STABILITY AND CHANGE AT NUMMI

by

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Japanese auto manufacturers achieved great success in world export markets during the 1970s. This success lead to trade conflicts with the United States, and in an attempt to defuse these conflicts, many Japanese auto firms decided to build North American plants. The Japanese companies' export success was often attributed to their highly effective production system — later it would be labeled "lean." Two questions were thus posed. First, could this Japanese lean production system be effective in the US "transplants," or did its effectiveness depend on a Japanese context? Second, to what extent would firms implement this system, or would they adapt it to the very different social context of the US?

The transplants thus constitute an unusual natural experiment for organizational theory. Two broad types of theoretical predictions have been formulated. The first type anticipates that the transplants would closely resemble their parent organizations because the challenges facing the modern capitalist firm are essentially similar across a broad range of settings, and the progressive rationalization of management structures and processes reveals "best practices" — in this case, the lean production system — that are substantially context-independent (Hayes and Wheelwright, 1984; Womack, Jones and Roos, 1990). The second type of prediction anticipates that the transplants would look very different from their Japanese parents and far more like US organizations, because the effectiveness of such complex social practices as lean production depends critically on their fit with the broader social, institutional, and cultural patterns (Cole, 1971; Nakane, 1970; Maurice, Sorge and Warner, 1980).

This chapter explores the issues raised in this debate through an analysis of one transplant, NUMMI, a Toyota/General Motors joint venture in northern California. NUMMI is an interesting plant to study in the light of this theoretical debate because its day-to-day operations were under Toyota control, and NUMMI represented one of the first attempts to export the Toyota production system — the exemplar of lean production — outside of Asia. Research on NUMMI and on other North American transplants has found that in practice, the organizational forms and policies of the transplants have been shaped by both best practices and societal effects, and that the result is typically something of a "hybrid" between home and host country practices (Abo, 1994; Florida and Kenney, 1991; Adler, forthcoming (a)). More specifically, as we will show below, NUMMI made very few changes to the Toyota production system itself, while other elements of Toyota's management system — most notably, in human resource management and industrial relations — were hybridized with elements of the host country's traditional approaches.

NUMMI's initial configuration proved very successful, as NUMMI rapidly achieved world-class levels of productivity and quality. However, at NUMMI as at other transplants, a number of tensions — most notably in union-management relations — have surfaced over the intervening years, prompting observers to wonder whether their initial organizational designs are stable. The term "hybridization" does not only denote a state; it may also refer to an ongoing process. Whence the question addressed in the present study: Were subsequent changes at NUMMI evidence of such an on-going process of hybridization, and if so, how should we characterize the underlying vector of change? Has NUMMI been drawn towards a more American model — consistent with the societal effects position — or towards a more Japanese model — consistent with the best practices position? Or again, perhaps NUMMI was creating a new synthesis distinct from both the reference model? The possibility of a new synthesis is particularly interesting because the Toyota production system itself has been described as a synthesis between Ford's mass production and Japanese setting (Cusumano, 1989).

This chapter therefore contrasts NUMMI's initial configuration with its subsequent

data and an analysis of the sequence of collective bargaining agreements between 1985 and 1994. The third section analyzes in more detail the circumstances surrounding one of the more notable changes in NUMMI's management system, a change relative to the governance of ergonomics issues. A findings section summarizes our analysis of the extent and nature of the post-start-up hybridization process, and a conclusion suggests some more generalizable implications.

NUMMI: THE INITIAL CONFIGURATION

Laying the foundations

NUMMI was formed in 1983 as a joint venture between General Motors and Toyota. For Toyota, the establishment was the first step in a strategy designed to alleviate trade frictions by establishing plants in the US. NUMMI, as the first of several projected plants, would not only contribute its own economic and political benefits, but would also help Toyota learn about US suppliers and labor. For its part, General Motors wanted to learn about Japanese manufacturing systems, and they needed a small car to fill a competitive weakness in their product line. Toyota contributed $100 million in cash, took responsibility for the plant's day-to-day operations, and provided the design of the plant's main product, the Nova, a variant of the Corolla. GM contributed the facility and was responsible for marketing the new vehicle. As an independent California corporation, NUMMI raised the remaining $250 million needed to prepare the plant for production.

The Federal Trade Commission studied closely the proposed venture. As a joint venture between the largest US and the largest Japanese auto firms, it had possible antitrust implications. Moreover, Ford and Chrysler filed a lawsuit attempting to block it. In 1984, the FTC approved the formation of the company, but limited its lifetime to 12 years. (In November 1993, this sunset clause was vacated.) In 1985, a settlement was reached with Ford and Chrysler.

The facility that GM contributed to the venture was located in Fremont, California. The GM-Fremont plant had closed in 1982. It was one of GM's worst in terms of productivity, quality, and labor relations. Although Toyota was initially reluctant to work with the United Auto Workers, eventually the company agreed to recognize the union and to give priority to rehiring laid-off GM workers. With the UAW threatening to take refusals to rehire these workers to arbitration, NUMMI ended up rehiring almost all the laid-off workers who applied. Of the 1200 workers employed when production began in December 1984, 99 percent of the production workers and 75 percent of the skilled trades workers were former GM-Fremont employees and UAW members. Like the work force, the factory underwent minimal modifications — with the significant exception of the addition of a new stamping plant. When it opened, NUMMI was at best a mid-technology factory, with a few robots but little of the high-tech equipment in the newer GM factories.

The joint venture agreement gave Toyota responsibility for plant operations; but it was not obvious how Toyota would tackle this task. According to an American consultant brought in by Toyota to help them with the organizational design of the new US subsidiary, Toyota managers were at first very unsure which policies could or should be exported to NUMMI given its very different institutional and social context and given Toyota's inexperience in that context. On the one hand, by the early 1980s it had become clear to Toyota managers (and many external observers) that Toyota's success in exports had been due not just to exogenous factors such as currency rates, but also to its distinctive management policies and practices. On the other hand, two questions were still very difficult to answer: Which specific policies and practices were responsible for Toyota's success, and could these be transplanted into another social context?

It is difficult for us to reconstruct the precise terms under which these issues were debated within Toyota, but our interviews suggest a complex set of interrelated sources of uncertainty. First, Toyota had for at least a decade considered the Toyota production system as a key factor in its

plants have an "andon" (signal) cord which workers are encouraged to pull to alert the Team Leader whenever they notice a problem, and if they cannot solve the problem within 60 seconds, the line will stop. NUMMI's second president Kan Higashi recalled in an interview: "We had heavy arguments about installing the andon cord here. We wondered if workers would pull it just to get a rest."

Second, there was considerable uncertainty about other parts of Toyota's management approach, the parts beyond the production system such as administrative structure, human resource management practices, industrial relations, and supplier relations.[1] These might well have been critical to Toyota's Japanese plants' success, either directly or as preconditions for the effective implementation of the production system. If so, could these practices be transplanted? If not, what practices more consistent with the US context might serve as adequate functional equivalents? How far could NUMMI deviate from the overall configuration of Japanese practices before the powerful complementarities between the various practices were lost?

By the time NUMMI began operating, a response to this tangled set of questions appears to have emerged. NUMMI would be charged with transplanting as faithfully as possible all the elements of the Toyota production system — which Toyota management saw as a distinctive competence — but NUMMI would be given considerable latitude in hybridizing the other components of the management system — so long as they buttressed rather than impeded the functioning of the production system. It was decided that the cherished "three pillars" of the Japanese employment system — life-time employment, enterprise unions, and seniority wages — would need to be extensively redesigned to fit the US context; but NUMMI management was charged with finding functional equivalents wherever possible, and in any case ensuring complementarity with the requirements of the production system.

The NUMMI Production System

NUMMI's production system was modeled directly on Toyota's. NUMMI described its production system as composed of the following "techniques":

• **Kanban**: NUMMI did not use a computerized in-plant scheduling system. Instead, signs — kanban — would be passed to the upstream department whenever inventory pallets or dollies needed to be replaced. When no kanban arrived, the upstream department stopped production because no inventory was allowed to build up.

• **Heijunka**: Under NUMMI's policy of heijunka, the schedule was leveled over several months, and periodic adjustments were made to output levels by varying the line speed. The principle underlying the leveling policy was that changes in output rates were likely to hurt efficiency and quality. The same principle gave rise to the policy of mixed-model production, under which different models were mixed evenly throughout the day's schedule rather than batched. To avoid the costs potentially associated with such a schedule, great attention was paid to reducing set-up times.

• **Kaizen**: NUMMI put great emphasis on kaizen — the continuous improvement of all aspects of production. All NUMMI workers were given training in problem-solving for kaizen. Workers'

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1 There are a number of competing conceptualizations of the overall structure of the firm. Boyer and Freyssenet (1995) distinguish "apparatuses and practices"— design, buy, make, and sell — from a superstructure layer — administration, and employment relation — and a third decisional layer — power structure, and strategy. Porter (1985) distinguishes a core — inbound logistics, operations, outbound logistics, marketing and sales, and service — and a supporting infrastructure — procurement, technology development, and human resource management. Neither have much

participation in the suggestion program was seen by management as a key measure of the plant's performance.

• **Visual control**: This policy was designed to signal abnormal conditions as rapidly and automatically as possible. Kanban was one form of visual control, signaling the need to replenish an inventory pallet. Another key element of visual control at NUMMI was the andon cord connected to lights on the andon board that signaled problems on the line.

• **Poka-yoke**: The overarching goal of the Toyota production system was jidoka — assuring quality in the production process itself. This goal was pursued through the design of numerous poka-yokes, or error-proofing devices: parts packaging, equipment designs, and tool setups were specified so as to make inadvertent error almost impossible.

• **Team concept**: The team concept at NUMMI encompassed both the philosophy of cooperative labor relations system described below and the organization of small production teams of four to six workers. Workers in each team were cross-trained on each others' tasks, and most workers rotated between tasks.

• **Standardized work**: This practice was, in the words of a NUMMI manager, "the intelligent interpretation and application of Taylor's time and motion studies." Each job was analyzed down to its constituent gestures, and the sequence of gestures was refined and optimized for maximum performance. Every task was planned in great detail, and each person performed that task identically. Unlike traditional Taylorism, standardized work at NUMMI was conducted not by staff methods engineers — NUMMI had none — but by Team Leaders and Team Members themselves.

While these policies were transferred basically unchanged from Japan, details were adjusted. Kan Higashi explained NUMMI's approach in these terms:

"Workers in the US are used to a more individual approach. Even in schools, Japanese students are used to a more disciplined approach. So we had to adjust our manuals and our polices in areas like standardized work. Even at the simplest level of vocabulary, when we Japanese use what we think is the exact English, the concepts are so foreign to them that Americans often think we are still speaking Japanese."

Translation is always interpretation, and in some areas, this interpretation was more complex than others. The "team concept," for example, is not typically listed as a core element of the Toyota production system in Toyota's Japanese publications, since small groups are often seen as the natural, taken-for-granted organizational form even when the technical interdependence of tasks is relatively low. Coming to the US however, Toyota was concerned about the reaction of reputedly more individualistic American workers, and was therefore eager to make the small group structure look appealing, and so, leveraging the positive connotations of teams in sports, the "team concept" was written into the characterization of the NUMMI production system. Similarly, intra-day rotation was relatively rare in Toyota's Japanese plants, but it was written into NUMMI's collective bargaining agreement as an expression of management's concern with ensuring worker involvement and stimulating work.

NUMMI's Management System

NUMMI's production system, like Toyota's, relied on a distinctive approach to internal administration, external suppliers, and workers. In this subsection, we review the initial configuration of each in turn.

NUMMI's internal administration was modeled rather directly on Toyota's. The formal organizational structure resembled Takaoka's rather than GM's. The number of layers was not significantly different between the two reference points — Toyota, like other large Japanese firms had a finely graduated hierarchy — but NUMMI's division into functional subunits was closely matched to Takaoka's and quite unlike GM-Fremont's, so to assure easy trans-Pacific

Adler, forthcoming (a)), second only the Production Control. Some Japanese administrative practices were conspicuously absent, most notably hoshin kanri which only appeared in 1993, but even such a distinctively Japanese practice as ringi-sho was implemented — and not without difficulty according to Kan Higashi:

"It took us almost one full year to work out how to apply the ringi-sho style of management communication and decision-making. In Japan, it's traditional to get as many opinions as possible before taking a decision and to make the decision as much as possible on a consensus basis. It took us a year to translate that into a process that the American managers could understand and begin to feel comfortable with. For example: American managers are used to being free to use their own department's budget however they think is appropriate, while for us, even if you have the budget, you should still get consensus from other department managers on specific non-repetitive projects that you want to spend it on. We think it's a good system because your colleagues might have some valuable suggestions or important concerns, and also, when it comes to implementing your decision, the other department will be more cooperative. But American managers were used to another way, and it took a long time for them to become comfortable with our way."

Supplier relations were also patterned directly on Toyota's Japanese practices. But the implementation of this approach proved difficult. Reflecting on NUMMI's early period, Kan Higashi made this observation on the shift to a Toyota style of supplier relations:

"Our biggest hurdle was trying to establish Japanese style relationships with US suppliers. About 65 percent of our cars' value is locally sourced. So supplier relations are very important. We want to establish long-term relationships with suppliers, but we also want them to compete aggressively among themselves for a portion of our business. Competing while remaining dedicated to product improvement and exceptional quality is a key to good business in Japan. This was a difficult concept for American suppliers to accept, and we got a very negative reaction from them in the beginning. They were used to long-term relationships, but only sweetheart ones. After two years, suppliers have begun to understand our concepts and are now performing very well."

Partly because of the geographic distance separating NUMMI from key suppliers in Japan and the mid-west, "just-in-time" supply schedules would be measured in days rather than hours. NUMMI held on average nearly three days of inventory.

While NUMMI's modifications of Toyota administration and supplier relations were primarily a matter of degree, its modifications of Toyota human resource and industrial relations policies were at least in part more substantial. But simple adoption of US practices was not an option since NUMMI's production system relied on a distinctive relationship with workers. Under kanban, for example, production problems rapidly would bring the entire line to a halt, and a high level of worker involvement was required to ensure a timely response to problems. Under andon, workers needed to use their judgment as to whether a problem was serious enough to risk stopping the line. Under standardized work, workers rather than methods engineers defined the procedures. Under kaizen, workers were called upon to generate improvement ideas and were mobilized in a constant process of adaptation. Under the team concept, workers rotated jobs rather than fighting for the right to keep the easier ones.

To create and sustain this high level of worker involvement, NUMMI needed a comprehensive set of supporting human resource management and industrial relations policies. In many areas these policies created different incentives and broader opportunities than those at GM-Fremont and other traditional Big Three plants, including greater job security, career mobility, and employee voice. But Toyota's Japanese policies did not provide a very useful template either, and as a result, in many policy domains, the weight of social, cultural, legal, and institutional factors forced considerable adaptation and hybridization.

NUMMI's approach to training was relatively close to the Japanese model — at least in

hours of training in areas such as standardization techniques, the principles of kaizen, and leadership development, far more than the 20 hours that was standard at American auto makers.

Training in the skill trades area, however, was more of a hybrid. On the one hand, NUMMI leaned in the Japanese direction by extensively cross-training and grouping them into only two classifications — general maintenance and tool-and-die — compared to the 18 classifications at the GM-Fremont facility. On the other hand, NUMMI maintained the traditional US apprentice system with its sharp distinction between skilled trades and production worker categories, unlike Toyota's Japanese plants where the lines are very blurred.

NUMMI's commitment to employment security reflected Toyota's Japanese policy, but made it more explicit. Whereas in Japan, Toyota commitment to employment security was largely tacit, the NUMMI contract stated explicitly that before laying off workers, the company would cut managers' pay and bring in work contracted out to suppliers. Many workers initially doubted the credibility of this commitment, but slow sales in the late 1980s afforded a test. During much of 1987 and 1988, demand for the Nova was weak, and NUMMI was running under 65 percent of capacity. Instead of laying off shop-floor workers, the company sent the entire work force to training classes, took back in contracted maintenance tasks such as painting, and placed surplus workers into teams that designed the production process for the next model car.

In pay practices, NUMMI was much closer to the traditional Big Three pattern. NUMMI's wage levels were pegged to those in the Big Three. But even in the pay arena, some innovative hybridization was visible. On the one hand, the Big Three had multiple pay levels based on job classifications that in practice were closely correlated with seniority. On the other hand, in Japan Toyota had a pay system of byzantine complexity, combining skill level, seniority/age, supervisor's evaluation of attitude and performance (satei), and department performance. NUMMI followed the Japanese approach to the extent of radically simplifying the job classification structure with only one production worker category and two skilled trades categories, but largely eliminated direct or indirect linkages to seniority, and — reflecting a long-standing position of US unions — NUMMI had no performance-based pay based on supervisor's evaluation, nor (at first) even any gainsharing.

In other ways too, NUMMI had to create policies that departed from the Japanese practices. Unlike the Japanese workforce, NUMMI's was very diverse, with over half the production workforce composed of minorities and nearly one-fifth women. Unlike some other Japanese firms that established plants in the US, NUMMI took an proactive stance in assuring equal opportunity. Hispanics, African-Americans, and women were brought into management positions as well.

In some respects, NUMMI's policies drew inspiration from some of the more "progressive" US firms' union-avoidance practices. Most notably, NUMMI paid considerable attention to the symbols of unity of purpose. Senior executives and workers parked in the same lots and ate in the same cafeterias as line employees. Managers (and those workers who chose to) wore a company uniform. We might think of these practices as functional equivalents of the "groupism" that appears to make the exercise of managerial authority less problematic in Japan.

Labor relations

Working within a very different legal and cultural environment than the Japanese parent, and forced by GM's choice of the Fremont facility to come to terms with the UAW, NUMMI and the UAW Local forged a novel relationship. The initial contract embodied a very different role for the union than in the former GM plant. The introduction stated, "We are committed to building and maintaining the most innovative and harmonious labor-management relationship in America."

The innovations here were, first, in the union's formal role. On the one hand, the union gave up the right to strike over work standards and health and safety. Problems in these areas that could not be resolved by union and management dialogue were to be sent for final resolution to the UAW

management on labor issues. Moreover, in exchange for the employment security provision, the union gave up the Supplemental Unemployment Benefit fund negotiated in the Big Three.

On the other hand, Management was contractually obligated to consult the union on matters ranging from the pace of work to major investments — areas of decision-making usually reserved solely for management. A range of meeting forums was specified, from the section level up to quarterly off-site joint conferences of the company and Local's leaders. The union committed itself to supporting ongoing kaizen efforts in the plant.

Innovations were also apparent in the mutual commitment to informal problem-solving. The dispute resolution procedure at NUMMI emphasized solving problems quickly and at the lowest level possible, without filing formal grievances. For example, a worker had a dispute with a Team Leader could call on the work group's union coordinator (a regular worker who works a few hours a week resolving disputes); if they failed to resolve the dispute, they called over a representative from the Labor Relations department and an elected full-time union representative. Only after these informal means were exhausted was a formal grievance written up.

But other features of labor relations reflected standard American practice. As in most union contracts, the grievance procedure included a series of appeals to higher levels of the company and union, culminating in binding third-party arbitration.

The effectiveness of the initial configuration

Within two years of start-up, NUMMI had reached world-class levels of efficiency and quality. With largely the same work force and equipment, NUMMI had achieved productivity levels almost twice those of GM-Fremont in its best years and 40 percent better than the typical GM assembly plant. It was producing not only the highest quality levels GM had ever known but also the highest of any domestic auto plant (Krafcik, 1989).

Worker satisfaction at the plant was also high. When researchers asked NUMMI workers whether they would switch jobs if a GM plant were across the street, the response was uniformly negative. Absences, which had run over 20 percent at GM-Fremont, were less than three percent (excluding only scheduled vacations). In the first couple of years, the UAW filed only about 50 formal grievances against NUMMI per year, about as many as were filed every two weeks at GM-Fremont.

NUMMI'S SUBSEQUENT EVOLUTION

Several indicators suggest that in the decade since its inception, NUMMI managed to retain a level of performance close to the evolving world-class frontier. Efficiency continued to climb, with the number of hours required to assemble a vehicle gradually falling. Quality too has continued to improve. Exhibit 1 summarizes the J.D. Power and Associates data on the quality of NUMMI's products and compares NUMMI's record with that of the industry average, the best vehicle in the small car segment, and the Corolla assembled in Takaoka, Japan.

[put Exhibit 1 about here]

In the following sub-sections, we analyze the sources and implications of this performance through an analysis of the evolution of NUMMI's policies and practices over this period.

Plant charter

NUMMI's basic charter evolved only modestly. In 1986, the company began producing the

expand the plant and begin production of Toyota compact pickup trucks. The new line opened in September 1991, adding 700 workers to the factory. In 1993, the plant added a plastics plant for the production of bumpers, adding another 250 jobs. By 1996, the passenger car line was producing about 220,000 units a year, and the truck line about 141,000 units. Total plant employment grew from 2500 in 1985 to 4600 in 1996 — see Exhibit 2.

[put Exhibit 2 about here]

In 1993, the FTC approved a petition by GM, Toyota and NUMMI to vacate the original order limiting NUMMI's life to 12 years, and NUMMI was allowed to continue operating indefinitely. Opposition from competitors to the venture had abated: in the years since their initial lawsuit, both Ford and Chrysler had established their own joint ventures with Japanese firms.

Since 1983, NUMMI had become progressively more independent of its parent plant at Takaoka and other corporate support from Japan. Like GM, Toyota was restricted to a limited number of regular staff — in Toyota's case, a total of 36. At first, these expatriates were all in managerial roles. The first managers of Quality Control, Production Control, and Quality Engineering, for example, were all Toyota "assignees." With the passage of time, they shifted out of direct managerial roles to serve instead as "coordinators" who advised American managers and facilitated liaison with their counterparts in Japan.

Another index of this growing independence was the progressive reduction in the number of Toyota people coming the NUMMI to help out on the major model changes that occurred every four years. Toyota sent both "resident engineers" who came for three to six months and "advisors" who came for a couple of weeks to work on more specific issues. During the first major model change in 1984, the total number of such visitors was around 300. During the second changeover in 1988, the number fell to 150; in 1992, it was around 50, and in 1996 around 20. The number of advisors visiting the plant between major model changes was also progressively reduced.

In part, this growing independence reflected the natural maturation of NUMMI's technical and managerial capabilities. For another part, however, it reflected a policy of forced weaning driven by Toyota's strategic goal to make NUMMI self-sufficient. And finally, it was driven in part by the fact that Toyota was being stretched much thinner as the number of its overseas subsidiaries grew, and so it could not afford the earlier level of support.

A third index of NUMMI's independence and maturation was the progressive increase in the number of parts it purchased in North America. While in 1986 the domestic content of NUMMI vehicles was around 55 percent, over the subsequent decade it rose to 75 percent.

Finally, as NUMMI matured, it took on a more substantial role in helping design each new model. In the early years, NUMMI did not introduce its new models until two years after Takaoka. By the model change in 1992, the interval had fallen to only one year.

These shifts in charter provide indirect evidence relevant to this study's central research question. From Toyota's point of view, NUMMI's growing independence reflected growing confidence that the subsidiary was progressively mastering the Toyota production system and refining its supporting administrative, supplier, and human resource pratices to better support that production system. Over this period, NUMMI's production system, administration, and supplier relations moved progressively close to Japanese practices. Quality provides one indicator of the shift in the production system: underlying the continuing improvement in NUMMI's product quality lay progressive mastery of Toyota's quality assurance and kaizen policies in both NUMMI and supplier operations. Planning practices provide an indicator of the shift in administrative processes: in 1993, NUMMI introduced Toyota's hoshin kanri system for ensuring that strategic goals were translated into actionable commitments at successively lower levels in the organization.

Evolving human resource management and labor relations policies

A review of the successive collective bargaining agreements signed in 1985, 1988, 1991, and 1994 reveals a number of changes in personnel management and labor relations policies. Several of them first made their appearance in 1991. The timing reflects the impact of the start of the truck line, which brought with it the first significant wave of hiring since NUMMI's start-up.

A first notable change was in the wage structure. Up until 1991, new production workers were paid at 85 percent of the regular rate, and their pay increased to the full rate over 18 months. In the 1991 agreement, the starting rate was reduced to 75 percent and the "grow-in" period extended to 24 months. In the 1994 agreement, this was further reduced to 70 percent and 36 months. Our interviews at NUMMI suggest that the union agreed to these changes in exchange for the job creation opportunities provided by the truck line and subsequently by the plastics plant. Toyota could have chosen not to locate these activities at NUMMI and could instead have put them in its other plants in Kentucky and Canada. The 1991 collective bargaining contract thus included a memorandum which begins: "In view of the Union's deep concern about the long-term job security of its members and the ongoing viability of the Fremont operation, the Company has agreed to institute truck production at its Fremont Facility. In recognition of the foregoing, the parties hereby agree that" the hiring rate would be set at $11.60 to rise to $15.46 over 24 months. The memorandum went on to state that this pay schedule was supposed to be temporary, with a return to the original levels and grow-in rates in 1994. However, the 1994 contract eliminated the memorandum and the explicit rationale it provided, and simply changed the rates cited in the body of the contract to 70 percent and 36 months.

While this jobs-versus-pay trade recalls the old-style strategy of "whipsawing," we might also note that the 36-month grow-in period may be closer to the real growth in the skills and productivity of new hires at NUMMI. The traditional policy of the Big Three was to simplify production workers' jobs to the point where a new production worker could be fully effective within a few days. By contrast, NUMMI, like Toyota, invested considerably more in up-front training, annual classroom training, and skill-broadening on-the-job training. A longer grow-in period might be seen as a functional equivalent to the Japanese practice of distinguishing five or six skills grades among production workers.[2]

Perhaps in order to sweeten the 1991 deal, NUMMI introduced a gainsharing program in that same year, the "Performance Improvement Plan Sharing" (PIPS). The program rewarded workers for improvements in quality and efficiency and, since it was negotiated in the latter part of the year, specified that "In the first year only, a guaranteed payment of $600 will be paid in December 1991." In subsequent years, this payout remained relatively stable: see Exhibit 3. PIPS seems to have served a similar function to Toyota's home country practice of productivity-based components in Toyota workers' monthly wage.It was even more similar to the system introduced in Toyota's Kuyshu plant which opened in 1991, where the productivity component in the monthly wage was eliminated and replaced by PIT (Performance Incentives of Toyota Motor Kuyshu), which rewarded workers bi-annually based on output, quality, safety, and cost performance relative to targets (Shimizu, 1995).

[put Exhibit 3 about here]

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2 Note that even at 70 percent of full pay, the starting rate represented a relatively high pay level compared to workers' alternatives. Brown and Reich (1989) cite data from the California Employment Development Department indicating that of the workers who lost their jobs when GM-

In 1991, NUMMI also introduced QC circles (called Problem Solving Circles, or PSCs). Unlike many American firms who tried and failed QC circles, Toyota and NUMMI managers thought of these small-group activities as an "advanced" practice, requiring of the whole workforce deep production knowledge that takes many years to acquire, and also requiring of Team and Group Leaders considerable leadership skills. The PSCs thus reflected a convergence towards Japanese practices. NUMMI's PSCs were more truly voluntary than at Toyota plants in Japan, although participation was expected of workers hoping for promotion to Team Leader positions. PSCs were structured as a standing committees based on work Groups (not Teams, as in Japan).

In 1994, changes were made to the Team Leader selection process. Team Leaders at NUMMI were hourly UAW workers paid a 50 cent per hour premium (increased to 60 cents in 1988). They had no supervisory responsibilities, and played a role closer to that of a "utility worker," replacing absent workers in their team, training new workers in their tasks, and assuring minor administrative responsibilities. In NUMMI's early years, NUMMI followed the Japanese practice and Team Leaders were selected by management. This gave rise to loud and persistent complaints of favoritism. As a result, in 1994 the union and management negotiated a more formal process in which the evaluation and final selection are conducted by a joint union/management committee. In this new process, seniority was only used as a tie breaker and all Team Leader openings were posted. People wanting promotion to Team Leader undertook 20 hours of pre-selection training on their own time, and selection was based on their performance in these classes and in their current jobs. (On teams at NUMMI, see Adler, forthcoming (b).)

This joint selection of Team Leaders gave the union a more formalized role than in Toyota's Japanese plants, but its underlying rationale was similar. Like Toyota, NUMMI saw the Team Leader position is an essentially technical one, rather than either as team spokesperson or manager. A joint selection process was therefore an acceptable formula to management. By contrast, it is rare in the US that union and management jointly select personnel. The US industrial relations tradition relies on seniority (in unionized settings and for non-supervisory positions) or management prerogative (in non-union settings and for supervisory positions). The unions at Mazda Flat-Rock and the CAMI plant have fought hard for the principle that Team Leaders should be elected as worker representatives. Even at Saturn, the union selects its "module advisors" and these are paired with management-selected module advisors.

The 1994 agreement also embodied another important change: the extension of the section on Safety to cover "Health, safety and ergonomics." This agreement created a new union representative for Ergonomics (alongside the single existing Safety representative); upgraded the level of management representatives co-chairing the Joint Safety Committee; and specified a Health, Safety and Ergonomics problem resolution procedure. A letter was appended to the agreement, specifying a series of management and union commitments in the ergonomics arena and explaining how the company would implement the provisions of a Cal-OSHA Special Order of January 1994. (We return to this issue below. Cal-OSHA is the California state agency that performs the role that the federal Occupational Safety and Health Administration plays in most states.)

Several other changes over the period should be noted. The contracts show a growing sensitivity to gender, with a marked shift to gender-neutral language in the 1998 document, and the addition of harassment to the Code of Conduct in 1994. There was also a progressive increase in the proportion of union representatives in both 1991 and 1994.

Over time, the contracts also show a broadening and upgrading of worker benefits including a legal services plan, supplemental workers' compensation plan, mental health coverage, and retiree supplemental health insurance — all fairly conventional in unionized parts of US industry. Along

The combined effect of all these changes is that the number of pages in the contract grew from 96 in 1985 to 147 in 1994. By comparison, the 1979 agreement between GM and the old GM-Fremont UAW Local 1364 ran 250 pages and piggy-backed on a national agreement which ran over 1000 pages**.**

Evolving worker attitudes

These changes reflect shifts we found in the plant's climate and in the relationship between workers and management. As the memory of GM-Fremont days receded, and as some 2100 new hires were brought into the plant since 1986, NUMMI entered a new phase. Many workers we interviewed during several visits since 1994 remained enthusiastic about the idea of labor-management cooperation and continuous improvement. Nevertheless, almost every worker, manager, and union leader we interviewed noted tensions between NUMMI's vision of cooperation and the day-to-day realities of life in an automobile plant. This subsection reviews a number of symptoms of this change of climate.

Some of the changes were evident in the area of communication. Some teams and safety committees were meeting less frequently than in earlier years. One Team Member expressed her assessment: "They've reduced the number of team meetings we have. Now we're lucky if we get one group meeting a month. It used to be when something came up, you were always informed. But now, often even the Group Leader isn't informed."

While job rotation had never been universally practiced, we encountered numerous complaints about increasingly common impediments to rotation. On the passenger car line, many workers complained that rotation opportunities had been affected by absences, insufficient cross-training, and the attitudes of some workers who held onto easier jobs. Another worker commented: "We have a lot of older workers here, and we have to have some easier jobs for them, and so we don't always rotate." We encountered concern over the fact that management had minimized rotation on the truck line, arguing that the long cycle times — 140 seconds from September 1991 to September 1992, then 135 seconds until April 1993, then 106 seconds till August 1994, and 96 seconds since then, compared with 60 seconds on the passenger line — made rotation less necessary and more costly. Less frequent rotation can, however, have ergonomic implications, as we will see below. Furthermore, said one Team Leader, reduced rotation had an additional, subtle effect: team cohesiveness, she claimed, was "not like it used to be," largely due to the resulting higher stress and lower interaction among Team Members.

Another symptom of the change could be found in workers' attitudes toward kaizen activity. Participation in the suggestion program (that is, the proportion of workers contributing at least one suggestion a year) rose to 94 percent by 1992. But this level subsequently slipped back to 87% in 1996, and the average number of suggestions per worker slipped from a high of 4.6 in 1992 to 3.2 in 1996. These levels, while far higher than found in Big Three plants, were well below those found at Toyota plants in Japan, where the participation rate was over 90% since 1980 and the average number of suggestions per workers commonly ran over 40. In some areas where work processes had remained stable, prior kaizens had captured the main improvement opportunities, and new kaizens were typically smaller in scope. "We don't have as many kaizen teams as we used to," said one worker in an inspection area. "We can only go so far in our area. After eight years, we've set up all the equipment. There's not that much left to change." In most areas, however, processes had been changed by the periodic introduction of new models or new equipment, thus renewing the opportunity for kaizen; but even in these areas, workers' active involvement in improvement efforts was no longer the novel experience that it had been for GM-Fremont veterans in the early days of NUMMI. It had become a taken-for-granted part of the job.

Although most workers we spoke with endorsed NUMMI's management philosophy, many

that had been implemented. She subsequently refused to submit any suggestions except safety-related ones. Moreover, some interviewees argued that management failures had been growing in frequency and importance, and that the early emphasis on cooperation and participation was fading. Leo Garcia, a union official affiliated with the People's Caucus, reflected the sentiments of these more critical interviewees:

"Workers offer ideas about how to the change the structure of their team or an operation. But the bottom line is that while it sounds good to let people give their input, there's no implementation. They say, 'Well, I don't think it will work. We're going to do it our way.' That's why people get discouraged and after a while they stop attending meetings or making suggestions."

A common complaint was that management had become distrustful of individuals who developed work-related injuries and illnesses. Said one Team Member: "They don't listen, or try to figure out what to do. You go longer [before getting medical care], letting it get worse, because the company makes you feel like you're causing trouble. The Group Leaders and Team Leaders aren't very receptive either." The California workers' compensation system certainly added to the contentiousness surrounding injuries, but workers also felt that management's overall response was lacking.

Some workers suggested that management attitudes were "drifting back to traditional American habits" as the number of Toyota coordinators and trainers was progressively reduced. Others noted that the composition of management itself had changed. Some interviewees argued that during NUMMI's expansion, some Group Leaders were promoted who had little plant experience. The few managers who were hired from the outside were sometimes not in tune with NUMMI's philosophy.

New Team Leaders, too, did not always inspire confidence. One worker told us, "You've got a lot of Team Leaders who probably shouldn't be Team Leaders. They just wanted to get off the line because they don't want to work. 'I became a Team Leader so I wouldn't have to work' — those aren't my words, those are their words!" While workers pointed out that the introduction of the joint union-management selection process had reduced favoritism in the selection of Team Leaders, some felt that an emphasis on objective performance criteria, especially on classroom tests, was having a negative effect: the same worker said, "A+ students may not be good Team Leaders. You need common sense and mechanical sense. You need to really understand the jobs to be a good Team Leader." Partly in response to these concerns, the 1994 collective bargaining agreement specified a four-month evaluation period for all new Team Leaders.

Some interviewees commented on the disaffection of workers who felt they were unfairly passed over for a promotion to Team Leader or for appointment to a special project team. (The 1994 agreement stipulated that the union would be consulted on the criteria for selecting participants in such project teams.) As the plant matured, these cases became more numerous, leaving a residue of frustration. Favoritism still ranked as the number one concern in the employee surveys (with communications listed as the next-most important concern). While some workers and several People's Caucus union officials we interviewed felt that favoritism was a substantial and growing, other interviewees felt that the complaints were for the main part inconsequential — in the words of one Team Member, "just sniveling."

One result of changing attitudes — and a major source of concern for both workers and managers — was the recent rise in absenteeism. NUMMI's vice president for Human Resources Bill Childs wrote in the employee newsletter "Our attendance has slipped over the past two years. We have lost two days of production in the last eight months because we couldn't start the line on time due to absenteeism; particularly on Mondays and Fridays" (1994). NUMMI's unscheduled absence rate in the very early years had averaged around 2.5 percent; but by 1993, it had risen to around 3 percent. While this level was very low compared with an industry average of around 9

Following the Toyota model, NUMMI sought to reduce absences through both informal and formal means. Because there were no roving replacement workers, when Team Members were missing, Team Leaders had to step in and do their work. Absences would also affect the work and break opportunities of other Team Members. The resulting peer pressure deterred some absences. NUMMI also had a strict absence policy. A worker who was absent for any reason on three occasions within a 90-day period — with two consecutive days, for instance, counting as one occasion — was charged with an "offense," and four offenses in a year could lead to dismissal. Indeed, even though personnel turnover had remained at a low level of around 6 percent, absences were by far the most frequent reason for dismissals. The rigidity of this policy chafed many workers. Quipped then-UAW Committeeman Richard Aguilar, "You have to schedule your illnesses in advance" (quoted in Holusha, 1989).

Notwithstanding these pressures, absences had increased somewhat, creating multiple problems. Several interviewees, both managers and workers, pointed out the corrosive effects of a kind of vicious circle. Partly in response to justified and unjustified absences, and partly as a result of other factors we have already mentioned such as management turnover, some managers had slid toward a less participative style. Workers in turn resented the implied lack of trust: their commitment to production sometimes made them hesitate to act on emerging health problems, but they ended up even more resentful as a result, thus undermining their commitment and ultimately leading to a greater likelihood of absences — and a further management retreat from participative values.

Our overall assessment was that while the overall level of commitment and the resulting behavioral outcomes appeared to have slipped only a little from the high levels documented in previous research on NUMMI's early years, the subjective meaning of their work experience had changed significantly for NUMMI workers. On the one hand, the bi-annual attitude surveys showed that the proportion of Team Members reporting themselves satisfied with their job had progressively climbed to 90 percent in 1991 and barely changed in 1993 or 1995 (although the non-participation rate climbed from less than 5% to over 8% in 1995)**.** In absolute terms, absences had increased only slightly and were still very low by industry standards. Turnover remained low, at around 6 percent per year. Participation in the suggestion program remained at levels that were very high compared to American plants. And the cars produced at the plant were still among the top-ranked small cars and light trucks in the J.D. Power initial quality surveys, with quality and efficiency levels continuing to improve over time.

On the other hand, it was much less frequent to hear the kind of enthusiastic endorsements of NUMMI by workers in the late 1980s (Adler, 1993(a)). The following Team Member's views were probably more representative of the climate in the mid-1990s:

"It's not utopia — there's 4,000 workers here, and a lot of people who work here don't like it. But at least they make an effort to allow you some involvement. I can't say I jump up at 4:30 every morning and say 'whoopee,' but I don't mind it. I'm satisfied. There's been a lot of hiring recently. People come in — the money and benefits are excellent — but they quickly forget that part. They take for granted the good aspects, and dwell on the negative aspects."

Evolution of Local 2244

The climate within the UAW Local evolved in ways that both reflected and reinforced the changes in the plant. Although the factional wars within Local 1364 were legendary during GM-Fremont days, NUMMI started operation with the strong backing of the GM sector of the UAW International and the regional UAW leadership. Some 92 percent of the work force endorsed the first contract.

Within two years, however, the union had split again, and a dissenting People's Caucus was

aggressively enough to protect workers' rights in cases such as injuries, transfers, or overloaded jobs. The Administration Caucus in turn saw the People's Caucus as naysayers with few positive proposals who were more comfortable the old union posture of "Let management make the decision, and we'll grieve it if we don't like it."

In the 1991 elections, the People's Caucus won the presidency of the union Local as well as most of the other elected offices. Of the Administration Caucus incumbents, only veteran Bargaining Committee chairman George Nano won reelection, and his winning margin was small. (Soon after the election, the new union president Charlie Curry broke with the People's Caucus and realigned with the Administration Caucus.) By 1993 the Local was partially paralyzed by its internal conflicts. Many union committees were not functioning, and long-time members were bitter about the high level of acrimony at union meetings. In the 1994 elections, Richard Aguilar took over George Nano's position, which gave the People's Caucus control of all the main positions with the exception of the presidency, which Charlie Curry won again. In 1997, however, the Administration Caucus retook the Local, with George Nano elected as Bargaining Committee chair and a new President, Tito Sanchez.

Neither caucus had clearly articulated a compelling vision of the union's role in the new labor-management climate. The Administration Caucus had become comfortable as a participant in discussions about the policies that affect the plant's overall direction, decisions that management at most plants made without union input. The caucus had been less successful in convincing a majority of its members that it would aggressively defend their interests.

The difficulties facing the Administration Caucus were indeed considerable. When opportunities for dialogue between labor and management leaders increase, the union must make more frequent, more complex, and more important decisions. Thus the union needs to be better informed about what members want, and members need to understand better the issues over which the union is bargaining. When union participation in management decision-making increases, so does the need for rank-and-file participation in union decision-making. The Administration Caucus did not have a model of such internal democracy. The traditional UAW model, well exemplified by Bargaining Committee Chair Nano, assumed that members trusted leaders to bargain on their behalf, and if members decide they do not like the leaders' performance, they would replace them with others at the end of the their term.

In the 1994 elections, the People's Caucus did a better job of convincing the work force that it would defend their rights. The People's Caucus's more militant stance appealed to the new, younger workers who (although turning out in low numbers) provided the Caucus with its winning margins. At the same time, the People's Caucus too lacked a compelling vision of how it would take advantage of the possible benefits of labor-management cooperation, such as the ability to influence decisions concerning new technology or management policies.

Workers appeared for the main part to have an essentially pragmatic attitude towards internal union politics. In the 1997 elections, the People's Caucus was voted out at least in part because they had agreed to the extension of the grow-in period to three years and to the extension of the contract period from three to four years. One veteran worker expressed a commonly encountered view in these terms:

"In the old GM-Fremont days, we had to worry about management playing its games, and the union was there to defend us against them. But now, with the union taking on their new role, it's not as simple as before, and we have to worry about both the management games and the union games. I don't want the type of union muscle we used to have. You could get away with almost anything in the old plant, because the union would get you off the hook. It was really crazy, but it wasn't productive. I still want a union that's honest and that can help the people that really need it. But we've never seen the Administration Caucus really stop management with that "Hey, wait a

ERGONOMICS AT NUMMI

So far, our analysis has suggested that while there have been evolutionary shifts in management policies and systems and in workers' behavior, there has been radical changes in neither. Two interpretations of this relative stability are possible. Citing the elements of stability, one might argue that NUMMI's initial configuration proved robust. Alternatively, citing the elements of change, one could argue that the apparent stability masked powerful forces for change hidden beneath the surface.

One way to test these alternative interpretations is to analyze specific episodes of change. By examining such episodes in greater depth, we should be able to discern the nature of the "force field" — the constellation of forces — that generated the specific outcome of the episode. An analysis of this force field will allow us to judge whether the modest magnitude of the observed changes reflects the modest intensity of the driving forces or, on the contrary, reflects a precarious balance between very intense but opposing forces.

In this section, we undertake such an analysis, focusing on the episode that led to the appearance in the 1994 agreement of a set of provisions concerning ergonomics. (This analysis draws on Adler, Goldoftas and Levine, 1997.) The proximate cause of the appearance of ergonomics provisions in the 1994 contract was a surge in ergonomic problems during the introduction of the 1993 model car and two "serious" citations issued against NUMMI in January 1993 by the California state Occupational Safety and Health Administration (Cal-OSHA) for ergonomics violations:

"Ergonomic hazards were not adequately evaluated when the 1993 major model change was planned and implemented on the Corolla/Prizm passenger car assembly line. […] In many cases, the nature of particular tasks — repetitiveness, high necessary force from postures with high static loading — predict ergonomic problems from first principles."

These citations were appealed by NUMMI, and settled a year later when Cal-OSHA issued a Special Order obligating NUMMI to increase ergonomics monitoring, evaluation, training, and staffing. The 1994 collective bargaining agreement enshrined a separate agreement with UAW Local 2244 that created a new union ergonomics representative and health and safety problem resolution process.

To understand this episode, the following subsections first characterize NUMMI's ergonomics practices and then its management of the model change process. We then analyze the specific issues that arose in the 1993 model introduction, and the changes in ergonomics policy that they led to.

NUMMI's ergonomics practices

The data in the Cal-OSHA files reveal that over the period running from the latter half of the 1980s through the early 1990s, NUMMI's health and safety record was mediocre and showed no improvement trend. Unpublished OHSA data on work-related injuries and illnesses show that in 1992, auto plants in NUMMI's size class had an average incidence rate of 35.2 per 100 employee-years. The average for the lowest quartile was 24.2 and for the highest quartile was 53.7. For most of the 1988-1992 period, NUMMI's OSHA-recordable illness and injury rate hovered between 30 and 45. Even allowing that NUMMI's reporting in this period was probably more comprehensive than that of the average plant, this was not a world-class performance.The contrast is striking with NUMMI's world-class levels of quality and efficiency and its record of continuous improvement in

1993, the rate of work-related injuries and illnesses remained stable and — as best one can compare across plants that have very different reporting practices — rather high.

Three characteristics of NUMMI's ergonomics policies contributed to its unimpressive record. First, NUMMI lacked ergonomics expertise. NUMMI's safety staff were generalists, and none had more than a few weeks in formal training in ergonomics. Moreover, the Safety department at NUMMI employed a staff of only nine for a workforce of 3700, which compares unfavorably with, for example, the situation at Toyota's Kentucky plant where they have a staff of some 24 people for a workforce of around 6000. The NUMMI Pilot Team that laid out the assembly line for the 1993 model change — of which more below — had little or no ergonomics training nor access to specialized ergonomics expertise in the Safety Department. Even the Ergonomics evaluation teams received very limited training.

Second, even though NUMMI had a policy of job rotation, rotations were not specifically designed to balance the ergonomic stresses of the different workstations. Such a balance is often difficult to achieve within the individual work team because; for example, all the jobs may require similar motions that stress the same muscles or joints.

Third, NUMMI relied on Toyota's ergonomics evaluation methodology, but this methodology was weak in some key areas. It gave little consideration to vibration and did not highlight such ergonomically stressful postures such as extended joints and fine finger motion.

Alongside these policy considerations, a interrelated set of informal factors discouraged improvements on the ergonomics front. First, some senior managers appear to have set a negative tone by focusing more on weeding out the minority of "gameplayers" who faked injuries than on the solving the real ergonomic problems in the plant.

Second, the Assistant Mangers — who were the key people responsible for leading health and safety related efforts on the shopfloor —paid little attention to ergonomics. As one Safety Department employee put it, "Assistant Managers are very busy people. In the past, management has harped on them for quality and productivity, so they've focused on what they're being pounded on — not health and safety."

Finally, Group Leaders — who, as the first level of management, were the key resources for identifying and rectifying dangerous and unhealthy job designs — reflected the ambiguity of the messages they received from the higher levels. Moreover, according to one union official, "Group Leaders at NUMMI are way overburdened. Management has kept the manufacturing headcount so lean that Group Leaders just don't have the time to work on health and safety issues."

If NUMMI management seemed to have paid little attention to ergonomics, their approach was not modeled on Toyota in Japan. The assessment of a number of our interviewees was that ergonomic problems were more frequent at NUMMI than at its Japanese sister plant. According to UAW safety representative Enos,

"The Japanese work harder and smarter. They minimize health and safety problems because managers there take a more serious attitude to solving the worker's problem. Their Group Leaders have more time to devote to health and safety issues. They have fewer parts fitting problems. And they move people off the line by their early thirties."

In part, Toyota's Japanese plants had fewer ergonomic problems because their production workforce was young, all-male, and physically homogeneous. But the ratio of the safety and health staff to workers was also five times higher at Takaoka than at NUMMI. The Japanese health and safety staff typically did not have advanced degrees in ergonomics, and they needed to call in trained specialists from Toyota's headquarters' staff to tackle any more complex problems. Nevertheless, the plant staff brought to their task the benefit of an extensive knowledge of the jobs and equipment, and the headquarters staff was close by.

NUMMI management's relative neglect of ergonomics was mirrored by the union Local.

more urgent than health issues which over time lead to illnesses. The Local's newspaper mentioned ergonomics issues only four times between March 1986 and October 1992.

By 1992, the US Big Three auto companies had already agreed to create two or more ergonomics representatives in larger plants, and national agreements between them and OSHA had stipulated ergonomics training and evaluation procedures. NUMMI was thus significantly behind the industry norm.

NUMMI's model change process

Model changeovers are very stressful times for auto plants and their workers. In this subsection we analyze NUMMI's approach to the management of model changes to understand how that approach interacted with a weak ergonomics foundation to create a breakdown.

Unlike the traditional Big Three approach, NUMMI's management of the model change process — patterned closely on Toyota's — brought together the knowledge of workers, design engineers, manufacturing engineers, and suppliers, and brought all this knowledge together very early in the changeover process. More than two years before the August 1992 start of production of the 1993 model, an engineering team from NUMMI and a group of NUMMI suppliers were visiting Japan to work with Toyota's designers. By early 1991, a Pilot Team of line workers, made up of one Team Leader from each production group, was visiting the Takaoka plant to help design the new line. Toyota's Takaoka plant had begun production of the new model Corolla in summer 1991. NUMMI based most of its large-scale changes on the innovations already implemented at Takaoka, but a host of smaller-scale adaptations and innovations were specific to NUMMI.

This early interaction helped in the joint optimization of product and process parameters. The NUMMI team was particularly important in this process for the Prizm. While the Prizm was essentially a variant of the Toyota Sprinter, GM had requested numerous changes to its interior design, and the Pilot Team was the first to build the complete car. Toyota design engineers in Japan incorporated numerous design changes proposed by the team to facilitate production. For example, one small lever that helped attach the door latch was a bit too short to be reached easily. When a Pilot Team member suggested that the lever be extended a half inch, design engineers incorporated the change. It was a minor alteration, but one that saved a few seconds for each car and made the task easier to perform.

Suppliers played a key role in this fast model changeover process. But even the more experienced of NUMMI's North American suppliers had difficulty performing such a rapid model change. A GM supplier might build up its inventory from the normal four-weeks supply to eight weeks and then have a cushion of those eight weeks plus many more weeks that the GM plant was closed to retool and fine-tune its production process. With just-in-time deliveries, however, NUMMI suppliers could not build up a buffer, and NUMMI was closed only one week between the close-out of the old model and the start of production on the new. As a result, changeover management required considerable manufacturing and engineering expertise on the part of NUMMI suppliers and extensive interaction with NUMMI engineers.

Traditional Big Three model changes required plant closures of up to twelve weeks or more. Workers would be laid off and would receive unemployment benefits, often with supplements approximating full pay. At NUMMI, the plant was closed for only a week. A year in advance, workers had been warned that they would be required to use a week of their vacation during this period

When NUMMI reopened, the team members returned to new jobs. Instead of producing some 400 cars a shift, they began with four or five cars a day, trying to attain a 60-second cycle time per vehicle, but stopping after each assembly was complete to identify the sticking points. As the production process began to work more smoothly, production volumes grew. Output went from

determined to be overloaded. As problems arose, workers, Pilot Team members, and engineers all worked together to kaizen the production process.

The '93 Changeover

When production restarted in August 1992, everyone at NUMMI quickly discovered that they were facing a greater-than-normal number of unexpected "fit" and "workability" problems. Many parts of the car simply did not fit together: some parts could not be installed, and others did not align with adjacent parts. Gaps formed between pieces of the interior, and cars rattled when they were driven. Even when the parts did fit, the ease with which they could be assembled — workability — was often seriously deficient.

Several factors contributed to these problems. First, NUMMI had shifted from Japanese to North American suppliers for numerous parts, and as a result, 36 new suppliers were added to NUMMI's supply base for the '93 models. Second, many part designs had been altered in Japan in the course of the very close teamwork between Toyota engineers and their local suppliers, but not all the corresponding changes had been incorporated into the drawings and specifications communicated to NUMMI's US suppliers. Third, only two out of a total of 34 Pilot Team members had prior major model change experience. The others often felt overwhelmed and had difficulty knowing how to prioritize their efforts.

The result was serious quality problems; poor parts fit overall reduced the cars' overall quality. In addition, productivity fell. Parts that should have taken 10 seconds to snap into place were taking 20 or 30 seconds. With a cycle time of 60 seconds, that difference could require that the line be stopped repeatedly.

The workability problems also had a direct effect on workers' health and safety. When parts did not fit well, workers forced them in place by pushing, wrenching, and jerking. These problems were compounded by the suspension of job rotation during the model changeover. Rotation might have reduced the injury rate as workers moved to jobs that used different muscles and off jobs that were particularly likely to cause injury. At the same time, however, rotation would have reduced productivity and quality, because workers were not yet fully trained on all the jobs performed by their teams. NUMMI's plan was to increase rotation to a second job within the team only when all members of the team had mastered their primary job. The end result was a spike in ergonomic injuries and illnesses. In the month following the start of production, the number of workers recorded on the company's OSHA-200 logs as missing work because of work-related injuries and illnesses increased by 12 percent compared to the year before.

According to Gary Convis, NUMMI's vice-president for Manufacturing and Engineering, the unanticipated workability problems set off a vicious cycle. As the ergonomic problems worsened, absenteeism grew. Pinched for labor power, Team Leaders had to work as replacements instead of substituting for team members being cross-trained on their secondary jobs. The delay in cross-training in turn impeded the resumption of rotation. As a result, team members had to work long hours on what were often physically stressful jobs, which led to more ergonomic problems and more absences.

NUMMI reacted by focusing on the root causes: part fit and workability. With well-designed parts and jobs, the parts would fit together easily and the jobs would not require stressful pushing or reaching. NUMMI management focused on long-term solutions that would benefit both safety and performance.

However, this approach de-emphasized short-term countermeasures such as job rotation that might help safety albeit at the expense of quality or productivity. As a result, injuries continued to increase. In October, the union called in Cal-OSHA. A Cal-OSHA inspector visited the factory and came away unimpressed by NUMMI's responses to the problems. The citations noted, "Serious

[had] increased alarmingly." In addition, NUMMI did not respond quickly enough to correct the "numerous ergonomic hazards on the 1993 Model Corolla/Prizm assembly line."

Management reaction: The 1995 truck line launch

Following a Toyota policy, NUMMI conducted a hansei — translated as reflection-review — soon after the '93 model passenger car line reached full production. Before the lessons had time to fade, top management, section managers, Assistant Managers, Group Leaders, and Pilot Team members analyzed the launch. Topics included everything from the master schedule to training plans to workability and safety issues. NUMMI even sent out a questionnaire to their suppliers to capture their lessons learned. Each section prepared summaries of its performance against its targets, pointing out problems, and proposing countermeasures for the next project.

The review of the '93 changeover led plant management to accord a high priority to health and safety in both the company's strategic plan and the planning for the upcoming 285T (Tacoma) truck launch. The goal NUMMI set for 1995 was to cut the overall plant injury rate by 30 percent.

In the '93 changeover, each section had used one- or two-inch thick binders inherited from the prior launch as a basis for their own work. NUMMI captured lessons from the '93 reflection-review in revisions to this changeover management documentation. NUMMI also diffused lessons to the 285T team by ensuring some staffing continuity: the 285T Pilot Team was selected from among Team Leaders who had worked on at least one or two previous major model changes.

With a greater focus on ergonomics, the 285T project was managed rather differently than the '93 changeover. Unlike in the '93 Pilot Team members, the 285T Pilot Team members were given extensive ergonomics training. Toyota and NUMMI engineers worked with the Pilot Team to make the 285T easier to assemble than its predecessors. NUMMI's Quality department put more emphasis on workability issues than in the '93 case, spending a lot of time analyzing parts before and after each pilot. The Quality department also established better communications with suppliers, and suppliers in turn were able to respond more rapidly to design changes. NUMMI and the Toyota Supplier Support Center (based in Lexington, Kentucky) worked with suppliers who had been the locus of difficulties in the '93 changeover. Unlike previous changeovers, the policy in the '94 truck line changeover was to ensure that all Team Members rotated between at least two jobs from the very first vehicle. Plant management made full rotation the standard policy for all production teams on both the truck and passenger car lines.

As a result of these combined efforts, workability and part fitting problems at the start of production were significantly reduced. Whereas during the '93 launch, some 70 parts out of 1,000 required continuous inspection and repair, the corresponding ratio for the 285T launch was 20 out of 784. Within two months of the start of production, the plant was well ahead of its production goals. While the '93 passenger car changeover was scheduled to take 60 days to reach full output but took 77 days, the '95 truck changeover was scheduled to take 77 days (since management used the '93 changeover as its benchmark) but took only 48 days.

Moreover, the health and safety outcomes of this changeover were far superior to those of '93 changeover. In the first three months of the 285T launch, the truck area reported nearly 30 percent fewer injuries than during the prior year, and fewer than on the passenger line at the same time. This was a particularly impressive accomplishment, since in prior years, the truck line had had a worse health and safety record than the passenger car line.

Workers' reactions

In part, workers at NUMMI interpreted the relatively high rate of ergonomic problems in auto assembly plants in general, in regular production operations at NUMMI, and in NUMMI's 1993 changeover as technical problems — as the somewhat inevitable corollary of the inevitable

these occupational injuries and illnesses at least in part to failures of NUMMI management to live up to its commitments. As such, workers saw these problems as cause for resistance and conflict rather than dialogue and patience.

The lack of an effective plan for dealing with convalescing workers was one cause of conflict. Employees diagnosed with work-related repetitive-motion injuries were supposed to be put on light-duty jobs. However, there were not enough such light-duty jobs. Moreover, workers returning from light-duty jobs sometimes found themselves reassigned to the jobs that had injured them in the first place.

Management's skepticism of workers' injury claims was a further source of conflict. Both management and union officials acknowledged that some workers "gamed" the workers' compensation system. Such workers claimed an injury when they were not hurt, when they were not as disabled as they claimed, or when the injury was not work-related. These cases cast a pall on all injury claims. Numerous workers we interviewed complained that they had been given lengthy run-arounds in trying to prove that they had a work-related illness or injury.

As stories of colleagues who gamed the system proliferated, some Team Members came to distrust colleagues' claims of repetitive-motion injuries. In addition, norms at NUMMI encouraged workers to work through the pain. Complaining was frowned upon. In this atmosphere, workers sometimes delayed reporting their own injuries for fear of being labeled a shirker by peers or managers, thereby exacerbating the risk of more severe injury.

Workers and union officials were appreciative of the greater attention accorded health and safety starting in 1995. But they continued to express frustration at the difficulty they experienced in making ergonomic concerns heard. According to the UAW safety representative, some jobs such as those involving overhead work scored in the acceptable range in NUMMI's ergonomics evaluation, but nevertheless continued to cause strains; yet management appeared unwilling to analyze such jobs more carefully. Furthermore, "some Team Members still feel intimidated. They won't go to medical even when they are hurting." In short, line managers were not yet taking responsibility for safety and health issue.

The net result of the 1993 changeover problems and the ensuing events was a significant slip in the level of mutual trust between workers and management. Not surprisingly, this slip also contributed to changes at the UAW. In 1994, a year after the Cal-OSHA citations, the dissident People's Caucus won all major offices except President from the Administration Caucus.

On the one hand, we should not exaggerate the impact or significance of this change of leadership. Union and management continued to work together in a problem-solving mode to resolve grievances at the lowest possible level. They continued working together on issues such as policies concerning transfers between various parts of the plant, whether injured workers should receive preference over more senior workers for lighter jobs, and so forth. They continued to discuss normal union-management issues such as penalties for absences. There was no radical shift in the union's strategic posture nor in its ability to cooperate with management on issues of common concern. And in 1997, the Administration Caucus was voted back in.

On the other hand, the 1994 change in leadership did signal a change in tone. During the bargaining over the terms of the 1994 contract, the new leadership took the workforce out on strike. The strike lasted only one hour, but it symbolized the new assertiveness. The union leadership drew back somewhat from the cooperative decision-making process. And management seemed to make little effort to bridge the gap. For example, in 1966, when NUMMI fell behind its goal of a 30 percent drop in injuries, management decided to bring in a well-regarded outside consultant to completely revamp the safety system; the union, however, was not consulted on the decision, nor on the design of an ergonomics and safety training program the consultant put into place. This was consistent with a long-standing management tendency to reach out to the workforce while

FINDINGS

Our analysis of this episode of conflict over ergonomics at NUMMI yields some provisional findings. First, NUMMI was a capitalist firm in a capitalist economy, and it had not magically eliminated divergent interests between management and workers. Second, this particular conflict nudged NUMMI a little further from its own ideal of dialogue and joint decision-making as a way of managing such divergences. Third, NUMMI emerged from this incident with improved capabilities in ergonomics and model changeover management. Finally, if these shifts in industrial relations and management capabilities were modest in magnitude, it was because workers, union, and management saw substantial common interests that counterbalanced their divergent interests, not because these actors were caught in a force field of powerful opposing forces in gridlock. As long as this shared understanding of common interests persisted, NUMMI's overall configuration was likely to be robust.

Stepping back from the ergonomics episode, then, how should we characterize this overall configuration and its evolution? Previous research suggests that hybridization is likely when overseas subsidiaries are established because regions differ in many ways, including their union and management styles and traditions, workforce skills, experiences and expectations, and the legal and regulatory setting. Further hybridization is likely as the unique history of each company and worksite plays out. In each setting, conflict and learning should lead to a distinct evolution.

In spite of these forces for hybridization, our analysis suggests that NUMMI implemented the Toyota production system rather thoroughly, and indeed increasingly thoroughly as it matured. Similarly, its administration and supplier relations were initially modeled on those of its Japanese parent, and the resemblance grew closer over time.

Human resource management and labor relations practices, on the other hand, began with significantly more hybridization, and their subsequent evolution was more complex. Some practices grew closer to the Japanese model, for example NUMMI's introduction of quality circles. Some practices appeared to serve as (more partial or more complete) functional equivalents to Japanese practices, for example the longer grow-in period (somewhat equivalent to Toyota's skill grades) and gainsharing (bonuses). Some practices served as substitutes for Japanese social patterns, for example the union participation in Team Leader selection (management legitimacy), and NUMMI's symbols of unity such as a common cafeteria (groupism). However, in yet other cases, NUMMI's evolution appears to have drawn it closer to US patterns: witness the creation of a union representative for ergonomics, the accomodation to women in the production workforce reflected by the shift to gender-neutral contract language, a growing range of American-style benefits, and the increasing formalization of roles and responsibilities.

The different extent of hybridization in production system, administration, supplier relations and industrial relations is the result of the relative power of the actors involved. Toyota saw many benefits and few impediments to the transfer of the production system. The transfer of the Toyota administrative system and supplier relations was a little more difficult because the relevant external actors — potential management recruits and US suppliers — had to be convinced to change their expectations. But these actors were relatively powerless vis-à-vis NUMMI. The transfer of Toyota human resource management and labor relations, on the other hand, had to accommodate powerful, organized, local actors — the UAW and Cal-OSHA — and more extensive hybridization was the natural result.

Our overall findings contrast with a common assertion in the international management literature that overseas subsidiaries will over time necessarily grow closer to local practices, rather than to home country practices. Some theories predict this based on an assumed desire by subsidiary management for autonomy from headquarters control; other predict it based on an assumed need for

by Oliver (1991), DiMaggio and Powell (1991), and Florida and Kenney (1991) for more sophisticated theory that can accomodate stronger notions of agency, strategy, and power.

CONCLUSIONS

After over a dozen years of operation, NUMMI's experience thus provides mixed evidence for both the "best practices" and "societal effects" positions. Proponents of the best practices view can cite the fact that Toyota managed to transplant the bulk of the its production system as well as much of its administrative structure and supplier relations into NUMMI. As NUMMI has matured, practices in these domains grew closer to the Toyota model. Moreover, the transplantation was a success: NUMMI achieved quality and productivity close to world-class levels.

Proponents of the societal effects view, on the other hand, can point to the fact that NUMMI always claimed to be a hybrid model, tailoring its Japanese management system to its American workforce, union, regulations, and culture. NUMMI had to develop organizational systems that fit the US context, in particular in their labor relations. Even the production system showed signs of some adaptation to the US institutional, cultural and social context.

Overall, however, it is difficult to see NUMMI's hybridizations and adaptations as the germ of a distinct regional model. Rather, NUMMI's key features were those of the lean production model; the hybridizations we observe were in secondary features; and these hybridizations buttressed rather than reshaped the production system. The NUMMI case shows that such a transfer-with-secondary-adaptations can yield levels of performance that are close to world class.

NUMMI is one of the most studied plants in the world; but evaluations of both its technical and social performance have been contradictory. While its technical performance was close to that of its Japanese parent plant, gaps persisted. In social terms too, NUMMI's performance was mixed. Coming to the USA, Toyota had to adjust to a context of industrial unionism rather than enterprise unionism and to a workforce with very different expectations of work. NUMMI and the UAW forged a relationship that avoided most of the Big Three's traditional dysfunctionality. The new relationship also engendered noteworthy innovations in structures and processes for joint decision-making. However, our case analysis suggests that NUMMI did not manage to turn this relationship to significant advantage. A more effective union Local would have raised concerns about ergonomics earlier and more forcefully. A more proactive management would have worried less about weakening the union and more about listening to the collective voice it provided workers so as to stimulate organizational learning. And better organizational learning would have led to a faster rate of improvement in a broader range of indicators.

For our part, we conclude that NUMMI was not a stunning success that dominated its competitors on all counts, but nor was it a stunning failure — and this, in itself, was remarkable enough. NUMMI demonstrated that unionized American workers could achieve levels of productivity and quality very close to the constantly advancing standards set in Japan — a result that skeptics doubted was possible when NUMMI opened its doors. However, NUMMI did not set a new global standard for performance: Japanese plants maintained their lead in the technical dimension. Nor did NUMMI set a new global standard for industrial relations: Saturn in the US and at other plants in Europe created more collaborative and effective partnerships that were more advanced in the social dimension. But NUMMI was remarkable in its unrivaled combination of excellent performance and innovative industrial relations.

Optimists such as Adler (1993(b)) had hoped that the aggressive exploitation of the opportunities afforded by this unusual combination would lead NUMMI eventually to best its competitors in both technical and social dimensions. One might have imagined that the combination of the Japanese production system's enormous discipline — the foundation of Toyota's

advanced, production model, a model that overcame both the paternalism often attributed to Toyota and the underperformance often manifest in American firms. After all, the Toyota production system itself emerged from the hybridization of the Ford system within the Japanese context. But as of 1997 at least, this seemed to be out of reach.

It remains unclear how much of NUMMI's mixed record was due to idiosyncrasies of personality and history, and how much reflected deeper, structural limitations of the Toyota model. Corporate strategy, too, may be salient, since in Toyota's eyes, NUMMI was essentially a branch plant and a stepping stone to other North American investments, and it was therefore not likely to be the locus for fundamental innovation. Toyota was more innovative both technically and socially in some of its home-country plants (Fujimoto, 1996). Moreover, unlike GM at Saturn, Toyota had little incentive to develop a radically novel relationship with the UAW, given the latter's overall decline. Future research might help identify the most important of these constraints and the conditions under which they might be lifted.

References

Abo, Tetsuo, ed., **Hybrid Factory: The Japanese Production System in the United States**, New York: Oxford University Press, 1994.

Adler, Paul S., "The New 'Learning Bureaucracy': New United Motors Manufacturing, Inc." in Staw and Larry Cummings, eds., **Research in Organizational Behavior**, pp. 111-194. Greenwich CT: JAI Press, 1993(a).

Adler, Paul S., "Time-and-Motion Regained," **Harvard Business Review**, Jan-Feb 1993(b), pp. 97-108.

Adler, Paul S., "Hybridization of Human Resource Management at two Toyota transplants," in Jeffrey Liker, Makr Fruin, and Paul S. Adler (eds), **Remade in America: Transplanting and transforming Japanese production systems**, New York: Oxford University Press, forthcoming (a).

Adler, Paul S., "Teams at NUMMI," in J.-P. Durand, J.J. Castillo, and P. Stewart (eds.), **Teamwork in the Automotive Industry**, New York: Oxford University Press, forthcoming (b).

Adler, Paul S., Barbara Goldoftas and David Levine, "Ergonomics, Employee Involvement, and the Toyota Production System: A Case Study of NUMMI's 1993 Model Introduction," **Industrial and Labor Relations Review**, April 1997.

Boyer, Robert, and Freyssenet, Michel, "The emergence of new industrial models," **Actes du GERPISA**, 15, July 1995: 75-145.

Brown, Clair, and Michael Reich, "When does cooperation work? A look at NUMMI and GM-Van Nuys," **California Management Review**, 31, 4, Summer 1989, pp. 26-37.

Childs, Bill, Inside Track, NUMMI newsletter**,** Sept-Oct 1994, p. 2.

Cole, Robert, **Japanese Blue Collar**, Berkeley: University of California Press, 1979.

Cusumano, Michael A., **The Japanese Automobile Industry**, Cambridge, MA: Harvard University Press, 1989.

DiMaggio, Paul J., and Walter W. Powell, "Introduction," in Walter W. Powell and Paul J. DiMaggio, eds., **The New Institutionalism in Organizational Analysis**, pp. 1-40, Chicago: University of Chicago Press, 1991.

Florida, Richard, and Martin Kenney, "Organization vs. culture: Japanese automotive transplants in the US," **Industrial Relations Journal**, 22, 3, Autumn 1991: 181-196.

Florida, Richard, and Martin Kenney, "Transplanted organizations: The transfer of Japanese industrial organization to the US," **American Sociological Review**, 56, 1991: 381-398.

Fujimoto, Takahiro, "An evolutionary process of Toyota's final assembly operations: The role of

Hayes, Robert H., and Steven C. Wheelwright, **Restoring Our Competitive Edge**, New York: Wiley, 1984.

Holusha, John, "No Utopia, but to Workers It's a Job," **New York Times**, January 29, 1989, Section 3; p. 1.

Krafcik, John. 1989. "A New Diet for U.S. Manufacturing; The Auto Industry Enters the 1990s." **Technology Review,** January: 28-35.

Maurice, M., S. Sorge, and M. Warner, "Societal differences in organizing manufacturing units: A comparison of France, West Germany and Great Britain," **Organization Studies**, 1980, 1: 59-86.

Nakane, Chie, **Japanese Society**, Berkeley: University of California Press, 1970.

Oliver, Christine, "Strategic responses to institutional processes," **Academy of Management Review**, 1991, 16, 1: 145-179

Shimizu, Koichi, "Kaizen and gestion du travail chez Toyota Motor et Toyota Motor Kyushu: Un probleme dans la trajectoire de Toyota," **Actes du GERPISA**, 13, March 1995: 13-44.

Womack, James, Daniel Jones and Daniel Roos, **The Machine that Changed the World**, New York: Rawson Associates, MacMillan Publishing Company, 1990**.**