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THE IMPACT OF THE USE OF JUST-IN-TIME ON THE USE
OF INBOUND TRANSPORTATION BY MANUFACTURERS

by

Donald V. Harper

and

Karen S. Goodner

Carlson School of Management
University of Minnesota

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EXECUTIVE SUMMARY

Development of Just-In-Time in the United States

In the 1970's United States manufacturing was losing its competitiveness. Many countries, notably Japan, were outperforming the United States. Although external factors were blamed by some, American management became the focus of interest in an effort to solve the problem.

Since then there have been changes in American manufacturing in terms of its management (including the adoption of just-in-time (JIT) principles), its use of technology, and in the economic and political environment in which it operates.

Because extensive use of JIT originated in Japan, the Japanese approach was adapted to the United States. However, the use of JIT in this country developed slowly until recently because of the fear that cultural differences between Japan and the United States would prevent successful transfer of JIT management techniques, the lack of adequate study of Japanese JIT concepts, and the belief by some that existing United States systems could be improved and JIT was not needed. In more recent years growth in the use of JIT in the United States has been rapid, because of competitive pressure on American manufacturers, better understanding of JIT, the benefits that early users received, and the adoption by some large companies of JIT which encouraged their suppliers to do likewise.

There are several different definitions of JIT. In this report, JIT means a system of production and inventory management in which inbound raw materials and/or parts arrive at the production site from suppliers just-in-time to be used in the production process.

Many American companies that have adopted the JIT concept have benefitted from the decision in terms of inventory levels, lead times, transportation control, and other factors. However, there have also been failures, as can be the case with any management system.

Just-In-Time and Transportation

Transportation is a critical element in any JIT system and several transportation practices can be affected by the need to support a manufacturer's inbound JIT system. These include increased importance attached to inbound transportation, a shift in who has control over inbound transportation, the size of and frequency of shipments, the lengths of haul, the mode and carrier choice, the number of carriers used, and vehicle utilization. In addition, energy consumed in transportation and transportation costs can be affected.

Purpose of the Mail and Personal Interview Study

The objectives of the mail and personal interview study reported on here were, first, to determine the extent to which manufacturers in Minnesota and Wisconsin have adopted the JIT

concept for inbound movements and what kinds of firms they are in terms of size, products produced, and plant location. The second objective was to determine, for those manufacturers included in the study, why they did or did not adopt the JIT philosophy. The third objective was to determine to what extent the implementation of inbound JIT caused a change in the use of transportation.

The study was a preliminary study in that it was intended to provide information that could be used as a foundation for a more detailed study later.

Methodology Used in the Mail and Personal Interview Study

Mail questionnaires were sent to 75 manufacturers located in the two states. The return of usable questionnaires was 31, or 41.3 per cent, which is considered good for this kind of study. Of the 31, eight of the respondents that were using JIT were also interviewed on an in-depth basis.

Twenty-seven of the 31 responding manufacturers said that they have implemented inbound JIT.

Conclusions

The tentative conclusions or "indications" drawn from the results of the preliminary mail and personal interview study are discussed below.

The Use of Inbound JIT by Manufacturers

The size of firm does not have much importance in determining whether or not a manufacturer can make use of inbound JIT. Location in the Upper Midwest also has no bearing and the assertion that inbound JIT systems require that distances between manufacturers and their suppliers be relatively short was refuted. In addition, plants located in sparsely populated areas are able to use inbound JIT.

A wide variety of manufactured products are amenable to the use of inbound JIT in their production, provided that there exists repetitive production over time.

The objective of most firms using JIT is to reduce inbound inventory. Implementation of a JIT system is often a long-term process.

Written agreements between manufacturers and vendors and close "partnership" arrangements between them are not necessary for a JIT system, although they are found in some cases. There usually are fewer suppliers under JIT.

Inbound JIT and Transportation

The assumption that the manufacturer takes control of inbound transportation under an inbound JIT system was verified in the study.

The assertion that the adoption of JIT results in shorter lengths of haul was not verified by the study. However, the assumption that JIT systems require smaller shipments was

supported to a degree. The assumption that JIT results in more frequent shipments was confirmed.

The theory that JIT results in fewer inbound carriers being used and closer relationships between the manufacturer and the carriers was partially supported by the study.

Poorer vehicle utilization under JIT was not generally found in the study.

The adoption of JIT means that there will likely be greater use of air transportation and various kinds of for-hire and private motor trucking, with less use of rail service. Motor trucking dominates in JIT systems, with a large part of it consisting of private carriage.

Greater energy consumption and higher transportation costs do not necessarily follow from implementation of a JIT system, although both are greater in some instances.

Opportunities for Manufacturers

The implications for manufacturers in Minnesota and Wisconsin are that their location in the Upper Midwest is not a barrier to using JIT and JIT can be used by different kinds of firms in many different kinds of situations. In fact, a manufacturer may be a good candidate for a successful JIT experience even though it does not fit the usual "requirements" for JIT firms in terms of size of firm, the location of the firm, the distance from vendors, etc.

Manufacturers that adopt inbound JIT should be prepared to integrate their inbound transportation into the system by taking

control over transportation decision making, choosing vendors with transportation factors in mind, selecting carriers in terms of JIT requirements, probably using fewer carriers, considering using private carriage for the inbound moves, and possibly incurring higher inbound transportation costs that should be offset by lower inventory carrying costs.

Opportunities for Carriers

For private and for-hire carriers, particularly in motor trucking, it appears that JIT represents an opportunity as more firms in Minnesota and Wisconsin adopt the JIT concept or expand their use of JIT. A carrier can probably benefit greatly from becoming part of a JIT system if it is willing to comply with what is required in terms of shipment size, frequency of shipment, length of haul, consistency of service, loss and damage, and so on. The fact that sometimes fewer carriers are used in a JIT system means that those that participate will have a larger share of the traffic than before, and this traffic is sometimes "guaranteed" in the future.

Part I--INTRODUCTION

The production system of the United States has gone through dramatic change in the past twenty years as a response to oil crises, internal economic difficulties, a quality problem, a productivity problem, lagging technological development, and growing international competition.

One of the more important innovations that has occurred has been the adoption by many American manufacturers of the "just-in-time" (JIT) concept. There are a variety of definitions of JIT. However, one straightforward version defines JIT as an attempt to eliminate waste by reducing or eliminating inventory. This is accomplished by adopting a system of production and inventory management in which inbound raw materials and/or parts arrive at the production site from suppliers "just-in-time" to be used in the production process, thereby reducing substantially or eliminating entirely the amount of inbound inventory carried by the manufacturer.

Regardless of the exact definition used, JIT can have significant impact on the management of inbound transportation by the manufacturer. Therefore, it is in the interest of manufacturers contemplating adoption of JIT and of the transportation industries to know more about the connection between JIT and transportation.

However, the published literature on this subject is limited. An extensive search was made to determine what information was available on the development of the JIT concept in the United States, the extent of its use in the country and by what kinds of

industries and companies, and the results of its implementation in terms of success or failure. Included also was a search for published material on the impact of the implementation of JIT on the use of inbound transportation by those manufacturers that have made use of it. It was found that, although there is a great deal of published work on the concept of JIT, including what it is and what it is supposed to accomplish, there is a lesser amount of literature available on the extent to which it has actually been used in the United States and by whom in specific rather than general terms. And there is a limited amount of published work on the impact of JIT on the use of transportation.

Therefore, it was concluded that the preliminary study reported on here dealing with the relationship between JIT and the use of inbound transportation by manufacturers in Minnesota and Wisconsin and the proposed following study could make a valuable contribution to the JIT literature.

Part II of this report deals with changes in United States manufacturing in recent years. Part III discusses the JIT concept and its development in the United States and Part IV explains the assumed or expected relationship between JIT and transportation. Parts V and VI include a discussion of the purpose of the Minnesota and Wisconsin study and the methodology used. Part VII contains the findings of the study, and the conclusions may be found in Part VIII.

The study reported on here was sponsored by the Center for Transportation Studies of the University of Minnesota utilizing

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Donald V. Harper is Professor of Logistics Management and Karen S. Goodner is a Ph.D. candidate and Research Assistant in the Carlson School of Management, University of Minnesota.

Part II--CHANGES IN UNITED STATES MANUFACTURING

The Need to Change

In the 1970's it became quite clear that manufacturing in the United States was losing its competitiveness. Declines in productivity, in capital spending, in research and development expenditures, and in the number of patents being issued indicated that leadership in productivity and technology was at risk.¹ Analysts compared the United States with its foreign competitors on those factors and found that many countries, notably Japan, indeed outperformed the United States.² And, if more confirming evidence was needed, the export of manufactured goods no longer exceeded imports in the United States.³

This loss of competitiveness motivated thought. Some wanted to place blame on factors external to the business or company environment. Among the external reasons proposed:

--Government policy did not encourage or protect our industries.

--The oil crises of the 1970's not only revealed a dependence on foreign oil, but caused price

increases that hurt manufacturing in the United States.

--High inflation rates and high interest rates hurt business.

-- American workers' attitudes and skills were deteriorating.

However, these reasons failed to explain the decline. It was apparent that many of the United States' more successful competitors were faced with exactly the same, if not worse, external environments. The attention shifted to the internal environment and focused on management.

According to researchers such as Skinner,⁴ manufacturing management needed to break out of its existing patterns. He was just one of several people who stressed the need to place a strategic emphasis on manufacturing and to change the way business viewed and managed its manufacturing processes. Recognizing the need to change enabled other developments and changes that have recently occurred.

The Changes

Three areas have seen significant changes in American manufacturing: (1) management, (2) technology, and (3) environment.

Management changes have revealed Japanese influence. For example, quality now has been emphasized throughout the organization in many manufacturing firms, not just in the Quality

Control department. The approaches have names such as Total Quality Control (TQC), Statistical Process Control (SPC), Quality Circles (QC), and Zero Defects.

On the shop floor we have seen different management ideas. In some plants, machines have been rearranged into flow lines or cells (referred to as cellular manufacturing) that have been formed with techniques like group technology. Also, workers have been rewarded for learning new skills and this has produced cross-trained, multifunctional workers.

Efforts to eliminate waste and add value, two components of JIT, have become important in many manufacturing firms and have affected many functions within a company, such as production control, inventory control, purchasing, transportation, and personnel. The management efforts made by many firms to apply JIT concepts throughout the company have been credited with improving manufacturing competitiveness in the United States. Jordan said, "The JIT philosophy of production is recognized as one of the key factors contributing to the comeback."⁵

Technological advances have provided tools to support some of the management changes. Telecommunication devices such as facsimile transmission have made information exchanges faster. Electronic identification of products, including barcoding, and electronic data interchange (EDI), have automated and expedited record keeping. Computer hardware and software improvements have enabled development of decision support systems like distribution requirements planning (DRP) or material requirements planning

(MRP) software, and other specialized expert systems. Also, real time data update and access have meant more current information can be used. Computer engineering graphics has matured. Computer Aided Design and Computer Aided Manufacture (CAD/CAM) concepts are available to more manufacturing firms. In an effort to improve productivity, robotics have been refined and flexible manufacturing systems (FMS) have been developed.

Changes in the external environment composed of the economic and political structures affecting business have also occurred. One important change was that business became global. The markets for products, the manufacture of products, and the sourcing of materials have become international as has competition. No longer can businesses look only at conditions within their national boundaries. An upcoming event, the 1992 unification of the European business community, will continue that change. While this globalization has perhaps added complexity, it also has offered opportunities to enter new markets and to produce and source products in locations where total costs are minimized.

Within the United States, government policies have also changed. One relevant example, the deregulation of transportation, gave companies more transportation alternatives to choose from. This ability aided the companies' efforts to improve productivity and performance.

Thus, many changes have been occurring as United States manufacturers struggle to improve performance. The single most

important one, according to Jordan⁶ has been the implementation of the JIT concept. The next section examines JIT more closely.

Part III--The-Just-In Time Concept

Just-In-Time Defined

The loss of competitiveness in the American manufacturing sector motivated interest in the JIT system. Because extensive use of the system originated in Japan, early investigations examined Japanese management in general. This eventually led to a focus on Japanese production methods which, according to Im, was a new "practical approach" to the study of Japanese management.⁷ While this new, practical approach contributed to our understanding of how JIT works, it did not produce a standard definition of JIT.

Japanese Definition

If a standardized, Webster-like definition did exist, it would be broad because JIT itself is a broad concept. The father of JIT, Taiichi Ohno, developed a simple, but comprehensive, system that enabled Toyota to compete. The system, called the Toyota Production System, was built on a few principles that affected all parts of his company. His focus was to identify and remove the waste from the production of the product. He believed his system had two pillars:

(1) Just in time. As a goal, the right parts, in the exact quantity, would arrive at the right time.

(2) Autonomation. This is more than automation. Machines operate automatically, but they also have a "human touch" which is the ability to shut themselves down when they malfunction.

With these two principles and a continuous effort, he developed the production system now called JIT. One element of the system was a production scheduling approach that allowed a work station to produce only what the next station needed. This system has been called a "pull system" because the production at one work center is "pulled" by the demand at the next work station. Other elements incorporated in the system were analysis of waste, employee participation, worker flexibility, preventive maintenance of equipment, and perfect quality. The system included the flow of materials into the plant as well as the production within the plant.

Americanized Definition

In the United States, Ohno's comprehensive definition has been recognized by many researchers. Schonberger, who did much to popularize JIT, pointed out that, in addition to the production activity, JIT was also applied in a backward direction to suppliers in Japan, and to suppliers of suppliers.⁸

While many researchers speak of the complexity of JIT, many narrow their focus and study a small subset of JIT. Kanban (the Toyota system), as a scheduling technique, has been studied. Kanban, as an inventory control method, has been described and compared with other techniques such as reorder point. The need for process improvement has been studied. The relationship with suppliers and carriers has been examined. The relationship between quality, lot size, and JIT has also been discussed. Studies of these focused areas contribute to our understanding of JIT, but perhaps they have also contributed to the use of the term JIT to apply to only one of the components of the system.

In fact, in practice today, the term JIT has been used to refer to very different things. Popular synonyms for JIT include Kanban, stockless production, and zero inventories. If a company has flow lines with a "pull" system, it may say that it has JIT even though the raw materials are not delivered just-in-time. On the other hand, if a company has started to lower inventories of raw materials by partnership-like relationships with suppliers, it may say it uses JIT even though production methods still use a functional layout with piles of work-in-process inventory.

Viewpoint in This Report

Any discussion of JIT must at some point address the meaning of JIT for that discussion. The definition used here is based on the ideas set forth by both Schonberger and Perry.

Schonberger believed that JIT in production alone will not

succeed. The suppliers must be included. However, he believed that the materials could flow just-in-time even if the production did not.⁹

Perry asserted that JIT is more than a new approach to inventory management, stating that JIT concepts affect every aspect of the logistics process within a company from purchasing and quality control to transportation and physical distribution. Additionally, he believed that to optimize the JIT system's performance, all firms at all levels in a channel must adopt JIT.¹⁰ Both of these scholars expressed the idea that the key to whether or not a firm has a JIT system is found in the link with the channel members, specifically with the immediate suppliers. These logistical activities, as Perry pointed out, are essential. Without support from the logistics function, JIT cannot survive.

Therefore, in this report, JIT means a system of production and inventory management in which inbound raw materials and/or parts arrive at the production site from the suppliers just-in-time to be used in the production process.

Development of Just-In-Time

In Japan

According to Taiichi Ohno,¹¹ the JIT system gained ground in Japan after the 1973 oil crisis that caused recession in many countries, including Japan. Because the Toyota Motor Company was outperforming other Japanese manufacturers, interest in its JIT

manufacturing system grew and many companies implemented systems based on its principles. However, each company adapted Toyota's system to match its own environment.¹² Each JIT system was different, but it was guided by the underlying philosophy found in Toyota's operations. Before this change, many Japanese manufacturers used a production control system called Seiban.¹³ The Seiban system, which still exists, is a jobshop-type production environment where orders for materials are released, then materials are expedited as needed.

In the United States

The Japanese JIT system gained ground in the United States more slowly. Evidence exists that JIT principles were employed in some American industries in the early 1900's. As pointed out by Deakin¹⁴, a 1950's example of JIT in the United States was in Chicago at R.R. Donnelly printing company, where daily requirements of paper arrived each morning and shipments of printed phone books occurred each night. This was obviously an exception and the use of JIT in the United States was very limited until recently. Acceptance of JIT in the United States was slow, even after the great strides made in Japan.

Many reasons for the slow adoption have been proposed, but most fall into one of three categories.

First, some felt that the cultural differences between the two countries would prevent transfer of Japanese management techniques to the United States environment.¹⁵

Second, perhaps because of the concern over cultural differences, the focus of early literature was on Japanese management in general, not on JIT. Schonberger pointed out that the initial publications did not even mention JIT and that even by 1982, only a few authors talked about JIT.¹⁶ Adding to the lack of attention to JIT was the lack of examples of successful implementation of JIT in the United States. By 1982, only General Motors had begun implementing a complete JIT system.¹⁷

The third reason for slow acceptance was a belief that the existing systems in the United States could work. Some authors believed that JIT was based on principles similar to MRP, and that, if properly used, MRP would work as well. For example, Mayer wrote that JIT was not suited to the United States because "other factors" existed in the United States that did not exist in Japan. He believed that MRP was better suited.¹⁸

However, the resistance gave way as the competitive pressure and the understanding of JIT increased, and JIT became a popular concept for many business managers. In fact, its growth has been quite rapid in recent years. A 1988 Touche Ross survey¹⁹ of almost 200 companies showed that JIT is used in many companies in many industries. Of the companies studied, 70 per cent had implemented or were implementing JIT in either purchasing, production or distribution areas. Table 1 summarizes the survey's findings on the stage of implementation of JIT in those companies.

TABLE 1
STATUS OF JIT PROGRAMS IN THE UNITED STATES

| | PURCHASING | PRODUCTION | DISTRIBUTION |
|--------------|------------|------------|--------------|
| OPERATIONAL | 28% | 24% | 29% |
| START UP | 24% | 33% | 31% |
| PLANNING | 36% | 31% | 23% |
| NOT PLANNING | 12% | 12% | 17% |
| | 100% | 100% | 100% |

The survey also showed that JIT was viewed as strategically important by companies in several industries. Table 2 shows the relative strategic importance of JIT to almost 200 companies in six different industries.

TABLE 2
STRATEGIC IMPORTANCE OF JIT TO UNITED STATES COMPANIES

| | Level of Importance | | | |
|-------------------------------------|---------------------|----------|------|------|
| | VERY | SOMEWHAT | NONE | |
| Metal products | 65% | 23% | 12% | 100% |
| Automotive and transportation | 48% | 48 | 4% | 100% |
| Electronics and related instruments | 45% | 55% | 0% | 100% |
| Food and beverage | 38% | 57% | 2% | 100% |
| Chemical, plastics, and petroleum | 16% | 68% | 16% | 100% |
| Paper and related products | 13% | 59% | 28% | 100% |

It appears that the use of JIT has finally been growing rapidly. What exactly is behind the rapid growth?

Reasons for the Growth of JIT

Initially, the interest in JIT existed because manufacturers needed to improve their performance to maintain their ability to compete. One primary reason that interest continued was that benefits were perceived. Companies believed that JIT offered the opportunity to improve their overall, total performance. Some of the benefits discussed were tangible, producing measurable improvements. Among these benefits were reduction in inventory, improvement in quality, increase in productivity, reduction in lead time variation, and lower prices for purchased items. Other benefits discussed, intangible ones, were difficult to measure, but were still considered important to the overall improvement that JIT produces. Improved worker morale and increased flexibility in production were examples of these benefits.

As noted earlier, the interest grew slowly at first partly because little information about JIT existed. But, as success stories appeared in the business literature, increased awareness sparked interest. Not only did these stories create interest, the success stories were from diverse applications, showing that implementation could be approached differently in different environments. The successes were demonstrating that JIT is not a rigid, culturally based system.

The second reason that interest grew was that the large manufacturers, particularly the automobile manufacturers, who were implementing JIT, began to require their suppliers to become "partners". In many instances, this meant that the JIT supplier delivered in small, but frequent shipments. This encouraged the JIT supplier to become a JIT manufacturer to avoid an increase in its finished goods inventory that being a JIT supplier caused. Manoochehri listed this as one cause for the spread of JIT,²⁰ and a study by Perry confirmed that it was a cause.²¹

Industries involved

Schonberger expressed the idea that JIT was a well suited approach for manufacturers that have products with high volume demand that can be produced with repetitive manufacturing techniques.²² Others, too, recognized this general category as the most appropriate for JIT success. For example, Jackson said that JIT is applicable to almost any high volume, repetitive manufacturing operation and can be successfully adopted outside Japan and outside the automotive industry.²³ Also, the American Production and Inventory Control Society (APICS) established a group to study situations where JIT is appropriate, focusing on repetitive manufacturing.

Initially the industries which implemented JIT were those which competed directly with the Japanese firms. They produced the same products as their Japanese counterparts, so that transfer of JIT methods was more direct. The automotive, motorcycle,

electronics, and appliance industries were the primary industries involved in early JIT implementation.

However, Schonberger stated that any firm in any industry should be able to benefit by heading in the general JIT direction. As the United States gained experience with JIT, industries that do not have high volume demand and that do not have products that can be produced with repetitive manufacturing techniques have been examining the JIT philosophy and have been finding that some of the principles can be adopted. Small businesses and services businesses have been particularly interested in using JIT concepts to improve performance.

Is JIT Successful in the United States?

Many have asked the question "Is JIT a fad or is it a real change in manufacturing philosophy that can produce tangible positive results?"

Perhaps the best way to answer the question is to examine those companies that have implemented JIT to see if their performance has improved. Reference was made previously to early successes in using JIT in the United States. More recent evidence is found in Perry's 1988 study which indicated that differences between JIT and non-JIT companies indeed exist relative to several operational factors including inventory levels, material lead times, transportation discipline and control, order processing times, use of electronic data, and material handling efficiency.²⁴

However, only the success stories appear in the business literature, and JIT is not guaranteed to succeed. Failure can occur. According to Myers,²⁵ JIT could fail like any other management system. He also pointed out that the primary reason why any system fails is uncommitted leadership.

According to one author,²⁶ the obstacles to successful implementation include organizational resistance, lack of systems support, lack of manufacturing capability, lack of purchased goods quality, and poor planning.

Other experts discussed the factors that are needed for success. If these factors are not present, then the JIT implementation might fail. Ansari²⁷ described the success factors either as human resource factors such as top management commitment, human resource readiness, and union leadership support, or as operational factors such as a new purchasing philosophy, controlled transportation, and efficient receiving and materials handling.

Hahn, Pinto and Bragg²⁸ pointed out that the partnership relationships are one key element in the JIT philosophy, and they emphasized that the cost reductions that are achieved through the cooperation must be shared. Others concurred in the importance of mutual benefit in the partnership relationship.

JIT can fail if there is a lack of management understanding and support or if the factors required for JIT are not present, but JIT can also fail if it is never tried. Business managers themselves offer a list of reasons for not trying JIT. That list

includes supplier problems, late or poorly scheduled production, information systems that will not support JIT, low volume production, or a jobshop/batch production environment.

Part IV--JUST-IN-TIME AND TRANSPORTATION

As defined here, JIT includes linkages between manufacturer and channel member and carrier. Therefore, transportation is a critical element in any JIT system and many traditional transportation practices can be affected and require change in order for transportation to support the JIT system. Who controls the inbound transportation, the size of and the frequency of shipments, the lengths of haul, the mode and carrier choice, the number of carriers used, the problem of backhaul traffic, vehicle utilization, and overall efficiencies are the transportation-related issues that JIT can impact. JIT may even affect the energy consumption in transportation because of the changes that occur. Each of the transportation-related issues is important, but only a few authors have addressed them.

Traditionally, a manufacturer's transportation or traffic function often focused on outbound transportation. However, when JIT is implemented, inbound transportation becomes important because the transportation of the inbound materials directly affects production when no buffer inventory exists. In fact, inbound transportation is as important, if not more important, than outbound transportation. Therefore, because inbound

transportation is important to a JIT buyer, it is likely that the buyer will seek control of that transportation.

It is generally agreed that the shipments required by JIT companies are smaller and more frequent. In the Touche Ross survey, daily deliveries of items were used by 70 per cent of the companies with JIT systems.²⁹

Not so much agreement can be found on the length of haul. Some, but not all, experts believe that suppliers should be located near the buying firm. However, Anderson and Quinn³⁰ suggested that the deregulation of transportation made longer distances feasible because the transportation costs can be better controlled than in the period prior to deregulation.

And Ansari³¹ observed that in spite of the indication in the literature that geographic location of suppliers was important in JIT, only two out of 21 companies responding to his survey indicated that location of suppliers was an important factor. In fact, eleven of those 21 said that location was of little or no importance. Issues like quality, on-time delivery and fair pricing were more important in the selection of suppliers.

Bartholomew³² agreed, observing that United States auto suppliers are not necessarily close to the assembly plants. He did not expect that suppliers would move their plants closer to the customers in the United States.

The mode used for JIT may be different. Hoeffler said there is a natural implication in JIT that trucks will replace rail. In his interview with Robert B. Stone, Vice-President of Materials at

General Motors, he found that Mr. Stone thought that a company had better control over the shipping process with truck than with rail.³³ Furthermore, air freight which provides reliable service might see more use.

It is assumed that, in a JIT system, the selection of the individual carrier will be controlled by the buyer. The relationship with the carrier will be expanded, and the carrier will need to provide services such as consolidation, tightly scheduled deliveries, shipment tracing and improved communications, and perhaps even specialized vehicles to enable the delivery of the shipment to the shop floor rather than to a shipping dock. Fewer carriers with longer term relationships might result because of the need to have improved service.

Because of the increased frequency of inbound shipments and their small size, vehicle utilization can be poorer in a JIT system, i.e., there is less likelihood that full vehicle loads are possible. In addition, because of the frequency of round trips and the need for dependability, the possibility of empty return hauls to vendors is increased because it is difficult to match loads with vehicles under such circumstances. This also contributes to poorer overall vehicle utilization.

Finally, it is often accepted that, because of the small shipments, frequency of delivery, poorer vehicle utilization, and shift to higher-cost modes, that the adoption of JIT results in higher transportation costs.

Part V--PURPOSE OF THE MAIL AND PERSONAL INTERVIEW STUDY

The practicality of the use of JIT by manufacturers may vary by geographic region in the country. A reason for this could be the spatial relationships involved in JIT. For example, distance from vendors may be important in implementing JIT because it affects inbound delivery time. Minnesota and Wisconsin are not in the industrial belt of the United States and they are far from most markets and, possibly, far from their suppliers. Therefore, it may be that manufacturers in Minnesota and Wisconsin are less likely to adopt the JIT philosophy than are manufacturers in Ohio or Michigan because of their greater distance from suppliers.

A second reason for the practicality of JIT varying in different parts of the country has to do with the kinds of products manufactured. It may be that the kinds of products produced (and inbound products received) in Minnesota and Wisconsin are less well suited to JIT than products produced elsewhere in the United States.

Therefore, objective (1) of the study reported on here was to determine the extent to which manufacturers in Minnesota and Wisconsin have adopted the JIT concept for inbound movements and what kinds of firms they are in terms of size, products produced, and plant location.

Objective (2) was to determine, for those manufacturers that have adopted the JIT philosophy, what their reasons were for doing so. Conversely, for those manufacturers that have not embraced JIT, an attempt was made to determine why they had not done so.

The study also inquired into the completeness of implementation of JIT, how suppliers are selected, and the effect of JIT on inventory levels.

Finally, the use of the JIT concept by a manufacturer can profoundly change the way in which inbound transportation is used. As indicated earlier, it is assumed by many writers and other experts in the field that the adoption of JIT means that the manufacturer must take control of inbound transportation, shipments of inbound materials will be smaller, deliveries will be more frequent, the lengths of haul will be shorter, a smaller number of carriers will be used with longer-term relationships between manufacturer and carrier, vehicle utilization will be poorer, modal shifts will be made by the manufacturer, inbound transportation costs will rise, and more energy will be consumed in transportation. There is some disagreement among the experts in the field on some of the above.

Objective (3) of the study was to determine to what extent the above assumptions about the use of inbound transportation in a JIT environment are supported by the experience of manufacturers in Minnesota and Wisconsin.

The study reported on here was a preliminary study in that it was intended to provide information that could be used as a foundation for a more detailed study later among manufacturers in Minnesota and Wisconsin. Of special importance was objective (1), to determine to what extent manufacturers in the two states have adopted the JIT concept.

Although the study was a preliminary one, it was intended that some tentative conclusions could be drawn relative to the suitability of JIT for manufacturers in Minnesota and Wisconsin and the opportunities presented by JIT to private and for-hire carriers in the two states.

Part VI--METHODOLOGY USED IN THE MAIL AND PERSONAL INTERVIEW STUDY

A combination of a mail questionnaire survey and personal interviews was used to identify the extent of use of the JIT concept by manufacturers in Minnesota and Wisconsin and the effect of JIT on the use of inbound transportation.

Mail Questionnaire Study

The Sample

Mail questionnaires were sent to 75 manufacturers located in the two states. They were selected from the membership list of the national Council of Logistics Management (CLM) and also from the Minnesota Directory of Manufacturers.³⁴

The CLM membership list for Minnesota and Wisconsin was used to develop the mailing list. The Council membership consists of persons that are involved in logistics management and who, presumably, work for companies that would likely be somewhat advanced in dealing with the movement of goods. Because the membership in the Council is relatively small in number, the

Directory of Manufacturers was used to add additional Minnesota firms to the mailing list.

Selection of firms to be included in the mailing list was based on four criteria. One was the size of firm. In an attempt to include firms that were large enough to employ a JIT system, an arbitrary minimum size of 250 employees and \$10 million in annual sales was used in selecting firms from the Minnesota Directory of Manufacturers. The size requirement was not used in connection with CLM members. It was believed that membership in CLM was sufficient to indicate that there was a chance that JIT was being used.

A second criterion was that firms were selected from both lists that were thought to manufacture products that were conducive to JIT production and inventory management. These were firms that were engaged in repetitive manufacturing of a product over time.

A third criterion was that an attempt was made to include a substantial number of firms that were not located in the large metropolitan areas of Minneapolis-St. Paul, Madison, or Milwaukee. Twenty-six of the 75 firms selected had mailing addresses that were outside of those metropolitan areas.

Questionnaire Returns

An eight-page, 22-question questionnaire was sent to 58 firms in Minnesota and seventeen in Wisconsin, a total of 75. The return of usable questionnaires from Minnesota was 23, or 39.7 per cent.

From Wisconsin, it was eight returns, or 47.1 per cent. The overall return of 31 was 41.3 per cent, which is considered good for this kind of study.

Reliability

It is recognized that there is bias in the method used. By selecting firms that were thought to be able to use JIT, the results are biased in the direction of receiving positive responses to the question of whether or not JIT was being used. In addition, there is the deficiency in all mail surveys caused by the fact that we do not know what the use of JIT was among those manufacturers that did not return the questionnaire. It is possible that the rate of use of JIT was less among those firms than among those that returned the questionnaire because users of JIT may have been more likely to respond. However, we are not concerned because this was a preliminary study largely intended to find out if there are a significant number of JIT manufacturers in the two states without trying to accurately measure the total number of firms that have adopted JIT. The second major objective was to examine the relationship between JIT and the use of inbound transportation and the results in that area are probably not biased by the sampling method used.

Characteristics of Respondents

The manufacturers that responded had at least 100 employees, with eighteen of the 31 having at least 1,000. All responding

firms had annual sales of at least \$20 million with twenty of them having \$100 million or more. Therefore, the size of firm was fairly large.

The fields worked in by the 31 persons that filled out the mail questionnaire included transportation management, inventory management, purchasing, materials management, distribution management, manufacturing, logistics management, general management, packaging, and finance. They were vice presidents (5), directors (6), "managers" (16), "administrators" (1), and one was an engineer. Two were not identified as to title.

Personal Interviews

In order to gather more complete information than was obtainable via the mail survey, eight of the mail respondents that were using JIT were selected to be interviewed on an in-depth basis. The selection was based on the degree of interest shown in the study by their returned mail questionnaire, the organizational level of the person who filled out the questionnaire (the higher the better), the kinds of products manufactured, and whether or not the plant location was in a large metropolitan area--four of those selected were in a major metropolitan area and four were not.

The interviews covered the same material as the mail questionnaire where clarification or more information was desired. They also dealt with some issues that were not included in the mail questionnaire.

Part VII--FINDINGS OF THE MAIL AND PERSONAL INTERVIEW STUDY

Non-Users of Just-In-Time

Characteristics of Non-Users

Size of Firm. Of the 31 manufacturers who returned the mail questionnaire, 27, or 87.1 per cent said that they have adopted the concept of JIT in their companies. Two of the four companies that did not make use of JIT had less than 1,000 employees and two had 1,000 or more employees. Three had an annual sales volume of \$100 million or more. Therefore, size of firm does not seem to be a factor in a decision not to use JIT. Recall, however, that all of the 31 responding firms were fairly large firms.

Products Produced. The products produced by the four firms were cereal, flour, and dessert items by one company; coffee in another case; health and beauty aids in another case; and military hardware by the fourth company.

Location of Plant. In all four cases, the manufacturing plants of the non-using respondents were located in a large metropolitan area. Therefore, distance from population centers does not appear to be a factor in the decision not to use JIT.

Reasons for Not Using JIT

The respondents were asked why they had not adopted JIT. The food products respondent said that JIT was impossible in that company because of the large number of vendors (400-500), the long

distances between vendors and production points (up to 2,800 miles), a large number of production sites (20-25), and the production scheduling practices the company was forced to follow. JIT would create a great deal of "confusion" in such a situation, according to the respondent.

Perhaps the coffee company should not have been on the mailing list because coffee roasting is not "manufacturing" in the usual sense. In any event, the coffee company reported that the inventory levels of green coffee depend on the market price and its relationship to inventory carrying costs and, hence, JIT principles could not be used.

The company that produces health and beauty aid products said the firm was working toward JIT but was a long way from implementing it.

The manufacturer that produces military hardware said that it made small quantities of individual items on a job shop basis over a long period of time (18-30 months to build a product) and this is not conducive to JIT, but the company would like to implement the JIT idea in the "broader sense."

Some evidence of the basic conditions necessary for JIT to work are evident in these four companies. The food processor, in effect, said its inbound system was too complicated for JIT to be practical, implying that JIT is more likely to be successful when the inbound system is "controllable," meaning that the number of vendors and carriers and production sites are manageable. The respondent also stated that long distance works against successful

JIT, which is contrary to what other respondents reported (see below).

The coffee processor illustrates a product that is not conducive to JIT--the company was not engaged in repetitive "manufacturing." It also had a volatile raw material price which works against long-term agreements with suppliers and carriers.

The health and beauty aids products company could be a candidate for JIT but had not yet tried it.

Finally, the military hardware company is an illustration of a product and a production system that does not lend itself to JIT. It was not engaged in repetitive production over time, it was, in fact more like production to order or "custom" production of small numbers of units rather than repetitive production of large quantities for stock and future sale.

The four negative responses are evidence that JIT is not applicable to all manufacturing situations. However, they do not indicate that JIT cannot or should not be used by Upper Midwest manufacturers.

Users of Just-In-Time

Characteristics of Users

Size of Firm. A variety of firm sizes (within the original sample limitations) were found to be users of JIT. It is to be remembered that the group of responding manufacturers consisted of fairly large firms. Eleven of the JIT users had less than 1,000

employees while sixteen had 1,000 or more employees. Ten had annual sales of at least \$20 million but less than \$100 million. Seventeen had sales of \$100 million or more. This seems to show that the use of JIT is not limited to very large firms.

Location of Firm. Of the 27 JIT users in the study, eight were in Wisconsin, nineteen were in Minnesota. Fourteen had at least one manufacturing plant located in a large metropolitan area. Of these fourteen, two had a plant in a small city of less than 7,000 in population in addition to the plant(s) in the large metropolitan area. One manufacturer not located in a large metropolitan area had its plant in a city of about 91,000 in population. In another case it was a city of 79,000. A third had its plant in a city of 54,000 and fourth had its plant in a city of 33,000. The plants of the remaining nine companies were located in small cities of 20,000 or less in population that were not part of a large metropolitan area. The fact that so many of the plants making use of inbound JIT were located in smaller cities often far from large population centers tends to cast doubt on the idea that, because JIT depends on frequent and timely transportation, it cannot work well in such locations because they are too hard to reach or are too far away from vendors.

Products Produced. A very wide variety of products were collectively manufactured by the JIT users, with no discernible pattern emerging. The main products manufactured by these firms (there were others as well) included agricultural implements, breakfast cereal, mainframe computers, computer parts, corrugated

paper, electronic components, envelopes and paper tablets, fiberglass parts, engines and transmissions, hand tools, hydraulic valves, integrated voice and data processing equipment, lawn care and snow removal equipment, leather goods, medical foods, motors and associated equipment, generators, medical instruments, papers of various kinds, computer power supplies, processed meats, snowmobiles, tractor cabs, cabinets for electronic devices, v-belts and hoses, windows and doors, and molded rubber and plastic parts. This list does not reveal any concentration of JIT users in certain kinds of product lines.

This variety of industries using JIT is in agreement with the Touche Ross survey and with the ideas of Schonberger and others referred to in Part III above relative to the wide variety of industries that can make use of JIT.

Inbound Materials and Parts. In order to manufacture the wide range of products mentioned above, an even wider variety of materials and parts were brought to the manufacturing sites of the respondents. It is not practical to list them all here. They included such things as leather, wood pulp, iron castings, chemicals, paper-roll stock, oat flour, engines, bearings, electronic components, fabricated sheet metal, copper magnet wire, sugar, glass, fasteners, clutches, packaging materials, and many others.

The distances travelled to receive the inbound materials and parts ranged from two miles to 8,000 miles and the number of

shipments received of a given item per year ranged from ten to several hundred.

Definition of JIT

The definition of JIT that was used in explaining the research project to respondents was that it is a system of production and inventory management in which inbound raw materials and/or parts arrive at the production site from suppliers just-in-time to be used in the production process, thereby reducing substantially or eliminating entirely the amount of inbound inventory carried by the manufacturer.

The returned mail questionnaires did not indicate any disagreement with the definition. In the personal interviews, respondents were specifically asked for their definition of JIT. Except for one case, the responses were the same or nearly the same as the study's definition. In the one instance, the respondent insisted that JIT is a quality improvement program, not an inventory management program, and that inventory management is merely a means to achieve quality improvement. The difficulty with this approach is that inbound product quality can be improved without change in inventory management and without the use of JIT. On the other hand, JIT cannot work without high quality of inbound materials and parts because it assumes that inbound goods are acceptable quality-wise and do not need much, if any, inspection by the receiver and, if inspected, will rarely be rejected.

Motivation for JIT

The usual motivation for installing a JIT system given by the respondents was to reduce inventory of inbound materials and parts by having them arrive when they are needed. This was often tied in with an effort to improve quality of the inbound goods in order to achieve lower costs and improve the quality of the goods manufactured.

In fact, as noted above, the JIT concept rests in part on the idea that the materials and parts received from vendors are of suitable quality, with few or no rejects, so that inspection by the manufacturer can be reduced or eliminated, making it possible to move the goods directly into production. The "just-in-time" idea breaks down if inbound goods are rejected. Some respondents reported that they had been able to sharply reduce the inspection of inbound materials and parts. One said that eventually there will be no inspection of inbound parts because the processes followed by its vendors will be so improved under the partnership arrangement it has under the JIT program.

In a few cases, the motivation for adopting JIT came from the fact that the manufacturer was a JIT supplier for some other firm, the company saying that it had to become more efficient overall in order to perform well as a JIT vendor.

Completeness of Implementation

Implementation of JIT in a firm can be a difficult process and not likely to be accomplished in a short period of time. This is

especially true when the inbound system is complicated by large numbers of vendors, inbound materials and parts, and production sites. We noted above that one respondent has not tried JIT because of such complications.

Along these lines, respondents using JIT were asked if their implementation has been complete. Only six of the 27 JIT users said that the implementation was complete. Implementation was interpreted by respondents in various ways to mean that not all inbound materials or parts were included in the system, or certain vendors or certain sizes of orders were not included, or the right kind of vendors had not yet been selected for the system, or the tie-in with production was not completed, or completeness will not occur until there is zero inventory of inbound materials or parts.

Several respondents stated that implementing JIT is a long process and some said it is a continuous improvement process that is never completed. One manufacturer said that it was only about half way to completion and the most difficult part is to make the "cultural" (attitude) change necessary among the manufacturer's employees and vendors. On the other hand, a different respondent said that JIT was complete in the company and all inbound materials and parts were part of it. Inbound inventory could be reduced further but the cost of doing so would be too great because it would involve the use of more air freight transportation.

Selection of Vendors

Part of the process of establishing a JIT system is to select suppliers or vendors that are willing and able to supply inbound materials and/or parts in a manner suitable for JIT manufacturing. This may require suppliers to make small and frequent shipments with corresponding effects on the length of their production runs, inventory carried, and other aspects of their business. According to one respondent, the job of getting the cooperation of JIT suppliers is a job of selling them on the benefits that exist for them. The benefits basically have to do with a "guarantee" of a large and continuous volume of sales to the manufacturer.

Vendors used by the manufacturers in the study were sometimes under written contract with the manufacturer covering a period of time. In one company, two-year to five-year contracts were entered into with vendors. Its contracts guaranteed a specific volume per month or quarter and contained provisions for price adjustments in the future. The details of what was to be shipped and when were set forth monthly or quarterly as time passed. In other cases, respondents reported that there was only a letter of intent or an oral understanding that a certain amount would be purchased over a period of time.

In some cases, the relationship between manufacturer and vendor was very close and a "partnership" was entered into and vendors were "certified" as qualified vendors for the JIT system. The manufacturers and vendors worked very closely in those situations, with the manufacturers helping the vendors to improve

their methods in order to be more efficient which, in turn, could help the manufacturer via lower prices and/or better quality and service. One manufacturer stated that a few vendors refused to participate in its JIT system because they had been "burned" by other manufacturers who wanted manufacturer-vendor partnerships. The partnerships turned out to be one-sided in that the manufacturers demanded better product quality and better delivery but they did nothing on their end to help out.

The usual assumption is that implementation of JIT results in fewer suppliers being used than was the case previously. This was generally true in the study. One respondent decreased the number from 350 to 190. Another reduced the number from 660 to 220.

Reduction in Inventory

It is usually an objective of JIT to reduce the amount of inbound materials and parts held by the manufacturer. In 24 of the 27 firms that have adopted JIT, inventories had been reduced, thus indicating success with JIT, at least in connection with this variable. In the case of an electronics manufacturer, the reduction was 54 per cent in three years. A manufacturer of engines and transmissions reduced inbound inventory by thirty per cent. A manufacturer of hydraulic system parts reported an inbound inventory reduction from an average inventory of \$8.5 million to \$4.5 million, while annual sales rose 33 per cent in the same period. Some respondents said that they had been able to move inbound materials right to the production floor and not to a

warehouse, because the system was working so well. Others were still using conventional warehousing.

Control Over Transportation

In order for a manufacturer to be able to implement an inbound JIT system, it is usually necessary to have control over the inbound transportation. All respondents that use JIT reported that they had such control, i.e., the decisions relative to inbound transportation were made by them. However, several qualified this by saying that they shared the responsibility with vendors in some circumstances and that some inbound moves were made f.o.b. destination.

Size of Shipment

It is generally assumed that inbound JIT results in smaller and more frequent inbound shipments. This was substantially verified in the study. The shipment size was said to have declined with the adoption of JIT in twenty of the adopting firms, while seven firms said that there had been no change in the size of inbound shipments. In no case was an increase in the size of shipment reported. In several cases, where the size of shipment had not changed, the manufacturers reported that, although the size had not changed, they now combined smaller orders of a variety of inbound items from the same supplier in the same shipment, whereas there previously were one-item shipments.

Frequency of Shipments

Twenty-four of the 27 JIT users in the study indicated that inbound shipments had become more frequent under JIT, while three said there had been no change. This is in agreement with an assumption usually made about JIT and follows from the fact that there is a smaller size of shipments.

Length of Haul

Because JIT is based on the idea of small and frequent deliveries of inbound materials and parts, and very dependable service, it is often assumed that the distance between manufacturers and their vendors should be less under a JIT system than it would be otherwise. It would appear that long hauls would make the timing of JIT deliveries more difficult and would result in the manufacturer carrying more inbound inventory than if suppliers were closer. However, as noted earlier, there is disagreement on this question on the part of those who have written on the subject (see Part IV above). In the study reported on here, 22 of the 27 JIT users said that the adoption of JIT had not reduced the length of haul from their suppliers; four of the other five said distances had been reduced.

One manufacturer reported that, "Distance is not necessarily pertinent. The important thing is the total cost involved when dealing with a particular vendor." Another said that, in selecting suppliers, "Distance is only one factor in the decision. The ability to provide quantities when needed, price, etc., are the

other factors. We rank the vendors on these factors, add up the score, and select the supplier with the highest score."

One respondent said that the distance from vendors had no bearing on vendor selection. One of its former vendors was less than two miles away and was dropped in favor of two that were 300 and 750 miles away. The respondent said that the attitude of the vendor is the major factor in supplier selection--the willingness to make changes. It should be pointed out that, in this case, fast and frequent delivery was not necessary under the JIT system.

A medical products manufacturer said that location was a factor in selecting vendors, but it was not the most important thing. "If we had two potential suppliers and one was nearer but not as good as the other one, we would take the more distant one. If they were equal in other respects, we would take the one that is closest to us." Another respondent said that the distance from vendors was important but the overall cost when dealing with a particular supplier and the quality issue could offset the location factor. Finally, a manufacturer reported that location of the supplier was not a factor in vendor selection unless it affected price. However, the company tried to keep vendors no more than 300 to 600 miles away.

Number of Carriers Used

The JIT philosophy calls for a smaller number of carriers with closer relations with them than in conventional inbound transportation. This ties in with the need for better service from

the carrier in a JIT system in terms of consolidation, tight schedules, consistency, communications, and so on. However, only about one-half of the manufacturers in the study that have implemented JIT said that they used fewer carriers as a result. In fact, two respondents said that they used a larger number of carriers; eleven said the number of carriers used had not changed. One respondent said that it is risky to have too few carriers. The responses were not related to the size of the firm. Nevertheless, some manufacturers reported dramatic reductions in the number of carriers used and some said that they had established close "partnership" relationships with the carriers. This means that the manufacturer and the carrier have a long-term and very close relationship in which they work together toward a common goal.

Vehicle Utilization

With JIT's smaller and more frequent inbound shipments and very tight schedules, and where dependability of delivery time is paramount, it is expected that full inbound vehicle loads would be difficult to attain, and partially filled and empty return hauls after delivery of inbound materials and parts would be frequent, resulting in poorer vehicle utilization. However, only seven of the respondents that have adopted JIT said vehicle utilization had become poorer. Eight said there had been no change, while seven said utilization had become better. Five respondents said that they did not know what the effect on vehicle utilization had been.

Several respondents explained their poorer vehicle utilization by the fact that JIT led to deliveries in quantities less than vehicle-loads. This implies that consolidation of inbound small shipments is a way to improve vehicle utilization. One manufacturer required each vendor to ship mixed truckloads of its products rather than individual less-than-truckload shipments. Consolidation of the shipments of different vendors is difficult to accomplish but some examples were found in the study. One manufacturer arranged with local cartage companies in two distant cities to pick up small shipments from several vendors in those cities, consolidate them into truckloads, and then turn them over to the manufacturer's private trucks for delivery to the manufacturer's plants. Another respondent used both for-hire and private motor carriers to consolidate the small shipments of different vendors into truckloads so that the average size of shipment to the company plants increased under JIT. However, it would seem that consolidation is not in the interest of efficient JIT unless the need for timely frequent delivery of small shipments is not critical.

Respondents were asked specifically about the partially full or empty return haul problem. Again, there were mixed results. Eight said that JIT had led to a larger number of vehicles returning in the direction of suppliers empty or partially filled. Five said there were fewer instances of this kind, while six said there had been no change in the number of empty or partially filled back hauls. A large number, nine in all, did not know what

the effect of JIT had been on this issue. These latter firms tended to be those that used for-hire carriage for inbound transportation and had no information about what happened to the for-hire vehicles after deliveries were made.

Mode of Transportation Used

Reference was made earlier to the fact that the mode of transportation chosen for inbound transportation could be affected by a decision to adopt JIT. Whether or not a manufacturer should change modes of inbound transportation depends on the circumstances. The change is often to a more flexible, faster, and more expensive mode. In the case of the JIT users included in the study, nine reported greater use of air transportation, nine reported greater use of common carrier truck transportation, thirteen said they used more contract carrier trucking, five used more supplier-furnished private trucking, and eleven used more of their own private trucking. At the same time, four said they used less rail transportation, two used less air transportation, ten used less common carrier trucking, four used less vendors' private trucking, and three used less of their own private trucking. Of course, some firms reported that their choice of modes of transportation had not changed as a result of a shift to JIT.

When asked what inbound modes were now being used in their JIT systems, many manufacturers reported that they used more than one. Fourteen used air transportation, 26 used common carrier motor trucking, nineteen used contract carrier trucking, sixteen

used vendors' private trucking, and fourteen used their own private trucking. Only six firms used rail transportation and only five used water transportation.

Thus, motor trucking dominated inbound transportation in the JIT systems of the firms in the study. An example is a manufacturer of metal cabinets and similar products that relied on common carrier trucking for three per cent of its inbound traffic, contract carrier trucking for twenty per cent, vendors' private trucking for two per cent, and its own private trucking for 75 per cent.

Much of the trucking used by respondents was their own private carriage. A frequent arrangement was to use private fleets to deliver to customers and to bring in materials and parts on the return haul. One respondent reported that there were problems with the inbound side in such situations because of a lack of coordination between purchasing people who order inbound goods and traffic management which controls the private fleet, sometimes resulting in insufficient truck space to carry what had been purchased. Another problem mentioned by some respondents was that the need for outbound transportation dominated the scheduling of trucks and the available return trips did not always mesh well with the inbound requirements.

Several firms in the study that relied primarily on their own private trucking for inbound transportation used for-hire carriers when private carriage was not feasible--either long-term or short-term. Several were or soon will be engaged in for-hire as well as

private motor trucking in order to haul for others when necessary to fill their trucks or just to make money on transportation.

As to for-hire trucking service, both common and contract carriage were being used, as noted above. Several respondents complained that for-hire motor truck service was not as available in small cities as it was in more populated areas and this was at least a partial reason for using private carriage.

Railroads did not play a large role in the JIT systems included in the study. One respondent said that JIT and the railroads are not compatible because rail delivery is too unpredictable and railroads are unwilling to provide "other services" that are needed to support JIT. Obviously, railroads are not conducive to JIT when small shipments are involved. They can be used for bulk shipments, however. Examples include a manufacturer in the study that used railroads for inbound shipments of resin and paper roll stock and another that used it for inbound shipments of coal.

Transportation Costs

Related to the above discussion of vehicle utilization, back hauls, and modal choice, it is assumed in the theory of JIT that inbound transportation costs will rise in a JIT system, with the expectation that the higher transportation costs will be more than offset by lower inbound inventory carrying costs that result from an effective JIT system. This was the case in several responding firms. However, a higher freight bill did not necessarily follow

from implementation of a JIT system. Of the JIT using manufacturers in the study that responded to the question, eleven said that inbound transportation costs had risen, but five said they had declined, and nine said there had been no change. Two did not respond.

One manufacturer with higher inbound transportation costs said that if fewer carriers are used and greater service demands are made, higher transportation costs should be expected. Another said the company's use of air transportation and the frequency of delivery had increased but the high transportation costs were offset by lower inventory carrying costs. On the other hand, two respondents whose transportation costs had gone down said that it was the result of discounts received from carriers because of the larger volume they now carried under JIT.

Energy Consumption

Also related to the issues of vehicle utilization, back hauls, and modal choice is the matter of energy consumption in inbound transportation. It would seem that with smaller and more frequent deliveries and poorer utilization of vehicles plus the switch to less energy-efficient forms of transportation, that JIT would lead to higher energy consumption per ton-mile. When asked about this, however, only ten of the JIT users said that energy use had increased, while three said energy consumption had decreased, and eight said that there had been no change. Six said they did not know what the effect of JIT had been on energy consumption. It is

clear that there is a connection between the perceived change in inbound transportation costs and the perceived change in energy consumption in transportation.

Part VIII--CONCLUSIONS

Based on this preliminary study of manufacturers in Minnesota and Wisconsin, the tentative conclusions discussed below are drawn. These are tentative conclusions or "indications," rather than definite conclusions, because of the small sample and the other limitations associated with the sample that were discussed earlier.

Non-Users of Just-In-Time

There is evidence that size of firm does not have a bearing on the decision not to use inbound JIT, while the kind of product produced does have some influence on the decision. The distance of the plant from population centers is not of much importance in deciding against JIT and location in the Upper Midwest is not a factor in the decision.

Users of Just-In-Time

Characteristics of Firms Using JIT

Again, size of firm is not an important determinant of whether or not a firm can make use of inbound JIT, at least among the

firms that cooperated in the study. Recall that the firms that responded all had an annual sales volume of at least \$20 million.

It appears that location in the Upper Midwest has no bearing on whether or not a firm can make use of JIT, despite the distance from markets and, more importantly, from suppliers. The assertion that inbound JIT systems require that distances between manufacturers and their suppliers be relatively short was refuted in this preliminary study.

Plants located in sparsely populated areas are able to use inbound JIT, despite their lesser accessibility to transportation and their distance from vendors.

A wide variety of manufactured products are amenable to the use of inbound JIT in their production; there do not seem to be any "natural" JIT products or industries suitable for JIT, provided that there exists repetitive production over time.

Motivation for Adopting JIT

Most firms agree with the definition of JIT as being a method of eliminating waste by reducing or eliminating inventory of inbound materials and parts, and the objective of most JIT users is to reduce such inventory.

Completeness of Implementation

Implementation of inbound JIT is often a long-term process taking considerable time with, in some cases, the process never coming to an end.

Vendors in Inbound JIT Systems

Written agreements between manufacturers and their vendors and close "partnership" arrangements between them are not necessary for a JIT system, although they are found in some cases. There usually are fewer suppliers under JIT.

JIT and Transportation

That the manufacturer should have control of inbound transportation under an inbound JIT system was verified in the study.

The assertion that the adoption of JIT results in shorter lengths of haul (shorter distances from vendors) was not verified by the study.

The assumption that JIT systems require smaller shipments was supported to a degree in the study. The belief that JIT results in more frequent inbound shipments was confirmed.

The theory that JIT results in fewer inbound carriers being used by the manufacturer and closer relationships between the manufacturer and the carriers was partially supported by the study.

Although it might be expected that vehicle utilization would generally be poorer in a JIT situation, this was not generally found in the study.

The adoption of JIT means that there will likely be greater use of air transportation and various kinds of for-hire and private motor trucking, with less use of rail service. Motor

trucking dominates in JIT systems, with a large part of it consisting of private carriage, both vendors' and manufacturers' private trucking.

Higher transportation costs do not necessarily follow from implementation of a JIT system, although they are higher in many cases.

Energy consumption in transportation is increased with JIT in some instances, but it is decreased in others.

Opportunities for Manufacturers

This preliminary study indicates that inbound JIT can be implemented by manufacturers in Minnesota and Wisconsin and by different kinds of firms in many different kinds of situations; it is not restricted to a small number of large firms in specific industries. In fact, a manufacturer may be a good candidate for a successful JIT experience even though it does not fit the usual "requirements" for JIT firms in terms of size of firm, the location of the firm, the distance from vendors, and so on. If the firm is engaged in repetitive production over time, it may find that JIT is a way to reduce waste in inventory. The firms studied generally were able to do so and some of them did it without increasing their inbound transportation costs.

Manufacturers must, however, realize that implementation of JIT is a long process that requires a significant commitment of time.

Manufacturers that adopt JIT should be prepared to integrate their inbound transportation into the system by taking control

over transportation decision making, choosing vendors with transportation factors in mind, selecting carriers in terms of JIT requirements, probably using fewer carriers, considering using private carriage for the inbound moves, and possibly incurring higher inbound transportation costs that should be offset by lower inventory carrying costs.

Opportunities for Carriers

For private and for-hire carriers, particularly in motor trucking, it appears that JIT represents an opportunity as more firms in Minnesota and Wisconsin adopt the JIT concept or expand their use of JIT. Is it a good idea to become part of a JIT system? This, of course, depends on the circumstances. However, a carrier can probably benefit greatly from becoming part of a JIT system if it is willing to comply with what is required in terms of shipment size, frequency of shipment, length of haul, consistency of service, loss and damage, and so on. The fact that sometimes fewer carriers are used in JIT systems means that those that participate will have a larger share of the traffic than before, and this traffic is sometimes "guaranteed" in the future, removing some of the instability in both private and for-hire carrier operations.

There are, of course, questions about the costs incurred when operating in a JIT system and being compensated properly for what is done for the manufacturer. Some of these concerns have to do

with the effect on vehicle utilization of small and frequent shipments and empty back hauls.

Further Research

The results of this study are definite enough to indicate that a substantial number of Minnesota and Wisconsin manufacturers have adopted the inbound JIT concept and, therefore, there is a large group of JIT manufacturers in those states that can be studied. The study also indicates that there are some important effects of the adoption of JIT on the use of transportation, and that these consequences are often not consistent with the usual assumptions made about JIT. Therefore, it can be concluded that there is justification for further and more detailed research into the question of how the implementation of JIT affects the use of transportation by manufacturers in the two states.

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