has shown, restructuring and relocation recurred throughout the development of the U.S. steel industry. As Warren points out, ironmaking originated in New Jersey with bog iron in the eighteenth century, moved to eastern Pennsylvania for charcoal and local iron, and then moved again to northeastern Pennsylvania for anthracite coal. Each of these moves was linked to important organizational and technological changes. In the late nineteenth century, a major shift occurred as steelmaking moved to western Pennsylvania for bituminous coking coal in association with the development of new technology (e.g., the Bessemer process). During the early twentieth century, steel production shifted westward to the Great Lakes, in large measure because of the demand from the automotive and metalworking industries. Warren's evidence suggests a generalizable model of dynamic and evolutionary industrial development, characterized by geographically uneven development, the rise of new growth centers, and the creation of "locational relics." Thus, the geography of steel was never static, as classical location theory implies, but dynamic—driven by underlying shifts in technology and production organization.

More recent advances in geographic theory also took many of their cues from steel, or at least used recent geographic patterns in steel (e.g., the breakdown of the Pittsburgh area's steel industry) to support general claims about the changing nature of location and industrial spatial patterns under contemporary capitalism. This cluster of theories included those of the product cycle, the spatial division of labor, and flexible specialization. Each of these theories focused on a short-term manifestation of an evolving industrial and spatial process and, in doing so, missed the more fundamental restructuring that was unfolding.

According to the product cycle theory originally outlined by Vernon (1966; 1971; Kurth 1979) and later applied to steel by Markusen (1985) in terms of a related "profit cycle" model, the decline of U.S. steel reflected a more general process of industrial maturation, technological standardization, and shift of production to newly industrializing nations. The product cycle theory, however, neglected the transformations in the underlying technology that can redefine existing industries and open up new possibilities for production and accumulation, such as the current moves to production of higher-value, higher-quality, flat rolled steel in advanced integrated mills using new alloys, process technology, and restructured work relations.

Steel also provided the paradigmatic case for the deindustrialization thesis, which captured the obvious fact that U.S. steel was undergoing manufacturing disinvestment (Bluestone and Harrison 1982). The case of steel seemed to confirm the spatial division of labor models of geographic differentiation in the location of corporate functions (Massey 1984; Froebel et al. 1980; Hymer 1976; also Chandler 1962; 1977). As Walker (1989) has pointed out, both the deindustrialization and spatial division of labor theses are essentially "corporate theories" of industrial geography, the former emphasizing the flow of capital and "milking" of plants, the latter emphasizing the separation of corporate functions. Both theories basically rest on a neoclassical view of location as determined by labor costs. Fundamentally, these theories share the locational choice/environmental scanning perspective of traditional location theory, whereby rational economic actors scan existing environments and select the landscapes that optimize their functional requirements in light of various economic parameters (e.g., raw materials, transportation costs, infrastructure availability, labor costs). These approaches overlook the underlying technological and organizational factors that underpin the locational choices of individual firms and economic actors. For example, "just-in-time" production organization, which requires physical proximity and interaction, demands a different locational logic on the part of individual firms from that of Fordist production organization (Sayer and Walker 1992; Florida and Kenney 1992).

During the 1980s, geographers and other social scientists suggested that manufacturing industries, including steel, were undergoing a fundamental transformation from large-scale, integrated mass production to smaller-scale "flexible" production processes (Piore and Sabel 1984). In the case of steel, Barnett and Crandall (1986) argued that new mini-mill forms of production overturned the traditional cost advantages associated with the scale economies of large integrated steel facilities. Mini-mills use electric arc furnace technology to turn scrap metal into steel. According to Barnett and Crandall, they benefit from greenfield sites, lower-cost labor, in some cases a nonunion environment, and less restrictive work rules. The rise of steel mini-mills in the U.S. was theorized as part of a more general transformation in the nature of U.S. industry:

> Once a highly concentrated industry made up of a few integrated plants capable of producing millions of tons annually, steel is being transformed by a dynamic group of young firms. . . . These small firms, with narrow product lines, are usually far more efficient than most of their larger rivals. When challenged the larger firms often abandon product lines to their competitors rather than do battle with the upstarts (Barnett and Crandall 1986, 1-2).

Barnett and Crandall (1986) concluded that by the year 2000, mini-mills would account for one-half of all U.S. steel production. In their eclectic style, Piore and Sabel (1984) seized upon the growth of the mini-mills as further evidence of the collapse of large-scale production and a global shift toward flexible specialization. Clearly, the rise of the mini-mills in the U.S. was a kind of innovation and restructuring. The mini-mill proponents and the advocates of flexible specialization thus captured a surface-level manifestation of a far wider restructuring of technology and production organization occurring in global manufacturing. Both theories remained focused on the responses of declining capitalist industries and regions in the U.S. and western Europe, however, and thus were unable to comprehend the epochal shift in the underlying mode of production organization that was taking form in Japan.

By the late 1970s and early 1980s, then, the consensus view in the literature predicted a general shift toward offshore steel production or smaller units of production in the United States. These approaches, based on a partial understanding of the evolving process of spatial, technological, industrial, and organizational restructuring, failed to grasp its essence. Simply put, these theories—which were focused exclusively on the U.S. economy or on developments in northern Italy—missed the more fundamental technological and organizational revolution going on in Japanese industry. These epochal advances and the spatial implications of the Japanese model would become apparent with the Japanese penetration of the U.S. steel industry in the 1980s.

Production Organization in U.S. and Japanese Steel

The decline of U.S. steel and the rise of Japan were due to fundamental differences in the technological and organizational bases of production. The U.S. steel industry was the paradigmatic case of "Taylorist" scientific management, which rationalized production organization and maximized physical labor output (Nelson 1977; 1980; Nuwer 1988; Fitch [1910] 1989; Lazonick 1990). Taylorism decomposed tasks into their most elemental components, transferred skill from workers to management, and organized work to maximize the output and efficiency of physical labor. In response, U.S. steel workers and their unions struggled to create an extensive apparatus of rules, job descriptions, and social norms governing the factory floor, in part to protect themselves from arbitrary management authority (Brody 1960; 1971; Montgomery 1979; 1987). With the labor agreements and "class accords" of the 1940s (Prezworski 1985), these became the "trench lines" (Gramsci 1971) that protected workers against managers, while providing managers a stable framework within which to deal with workers (Davis 1986; Gordon et al. 1982). The central rampart of this system was the extensive system of job classifications, which delimited the activities of each worker. These job classifications created formal rules that controlled management's ability to allocate work within the division of labor. An internal labor market (Jacoby 1981) and wage structure (Novack and Perlman 1962; Doeringer 1968) grew up around this job classification system, further reinforcing it. Other rules delineated management and worker rights, production standards, layoff procedures, and rules of behavior on the shop floor (Hoerr 1988). A formal contractual structure, governance system, and set of grievance mechanisms institutionalized and ultimately rigidified patterns of work organization and labor-management relations in steel.

In contrast, the Japanese steel industry developed a system of production organization and labor-management relations that harnessed workers' intellectual as well as physical capabilities (Kenney and Florida 1988; 1993). Key elements of this system included the movement from task specialization to task or functional integration, the use of work teams, long-term employment, seniority-based wages, and the integration of intellectual as well as physical capabilities through the use of *kaizen*, or continuous improvement activities, and quality circle activities. Taken together, the organizational structures and practices harness workers' ideas and intellectual capabilities as well as physical labor at the point of production. NKK, for example, pioneered the use of JK circles (essentially quality control circles) in the steel industry (Nonaka and Yonekura 1985). In 1990, 38 steel mills and steel related companies used JK circles; 20,878 such circles were in operation, involving 126,608 workers or 40 percent of the steel workforce (Japan Iron and Steel Federation 1991).

The U.S. and Japanese steel industries were further distinguished by differences in investment and the implementation of technology. The postwar U.S. steel industry emphasized short-term financial returns and made insufficient manufacturing investment. Roughly two-thirds of all U.S. investment in the U.S. steel industry between 1950 and 1979 occurred in the 1950s (Mueller 1991). The U.S. steel industry expanded by adding to existing mills, a process referred to as "rounding out." A postwar analysis of the U.S. steel industry described this as follows:

> Capacity is increased by adding to existing facilities—to the point where most mills are so hopelessly cluttered that any attempt at efficient operations in the charging-room floor is hopeless. Rounding-out is popular because it costs only about $100 a ton of capacity,

> but is obviously no long term solution to the production of steel. Eventually, in those steel plants something has to give (quoted in Tiffany 1988, 143).

Indeed, it has been decades since a major U.S. corporation built a major integrated steel mill. The last two were U.S. Steel's Fairless mill, built in the 1950s, and Bethlehem's Burns Harbor Works in the 1960s (Barnett and Crandall 1986).

Japanese corporations invested massively in steel plant and equipment from the 1950s through the 1970s as part of a general "scrap and build" approach to steel industry development (Lynn 1982; Kawasaki 1985; Yonekura 1989; 1990; Abe and Suzuki 1991). From 1950 to 1979, Japanese steelmakers built 11 major integrated steel mills, incorporating modern layout, state-of-the-art technology, and location on coastal deep-water harbors. Such modern integrated steel mills required huge amounts of capital; NKK's Ogashima Works on Tokyo Bay (completed in the late 1970s) required an estimated $7.6 billion investment (Long-Term Credit Bank of Japan 1989). Japanese steel mills incorporated state-of-the-art continuous-process technology: highly efficient furnaces, continuous casters, vacuum degassers, ladle metallurgy facilities, and modern hot and cold rolling mills (Japan Iron and Steel Federation 1991). In 1990, capital investment in new steel plants and equipment increased by 23.1 percent and exceeded $7 billion. Between 1983 and 1989, the Japanese steel industry devoted an average of 1.5-2.5 percent of total annual sales to R&D. In 1989, total R&D expenditures for the industry exceeded $2 billion. Steel R&D employed 5,946 scientists and engineers (Japan Iron and Steel Federation 1991). These investments transformed the Japanese steel industry from a traditional, batch-process heavy industry to a highly automated, continuous-process, materials industry—a transformation referred to in Japan as heralding a "new iron age" (personal interviews with Japanese steel executives, April, 1991).

The Japanese and U.S. steel industries took different trajectories. The Japanese steel industry grew rapidly. It overtook U.S. steel output by 1975 and surpassed it in the early 1980s. Japanese steel production capacity increased from 4 million to more than 110 million metric tons per year in 1990 (Mueller 1991; MIT Commission on Industrial Productivity 1989). Japan's advantage became particularly significant in the area of finished automotive steels, the highest value-added segment of the steel industry. The U.S. steel industry's strategy was cost-effective in the short run, but in the longer term it left the industry with antiquated plants and technology (Hogan 1991). By the mid to late 1980s, domestic capital investment was virtually nonexistent and plant and equipment were obsolete. The U.S. Department of Commerce (1991, 60) concluded that:

> As a result of the industry's poor earnings and its difficulty in raising capital, investment in plant and equipment fell from $2,650 million in 1980 to only $862 million in 1986, leaving the industry starved of capital and with an aging technological base. One steel industry executive in 1990 still placed industry capital requirements at between $10 and $15 billion for the industry to regain a competitive position in world markets.

The result was a long slide from technological leadership to technological backwardness (Misa 1987; Lynn 1982; Yonekura 1988), epitomized by the fact that in 1989 the continuous casting rate for the U.S. steel industry was 64.8 percent, compared to 93.5 percent for Japan (Japan Iron and Steel Federation 1991).

Deindustrialization was the ultimate economic consequence for the U.S. steel industry. Between 1951 and 1971, major U.S. integrated steel producers closed more than 100 plants (Clark 1988). Between 1967 and 1987, total U.S. steel industry employment declined by 64.4 percent, from 533,100 to 189,900, and the number of production workers fell by 65.9

percent, from 434,000 to 147,600 (U.S. Census of Manufactures, various years). As much of the steel production infrastructure was abandoned, U.S. steel producers took the next step and shut R&D laboratories. U.S. Steel, for example, closed its Pittsburgh R&D facility in the 1980s, idling approximately 1,500 scientists and engineers.

The final period took shape in the late 1970s and early 1980s as major U.S. steel corporations embarked on a strategy of diversification designed to exit the steel industry. National Steel diversified and changed its name to National Intergroup. U.S. Steel purchased Marathon Oil and changed its name to USX. It later formally separated its oil and steelmaking subsidiaries by partitioning its stock. Corporations frequently used existing steel business units as "cash cows" to finance diversification efforts or to pay high dividends. The U.S. steel industry lost its core competence and became increasingly unfocused.

The U.S. and Japanese steel industries differ in two other major areas: the role of product quality and the relationship between the producers and the end-users of steel. The automotive industry is the most important consumer of steel in both countries. Japanese steel mills operate on a just-in-time basis to minimize inventory and reduce cost. In contrast, U.S. steel mills have traditionally produced in enormous batches, which are then stored as inventory. This production pattern was required by Big Three automotive companies, whose swings in demand meant that steel companies were required to retain large inventories "just in case" they were needed to meet an upswing in production. Traditionally, Big Three customers ordered steel on an annual basis, but actually utilized the steel at a highly variable weekly rate that was predicated on how many cars they built that week. This variable "withdrawal rate" forced the steel companies to keep large inventories just in case a Big Three customer wanted to withdraw its full quota in any given week.

Quality is another major difference between the Japanese and U.S. steel industries. The Japanese production system in general, like the automotive industry in particular, was built around high-quality inputs and zero defects. All irregularities were eliminated, and all inputs and outputs had to meet rigorous specifications. In contrast, until recently U.S. automotive producers did not demand such high-quality steel from U.S. steelmakers. U.S steel was of highly uneven quality. The relationship between the two sectors adjusted to this environment, and the steel delivered to Big Three assemblers was of lower quality than that considered acceptable by Japanese automotive assemblers (American steel official, personal interview, November, 1990). Even in 1991, a survey of domestic steel users by the U.S. International Trade Commission (1991) concluded that:

> Domestic [steel] producers have narrowed, but not closed, the perceived gap in quality and service relative to their main foreign competitor, the Japanese steel industry. Questionnaire responses indicate that: Japanese companies more consistently offer a higher-quality product compared with the United States. . . . Only Japanese companies were identified by a majority of steel processors and purchasers in any consuming group as having excellent overall steel product quality.

The Geography of Japanese Direct Investment in U.S. Steel

There are currently 74 Japanese-owned and Japanese-U.S. joint venture steel facilities in the United States. Roughly 20 represent significant investments in integrated steel mills, mini-mills, and galvanizing or finishing lines; the rest are smaller investments in steel processing facilities. Table 1 presents a summary of major Japanese direct investments in U.S. steel production. Most of these major investments have come in the form of

Table 1.

Major Japanese Investments in the U.S. Steel Industry

Japanese Company	U.S. Partner	Joint Venture	Type of Operation	Location	Site	Facility	Date	Employed	Investment (millions)	Japanese Share
Nippon Steel	Inland Steel	I/N Tek	Cold-rolling mill	New Carlisle, IN	New	New	1990	280	$520	40%
Nippon Steel	Inland Steel	I/N Kote	Galvanizing line	New Carlisle, IN	New	New	1991	250	$550	50%
Nippon Steel	Inland Steel	Inland Steel	Integrated steel mill	Indiana Harbor, IN	Existing	Existing	1989	11,500	$186	14%
NKK	National Intergroup	National Steel	Integrated steel mills	Ecorse, MI, Granite, IL, Portage, IN	Existing Existing Existing	Existing Existing Existing	1984	12,000	$2,200	70%
Kawasaki Steel	ARMCO	ARMCO Steel Co. Ltd	Integrated steel mill	Middletown, OH	Existing	Existing	1989	9,500	$1,600	45%
Kawasaki Steel	ARMCO	ARMCO Steel Co. Ltd	Galvanizing line	Middletown, OH	Existing	New	1991	100	$150	50%
Kawasaki Steel	CVRD (Brazil)	California Steel	Rolling mill	Fontana, CA	Existing	Existing	1984	725	$275	50%
Kobe Steel	USX Corp.	USS-Kobe Steel	Integrated bar and pipe mill	Lorain, OH	Existing	Existing	1989	3,000	$300	50%
Kobe Steel	USX Corp.	Protec Coating	Galvanizing line	Leipsic, OH	New	New	1992	100	$200	50%
Sumitomo Metal	LTV Corp.	LSE I	Galvanizing line	Cleveland, OH	Existing	New	1986	83	$100	40%
Sumitomo Metal	LTV Corp.	LSE II	Galvanizing line	Columbus, OH	New	New	1991	100	$180	50%
Nisshin Steel	Wheeling-Pittsburgh	Wheeling-Pittsburgh	Integrated steel mill	Steubenville, OH	Existing	Existing	1988	5,500	$15	10%
Nisshin Steel	Wheeling-Pittsburgh	Wheeling-Nisshin	Galvanizing and coating line	Follansbee, WV	Existing	New	1988	100	$96	67%
Nisshin Steel	Wheeling-Pittsburgh	Wheeling-Nisshin	Galvanizing line	Follansbee, WV	Existing	New	1993	100	$120	100%

Sources: Compiled by authors from Japan Economic Institute, Japan Steel Information Center, Japan Iron and Steel Association, various government and industry reports, and personal interviews.

joint ventures between Japanese and existing major U.S. steel producers. We estimate the total investment in Japanese-owned and Japanese-U.S. steel facilities in the U.S. to be $6.9 billion. This accounts for more than a quarter of the $23 billion in new capital expenditures in the U.S. steel industry since 1980. We estimate that Japanese-owned and Japanese-U.S. steel joint ventures employ 27,418 workers, or about 16.6 percent of the industry total. This employment estimate is rather conservative in that it does not include employment in large integrated steel mills such as Inland Steel and Wheeling-Pittsburgh in which Japanese companies hold significant minority interests. The U.S. Department of Commerce International Trade Administration (1990) estimated that in 1989 32,727 American workers were employed in just 17 Japanese-U.S. joint venture steel mills (SIC code 3312) and that 41,280 workers were employed by the U.S. affiliates of Japanese firms in the entire primary metals industry (SIC code 33).

A number of factors prompted Japanese investments in U.S. steel production. First among them was the need to open new markets and bolster profits that were falling because of declining domestic demand and increasing import penetration from low-cost steel producers of the Third World (Hogan 1991, 37-51). Second, Japanese steel corporations saw direct investment in the U.S. as a way to circumvent trade protectionism. By forming joint ventures with U.S. steel producers, Japanese steel corporations gained access to the U.S. market without adding major new production capacity to the oversaturated North American and worldwide steel markets. Third, joint ventures had an important political aspect. They allowed Japanese steel corporations to "buy off" opposition from U.S. steelmakers who received significant cash inflows from the sale of domestic steel mills and gained a share of the profits from the investments. Such a strategy also enabled Japanese steelmakers to overcome the opposition of trade union officials by continuing to provide employment for U.S. workers. Japanese direct investment in existing U.S. facilities circumvented charges that the Japanese were destroying an industry that was "vital for U.S. national security."

Fourth, American steelmakers required Japanese capital and technology to rebuild domestic steel operations (Lynn 1987). In the early 1980s, obtaining Japanese capital and technology became a survival strategy for U.S. steel units. Indeed, the American managers of a number of U.S steel companies indicated that they welcomed Japanese investment as a source of capital and technology (personal interviews, 1990-1991). For years, these managers (as well as workers and unions) had complained about technological neglect and the use of their steel divisions as "cash cows" for corporate diversification efforts. For example, National Steel's American managers lobbied against a proposed merger with U.S. Steel because they believed that the merger would result in the milking of National Steel's plant and facility. These same managers, however, welcomed NKK's investment as a way to rebuild their steel units. National Steel's union also opposed the proposed U.S. Steel takeover of National (citing U.S. Steel's legacy of strained, adversarial labor relations), but it decided to support the new NKK-National joint venture. The United Steel Workers also accepted Japanese investment as necessary to ensure the survival of a domestic steel industry.

Fifth, Japanese transplant automobile assemblers initially experienced greater than expected problems in getting high-quality steel from U.S. producers. Because U.S. steel producers had inferior technology and production skills in galvanized steel, the transplant automobile assemblers initially imported these products from Japan. Further, steel produced by existing mini-mills technology is of insufficient quality to serve transplant automotive end-users. Mini-mills, which use only scrap metal, have inconsistent quality and cannot meet the requirements of transplant auto assemblers or the steel galvanizing lines and processors that serve as intermediaries for the automotive end-users. So, by the mid-1980s, in response to the success of the automotive transplants and escalating pressure on the transplants to increase domestic content, Japanese steelmakers began investing in U.S. production.

Figure 1 shows the location of Japanese-owned and Japanese-U.S. joint venture steel plants in the U.S. Japanese direct investments are clustered in the industrial Midwest. This geography resulted from two forces: the high fixed capital costs of integrated steel production, which constrained Japanese producers to existing U.S. steel mill sites, and the need for proximity to the automotive transplants (Mair et al. 1988). The patterning of Japanese steel production in the U.S. further reflects a spatial production chain running from integrated steel production, to galvanizing and finishing, to steel processing, and finally to automotive parts production and automotive assembly. The integrated steel facilities are joint ventures between Japanese and U.S. producers, located on sites of U.S. integrated steel production facilities in the industrial Midwest. The galvanizing and finishing lines, also joint ventures, are located both at traditional steel mills and on new greenfield sites near the automotive transplants that are their major customers. The smaller steel service centers, mainly wholly Japanese-owned ventures, are mostly new greenfield facilities, located in the upper South as well as the industrial Midwest close to the automotive transplants and their transplant suppliers. We now turn to the more

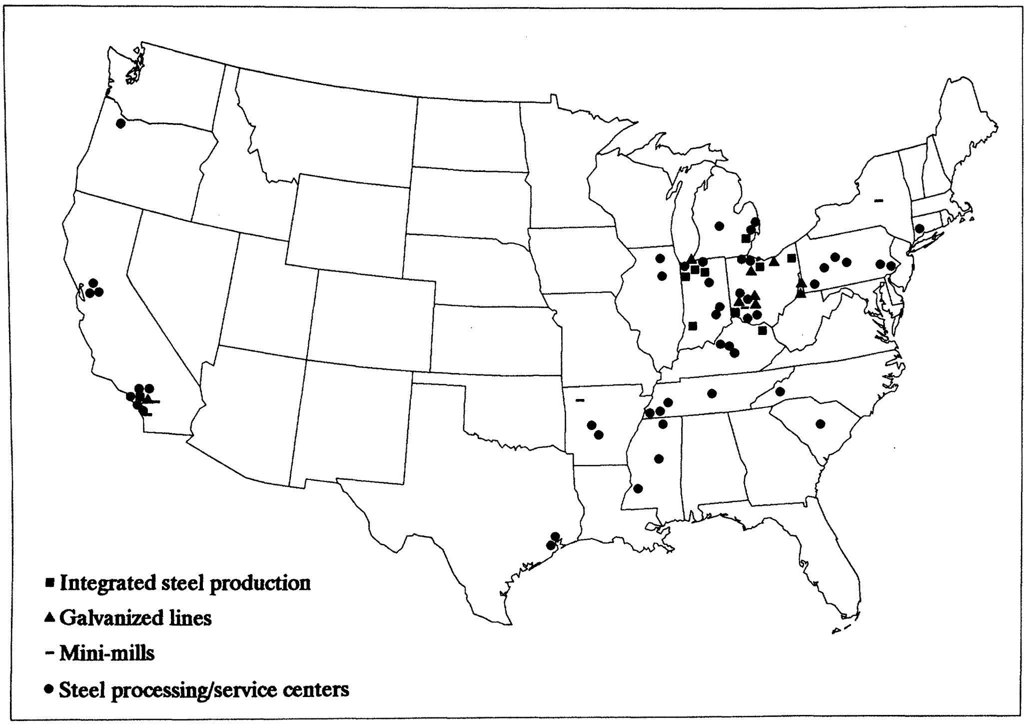

Figure 1. Location of Japanese-Affiliated Steel Plants in the U.S. Source: Compiled by authors from Japan Economic Institute, Washington, DC (various years), Japan Steel Information Center (New York, 1992), Japan Iron and Steel Association (various years), and various government and industry reports.

detailed spatial patterns of each of these industry segments.

Integrated Steel Production

There is now signifcant Japanese involvement in U.S. integrated steel production. NKK, Kawasaki Steel, and Kobe Steel currently operate integrated steel mills in the U.S. as part of joint ventures with U.S. steelmakers. Japanese-U.S. joint ventures have made $2.8 billion in new capital expenditures, roughly 60 percent of new capital expenditure in U.S. integrated steel production.

Figure 2 shows the location of major Japanese-U.S. joint ventures in integrated steel production. All of these joint ventures are located on existing U.S. steel mill sites in and around the industrial Midwest. There are four reasons for this locational pattern. First, unless the market for steel is growing, the high fixed capital costs of a new integrated steel mill are prohibitive. The stagnation in U.S. steel demand has constrained production to existing mills. The extreme cyclical volatility of the U.S. economy lengthens payback periods and creates much higher risk—an important factor in multibillion dollar investments. Second, the construction of new integrated facilities by the incoming Japanese would have delayed the supply of steel to the automotive transplants. Third, Japanese steel producers were further constrained by the need to buy off the political opposition of domestic steel interests and their political supporters (personal interviews with Japanese steel officials, 1991). Fourth, the most modern automotive steel facilities in the U.S. were already concentrated in this area.

Figures 3 and 4 enable us to compare the location of Japanese investments in

Figure 2. Location of Japanese-Affiliated Integrated Steel Mills in the U.S. Source: Japan Steel Information Center (New York, 1992).

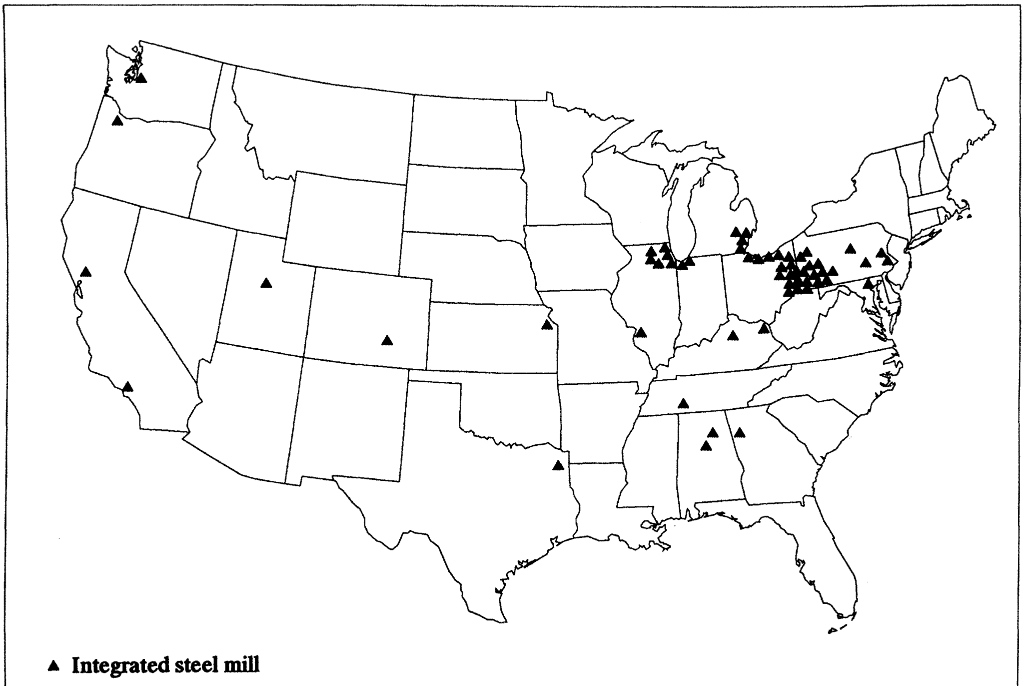

Figure 3. Location of Major Integrated U.S. Steel Mills. Source: American Iron and Steel Institute (1990).

integrated steel production to those of U.S. steel firms. Figure 3 shows the location of existing U.S. integrated steel mills, and Figure 4 shows the location of plants closed between 1951 and 1971. Here, it is important to highlight two points. First, the major Japanese investments in integrated steel production are clearly located in the traditional U.S. steel-producing region of the industrial Midwest. This spatial pattern undermines the argument that the decline of the U.S. steel industry was caused by high wages, unruly workers, or a poor business climate. Second, Japanese investment in integrated steel production reinforces a westward shift in the center of steel production from the traditional Pittsburgh-Monongahela Valley steel belt to Ohio, Indiana, and Michigan. The reason for this is that the Japanese investments in integrated steel production were aimed at supplying steel (eventually on a "just-in-time" basis) to automotive transplants. As Figures 3 and 4 show, this shift in the geographic locus of integrated steel production was already under way in the U.S. steel industry, as many of the most modern mills were located on the Great Lakes shore around Chicago with marginal plants concentrated in the Pittsburgh-Monongahela Valley region. This shift is likely to become more pronounced during the 1990s as the domestic steel industry experiences further closings of older, technologically obsolescent mills. A report on the global steel industry by the Long-Term Credit Bank of Japan (1989, 90) concluded that:

> At present, there are 24 or 25 integrated steel mills [in the United States], but the number is expected to decline to at least half, or four to five in the worst case, in 10 to 15 years.

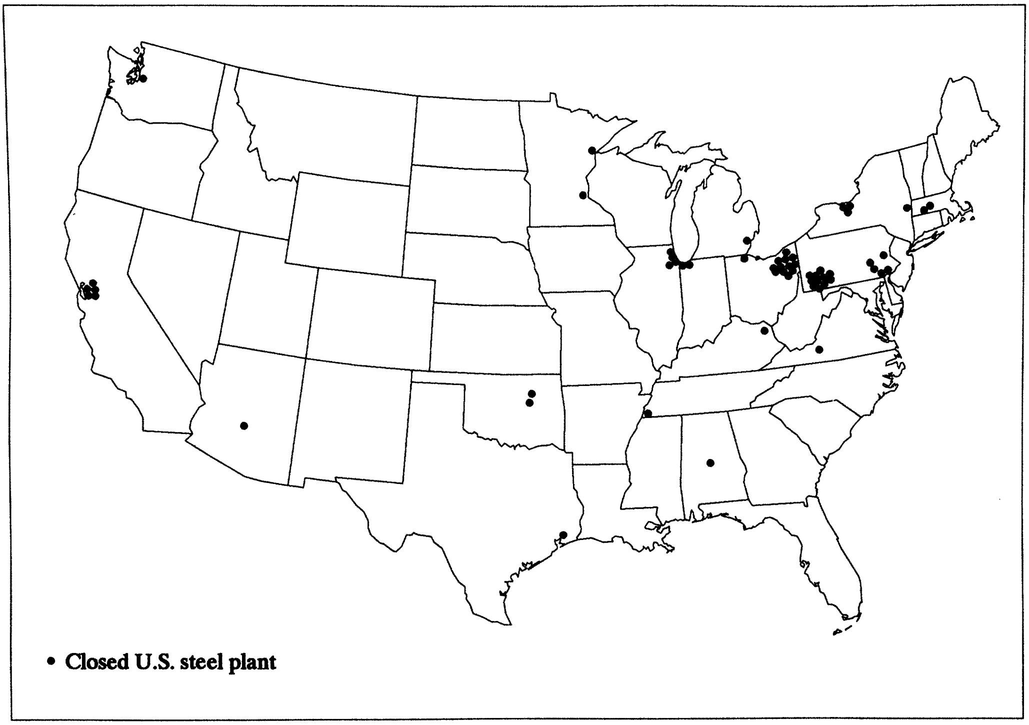

Figure 4. U.S. Steel Plant Closures, 1951-1971. Source: Clark 1988.

Expected to survive are those which have made considerable capital investment for producing automotive steel products with little unbalance in process capacity and efficiency. Most of them are located in the area extending from Chicago and Lake Michigan's south coast to Detroit.

Of the 11 U.S. steel mills classified as "likely to survive," four are majority Japanese-owned and another three have Japanese investment (Long-Term Credit Bank 1989).

Galvanized and Coated Steel

Steel galvanizing is a major area of Japanese involvement in the U.S. steel industry. Galvanizing is a high value-added finishing process that makes steel corrosion-resistant and easier to paint. Galvanized steel is used for automotive body parts, frames, and mufflers and is in high demand from the automotive transplants. Galvanizing, especially electrolytic-galvanizing, is a technology that the Japanese have improved into a modern continuous production process—far beyond the level of U.S. technology. Galvanizing facilities are self-contained and can be located on or off existing steel mill sites. Their major input is cold-rolled steel coil, which typically is supplied from an integrated steel mill. Table 2 lists recent galvanizing lines in operation in the U.S. Japanese-U.S. joint ventures in electrolytic-galvanizing have provided roughly $1.2 billion in new capital expenditures since the mid-1980s and account for approximately two-thirds of total U.S. capacity.

Figure 5 is a map of the Japanese-affiliated steel galvanizing and coating lines in the U.S. They are all new facilities, located on both new and existing plant sites, mainly in the traditional

Table 2.

Major New Galvanizing Lines in the United States

Company	Location	Capacity (tons)	Date Established	Ownership
Electro-Galvanizing				
USX-Rouge	Michigan	700,000	1986	U.S.
National-NKK	Michigan	400,000	1986	U.S.-Japan
LSE I (LTV-Sumitomo)	Ohio	400,000	1986	U.S.-Japan
Bethlehem-Inland	Ohio	400,000	1986	U.S.
Armco-Kawasaki	Ohio	250,000	1986	U.S.-Japan
LSE II (LTV-Sumitomo)	Ohio	400,000	1991	U.S.-Japan
I/N Kote (Inland-Nippon)	Indiana	400,000	1991	U.S.-Japan
Armco-Kawasaki	Ohio	290,000	1991	U.S.-Japan
Hot-Dip Galvanizing				
Wheeling-Nisshin	West Virginia	270,000	1988	U.S.-Japan
Metaltech	Pennsylvania	100,000	1990	U.S.
I/N Kote (Inland-Nippon)	Indiana	500,000	1991	U.S.-Japan
Wheeling-Nisshin	West Virginia	240,000	1991	U.S.-Japan
NKK-Dofasco	Ontario, Canada	400,000	1992	Japan-Canada
Bethlehem	Indiana	450,000	1992	U.S.
USS-Kobe	Ohio	595,000	1992	U.S.-Japan
Bethlehem	Southwest	260,000	1993	U.S.
Mitsubishi-Stelco	Ontario, Canada	NA	1993	Japan-Canada
California Steel (Kawasaki)	California	240,000	1994	Japan

Source: Wharton Econometric Forecasting Associates, Steel Division, December, 1991.

industrial Midwest. These locations represent a tradeoff between two spatial factors. They must be close to the integrated mill, and they must be close enough to the steel processors and automotive transplants to deliver on a just-in-time basis. The galvanizing lines are a critical link in the expanding transplant heavy industrial complex in the U.S. A further deepening of this reconstruction of the chain from steel to automobiles is the Nippon Steel-Inland Steel joint venture, which includes I/N Tek, a continuous cold-rolling mill, as well as a new galvanizing line, I/N Kote.

Japanese investment in advanced galvanizing facilities reflects the relationship between Japanese steel producers and Japanese automotive producers. The most important basic input for producing an automobile is steel. In 1986, the average U.S. automobile weighed 3175 pounds (1441 kilograms); of this, 2160 pounds (981 kilograms) were steel and iron (U.S. International Trade Commission 1986). Because Japanese automobiles used less plastics, in 1986 steel accounted for 76 percent of the total materials content of the average Japanese car. According to Wharton Econometric Forecasting Associates (WEFA), in 1990 coated galvanized steel comprised roughly half (48.5 percent) of all steel used in automotive applications.

Increasing Japanese upstream penetration of the U.S. steel industry has been coupled with and motivated by the need for quality inputs to ensure the high quality of steel that the automobile assemblers demand. Japanese investments in galvanizing and finishing lines have created the need for additional Japanese investment in integrated steel production. The reason is that modern continuous process galvanizing technology demands cold-rolled steel of a higher quality than traditional U.S. integrated mills can provide. Lower-quality steel can lead to machine breakdown, costly process interruptions, and a low-quality product. An

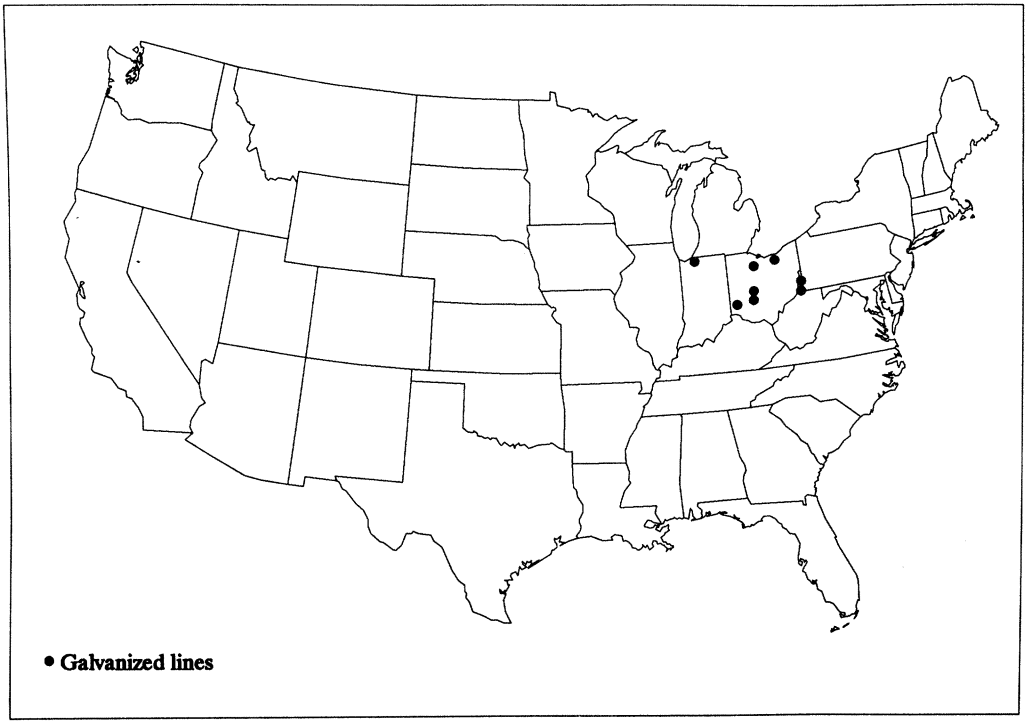

Figure 5. Location of Japanese-Affiliated Galvanizing Lines in the U.S. Source: Japan Steel Information Center (New York, 1992); Wharton Econometric Forecasting Associates (Philadelphia, 1992).

analysis of the U.S. steel industry by the Long-Term Credit Bank of Japan (1989, 96) succinctly highlighted the following issues:

> Investment in the [cold] rolling process involves only a small risk because: (1) it is limited to product lines geared to specific user demand, and (2) it is possible to separate the operation from the American partner's integrated mills, especially from existing labor relations. In terms of return on investment, however, it is less attractive because the joint venture company has the decision-making authority on the price and quality of both the raw material hot coil and the product cold coil. I/N Tek will need quality control assistance from Nippon Steel for a long period on the processes all the way from the upper processes [basic steelmaking processes] at Inland Steel. Its vacuum degassing facility was the company's first, introduced as a result of the formation of the joint venture. Inland's Indiana Harbor plant is the best in the United States in terms of balanced capacity. Still, the fact that it is far behind Japanese mills in product quality implies the desperate condition of other major mills.

To facilitate such upgrading, Nippon Steel recently took a 15 percent equity interest in Inland Steel and established a technical assistance program to upgrade Inland's Indiana Harbor Works. This effort has been constrained, however, by the entrenched Taylorist work organization and adversarial labor relations at Indiana Harbor (personal interviews with Japanese executives of I/N Tek and I/N Kote, American managers of Inland Steel, and union officials, 1990-1991).

Steel Processors and Service Centers

Japanese corporations have made significant investments in steel service centers and processing centers, which warehouse, cut, and prepare finished steel coils for automotive applications. These facilities are usually owned by Japanese trading companies, though often with an industrial firm as a partner. The involvement of trading companies in steel processors resembles their role in Japan as intermediaries between the steel companies and their customers. In the U.S., they have gone further and are doing some value-added processing. The Japanese steel processors and service centers perform a variety of blanking, slitting, and cutting operations for their automotive customers. They thus form a bridge between steel coating lines, which produce steel coils and transplant assemblers, or, more likely, the parts suppliers who form that steel into actual body parts. In this way, the Japanese steel service and processing centers differ from traditional U.S. steel service centers, which simply serve as warehousers of steel coils. The Japanese steel service centers/processors supply both Big Three and transplant automotive assemblers.

Figure 6 shows the location of Japanese steel processors and service centers in the United States. Note the geographic dispersion of these facilities throughout the Midwest and upper South, in the same six states in which transplant automotive investments are concentrated (Ohio, Indiana, Illinois, Michigan, Kentucky, and Tennessee). The service centers and processors are located near the automotive transplants in order to supply these automotive end-users on a just-in-time basis. In contrast to the steel mills or auto assemblers who pay union-scale wages,

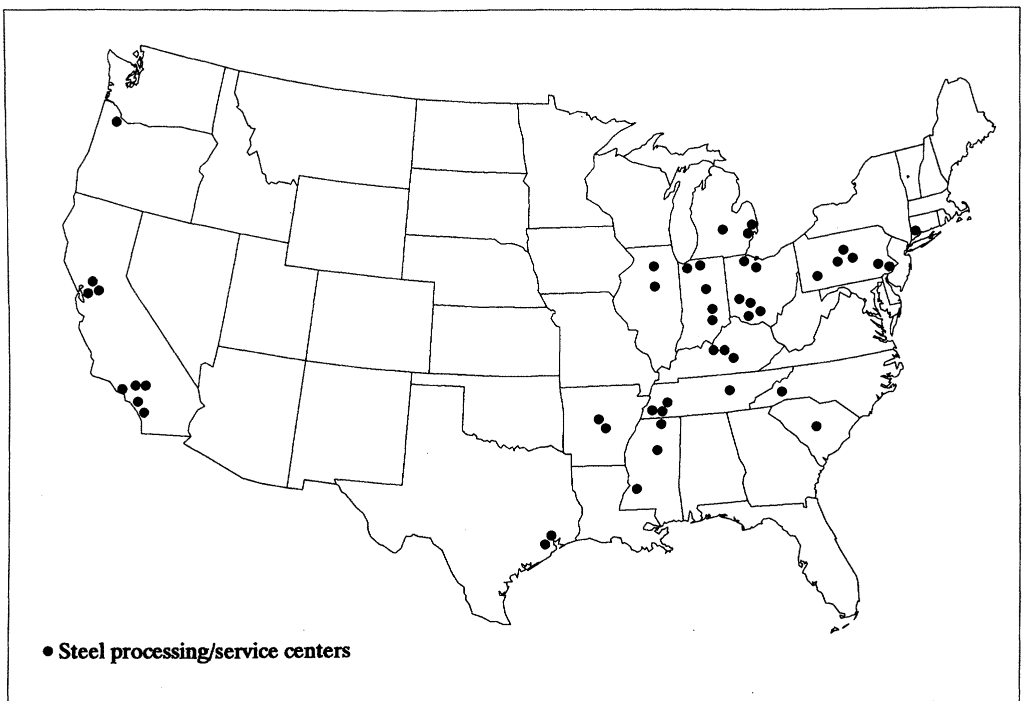

Figure 6. Location of Japanese-Affiliated Steel Processors in the U.S. Source: Japan Steel Information Center (New York, 1992); Japan Economic Institute (Washington, DC, 1991); company reports.

the transplant processors are mainly nonunion and pay wages of between $7.50 and $12.50 per hour. Japanese steel service centers are a small fraction of the more than 5,000 U.S.-owned steel service centers. Still, their pronounced concentration in the lower Midwest and upper South contrasts markedly with the highly decentralized pattern of U.S.-owned steel service centers (Patton and Markusen 1990).

Restructuring of Work and Production Organization

The success of Japanese investment in U.S. steel production is predicated upon restructuring traditional work and production organization. This restructuring process has focused on reorganizing the existing production system and dismantling ingrained Taylorist organizational practices in order to transfer and implant the new system of work and production organization. Restructuring has proceeded unevenly across firms and thus by place, proceeding slowly in larger integrated facilities with larger workforces and a historically embedded legacy of Taylorist relations, while being much more complete at the smaller galvanizing facilities. The following factors affect the depth and pace of restructuring: size of plant, size of workforce, extent of Japanese participation and share of ownership, greenfield versus existing plant site, preexisting organizational relationships, the existing nature of labor-management relations, the strategy devised to implement new production and work systems, and the compromises struck by management and labor.

Any change in production and work organization is complicated because these are the core issues in labor-management relations. In steel, job classifications and work rules have defined labor-management relations. They reflect historical battle lines and compromises reached as a result of daily skirmishes between labor and management and at times brutal industrial conflicts. Traditional U.S. steel mills are characterized by a large number of functional job classifications that have been explicitly written into employment contracts. These classifications reflect an employment system with an internal job ladder that ensures that the most senior workers receive the highest-paying and often most secure jobs (Edwards 1979). This system of rules and classifications has built up layer after layer over a long period and is now extraordinarily complicated and confusing, even for those who work and manage within it. For example, in one of our interviews the human resource director of a major integrated U.S. steel mill estimated that there were between 300 and 400 separate job classifications at the mill and added that it would take the industrial engineering department a couple of days to figure out the exact number (personal interview, October, 1990). U.S. steel mills have an additional system, referred to as "lines of progression," which specify patterns of pay and promotion within the job classification system. These arcane rules structure the environment in which workers and managers "manufacture consent" and ensure that steel is produced and the power relations of the workplace are reproduced (Burawoy 1979). Under normal conditions, disruption of these relations means that all, or at least some, of the players may lose. Thus, resistance can be stubborn and can come from any number of sources, including shopfloor workers, union representatives, foremen, and middle-level and even top-level management. Not surprisingly, any of these "interest groups" or combinations thereof may prove hostile to the introduction of Japanese-style production organization, which is premised upon functional integration of tasks, team-based work effort, and the integration of workers' mental as well as physical attributes.

Even with the obvious reasons for resistance, the following factors have favored Japanese attempts to reorganize the production system and existing framework of labor-management relations in

U.S. steel. First, the impending collapse of the U.S. steel industry weakened both managerial and labor resistance to new production systems. With jobs in jeopardy, all parties were convinced that a major restructuring was inevitable. Second, Japanese steelmakers developed conscious strategies to transfer and implement new work and production organization in U.S. environments. Restructuring agreements between the union and management were necessary before any investments were made. Clearly, these agreements differed depending upon the preexisting relations at the plant. Two general patterns are evident—one for the smaller galvanizing and coating lines, the other for larger integrated facilities.

The restructuring of work and production has been most complete at the new galvanizing and coating lines, especially those that are located at greenfield sites. These are relatively small facilities (employing 100-200 workers) that have implemented new technology. Most of these facilities were able to select workers from a large pool of existing employees and, at times, new recruits. Perhaps the most full-blown restructuring has occurred at LS Electro-Galvanizing (LSE), a new facility located within LTV's existing Cleveland steel production complex and employing workers recruited from LTV's existing and laid-off workforce (site visit and personal interviews with U.S. managers, union officials, and workers, November, 1990). LSE has reduced the number of job classifications from 100 to just 3 and instituted self-directed work teams. LSE does not pay hourly wages; rather, it has put all workers on a salary. This salary system is highly individualized, with each worker paid a salary based upon his/her skills. Base pay is supplemented by a gain-sharing and pay-for-knowledge system. LSE has gone farther than most other Japanese or Japanese-U.S. ventures in extending worker self-management to oversee much of the management of the plant. The vehicle for doing so is the worker-run committees for hiring, pay and progression, training, gain-sharing, safety, process control, scheduling, and many others. In effect, workers are responsible not only for shopfloor production activities but for higher-level management responsibilities that have typically been exclusive management prerogatives (personal interviews, 1990).

Another case is Wheeling-Nisshin, which is located on the site of an old Wheeling-Pittsburgh coating line in Follansbee, West Virginia. It has implemented a production organization system similar to, though not nearly as worker-oriented as, that of LSE. Wheeling-Nisshin management initially waged a union-avoidance drive, but the union won an organizing drive by a significant margin. Both management and union officials agreed that the plant is now characterized by fairly cooperative labor-management relations—significantly better than at the Wheeling-Pittsburgh plant that previously occupied the site (personal interviews, American and Japanese managers, union officials, and workers, fall, 1990). The plant has seven job classifications, in contrast to the roughly 50 job classifications at the old Wheeling-Pittsburgh coating line. Hourly wages range from \$10.50 to \$13.78 for production workers to between \$12.68 and \$14.80 for skilled positions. Work is organized in self-directed teams. Workers have considerable latitude in the design and performance of their jobs and are trained for and can perform many different jobs.

I/N Tek-I/N Kote is a new greenfield facility located outside South Bend, Indiana, approximately 60 miles (100 kilometers) south of Inland's main integrated steel production facility in East Chicago. Inland Steel and Nippon Steel officials initially debated whether to locate the facility on Inland Steel's huge Indiana Harbor steel complex or to move to a nonunion region such as the Sunbelt in order to implement a new work organization system. After internal debate, the company decided on a greenfield location that was close to its existing integrated production facility and close to its customers. The I/N Tek-I/N

Kote agreements are similar to that of LSE (site visit and personal interviews with Japanese and American managers and union officials, 1990-1991). There are four job classifications for skilled workers and one for semi-skilled workers. The skilled classifications are paid a base wage of $14.50 an hour, and the semi-skilled workers are paid $8.00, which increases to $10.00 at the end of one year. Average base pay is roughly $32,000 annually, and workers have the opportunity to earn bonuses adding up to an additional 45-50 percent of regular pay. The company uses a "pay-for knowledge" system to encourage workers to learn additional skills.

These Japanese-U.S. steel galvanizing lines have replaced front-line supervisors and foremen with team leaders. At Wheeling-Nisshin, for example, the center operator also functions as team leader. I/N Tek employs coordinators who are not tied to specific jobs and can move around to help with problem-solving efforts. During shift changes, coordinators participate in "face meetings" where they provide information on production problems to the next shift. They also have responsibility for monitoring equipment and for conducting equipment checks.

The restructuring of work and production has been significantly more complicated at integrated steel facilities with their long legacy of Taylorist production organization and labor relations. The most significant attempt at restructuring has occurred at the National Steel Great Lakes Works—a sprawling complex outside Detroit that supplies steel to the automobile industry (site visit and personal interviews with American and Japanese managers, union officials, and factory workers, 1991). National Steel reduced the number of job classifications at its Great Lakes mill from 86 to 16 and established a flexible assignment system to eliminate existing craft barriers to job performance and assignment. In return, management agreed to greater job security and a no-layoff policy (personal interviews with union officials, July, 1990). National Steel is the only steel company in the U.S. to offer workers a formal guarantee of employment security. National Steel's restructuring effort was coupled with and to some degree premised upon an extensive program to upgrade National Steel's production technology. Before NKK's involvement, the National Steel Great Lakes Works had not seen major investment in years, and even simple maintenance was neglected. A massive effort was required simply to bring the facility up to par. NKK has concentrated on rebuilding the primary steel production—the coke batteries, basic iron and steelmaking, and casting operations. It has made major investments in new coke batteries and continuous casters as well as high-technology vacuum degassers, which reduce the carbon content in the steel to very low levels, and sophisticated ladle metallurgy technology, which allows far more precise control of the steel chemistry. This technology makes high-quality production possible for automotive uses, especially the production of steel that is easier to bend and form for the new (increasingly curved) automotive body designs. National Steel plans to invest more than $1 billion to upgrade various steel production sites. This massive investment and restructuring program has already significantly improved quality and yield. Between 1985 and 1991, productivity at National Steel's Great Lakes Works almost doubled, as worker hours per shipped ton declined from 4.3 in 1985-87 to 2.8 by 1991. These investments provided National Steel the capacity to produce higher-quality steel at a competitive cost vis-à-vis the steel mini-mills and allowed the company to mothball its two electric arc furnaces of the sort used in mini-mill production.

A similar, though not as complete, restructuring has also occurred at the USS-Kobe joint venture in Lorain, Ohio, which produces steel pipes and bars used in automobile axles and chassis parts (site visit and personal interviews with American and Japanese managers, December, 1990). While the U.S. Steel Lorain mill was fairly modern by U.S. standards, it also suffered from a lack of reinvestment and creeping technological obsolescence. U.S. Steel's top management used the Lorain division as a cash cow and did not permit management to reinvest in improved production technology. Under the terms of the joint venture worked out between USS and Kobe, local management is able to reinvest earnings in the operation. USS-Kobe is installing a new continuous caster for the production of steel bars and undertaking major renovations of the blast furnace. Kobe's efforts to transfer Japanese work and production organization to the Lorain mill were enhanced by U.S. Steel's past financial mismanagement. Operating under extreme financial stringency imposed to fund the parent USX's acquisition of nonsteel companies such as Marathon Oil, the Lorain mill was unable to hire a full complement of managers. This forced the plant to move toward work teams and worker self-management. Indeed, the success of these early efforts was a factor in encouraging Kobe to purchase a stake in the plant.

To restructure the U.S. steel industry in light of the functional requirements of Japanese production organization meant not only transforming the concrete organization of work, but restructuring worker behavior and human labor power. This has centered around the strategic use of recruitment, socialization, and training programs to mold workers to the demands and requirements of new production organization.

The Japanese-U.S. joint venture steel firms in the U.S. sought a particular type of worker. A central requirement of Japanese production methodology is the ability of workers to apply both their intellectual faculties and their physical labor in a team-oriented, production environment. This means that hiring must differ markedly from the traditional practice of hiring "off the street," which was sufficiently selective for the Taylorist labor process, its only requirement being a large stratum of relatively unskilled physical labor. LSE, for example, selected its workforce from a pool of 10,000 workers comprised of both laid-off and current LTV employees. The selection process included rigorous application procedures and tests designed to identify workers who would fit into the new system. I/N Tek used a stringent process to select workers from the existing pool of 12,500 workers at Inland's Indiana Harbor Works. The company used a combination of aptitude, technical, and psychological screening tests, technical tests, and personal interviews. Workers who passed the initial tests were sent to an assessment center for an evaluation of their problem-solving capabilities and ability to work in a group context. Of the roughly 1,250 workers who originally applied, 950 took the tests, 345 passed the tests and went to the assessment center, and 220 completed the assessment. These candidates were interviewed to fill the 170 positions.

In addition, intensive training programs were undertaken to prepare and socialize workers for the new system of production organization. I/N Tek workers were sent to Japan for two to six weeks of training. Roughly 25 Japanese trainers then returned with them to the U.S. to provide additional instruction. At Wheeling-Nisshin, the original workforce was sent to a Japanese "sister" plant for three- to nine-month periods. These trips exposed workers to Japanese production methodology and behavioral norms, teaching them both the "hard" skills of operating production equipment and the "soft" skills of working in a team environment. Technology transfer was accomplished by learning-by-doing through working closely with Japanese trainers. For example, workers learned through actual observation and experience how to operate quality control circles or participate in *kaizen* or continuous improvement activities. Training and socialization have continued on the job, aimed at constantly improving the capabilities of the workforce.

Clearly, the existing legacies of organizational form, institutional structures, and regionally specific workforce behavior patterns intersected this process of restructuring human labor. Existing organizational and/or regional forms created obstacles to implementing Japanese production organization. These obstacles are embedded regional and organizational institutions and human social relationships and behavioral patterns, which are structured by historically and spatially specific work environments. They reflect a long legacy of social relationships that have built up and hardened over long periods. These structural rigidities and obstacles are thus highly localized and operate at what is perhaps the most fundamental and microscale level of human existence. The restructuring process has involved the restructuring of social relationships and of human labor itself.

Our research offers a number of interesting findings on this dimension. First, the restructuring of social relationships and human behavior has occurred unevenly. In general terms, the smaller organizations, in this case the stand-alone galvanizing lines, are most successful at restructuring worker behavior. The restructuring of social relations and modes of behavior is occurring much more slowly at the larger, integrated steel facilities. This is to be expected given their long legacy of Taylorist forms and behaviors both on the shopfloor and in labor-management relations. In particular, the behavioral legacy takes the form of direct and arbitrary management authority, which inhibits worker initiative and the mobilization of workers' intellectual capabilities, and of workers who have been programmed both on and off the job to "work—not think."

Second, the nature of these rigidities reflects highly localized and organizationally specific patterns bound up with the historical layering of labor-management relations. The salient factor here is the patterns of union organization at the plant site (see Clark 1990). Our field research identified important differences among steel facilities organized: (1) under established centralized and all-inclusive "industrial" union locals; (2) under established federations of multiple craft unions; and (3) as new union locals. The following examples drawn from our field research will help to elucidate this point. The implementation of Japanese-style production organization at National Steel's Great Lakes mill (organized under a single United Steel Workers local) has proceeded much more smoothly than at its Granite City mill organized under a federation of multiple United Steel Workers local unions (site visit and personal interviews with Japanese and American managers and union officials, summer-fall, 1991). Similarly, Armco-Kawasaki has experienced significantly greater resistance to production and work restructuring at its mill organized by a federation of fragmented, multiple craft unions than at a second mill organized under a single United Steel Workers local (personal interviews with Japanese executives of Kawasaki Steel, October, 1991). Resistance has been far less evident at the smaller galvanizing lines, where new, all-encompassing unions (with no established legacy) have been constructed to manage labor-management relations. Thus, those steel production sites that have a strong historical legacy of pre-Fordist craft union formations and adversarial labor-management relations are both more rigid and significantly less able than those with industrial unions to make the transition to new work and production organization. In this sense, local history as embedded in existing organizations and places plays an important role in restructuring.

Third, the greatest area of difficulty has involved getting traditional U.S. workforces to take on the actual behaviors associated with the Japanese model—to engage actively in intellectual labor and continuous improvement activities. Even those companies that have effectively implanted the organizational forms and structures associated with the Japanese model (e.g., few job classifications, work teams) have experienced difficulty getting workers to take initiative and engage in continuous improvement activities. One company, I/N Tek, encourages workers to be involved in individual *kaizen* and to contribute suggestions, but it does not yet have an organized quality control circle program. Its Japanese parent, Nippon Steel, however, is pushing to implement quality control circles (personal interview, Japanese vice-president of I/N Tek, November, 1990). In part, this may be because I/N Tek has been operating for less than two years, so it may be too early to expect full transfer of Japanese *kaizen* and quality control activities. Another joint venture company has experienced some worker opposition to such activities. This company disbanded its quality control circle program after it generated opposition from workers. But, interestingly, both company and union representatives ascribed the failure of the program to the nonresponsiveness of management. Workers initially displayed enthusiasm, but they became discouraged when management failed to act on their suggestions. The company is currently trying to reintroduce quality control circles, and it has begun to provide small cash payments for successful groups, though it no longer refers to them as quality control circles. The union local is cooperating in the reintroduction of continuous improvement activities because it believes that such activities can be used to improve elements of the production process, reduce injuries, and make work safer and less stressful.

Fourth, notwithstanding plant-specific obstacles and rigidities, workers are adapting to the new model of work and production organization. There is little evidence in the case of steel to support either the super-exploitation of workers thesis advanced by Dohse et al. (1985) or the "management-by-stress" argument of Parker and Slaughter (1988) for the Japanese automotive industry. Indeed, many workers in these plants prefer the new Japanese model over the old Taylorist one. There are a number of reasons for this. Steel industry jobs are relatively highly skilled, often individualized, and nonrepetitive. Steel production is not an assembly-line work process. The steel production process also allows workers a modicum of control over their own existence. Further, since they are largely long-time steelworkers, almost all of these workers remember the system under U.S.-controlled management and the social disorganization, disinvestment, dictatorial management, and outright crisis that at times went along with it (e.g., high levels of absenteeism and alcohol abuse). Few workers seem eager to return to that environment. Workers at the restructured plants recognize that while their own *kaizen* and continuous improvement activities may increase the pace of work, this is a necessary condition for ensuring the success of the firm and their own employment security. One worker who was interviewed stated that such activities are key to "long-term job security," and he perceived such activities as "working to protect his job" (personal interview with steel worker, Japanese-U.S. joint venture, fall, 1990). Workers in companies with performance bonuses and profit sharing saw such activities as a way to increase their income. According to a worker who is also a local union official: "We sped up our line. We sped it up 6 months into production. But we have a very lucrative profit sharing plan, so I'm making probably $12,000 a year more here than I was before [at a traditional steel mill]" (personal interview, November, 1990). Here, the workers agreed collectively to speed production. The firm had effectively linked the worker's interests and its own by tying economic incentives to the ideological component of "working to protect my job."

Fifth, the major obstacle to restructuring is not the factory-level workforce, but the deeply entrenched middle-management bureaucrats and supervisors. Many of the Japanese-U.S. joint ventures are traditional plants that inherited a large group of factory supervisors and managers accustomed to highly structured, rigidly bureaucratic, and adversarial management-labor relations. Given that work teams and increasing worker self-direction threaten this traditional system of control and supervision, the front-line management stratum has sought to protect itself and has at times worked to sabotage the restructuring process through disinformation, by continuing traditional top-down supervisory patterns, and by impeding communication between factory workers and upper-level (especially Japanese) management. Workers as well as senior management officials suggested that middle-level managers at times fall back upon traditional ways with detrimental effect. Japanese executives and upper-level managers increasingly recognize the problem posed by such a rigid middle-management stratum, but stated that they felt dependent upon this group (at least in the short term) and that it was difficult to find front-line and middle-level managers "something constructive to do" (personal interviews with American and Japanese executives, summer-fall, 1991). The complexity of this situation is exemplified by a union president at one steel transplant who stated that his counterparts in the Japanese union suggested that he communicate more with the Japanese managers, because "they would be a lot more sympathetic to what you want than your American managers" (personal interview, November, 1990). Recognition of the role of managerial rigidity provides an important dimension that is missing from most prevailing theories of restructuring, which focus on the constraints and rigidities posed by the factory-level workforce.

Summary and Discussion

Japanese direct investment is shaping the technological, organizational, and spatial restructuring of the U.S. steel industry. This restructuring is occurring on three related geographic scales. At the global scale, growing Japanese investment in U.S. steel reflects the more general shift in the global center of steel production technology and accumulation from the U.S. and Western Europe to Japan. These Japanese advances are now diffusing back to the U.S. via Japanese direct investment and Japanese-sponsored restructuring. At the national level, within the U.S., Japanese investment reinforces a westward shift in the center of steel production from the traditional Pittsburgh-Monongahela Valley region to Ohio, Michigan, and Indiana. This spatial redirection stems from the high fixed costs of integrated steel production, the increasing automotive orientation of the steel industry in general, and the particular requirement of supplying high-quality flat-rolled steel to the automotive transplants and their suppliers on a just-in-time basis. At the microscale, existing steel production facilities have undergone in situ restructuring of both the organization of production and the content of human labor power.

Underlying observed geographic patterns, then, is the deeper process of industrial, technological, and organizational restructuring at the point of production. Such restructuring is required to bring the immediate, plant-level environment of domestic U.S. steel production in line with the Japanese production system in general and the requirements for supplying the automotive transplants in particular. The restructuring process has occurred differentially. Smaller, specialized facilities (e.g., steel galvanizing and coating lines) have moved toward replication of Japanese production practices, while larger, integrated facilities are moving more slowly and partially toward the Japanese model. These findings suggest that production organization has a powerful effect on geographic and spatial organization and that large hegemonic firms can transform existing landscapes in line with and in light of the functional requirements of their underlying model of production organization (Florida and Kenney 1991).

The power of Japanese industry to transform the American steel industry has been remarkable. Japanese steel corporations have combined capital investment with a broad-based strategy of organizational restructuring and a simultaneous restructuring of human labor power. They have sought to implant the Japanese system of work and production organization in the steel sector—in the face of an apparently solid barrier of institutional forms, organizations, and historical practices. These long-established capital-labor trench lines described by Gramsci (1971) are collapsing in response to an entirely new system of organizing the capital-labor relationship at the point of production. Japanese involvement in the U.S. steel industry is likely to expand. If present trends continue, Japanese capital is likely to increase its control of the remaining U.S. steel assets, achieving, for lack of a better phrase, a "creeping takeover" of the U.S. steel industry. While these efforts have been considerable, the transfer and restructuring process is not complete or assured of final success.

At a more general level, our analysis of steel suggests that industries and industrial landscapes do not simply evolve according to fixed developmental trajectories. Rather, they go through a dynamic process of change, transformation, and reorganization during which new trajectories and new industrial growth curves open up. Such periods of dynamic restructuring combine technological change with sweeping organizational transformation, setting in motion a new technological-organizational model or regime (Freeman 1987). Ours is an explicitly spatial conceptualization of what Schumpeter (1947; 1975) referred to as the process of "creative destruction." Major recasting of technology and organization—of the underlying forces and relations of production—can and does push industries and industrial regions onto new growth trajectories. Geography enters in a fundamental way by simultaneously shaping and constraining this process of dynamic development. New models of production organization and new modes of capital accumulation do not require major spatial shifts and the opening of new geographic landscapes. Rather, the work and production process may be reoriented and transformed in place—as old organizational structures and places are restructured and new social relations and even human behaviors can be adopted within existing production geographies and industrial landscapes. This process of *in situ restructuring* is clearly an important driver of industrial and regional development—one that is common in Japan and likely will grow in importance over time in the U.S. and perhaps in the other advanced industrial nations as well. The fields of industrial geography and regional science would do well to reorient at least some of their research emphasis away from the more obvious issue of spatial and geographic shift to this increasingly salient and tractable question of the restructuring of established organizations, social relations, and human behaviors in existing spaces.

At the level of global industrial and spatial organization, current events in the steel industry are fundamental. The rise and global diffusion of a powerful new system of production organization and the rapid extension of Japanese foreign investment throughout key regions of the world economy may require a rethinking of our basic concepts of the economic, social, and spatial organization of capitalism, defined as they have been by the empirical realities of U.S. mass production. A new phase of Japanese industrial hegemony—if and when it comes to pass—would certainly entail new modes for organizing and integrating the world economy, new patterns of uneven development, and a new spatial division of labor. It is imperative that geography and the broader corpus of social and economic theory enrich, deepen, and reconstruct their most fundamental theories to explain the new industrial, technological, and geographic realities that will continue to transform the economic, political, and social landscape of advanced capitalism.

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