Logistical Support for Manufacturing Agility in Global Markets

Gyula Vastag, John D. Kasarda and Tonya Boone
Kenan-Flagler Business School, The University of North Carolina, Chapel Hill, North Carolina, USA

Introduction

Achieving success in the global market has required fundamental shifts in the way business is conducted and has dramatically affected virtually every aspect of manufacturing strategy. As millions of tons of raw materials, parts, and finished products flow internationally every day, commercial borders have effectively supplanted national borders. Global sourcing predominates as advanced telecommunications and transportation technologies allow a wide geographic dispersion of component manufacturing sites and places of final assembly. Networks of strategically aligned firms are replacing individual firms as competing units.

In this rapidly changing world, not only internal manufacturing processes but also its external logistical infrastructure need to be changed. Manufacturing companies require new supporting infrastructures to compete successfully in quickly changing global markets demanding flexibility and timely delivery. The Global TransPark, combining internal and external elements of agile manufacturing, offers one – potentially the most valuable – solution to this problem.

Background Literature

Most authors agree that time and flexibility will be the new driving forces of competitiveness, and quality is becoming more and more an order qualifier rather than an order winner. Collins *et al.*[1] concluded that one of the main forces to manufacturing restructuring in the next five years will be speed in product innovation and delivery. Respondents to the 1992 US Manufacturing Futures Survey indicated that they expected the biggest changes in environment to come from four areas:

(1) global market opportunities and competition;

(2) higher customer expectations for quality and speed;

(3) changing expectations, abilities, and attitudes in the workforce; and

(4) increasing concerns with environmental issues[2].

Flexibility is achieved through improved internal integration. McGrath and Hoole[3] contend that operational integration is required for successful global

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performance. Manufacturing and distribution networks must be tightly co-ordinated, without redundant processes. They highlight five basic processes from which change must begin:

(1) product development;

(2) purchasing;

(3) production;

(4) demand management; and

(5) order fulfilment.

Shapiro *et al.*[4] emphasize the importance of order management cycle in improving customer service.

Flexibility also hinges on successful implementation of advanced manufacturing technologies (AMTs). AMTs include:

- computer-aided design (CAD);
- computer-aided manufacturing (CAM);
- computer numerical control (CNC);
- automated guided vehicle (AGV);
- automated material handling (AMH);
- direct numerical control (DNC);
- automated assembly (AA); and robots.

Youssef[5] found that the most commonly used AMTs (i.e., CAD, CAM, and CNC) are used in design and early planning activities, while the AMTs used the least (i.e. AGV, AMH, DNC, AA, and robots) are considered the components of the factory of the future. Thus, flexibility requires a change in manufacturing practices, management systems, and approaches to design and engineering. Flexibility – and time-based competition as well – no longer implies a trade-off with cost, but presumes performance quality and global operations.

A survey by Giffi *et al.*[6] revealed that US manufacturers were eyeing technology to evoke time-based capabilities. US manufacturers did not attend to infrastructure components of manufacturing strategy in any consistent way. This finding suggests that the US has not yet developed a systematic approach to its manufacturing strategy in this arena.

Vesey[7] predicts that "the emphasis in manufacturing companies during the 1990s will be 'time-to-market' ". Leading competitors will increasingly be "accelerators", that is, able to capitalize on speed in engineering, production, sales response, and customer service. Accelerators manage the product life cycle so that it is characterized by abrupt spikes and short phase durations in lieu of gradual changes. Accelerator status is achieved by: creating an organizational environment where change and innovation come naturally; and adopting the technology that gives employees the best tools with which to perform their jobs.

There is a growing pressure on companies to promise shorter delivery lead times even if these promises cannot be kept[8]. Another empirical analysis by

Brown and Vastag[9] has underscored the importance of manufacturing lead-time reduction by confirming its close relationship to delivery lateness. They showed that the shorter the manufacturing lead time, the better the delivery reliability is; and this relationship is valid in both market and centrally planned economies. Tunc and Gupta[10] reported that a majority of firms surveyed were not competing on the basis of time. However, their sample size was very small (19 companies), and limited to firms located in Indiana.

According to Stalk and Hout[11], time-based competitors build their companies around customer needs by redesigning and compressing work processes in order to more directly provide those needs. Two concepts serve as the core for structuring work for time compression: organizing around the main sequence;

(1) those activities that directly add customer value in real time; and

(2) creating a smooth and regular flow of work.

They later[12] stress that time-based competitors must use time-based measures to drive performance. The gains achieved using time-based measures are particularly salient in new-product development, decision making, processing work along the main sequence, and servicing customers. Time-based measures are effective in minimizing costs and maximizing the value added to customers because longer development times, cycle times, and lead times invariably cause higher costs.

Stonich[13] stresses that implementing a time-based strategy "requires drastic changes in company culture, structure, systems, and the way the work is accomplished". He begins to focus on some of the white collar activities surrounding the actual manufacture of goods by noting that many manufacturers obtain substantial time compression by evaluating and redesigning the activities, such as sales and order entry, that precede and follow manufacturing. The plan that he offers for becoming a time-based competitor is centred on creating, planning, and assessing the feasibility of a time-based strategy.

Blackburn[14] also insists that "the administrative processes of the white-collar factory are a much more target-rich environment for time compression than the blue-collar areas," primarily because white-collar processes have not received the same attention as manufacturing and production processes. Many administrative processes are managed using methods that have been shown to be inefficient in manufacturing processes. He advocates applying just-in-time philosophies to white-collar activities in order to minimize waste, reduce mistakes, and increase internal integration.

Time-based competition and flexibility converge in agile manufacturing which, as Goldman and Nagel[15] write, "assimilates the full range of flexible production technologies, along with the lessons learned from total quality management, 'just-in-time' production and 'lean' production." Agile manufacturing hinges on streamlining organizations with a strategic focus, enhancing integral integration, and re-evaluating company culture. New-product development and customer service are the key drivers of agile manufacturing.

Nevertheless, most research into agile manufacturing has overlooked the logistics component. Logistics is ripe for increased evaluation because manufacturing has dramatically improved as a result of the intense scrutiny it has undergone over the past two decades[16]. In addition, the Council of Logistics Management predicts that, "logistics managers will encounter an even more complex business environment with greater pressure to improve service, increase efficiency, and evaluate new sources for services they provide"[17].

Similarly, Fuller *et al.*[16] recommend a logistics system that is tailored to service the diverse needs of distinct customer segments. Logistics managed in this way provides a means by which companies can increase the value that their products provide to customers. A tailored logistics system requires serving different customer segments with different channels, packaging, delivery timing, order response times, delivery frequencies, shipment norms, and product handling characteristics.

According to Fawcett[18], "Integration of logistics into the design and management of global manufacturing networks is critical to the success of a global manufacturing strategy." Skilful management of logistics should be essential to time-based competition. In this research, Fawcett has identified nine logistics techniques that are used to manage and reduce lead times (see Table I). There is a natural linkage between agile manufacturing and logistics management that has been overlooked. That linkage is addressed by this article.

Youssef[19] presents a model where the internal capabilities of the firm, suppliers, and customers are the main pillars of agile manufacturing. His model indicates that these three components, if integrated, can enhance the manufacturing performance.

This article reports the results of several research projects analysing the Global TransPark (GTP) concept, a new type of manufacturing infrastructure supporting agility and quick response in global markets. It starts by introducing the Global TransPark concept and then reports findings of research that was carried out in the design phase. This latter section consists of two parts. The first briefly describes the industry selection process targeted by the marketing and advertising

Table I. Logistics Techniques Used to Reduce Lead Time

1. Buying and shipping sourced items in container lot sizes on a periodic or systematic schedule
2. Developing partnership relationships with providers of transportation services
3. Developing partnership relationships with domestic and foreign suppliers of sourced components
4. Pre-clearance through customs
5. Greater use of airfreight for regular shipments
6. Reliance on third-party transportation companies
7. Increased use of intermodal transportation including sea-air and double stack
8. Use of advanced information systems including EDI to track and/or expedite shipments
9. Use of local third-party warehousing to buffer global and JIT purchasing

projects; the second, and more detailed, section focuses on determining company needs in the selected industries.

The Global Transpark (GTP)

Anticipating that manufacturing in the next century will be globally networked, time-based, and collaborative[20,21], the State of North Carolina is working with industry to create a logistical environment for successful twenty-first century manufacturing systems. In 1991, the state enacted legislation and allocated funds (during a revenue shortfall) that would facilitate the development of a highly innovative infrastructure called Global TransPark that synthesizes, in space and function, agile manufacturing systems with multimodal surface and airfreight systems. At its core, Global TransPark will have a 5,000-acre international air cargo-industrial complex centered by two 12,000-foot runways. Agile manufacturing and distribution facilities will be located directly along nearly 10 miles of customized taxiways that allow air cargo planes to nose-dock or side-dock with the manufacturing and distribution facilities.

The Global TransPark has been sited at a large, underutilized FAA airport in Kinston, North Carolina, about 70 miles east of Raleigh. Over 20,000 contiguous acres of surrounding land will serve as integrated industrial sites, and a Global TransPark Authority with considerable zoning and bonding power is functioning. A master planning process involving the nation's leading engineering and planning firms is under way. Unlike most traditional master plans, the engineers, planners, and architects have been joined by economists, industrial engineering consultants, communication experts, and others to assess emerging manufacturing system infrastructure needs that form the basis for the master plan[22]).

The site has direct road, rail, and air access with a seaport access by rail or highway. Industrial facilities emphasizing just-in-time logistics could have direct access to multiple transportation alternatives, including location along the taxiways. Other production and distribution facilities would be located throughout the complex. Various facilities for airfreight, air cargo companies, aviation service, and aircraft maintenance would support air transportation. Also, central facilities for both containerization and distribution as well as container storage would provide infrastructure support for industrial logistics. Personnel conveyance and dedicated office space provide for the separation of people and the movement of goods. Throughout the complex reliance on automated, electronically guided transport would exist. Commercial support and technical training centres as well as satellite teleports would also be located at the complex.

To assist in developing this prototype project, the Federal Aviation Administration and the state of North Carolina have joined to fund a unique combination of academic research and master planning to create a complex that will meet the competitive needs of industrial tenants and users well into the twenty-first century. The FAA Technical Center is administering a $1 million grant to support a series of research projects geared to the identification of probable industrial tenants, their logistical requirements, and intermodal product flows, as well as the fundamental TransPark design elements.

Industry Identification

The purpose of Project A[23] was to identify civilian industries and military and other governmental agencies that are new users or could be expected to employ air cargo services to a greater degree than currently experienced. In this article the logic and procedures used to identify civilian industries are summarized. The analysis, as illustrated in Figure 1, used both statistical data and qualitative information ("anecdotal evidence") derived from a literature search.

The objective of the quantitative analysis was to determine the current trends of air cargo usage. The analysis used the Massachusetts Institute for Social and Economic Research (MISER) database on export and import traffic by industry. The industries were identified at the four digit level of the Standardized Industrial Classification (SIC) system. Six variables were defined to measure the importance of air cargo services for the industries. Using the same variables, two analyses were carried out: one for the export industries and one for the import industries. At the end, the lists of desirable export and import industries were combined.

To ensure comparability, the variables were standardized and then a mean score was computed for each industry. If the mean score of the industry was greater

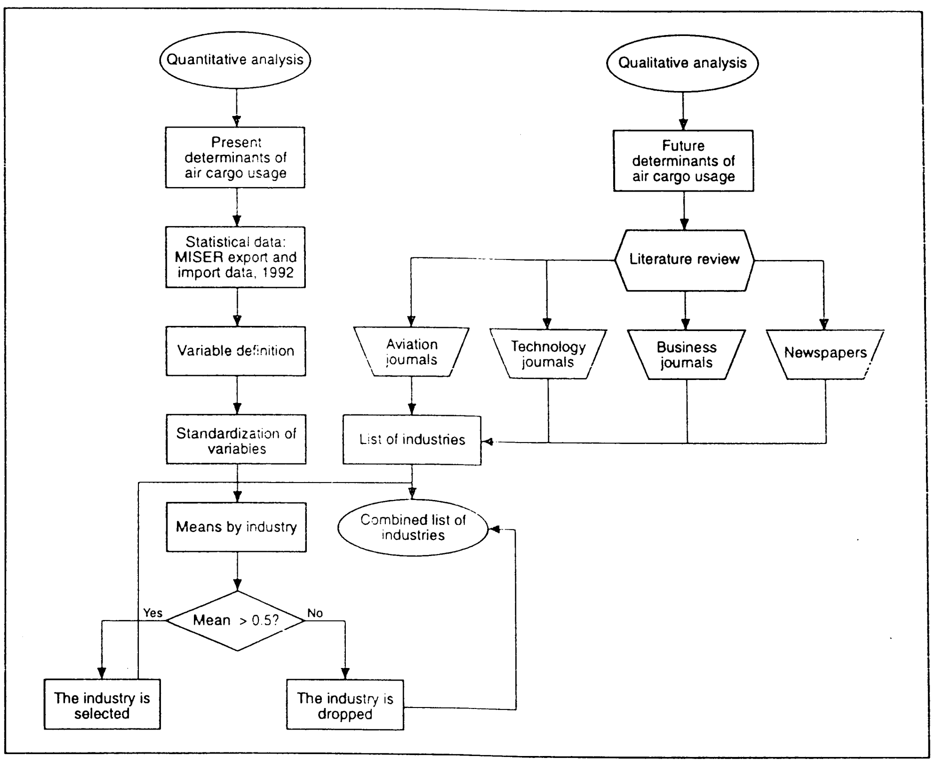

Figure 1.
Process of Industry Identification

than 0.5, the industry was determined to be a potential air cargo user, otherwise it was dropped from the industry list. This selection criterion ensured that about the top 30 per cent of the industries were retained.

Half of the variables used were original variables from the MISER database; half of them were derived from other original variables. The original variables were the following:

- total weight (in metric tons) of export and import shipments by air in 1992;
- value per weight ratio (USD/ton) of the export and import shipments delivered by air in 1992; and
- fraction of the total export and import value shipped by air in 1992.

The following derived variables measured the time sensitivity of industries and the changes in production processes and technology that took place between 1983 and 1992:

- sensitivity of export and import industries to time, meaning the extent to which an industry can tolerate longer and fluctuating delivery times[24];
- rate of change in weight of export and import goods delivered by air from 1983 to 1992; and
- rate of change in the value/weight ratios of the export and import goods delivered by air between 1983 and 1992.

The objective of the qualitative analysis was to get a picture about the future determinants of air cargo usage. A large-scale literature review of aviation, technology, and business journals was carried out to accomplish this objective. We searched 15 aviation, six technology, 18 business journals as well as 13 newspapers from January 1991 to February 1993. We were looking for information that could not be grasped through statistical data. The industries mentioned in the selected articles were also grouped into SIC categories. In the last step, the results of the quantitative and qualitative analyses were combined.

The results showed that in comparison to the quantitative analysis, the qualitative analysis identified:

- agricultural activities that were out of the scope of the quantitative analysis; and
- broader industry groups (i.e., industries at the 3-digit SIC code level) that were further specified by the quantitative analysis.

Determining Industry and Company Needs

Figure 2 illustrates the process followed in determining the industry and company needs[25]. The first area of emphasis was the industry analyses of the 89 industry types identified in earlier research. To develop an overview of each industry, many literature sources were studied. The results included a broad-based analysis of each industry as well as a list of companies and trade associations. Next, the 89 SIC codes were combined into 11 broad groups based on product or production process similarities. Table II shows the 11 groups.

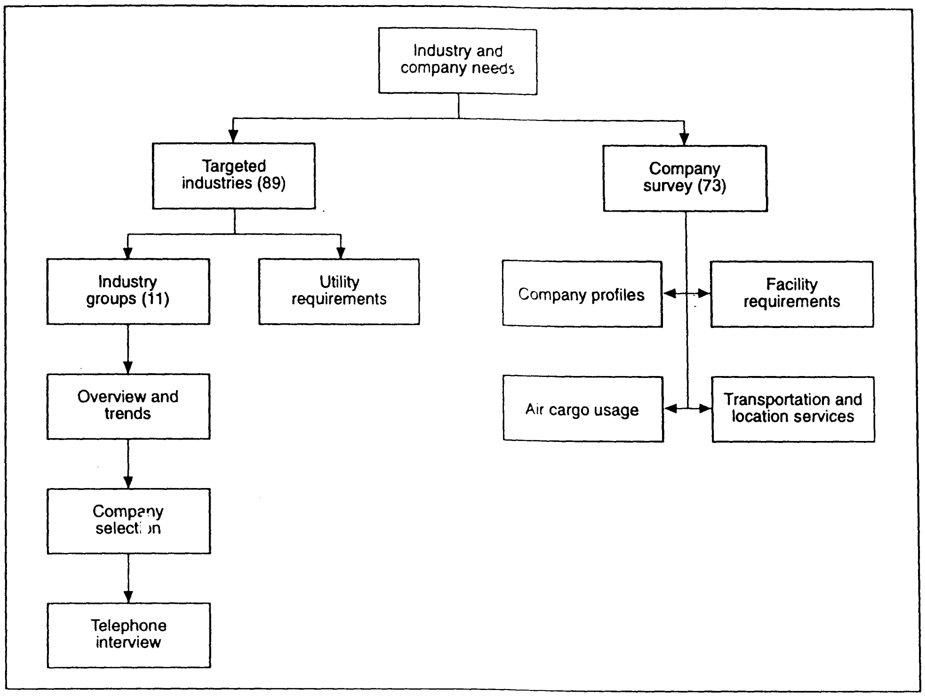

Figure 2.
Process of Determining Industry and Company Needs

The research attempted to uncover such trends as use of Just-in-Time (JIT) processes, networks and relationships with suppliers and customers, reliance on international and domestic markets, degree of technological change, level of automation, role of R&D, points of competition within the industry, and future growth prospects.

Within each group one or two representative companies were selected and interviewed over the phone to gain a general understanding of the groups characteristics. The goal of the telephone survey was to identify the manufacturing requirements and logistical needs of a firm as it plans for the future. The interviews with 15 companies identified some key logistical questions including the location of suppliers and customers, the use of JIT processes, and Electronic Data Interchange systems. The special requirements of manufacturing in this group and the factors and features required in a new facility were also discussed.

One of the main conclusions from the telephone surveys was that as the world of manufacturing is evolving slowly towards JIT-based systems, many companies use JIT with some but not all suppliers and few use JIT with customers. In addition, manufacturers of seasonal products have difficulty implementing JIT, with either suppliers or customers. Companies are realigning their distribution networks to accommodate shorter delivery times. Some are relying less on regional distribution centres and concentrating on direct links to end-users. In effect, the manufacturer becomes the distribution hub – the product goes from the

Name (number of four digit SIC industries)	Characteristic products
1. Electronic components (9)	Electron tubes, electronic capacitors, connectors, resistors, etc.
2. Machinery and metal parts (15)	Valves, pipe fittings, fabricated metal products textile machinery, ball and roller bearings, etc.
3. Pharmaceuticals and cosmetics (5)	Medicinals and bontanicals, pharmaceutical preparations, diagnostic substances, etc.
4. Wood products (3)	Furniture and fixtures, converted paper products, etc.
5. Raw materials (9)	Industrial inorganic chemicals, synthetic rubber, primary nonferrous metals, etc.
6. Textiles (4)	Weft knit fabric, apparel and accessories, dolls and stuffed toys, etc.
7. Food products (4)	Poultry slaughtering and processing, prepared feeds, etc.
8. Computers (4)	Electronic computers, storage devices, peripheral equipment, etc.
9. Electronic and electrical equipment (13)	Switchgear, household appliances, audio and video equipment, photographic equipment, etc.
10. Generating, vehicle, aircraft and space equipment (7)	Motors, generators, motor vehicle parts and accessories, search and navigation equipment, etc.
11. Instruments and technical tools (16)	Laboratory apparatus, process control instruments, optical instruments and lenses, measuring and controlling devices, etc.

Table II. Description of Industry Groups

factory's back door directly to the customer. At the same time, as noted in the company interviews, some distributors have become final assemblers for their manufacturing customers. This enables manufacturers to reduce inventories and respond quickly to customer orders. Ideally, the integration of suppliers, manufacturers, and customers would be facilitated by using Electronic Data Interchange (EDI). In reality, the use of EDI is sporadic. The level of service provided to customers has become an overwhelming concern. Many see logistics management as a key in supporting their interface with customers.

When asked about the required characteristics of a new facility in addition to the factors listed above, some companies emphasized that a *new facility is not only for expansion purposes.* It should serve as a means for changing current manufacturing practices. A new facility should be able to grow modularly; to provide access to new technologies and technical or engineering expertise; to be located in an aesthetically pleasing environment; and to provide multimodal transportation networks.

The second area of emphasis was the company analysis based on a questionnaire survey administered by North Carolina State University (NCSU). The questionnaire focused on four primary topics: company profiles, facility requirements, air cargo usage, and transportation and location services. The survey lists specific facility requirements such as water usage, waste output and storage requirements. Air cargo information is assembled based on five characteristics:

(1) time sensitivity;
(2) delivery speed;
(3) damage suspectibility;
(4) air cargo use; and
(5) air cargo raw materials.

The transportation and location services section sought to uncover the opinions of company managers who are involved in important logistical decisions affecting the firm and its position in the marketplace.

Company Survey

This survey, focusing on plant level information, was carried out in the first half of 1993. Approximately 200 survey forms were mailed to companies in 30 industries. While the companies within the targeted industries were selected at random, the contact person at each company was not. The selection was based on the NCSU alumni database in order to get a better response rate with these individuals and to make the "perception" type questions more comparable. Seventy-three questionnaires from 26 industries were sent back. The analysis focused on the survey respondents as a whole and did not try to analyse differences between the industries. Forty-two per cent of the respondents were middle managers; 19 per cent of them had a title of vice president or president. The average annual sales in the sample was $133.6 million and the average number of employees was 256.

The respondents were asked to provide some information about their major product line concerning the delivery speed of inputs and outputs. On average it takes about 39 days to order and receive raw materials (inputs). The listed values ranged from 14 to 84 days. On the output side, it takes about 22 days on average between receiving an order and delivering it. The extremes on the output side were nine and 67 days. The respondents were also asked to indicate how important delivery speed of inputs and outputs will be in the future. The inputs had a 3.9 average, and the outputs a 4.0 average on a five-point scale where 5 indicated that it will be much more important than it is today and 1 indicated that it will be much less important.

The respondents were also asked about the time sensitivity of their products. Of the 28 respondents whose products were time sensitive, 12 (42.9 per cent) of them said they were time sensitive because of changes in consumer tastes and fashion.

The questionnaire listed 24 transportation and location services and asked the respondents to indicate the importance of them on a five-point Likert scale. The scale ranged from 1 (does not matter) to 5 (very desirable). Principal components analysis was carried out to group the 24 listed services into 7 broader categories. The purpose of the principal components analysis was to explain as much of the total variation in the data as possible with as few factors as possible. The total number of services was reduced from 24 to seven broader factors explaining 71.58 per cent of the total variation (see Table III).

The factor loadings (the numbers in parenthesis after the service names) show the correlation between the service and the factor (principal component). A factor should be named after the dominant services listed in the factor. The first factor,

Factor (per cent of variation explained)	Services in the factor (factor loadings)	Proposed factor name
1 (30.40)	Location in a fully integrated multimodal site (0.770), Proximity to partnerships/alliances for resources sharing and gap filling (0.718) Co-generation power (0.702) Fully integrated to onsite suppliers/customers (0.677) Proximity to available raw materials and resources (0.610) Globally networked to knowledge and information centres (0.561) Proximity to a specific market (0.553) Local working training facilities shared with other companies (0.539) Direct airfield access (0.532)	Global Transpark: a twenty-first century infrastructure
2 (11.08)	Location with a low operation cost (0.881) Location with a low cost of living (0.840) Tax incentives (0.811)	Operation cost
3 (8.54)	Proximity to major highways (0.828) Proximity to rail (0.703) Proximity to low-skilled low-cost labour (0.589)	Transportation cost
4 (6.37)	Proximity to airports (0.785) Federal inspection facilities (USDA, FDA, Customs, etc.) (0.707) Foreign trade zone (0.585) Proximity to education and research centres (0.532)	External relations
5 (5.61)	Fully integrated to an on-site storage facility service (0.884) Fully integrated to a cargo handling and sorting onsite service (0.858)	Central cargo facility
6 (5.16)	Proximity to seaports (–0.706)	Seaports
7 (4.42)	Proximity to major metropolitan area (0.780)	Metropolitan area

Table III. Desirable Transportation and Location Services explaining almost one-third of the total variation, is highly correlated with services that are integral elements of the Global TransPark concept and can be labelled as twenty-first century infrastructure. The second factor shows the operation cost element of the traditional location decisions. The third factor combines the transportation-cost related elements of location decision. The external relations factor groups those services that are of vital importance in a global world. The fifth factor is closely related to the functions of the Central Cargo Facility in the Global TransPark. The last two factors consist of one variable each where the interpretation is straightforward.

The main message from this survey is that a new facility should provide what the potential customers are interested in, and they are mostly interested in infrastructure support, which is the primary objective of the Global TransPark.

Concluding Remarks

The Global TransPark concept and project, as described in this article, addresses major issues raised by previous theoretical and empirical studies in logistics. Moreover, the GTP is no longer a conceptual construct but a real laboratory that will provide many opportunities for researchers and practitioners to test models and actively influence the future of American manufacturing.

Many companies are struggling with the logistical realities of time-based competition which requires establishing JIT relationships with suppliers and customers, reducing manufacturing lead times, increasing customer service, reducing costs, and streamlining internal processes. In large part, their efforts are disjointed and disconnected. Companies are looking to logisticial functions to support the internal and external linkages that will help them improve productivity, reduce costs, and improve internal integration.

Logistical services that will be required to support the transition to agile manufacturing are centered on the links within the entire organizational network. These include provisional links to multiple modes of transportation, streamlined implementation of EDI, smooth interfaces for JIT relationships with customers and suppliers from all over the world, and the technology to connect manufacturing with sales, distribution, product design, and purchasing.

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