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Marvin B. LIEBERMAN
University of California, Los Angeles

Susan HELPER
Case Western Reserve University

Lieven DEMEESTER
Singapore Management University, ldemeester@smu.edu.sg
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THE EMPIRICAL DETERMINANTS OF INVENTORY LEVELS IN HIGH-VOLUME MANUFACTURING*

MARVIN B. LIEBERMAN, SUSAN HELPER, AND LIEVEN DEMEESTER
John E. Anderson Graduate School of Management, UCLA, Los Angeles, California 90095-1481, *USA*
The Weatherhead School of Management, Case Western Reserve University, Cleveland, Ohio, USA
PricewaterhouseCoopers LLP, Los Angeles, California 90071-2889, *USA*

This study uses survey data on several hundred automotive suppliers in North America to evaluate the determinants of inventory levels in high-volume discrete parts manufacturing. We assess the magnitude of raw materials, work-in-process, and finished goods inventories held at automotive supply plants. Inventories are shown to be jointly determined by technological and managerial factors in a manner roughly consistent with classical inventory theory.

Several categories of managerial practices are found to be important. Low inventories are linked to employee problem solving and frequent communication with customers. More unexpectedly, we find the absence of inventory differences between U.S.-owned and Japanese-owned plants in North America. This contrasts with substantial differences in inventory holding between US plants and those in Japan.
(INVENTORY; AUTOMOTIVE; SUPPLY CHAIN; JIT MANUFACTURING)

1. Introduction

What factors determine the inventories held by manufacturing companies? Does classical inventory theory explain the levels of inventory held in practice? Do Japanese management methods, involving problem solving by shop employees and frequent communication with customers, lead to lower inventories? To what extent do Japanese manufacturers operate with less inventory than their U.S. counterparts? This study examines these issues using survey data on several hundred automotive parts suppliers in the United States and Canada. Statistical tests are performed to assess the determinants of raw materials, work-in-process, and finished goods inventories.

The study also provides benchmarking data on plant inventories. Inventory levels are often viewed as indicators of process capability, and steps to cut inventory may stimulate efficiency gains (Lieberman and Demeester 1999). The inventory benchmarks in this study are supplemented by an assessment of factors that must be considered in making valid comparisons among factories.

The paper is organized as follows. Section 2 provides a conceptual framework on the determinants of inventory levels. A series of testable hypotheses are developed, based on classical inventory theory and an appraisal of how managerial intervention might diminish the need for inventory holdings. Section 3 describes the auto supplier survey and the measures used in this study. It also gives statistical tests of the connection between inventory levels and individual factors recorded in the survey. In Section 4 these factors are combined into a more complete explanatory model, using multiple regression analysis. The findings are summarized in Section 5, which concludes the paper.

2. Factors Expected to Influence Inventory Levels

2.1. *Factors from Classical Inventory Theory*

Numerous models of optimal inventory holding are described in the operations literature (c.f., Peterson and Silver 1979). The standard results of these models provide a framework for identifying the determinants of inventory levels in practice. Some predictions apply to specific types of inventory: raw materials, work-in-process (WIP), or finished goods. However, requirements for these three types of inventory are often interrelated, making it difficult to pinpoint predictions for one inventory type.

Optimal cycle stocks are commonly estimated using various forms of the economic order quantity (EOQ) formula:

$$Q^* = \sqrt{2DS/iC}$$

where Q^* is the optimal lot size (or order level), D is the demand per period, S is the setup (or ordering) cost, and iC is the holding cost per period, which we assume equals the interest rate, i, multiplied by the item cost, C. The average inventory level is $Q^*/2$. The EOQ formula leads to the following testable hypotheses:

HYPOTHESIS 1. *Inventory levels increase with set-up costs, S.*

HYPOTHESIS 2. *Inventory levels decrease with the item cost per unit, C.*

In our empirical analysis, we test measures of the item cost, C, and characteristics of the product and process that are likely to be related to the set-up costs, S. Given the strong theoretical basis for H1 and H2, empirical support may be viewed as a validation of the data rather than as a test of the theory.

In addition to the optimum cycle stock defined by an EOQ-type model, some level of safety stock is normally required. Common models of optimal safety stock imply that inventories should increase with (1) variability in demand, (2) variability in product quality, (3) the desired service level, and (4) the lead time needed to replenish supplies. Inventories should decrease with the cost of holding safety stock. These factors imply a set of testable hypotheses.

The first factor, demand variability, is a key determinant of safety stock in many industries. For automotive parts, however, demand is relatively stable and predictable with regularly scheduled deliveries. Moreover, our survey of auto suppliers provides no information on demand variability. Hence, we ignore demand variability in our analysis.

The second determinant of safety stock, variability in product quality, is important in the auto industry. We expect that quality is influenced by managerial practices such as the degree of worker problem solving and customer-supplier communication. Hypotheses relating to these practices are presented in Section 2.2 below.

The third determinant of safety stock, the desired service level, is largely set by the automotive assemblers. We hypothesize that Japanese-owned assemblers may require a higher service level than that set by their American counterparts. One reason is that the Japanese assemblers typically hold small buffers of raw materials, making reliable parts delivery essential. If suppliers accommodate by holding larger stocks of finished goods, the following hypothesis would be supported.

HYPOTHESIS 3. *Suppliers to Japanese transplant assemblers hold more finished goods inventory.*

It is possible that the opposite may apply; for example, suppliers can provide higher service levels with less inventory if they are successful at implementing just in time (JIT) internally. Moreover, the Japanese "transplant" assemblers in North America may have selected suppliers with streamlined manufacturing operations, or they may work with suppliers to achieve these objectives. Nevertheless, prior studies (e.g., Lieberman and Asaba 1997) suggest that American automotive suppliers have typically accommodated their customers' JIT delivery demands by holding larger buffers of finished goods.

The fourth determinant of safety stock, the lead time needed to replenish supplies, increases with the time required to produce a new lot. This leads to the following testable hypothesis.

HYPOTHESIS 4. *Finished goods inventory holdings are positively related to production lead time.*

The last determinant of safety stock, the holding cost per period, appears as parameters iC of the EOQ model discussed previously. Thus, support for Hypothesis 2 above is likely to arise from both cycle stock and safety stock motives.

2.2. *Managerial Influences*

Classical inventory theory takes most input parameters as given. However, the JIT revolution has shown that nearly all forms of variability are subject to managerial control. The JIT literature is replete with techniques for reducing set-up times, machine breakdowns, and worker errors (Monden 1981a, 1981b; Shonberger 1982; Hall 1983; Suzaki 1987). These methods typically require the active participation of the workforce. Hence we propose the following hypothesis.

HYPOTHESIS 5. *Inventories are lower in plants whose workforce is engaged in making process improvements.*

Communication with customers can promote the improvement process. For example, the sharing of warranty data and other information on defective parts can help the supplier to improve quality and reduce costs (Helper and Sako 1995). In the automotive industry, the frequency of face-to-face contact between suppliers and assemblers is strongly correlated with various measures of efficiency (Dyer 1996a, 1996b). Improved communication can help to coordinate the scheduling of upstream and downstream production, thereby reducing the need for intermediate inventories. Indeed, communication and inventory may serve as substitutes for each other (Milgrom and Roberts 1988). These lead to the following testable hypothesis.

HYPOTHESIS 6. *Inventories are lower in plants that maintain frequent communication with customers.*

Finally, we anticipate that Japanese-owned suppliers in the United States, following the practices widely adopted in Japan, will hold less inventory than their American-owned counterparts. In the early 1990s, automotive parts plants in Japan held roughly half as much inventory on average as similar plants in the United States (Lieberman and Asaba 1997). If Japanese suppliers are able to transfer their manufacturing systems from Japan to the U.S., they should require less inventory than most American-owned firms.

HYPOTHESIS 7. *Japanese-owned suppliers in the United States hold less inventory than American-owned suppliers.*

This hypothesis will not be supported if Japanese suppliers fail to transfer their lean manufacturing methods to the U.S. environment, or if they find it undesirable to do so, given the conditions that apply in North America (e.g., longer transport distances and lower real estate costs).

3. Survey Measures and Tests of Explanatory Factors

3.1. *Plant and Sales Manager Surveys*

The data in this study are from two surveys of automotive parts manufacturing plants administered by Helper in 1993 under the auspices of the Massachusetts Institute of Technology International Motor Vehicle Program. The surveys were administered to first-tier (direct) suppliers to auto assemblers in the United States and Canada. For many of the survey questions, respondents were asked to answer with respect to their most important customer regarding a product that was typical of their plant's output. Other items pertained to characteristics of the plant as a whole and its relations with customers and suppliers. In this study we generally combined the product-specific and the plant-specific information. The text of the survey questions used in our inventory analysis is provided in the Appendix.

3.2. *Dependent Variables: Inventory Ratios*

Plant managers were asked to report their turns ratio (annual sales/average value of inventory) for raw materials, WIP, and finished goods. In this study we use the reciprocal of these measures, i.e., the average level of inventory as a fraction of sales. Table 1 shows that raw materials, WIP, and finished goods inventories averaged about 6–7% of annual sales with a large standard deviation. We found wide variation in inventory levels from plant to plant, even for plants making ostensibly similar parts.

3.3. *Explanatory Factors and Their Effects on Inventory*

To perform our analysis, we linked the inventory measures with other information provided in the automotive supplier surveys. Most of the survey questions have dichotomous, 0/1 responses, although some of the responses are quantitative or on a five-point scale. Table 2 gives the mean values and the results of statistical tests linking individual survey questions to the inventory measures. Significant correlations are denoted by entries in the last three columns of the table. The coefficients in these columns represent the percentage change in the mean level of inventory associated with a unit change in the survey measure. (To compute effects as percentage changes, the inventory measures were converted to logarithms. The same logarithmic conversion was used for the regressions in Section 4.)

PRODUCT & PROCESS CHARACTERISTICS. Several measures deal with general characteristics of the product. The tests revealed a strong negative correlation between the price of the product and the levels of all three types of inventory, as predicted by classical inventory

TABLE 1

*Average Inventory Levels in the Supplier Survey Sample**

	RM/Sales	WIP/Sales	FG/Sales
Average	.071	.057	.059
Std. Dev.	(.062)	(.058)	(.058)
Number of Obs.	229	211	221

* Extreme observations (top and bottom 2%) deleted.

TABLE 2

Single-Factor Tests of Potential Determinants of Inventory Levels

Category	Measures	Units	Survey	Mean*	RM/Sales	WIP/ Sales	FG/Sales
			Product & Process Characteristics				
General	Number of component parts	1–N	PM	38.6			
	Product price/piece	1–5	SM	2.4	−28%**	−36%***	−32%***
Functional	Trim	0/1	PM	.07	−49%*	−80%*	−67%*
	Body	0/1	PM	.04	−98%**		
	Engine	0/1	PM	.04		48%*	
Material	Aluminum	0/1	PM	.02			
	Steel	0/1	PM	.44		31%**	22%*
	Plastic	0/1	PM	.20			
	Ceramics + glass	0/1	PM	.02			
	Rubber	0/1	PM	.07			
Mfg. Process	Stamping	0/1	PM	.12		36%*	
	Heat treat	0/1	PM	.11		35%*	32%*
	Weld	0/1	PM	.07			
	Mold, extrude, draw	0/1	PM	.21			
	Cast	0/1	PM	.04			
	Forge	0/1	PM	.02		49%*	50%*
	Paint	0/1	PM	.10			
	Machine	0/1	PM	.09			
			Managerial Factors				
Batch Size	Production lot size	Days	SM	12.6	2%**	3%***	25%**
	Delivery lot size	Days	SM	10.2			
Workforce	Formal improvement process	0/1	PM	.84		−87%**	−96%***
	Union	0/1	PM	.47			
	Quality circles	0/1	PM	.89	−32%*		
	Workers expected to make improvements	1–5	PM	2.9	−11%*	−14%*	−22%***
Vertical Communication	Communicate with assembler	1–5	PM	2.7		−11%*	−12%*
	Exchange scheduling info	0/1	SM	.72			
	Exchange warranty data	0/1	SM	.41		−74%**	
	Assembler visited to improve procedures	0/1	SM	.56	42%***	29%*	
	Frequency of face to face contact	1–5	SM	1.8			−24%**
	Frequency of phone contact	1–5	SM	2.5	−12%*		−14%*
	JIT delivery by upstream suppliers	%	PM	.55	−12%**		
Japanese Management	Supplier is Japanese-owned	0/1	PM	.14			
	Main customer is Japanese	0/1	SM	.44			
	Number of Japanese customers	0–N	SM	1.2	8%*		12%**
	Number of US customers	0–N	SM	4.0			

* Mean values for the survey sample.

Note. PM = plant manager survey; SM = sales manager survey. Percentages give average change in inventory for each unit change in factor listed. Figures are shown for statistically significant factors only. *, significant at 5% level; **, significant at 1% level; ***, significant at 0.1% level.

theory (Hypothesis 2). Inventories fell by roughly 30% for each unit increase along the five-point scale on which prices were classified. The number of component parts and management's assessment of product complexity had no discernible impact on inventories.

The survey provides no direct information on set-up times or costs. Nevertheless, set-up and processing times are likely to be correlated with technological characteristics of the product and process. With the assistance of an industry expert, we developed sets of dummy variables pertaining to (1) product function (mechanical, electrical, trim, body, engine), (2) raw material(s) (steel, aluminum, plastic, glass, rubber), and (3) manufacturing processes (stamping, heat treating, etc.).

Table 2 shows that many of these variables are significantly linked to inventory levels in a manner consistent with expected differences in set-up and processing times. For example inventories were low for trim parts, which are relatively simple and quick to manufacture. Engine components, on the other hand, had WIP levels about 50% above average. Engine parts often require more process steps, including heat treating and forging, which are directly associated with greater WIP. In general, steel parts had higher inventory levels, and differentials were found for specific steel fabrication processes such as stamping, heat treating, and forging, where inventories were 30–60% above the sample average. This evidence, while indirect, may be viewed as broadly supporting Hypothesis 1.

MANAGERIAL FACTORS *Production and delivery lot sizes.* Larger production lot sizes were accompanied by greater WIP inventories, as would be expected. Larger production lots were also linked to greater holdings of finished goods, presumably in response to higher cycle stocks leaving the production line. Although not shown in the table, we also observed a significant correlation between finished goods inventories and management estimates of the production cycle time. These findings lend support for Hypothesis 4.

Table 2 shows no significant correlation between the delivery lot size and the level of finished goods inventory. Suppliers that delivered to their customers in small, frequent lots held the same amount of finished goods inventory (on average) as other suppliers in the sample. Delivery lot size was also uncorrelated with WIP.

Workforce characteristics. Table 2 reveals a significant correlation between inventories and the improvement efforts of shop floor workers, as implied by Hypothesis 5. Most plants had fully trained at least one group of workers in a formalized improvement process. However, roughly 15% of plants had not; these plants displayed levels of WIP and finished goods nearly double the sample average. The data also show a link between inventory levels and management's expectation that workers make improvements within the plant. Quality circles, however, appear to have had little impact, except in the area of raw materials inventory. No connection was found between inventory levels and unionization.

Vertical communication. The surveys provide considerable information on the relationship between the plant and its customers. Table 2 shows that closer communication was generally associated with lower inventory (Hypothesis 6). The plant manager's overall perception of communication with the assembler (as indicated by agreement with the statement: "we are engaged in an ongoing discussion with our customer about ways to improve both their operations and ours") was associated with lower WIP and finished goods. No inventory benefits were detected for the exchange of scheduling information, perhaps because such exchanges were often a response to last-minute changes (which might increase inventories) as well as advance planning (which might reduce them). However, suppliers appear to have benefited greatly from receipt of warranty data. Suppliers that obtained such data from the assembler had WIP levels 74% lower than average. Receipt of warranty data may help weed out problems in the production process, or it may simply be correlated with the presence of other activities that have this effect.

Frequent face-to-face contact, and to a lesser extent telephone contact, was associated with lower finished goods inventory. This finding can be viewed as evidence that communications and inventories serve as substitutes within the supply chain. The length of the formal contract and the length of the more general relationship with the customer had no connection with inventory levels. Not surprisingly, suppliers held less raw materials inventory when their upstream vendors provided JIT delivery.

Some types of communication were linked to higher inventories. In particular, visits by the assembler to improve procedures at the supplier's plant were associated with higher levels of WIP and raw materials. This suggests that such visits may have been elicited by production and quality problems, rather than an ongoing commitment to process improvement.

Japanese influence. We observe whether the plant was under Japanese ownership and the degree to which it shipped to the Japanese auto assemblers. This information was used to test whether Japanese management had any differential effect on supplier inventory levels in North America.

Table 2 provides a mixed assessment of the impact of Japanese management. The inventory levels of Japanese-owned suppliers were not significantly different from the sample average, indicating lack of support for Hypothesis 7. This suggests that the remarkably lean operations of Japanese suppliers in their domestic environment have not been transferred to Japanese plants in the United States. One possibility is that the Japanese have encountered difficulties in implementation due to differences in language, culture, worker skills, or other factors. Alternatively, Japanese parts makers may have decided that higher inventories are a rational adaptation to conditions in North America, given lower real estate prices and longer transport distances.

Plants that sold to many different Japanese assemblers held above-average stocks of finished goods, thus giving support for Hypothesis 3. Also, these suppliers maintained unusually large holdings of raw materials. This may reflect greater use of components shipped from Japan, which commonly had a 90-day lead time.

4. The Japanese Influence: A Deeper Investigation

Table 2, discussed in detail in the previous section, shows simple correlations between the inventory levels and the individual survey measures. It is conceivable that the pattern and magnitude of influences might change when controls are included for other factors. For example, Table 2 shows no connection between Japanese ownership and inventory levels (Hypothesis 7), but a relationship might be found after controlling for product and process characteristics. To more fully investigate the unexpected findings regarding Japanese ownership, we performed multiple regression analyses which incorporate a variety of control measures.

Table 3 reports the regressions for WIP inventory. The dependent variable is the plant's average WIP inventory, divided by annual sales, expressed in logarithms. Regression 3.1 shows that (as in Table 2) there is no evidence that Japanese-owned suppliers held less WIP than their American-owned counterparts. If anything, Japanese ownership had a small positive effect on the level of WIP inventory.

There is, however, some indication of below-average WIP for U.S.-owned suppliers selling to Japanese assemblers. The coefficient of -.041 for "Main Customer Japanese" in Regression 3.1 implies that U.S.-owned suppliers selling principally to Japanese transplants held about 41% less WIP than other firms in the sample. For comparable Japanese-owned suppliers the differential was only 15% ($= -.41 + .25$), which is not significantly different from zero. This suggests that Japanese assemblers stimulated and helped their U.S. suppliers to achieve lean operations, or alternatively, that Japanese assemblers selected lean suppliers from the start.

Regression 3.2 adds the product and process variables that were found to be statistically significant in Table 2. The measures for product price, product functionality (trim, engine), and process type (stamping, heat treat, forging) appear with the expected signs, and most are weakly significant statistically. (Colinearity among these measures may account for the low t statistics obtained when the measures are included jointly.) Regression 3.2 shows that controlling for the product and process characteristics does not remove the effects found for the Japanese variables; on the contrary, it seems to strengthen them.

Regression 3.3 adds additional controls for managerial factors such as the presence of a formal improvement process and worker involvement. These are often considered to be components of Japanese managerial practices. The regression shows that when these factors are controlled for, the Japanese ownership coefficient becomes more positive and

TABLE 3

WIP Inventory Regressions

	Regression 3.1		Regression 3.2		Regression 3.3	
	Coeff.	*t* Stat.	Coeff.	*t* Stat.	Coeff.	*t* Stat.
Constant	3.28	44.8***	2.73	12.3***	2.60	8.1
Product & Process Characteristics						
Product price/piece			0.29	3.2***	−0.25	−2.8***
Trim			−0.28	−1.0	−0.26	−0.9
Engine			0.64	2.0**	0.54	1.7**
Stamping			0.48	2.4**	0.43	2.2**
Heat treat			0.30	1.4*	0.28	1.3*
Forge			0.64	2.0**	0.52	1.6*
Managerial Factors						
Formal improvement process					−0.44	−2.2**
Worker involvement					−0.09	−1.2
Japanese-owned plant	0.26	1.0	0.28	1.2	0.35	1.5*
Main customer Japanese	−0.41	−1.7**	−0.47	−2.1**	−0.50	−2.2**
R-squared	0.014		0.149		0.176	
Number of observations	209		209		209	

Note. Dependent variable: log (WIP/sales). *, significant at the .10 level, one-tailed test; **, significant at the .05 level, one-tailed test; ***, significant at the .01 level, one-tailed test.

weakly significant. Thus, the Japanese-owned plants held more WIP inventory than the average North American plant after adjusting for the beneficial effect. Further evidence from our survey shows that Japanese-owned suppliers set their production lot sizes 40% smaller than the sample average. Taken together, this pattern suggests that the Japanese-owned suppliers in our sample were attempting to imitate the leanness of plants in Japan but failed to even reach the U.S. average.

Table 4 reports the regressions for finished goods inventory. The dependent variable is the plant's finished goods inventory, divided by annual sales, expressed in logarithms. The explanatory variables include Japanese ownership, the number of Japanese customers, and various controls. The number of U.S. customers is included to verify that the rise in finished goods inventory with the number of Japanese customers is not simply an effect related to the total number of customers. The sample size for these regressions is smaller than that in Table 3, as limited overlap between the underlying surveys leads to a large proportion of missing responses.

The results in Regressions 4.1 and 4.2 are consistent with the simple correlations in Table 2. There is no evidence that Japanese-owned parts plants held below-average stocks of finished goods; indeed, their finished goods inventory holdings appear significantly above the U.S. average when all the control variables are included. Moreover, the regressions show that finished goods inventories increased significantly with the number of Japanese customers being serviced.

5. Conclusions

The results of this study give a broad picture of the factors that influence inventory levels in high-volume discrete parts manufacturing, as found in the automotive industry. Six of the seven hypotheses developed in this study receive empirical support (although in some cases the evidence is indirect). The data show that inventory levels are influenced

TABLE 4

Finished Goods Inventory Regressions

	Regression 4.1		Regression 4.2	
	Coeff.	*t* Stat.	Coeff.	*t* Stat.
Constant	−3.38	−19.4***	−4.10	−8.0***
Product & Process Characteristics				
Product price/piece			−0.13	−1.5*
Managerial Factors				
Production Lot Size			0.20	2.5***
Formal improvement process			−0.36	−1.7**
Worker involvement			−0.16	−1.7**
Face to Face contact			−0.20	−2.4***
Japanese-owned plant	0.41	1.3	0.53	1.8**
Number of Japanese customers	0.09	1.7**	0.14	2.6***
Number of US customers	0.01	0.2	0.02	0.3
R-squared	0.052		0.339	
Number of observations	112		98	

Note. Dependent variable: log (finished goods/sales). *, significant at the .10 level, one-tailed test; **, significant at the .05 level, one-tailed test; ***, significant at the .01 level, one-tailed test.

by set-up and holding costs, production lead times, the extent of customer communication, and the involvement of employees in problem solving.

The most unexpected finding of the study relates to the lack of support for Hypothesis 7 on the effects of Japanese ownership. Prior studies have shown that Japanese auto parts plants in Japan hold much less inventory than comparable plants in the United States. Yet the Japanese plants in our sample maintained average inventory levels that were virtually indistinguishable from those of American-owned plants. One possibility is that the differential between the geographic regions represents a rational adaptation to the longer transport distances and lower real estate costs in North America. Alternatively, it may be that the Japanese parts makers are still struggling to adapt their lean manufacturing methods to the U.S. environment.

Our regression analysis shows that after controlling for the beneficial effects of Japanese-style workforce and communication practices, Japanese ownership was associated with above average inventory holdings. Such evidence suggests that many Japanese parts suppliers may have encountered operational difficulties in North America, even though other studies show that they have been successful in transferring practices related to work organization (Florida and Kenney 1991; Jenkins and Florida 1999).

These findings have numerous implications for managers and researchers. From a research perspective, we have confirmed some basic predictions from inventory theory and have shown how technological and managerial influences interact to determine inventory levels in practice. From a managerial perspective, our data on the typical range of inventory levels and the calibration of explanatory factors provide guidance for benchmarking purposes. Contrary to expectations, we have shown that low inventories are not characteristic of the Japanese parts makers in our North American sample; indeed, these transplants appear to lag substantially behind their counterparts in Japan. Such findings, while specific to the automotive sector, may be applicable to other high-volume discrete parts manufacturing industries.[1]

Appendix

The measures in this study are from two surveys of automotive parts suppliers carried out in 1993 under the auspices of the International Motor Vehicle Program. The survey of plant managers, which dealt primarily with production issues, received 456 responses (representing a response rate of 31%), although only about half the respondents provided accounting data on their plant's inventory levels. A separate survey covering relationships with customers and business-unit performance was sent to marketing directors; this survey received 671 responses (55% response rate). It was possible to match half of the sales manager surveys with a plant manager survey. (See Leete and Helper (1995) for more detail.) Relevant questions from the surveys are reproduced below.

Plant Manager Survey

If data are readily available, please report the turnover ratios for raw materials (RM), work-in-process (WIP), and finished-goods inventories (FGI) for your plant.

RM turns (annual sales/average value of RM) ______
WIP turns (annual sales/average value of WIP) ______
FGI turns (annual sales/average value of FGI) ______

Are the shop workers at this plant unionized? (yes/no)

Has at least one group of workers at your plant completed a full cycle of a formalized improvement process (such as the Seven Step Improvement Process or the Plan Do Check Act cycle)? (yes/no)

Groups of workers such as quality circles or autonomous teams. Do you have this type of program? (yes/no)

"Each year we expect our shop workers to make substantial improvements in their own method of operations." (Strongly Disagree 1 2 3 4 5 Strongly Agree)

What percentage of your suppliers of raw materials, components, or intermediate processing for the product had adopted the following techniques in each year?

Just in time (JIT) delivery to you. ______%

Choose a *typical product* made for the automaker which is your *most important customer* at a typical plant of your business unit.

Name of typical product ____________
Name of customer ____________

How many components does your plant assemble to make the product you ship to your customer? ____________

For this product, what is your throughput time under normal operating conditions? (Define "throughput time" as the number of calendar days between the time when your plant begins processing until the part is placed into the finished-goods inventory.) ______

"We are engaged in an ongoing discussion with our customer about ways to improve both their operations and ours." (Strongly Disagree 1 2 3 4 5 Strongly Agree)

Sales Manager Survey

Choose a *typical product* made for the automaker which is your *most important customer* at a typical plant of your business unit.

Name of typical product ____________
Name of customer ____________

What types of information does your business unit provide to your customer about the process you use to make the product you listed above?

Detailed breakdown of process steps (yes/no)
Production scheduling information (yes/no)

Does your customer provide you with any of the following types of information?

Warranty or other data from final consumers (yes/no)

Over the last 4 years, what sorts of technical assistance have you received from your customer?

Provided personnel who visited your site to aid in implementing improved procedures (yes/no)

Provided personnel who worked two weeks or more on your shop floor to improve your processes (yes/no)

Last year, approximately how often did someone from your business unit have a substantive discussion with your customer? (Please include discussions about issues such as design changes and quality problems, but exclude routine delivery notifications and contacts by resident engineers).

	More than once a day	Daily	Weekly	Monthly	Every 6 months or less often
Face to face					
Phone					
Fax					
E-mail					

About how long would the lot size in which you *deliver* this product last your customer?

______

About how long would the lot size in which you *produce* this product last your customer? (Measure lot size as the time between tooling changeovers.) ______ days

Please check the appropriate range for the average piece price of the product in 1992.

<$1 ______ $1–10 ______ $11–50 ______ $51–100 ______ >$100 ______

Please indicate below the number of automakers of each nationality of ownership to whom you supply this product from this plant.

U.S. ______ Japanese ______

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Susan Helper is Associate Professor of Economics at the Weatherhead School of Management, Case Western University, Cleveland, Ohio. She holds a Ph.D. in Economics from Harvard University. Her research focuses on the impact of long-term relationships on company performance. Using survey and field research, she has examined the extent to which firms have adopted Japanese-style (long-term, communication-rich) relations with their suppliers, and the implications of these choices for labor relations, productivity, and quality.

Dr. Lieven Demeester is an Operations Strategy Consultant with PricewaterhouseCoopers LLP. For the past several years he has been assisting large global companies in identifying and developing critical operational capabilities. He holds a degree in Electrical Engineering from the University of Ghent in Belgium and a Ph.D. in Operations and Technology Management from the Anderson School of Management at UCLA.

Marvin B. Lieberman is an Associate Professor in the Anderson Graduate School of Management at UCLA. From 1982 to 1990 he was a faculty member at the Stanford Business School and a National Fellow at the Hoover Institution. He holds a Ph.D. in Business Economics and an A.B. degree fron Harvard University. His current research focuses on two areas: (1) comparing the productivity performance of U.S. and Japanes manufacturing firms, and (2) testing theories of industrial competition. His broader teaching and research interests are in the areas of business strategy, industrial economics, and operations management.