

31

# Implications for Transportation Planning of Changing Production and Distribution Processes

by

Alvaro E. Pereira

B.B.A. Finance

B.A. Economics

University of Massachusetts at Amherst, 1989

M.S. Transportation

Massachusetts Institute of Technology, 1991

Submitted to the Department of Urban Studies and Planning  
in Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy in Urban and Regional Economics and Studies  
at the  
Massachusetts Institute of Technology

September 1997

© 1997 Massachusetts Institute of Technology  
All rights reserved.

Signature of Author: \_\_\_\_\_

\_\_\_\_\_  
J Department of Urban Studies and Planning  
August 8, 1997

Certified by: \_\_\_\_\_

\_\_\_\_\_  
Karen R. Polenske  
Professor of Regional Political Economy and Planning  
Dissertation Supervisor

Accepted by: \_\_\_\_\_

\_\_\_\_\_  
Frank Levy  
Daniel Rose Professor of Urban Economics  
Chairman, Ph.D. Committee

NOV 26 1997

LIBRARIES



# Implications for Transportation Planning of Changing Production and Distribution Processes

by

Alvaro E. Pereira

Submitted to the Department of Urban Studies and Planning  
on August 8, 1997 in Partial Fulfillment of the  
Requirements for the Degree of Philosophy in  
Urban and Regional Economics and Studies

## ABSTRACT

Production and distribution processes of firms are changing. Whether this change or potential for change is comprehensive or merely selective is open to debate. Nevertheless, this change is significant enough that a general belief in a “restructuring” of production and distribution processes is found in a variety of forms throughout an increasingly voluminous literature. Clearly, firms are proceeding with such efforts in order to improve their own competitiveness in the marketplace. Increased efficiencies made possible by this focus will be achievable, however, only if existing or new institutions and organizations, both public- and private-sector, can accommodate these changes. Questions about the changing roles of labor and middle management are popular examples. The same applies to transportation and, more specifically, the functions of government in transportation, which is the focus of this study.

In this study, I establish a viable theoretical framework to examine the implications of restructuring on public policies and investments towards transportation. I focus on structuring an analytical framework that incorporates the changes, in both technology and organization, occurring in production and distribution processes in the planning and evaluation of transportation investments and policies. I then utilize this framework to revise the methods and models used to support planning decisions so that they account for these changes. In the end, my framework permits a detailed description of how firms operate their logistics systems and where (in terms of logistics decision areas), which (in terms of transport characteristics), and in what capacity (transformation, transaction, and innovation) transportation is used and, consequently, needs to be considered by policymakers. Such a description results in sound policy formulation and evaluation. In way of application, I use the framework to examine the role transportation plays in the metalworking sector in Chicago and how policymakers can assist firms in increasing their competitiveness.

Dissertation Supervisor: Karen R. Polenske  
Title: Professor of Regional Political Economy and Planning

Dissertation Readers: Professor Ralph A. Gakenheimer, Dr. Jonathan L.S. Byrnes



## ACKNOWLEDGMENTS

I want to first acknowledge that this is not a traditional acknowledgments section, which usually consists of emotional and profuse statements thanking a number of people, places, and things. It is not that I am not grateful for the assistance (in many forms) that I have received. Rather, I prefer to make (and have made) those acknowledgments in a more personal, face-to-face setting. Placing words on a piece of paper as part of a document that (hopefully) many people, most of whom would not be able to relate to my personal acknowledgments anyway, will want to read is somewhat tepid.

Well then, why have an acknowledgments page? There are two reasons: (1) I wish to acknowledge, in an official capacity, that this dissertation was partially funded by the Joyce Foundation, Chicago Manufacturing Center, and the National Institute of Science and Technology, as part of a larger study on the “Industrial Restructuring, Infrastructure Investment, and Transportation in the Midwest.”; and, more importantly, (2) I wish to acknowledge, also in an official capacity, but with a personal tinge, the contributions of my dissertation committee, Ralph A. Gakenheimer, Jonathan L.S. Byrnes, and, especially, Karen R. Polenske. Needless to say, without them there would be no dissertation. Each contributed important unique insights for which I will be grateful for a long time to come.

Now, please turn the page to continue...



# Implications for Transportation Planning of Changing Production and Distribution Processes

## CONTENTS

Chapter		Page
1	INTRODUCTION.....	13
	The Research Problem and Contributions .....	14
	The Research Hypotheses .....	15
	An Overview .....	20
2	PLANNING MARKETS AND EFFICIENCY OBJECTIVES.....	27
	Changing Production and Distribution Processes.....	27
	Markets and Objectives of Planning Efforts.....	29
	Serving Competitive Efficiency.....	31
	Evaluation of Policy Alternatives and the Use of Models.....	33
	Concerns Other Than Efficiency.....	35
3	RELATED ANTECEDENTS.....	38
	Transportation Use and the Economy.....	39
	Transportation Use and Industry .....	46
	Current Perspectives and Models in Transportation Planning .....	50
	Transportation Planning for the Future .....	57
	Evaluating the Literature .....	66
4	ADJUSTMENTS WITHIN A PARADIGM.....	73
	Defining the Firm and Its Place in the Supply Chain .....	74
	Logistics Decisions and Performance Measures in The Supply Chain.....	79
	Logistics Decisions and Performance Measures Under Two Paradigms .....	87
	Logistics Decisions and Performance Measures Under a Changed Paradigm... ..	94
	An Illustration of Supply Chains: The Case of Chicago's Metalworking Sector .....	104
	Production Tier .....	105
	Supplier Tier .....	109
	Customer Tier .....	111
	Transport Among the Tiers.....	113
	Logistics Decisions Within Different Supply Chains: The Case of Chicago's Metalworking Sector .....	116
	An Enabling Framework .....	122

5	THEORETICAL BASIS FOR USE OF TRANSPORTATION BY FIRMS.....	124
	Transportation as a Transformation Input.....	124
	Transportation as a Transaction Input.....	130
	Transportation as an Innovation Input .....	136
	Thinking of Transportation in Terms of Characteristics, Not Modes .....	139
	Characteristics Preferences in Chicago’s Metalworking Sector .....	143
	Demand and Supply and the Relevance of Certain Characteristics.....	147
	Concluding Remarks .....	149
6	AN EXPLORATION OF TRANSPORTATION USE IN A COORDINATED-SUPPLY-CHAIN ENVIRONMENT .....	150
	Analyzing Transformation, Innovation, and Transaction Inputs in Terms of Characteristics.....	151
	The Role of Transportation Use in Firm Decisions in a Coordinated-Supply-Chain Environment .....	154
	Firm-Supplier .....	155
	Firm-Labor .....	158
	Firm-Customer .....	160
	Firm-Consumer .....	162
	The Role of Transportation Use in Chicago’s Metalworking Sector.....	170
	Firm-Supplier .....	170
	Firm-Labor .....	172
	Firm-Customer/Firm-Consumer.....	173
	Accounting for Changes in Production and Distribution Processes .....	176
7	SUPPLYING DEMAND .....	178
	Investment as a Major Government Function.....	179
	Modeling and Evaluating Public-Investment Decisions .....	182
	Cost-Benefit Analysis .....	185
	Economic Efficiency.....	186
	Cost-Effectiveness .....	186
	Economic Growth and Impact.....	187
	Non-Economic Based .....	188
	Remodeling and Re-evaluating Public-Investment Decisions .....	190
8	REGULATING SUPPLY .....	199
	Regulation, Deregulation, and Re-regulation as Major Government Functions.....	199
	Modeling and Evaluating Regulation Decisions .....	201
	Economic Surplus .....	202
	Industry Structure.....	204
	Costs and Service.....	206
	Non-Economic Based .....	207



	Remodeling and Re-evaluating Regulatory Decisions .....	208
9	CONCLUSIONS .....	213
	A Summary .....	214
	General Policy Suggestions.....	218
	Do Industry Needs Matter? .....	225
	Benefits and Costs of Readjusting Planning Models.....	227
	Future Research Directions .....	229
	REFERENCES .....	232

## FIGURES

No.		Page
4.1	A Simplified Example of the Supply Chain .....	76
4.2	Paradigm Classification Scheme.....	90
5.1a	Inbound Characteristics—Weighted Score.....	145
5.1b	Outbound Characteristics—Weighted Score.....	145
5.1c	Passenger Characteristics—Weighted Score .....	145

## TABLES

No.		Page
3.1	Economic and Spatial Development Contributions to Transportation’s Function in Competitive Efficiency .....	45
3.2	Industry-Related Contributions of Transportation to Competitive Efficiency.....	51
3.3a	Transportation-Planning Evaluation Measures (Investment).....	58
3.3b	Transportation-Planning Evaluation Measures (Regulation).....	58
3.4	Forward-Looking Contribution to Transportation’s Function in Competitive Efficiency.....	67
4.1	Relevant Decision Areas for Process Analysis.....	82
4.2	Performance Measures for Logistics-Decision Areas .....	88
4.3	Supply-Chain Paradigms.....	102
4.4	SIC-Code Definition for the Metalworking Sector .....	106
4.5	Distribution of Survey Respondents By Standard Industrial Classification (SIC) Codes .....	107
4.6	Inventory Location, 1994 .....	108
4.7	Metalworking Supplies, 1994 .....	110
4.8	Origin of Supplies, 1994 .....	111
4.9	Destination of Products, 1994.....	112
4.10	Number of Customers, 1994 .....	113
4.11	Transportation Use By Metalworking Firms .....	115
4.12	Two Representative Supply Chains in Chicago’s Metalworking Sector .....	121
5.1	Transportation as a Transformation Input.....	126
5.2	Transportation as an Transaction Input.....	135

5.3	Transportation as an Innovation Input .....	139
5.4	Abstract-Mode Characteristics and Measures .....	143
6.1	Characteristics Analysis of Transportation Use—Prototype Table.....	152
6.2	Characteristics and Use Analysis—Supply Chain Management.....	164
6.3	Use and Characteristics Analysis--Chicago Metalworking Sector .....	175
7.1	Transportation-Investment-Planning Dimensions .....	182
7.2	Supply-Chain-Management Adjustments to Investment-Planning Models and Methods .....	195
8.1	Transportation-Regulation-Planning Dimensions .....	201
8.2	Supply-Chain-Management Adjustments to Regulatory-Planning Models and Methods .....	211
9.1	Transport-Policy Implications of Changing Production and Distribution Processes.....	223

## CHAPTER 1

### INTRODUCTION

Transportation is essential to the functioning of an economy. People and firms use transportation in the buying and selling of inputs and outputs. For example, firms utilize transportation when procuring raw materials, when shipping or receiving semi-finished goods for further production, or when distributing finished goods to customers; people use transportation in directly providing labor services or by making their labor services more accessible by traveling to work and, in analogous fashion, in consumption activities. In short, transportation has numerous important economic uses. Although such a proposition is obvious to analyze, what is of interest, especially from a public-policy perspective, is how transportation is used and how this use can be aided to advance economic goals. In this study, I investigate both of these issues by focusing on transportation use by firms in their production and distribution processes.

This focus is taken for two reasons. First, firms are the major players in a capitalist economy. It is not the macroeconomy or government that uses or demands transportation. Rather, transportation use in production and distribution activities is a demand derived from decisions made by firms (and individuals within or on the behalf of firms). Although many researchers have investigated trends in individual-passenger behavior and characteristics, such as demographics and socioeconomic trends (but not trends in consumption and employment characteristics), and how passenger-transportation services can be tailored to serve or even anticipate these trends, examination of derived demand for transportation services (both passenger and freight) from the perspective of incorporating (and thus serving) trends in firms' behavior is scarce.

This scarcity occurs despite the fact that production and distribution processes of firms and industries are changing greatly, which may significantly alter transportation requirements. This

change (or potential for change) is the second reason for the firm-level focus in this study and is significant enough that many analysts argue for a "restructuring" of production and distribution processes. Clearly, firms are proceeding with such efforts in order to improve their own competitiveness in the marketplace. Increased efficiencies made possible by this focus will be achievable, however, only if existing or new institutions and organizations, both public- and private-sector, can accommodate these changes. Questions about the changing roles of labor and middle management are popular examples. The same applies to transportation and, more specifically, the functions of government in transportation, which is the focus of this study.

In this study, I establish a viable theoretical framework to examine the transportation implications of restructuring. I develop an analytical framework that incorporates the changes, in both technology and organization, occurring in production and distribution processes in the planning and evaluation of transportation investments and policies.

### **THE RESEARCH PROBLEM AND CONTRIBUTIONS**

In sum, the underlying and primary proposition of this study is that the competitive efficiency, which is discussed in detail in the next chapter, of firms and industries can be improved through appropriate transportation policies and investments. Consequently, I seek to answer the following research question: how can firm- and industry-level supply-chain-management efforts (and their subsequent transportation requirements) be considered and modeled when evaluating transportation policy decisions? The research problem, of course, is to determine appropriate guidelines, measures, and models that capture the relationship between efficiency performance at the firm and industry levels and government investment and regulatory efforts.

Though my general contribution will be to introduce a better understanding of industry needs to government decision-making models and tools, my research also provides a more specific

contribution in four areas: (1) how firms and industry use and are affected by the particular transportation strategy they select; I anticipate that the micro-level focus of this study will contribute to a better understanding than previously of firms' objectives when making decisions about transportation; (2) how changes in production and distribution are affecting transportation requirements; (3) how both possible incremental and nonincremental technological changes, and institutional changes, such as access provisions and weight/length limits for trucks, may influence changes in production and distribution; and (4) how the government can be effectively involved in providing or (de)regulating transportation to complement the changes occurring in firms' production and distribution decisions.

In this study, I seek to document and organize in an analytical framework the transportation impacts of changing production and distribution processes in order to investigate appropriate reactions by government. A prerequisite to this end, however, is the reformulation and development of government decision-making tools that consider the relationship between production and distribution efforts by firms and transportation. This reformulation and development of evaluation models or tools comprises the aim of the study. As I discuss below, I will analyze changes in production and distribution in terms of supply-chain (or logistics-chain) management efforts in firms and industries, which seek to exert greater control and integration of the flow of goods and information from raw-material procurement to physical distribution of outputs to customers.

### **THE RESEARCH HYPOTHESES**

I will test, in a general form, four hypotheses derived from the research-problem statement.

(1) *Transportation has played and is playing an important part in the changes occurring in distribution and production processes.* This postulate runs counter to the notion that transport is a

ubiquitous input and thus has little, if any, impact on a firm's efficiency and competitiveness. In this study, I argue that this notion is false due to an incomplete understanding of the role of transportation in firms and the increasing emphasis on logistics as a competitively important function.

In its most obvious form, transportation use by firms can serve as a pure production facilitator by altering the location of production and thus overcoming spatial separation between connected production and distribution activities through a simple movement of inputs and outputs; minimization of mode cost could be the decision here. In addition, and increasingly more important in achieving control over a firm's product flow, is transportation's function as a transactional facilitator, by altering the efficiency of transactions and thus lowering the costs, occasioned by spatial separation of parties. These costs, which consist of expenditures and investments required by relationships among firms and costs of system failure, such as lost sales or higher replacement costs due to stockout conditions and lost customers, are greater under a logistics-focused environment where relationships among firms are stronger and closer than under a traditional, uncoordinated-supply-chain environment, such as mass production. This latter effect is more indirect and is related to the flexibility and reliability of transport services, the latter of which encompasses other considerations, such as safety of shipment. In essence, the cost/quality dichotomy in transportation services are related to these two (production- and transaction-) facilitating functions in the sense that higher-quality transportation modes will be preferred over lower-cost modes because of their ability to ensure successful transactions.

Transaction-cost scholars have acknowledged that transportation may have some impact on transactions, but have not explored the matter in detail probably for fear of expanding the definition of transaction costs too far (Wallis and North, 1986). They have instead focused on other matters,



such as opportunism, enforcement of agreements, and imperfect contracting, which are discussed in Chapter 5. These and other considerations involved in transaction efficiency, which are significant to increased intercompany operating ties and other restructuring changes, however, are affected by logistics and transportation decisions. As mentioned above, transportation planners do not include transaction efficiency as a measure of system performance, but reliability and flexibility of shipments (both passenger and goods) do affect the success of transactions. As will be seen later on in this study, reliability and flexibility of transportation services are routinely ignored in the evaluation of transportation policies. Finally, I consider transportation's role in innovation generation, which will alter the transformation and transaction functions within and across firms.

An important issue that I will explore and develop is the classification of industry types according to transportation requirements and thus, planning efforts. In particular, I will examine transportation planning under an uncoordinated-supply-chain, such as traditional mass-production, and a logistics-focused, coordinated-supply-chain environment. In mass production, there was an integration and strong degree of control of purchasing and distribution functions (Chandler, 1977). There is still this integration, but now the focus is on an even tighter coordination of flows. In addition, adjustments to mass production feature a spin-off of functions that were originally internalized. For example, flexible manufacturing and just-in-time (JIT) strategies attempt to minimize the time and amount of product in channel, which usually involves a great deal of close interaction among several firms. I contend that transportation plays an important role in the success or failure of such strategies.

*(2) Lack of public-sector action to assist these changes inhibits the ability of private-sector firms, including transport providers, to maximize the benefits derived from changed strategies.*

This hypothesis is contrary to the belief that public-sector actions in the transport sector have little eventual impact on firm performance and strategy.

A necessary condition in evaluating transportation planning efforts is the determination of the public or government planning role(s) relative to that of the private sector. In addition to past and current government involvement in transport investment, the private sector (both transport- and non-transport-service firms) is also involved in supplying demands. With much of the basic, public infrastructure, such as the interstate highway system, completed in the United States, the private sector's relative involvement in providing required supplies may be increasing. Efforts at privatization of transportation operations will also increase the involvement by the private sector.

Any required changes in transportation use or strategies (for different distribution and production processes) may be internalized to firm-level functions, such as altering production-cycle times, through improved logistics systems using in-house personnel, such as private trucking fleets; changes may also be internalized at the industrial-complex or supply-chain level where infrastructure may be coordinated and provided jointly by firms within the complex or across the supply chain. Government needs to determine where it will play a contributing role in these and other possible scenarios.

*(3) Current transportation-planning methods used in practice are inadequate when judged from the perspective of proposing and evaluating policies that support production and distribution processes in firms.* Instead of assuming that current policy-evaluation techniques indirectly solve logistics-related concerns, I argue that although this assumption may have been adequate under a more traditional competitive environment, this is not the case under a logistics-focused environment.

Transportation planners regularly do not use evaluation methods that encompass issues of production and distribution. One reason for this is that policy-makers may perceive that the role of transportation in production and distribution is unimportant or is an irrelevant market (in terms of serving important or influential constituencies) for planning efforts. In many instances, their efforts at planning for industry needs may be overridden by other concerns, such as political concerns or the practical utilization of simple planning methods. In addition, there is a general lack of knowledge about the impact of transportation-policy decisions on production and distribution at the firm or industry level.

As an example, much of transportation planning is directed, in one way or another, at reducing congested-network conditions. Currently, options to solve traffic congestion are evaluated primarily on the grounds of travel-time savings or costs, which are calculated by multiplying time impacts by some value-of-time constant. Though this method is analytically straightforward, it has minor correlation with capturing actual impacts on firms or industries. In particular, predictability of travel times appears more important, especially under changing production and distribution processes. I will develop a framework for evaluating the extent to which factors such as congestion are hurting productivity and freight/passenger movement by considering firm/industry-level factors, such as production cost and transaction efficiency, thereby linking transportation planning to broad economic goals, one of which is serving the demands of industry and the economy.

*(4) The number and influence of options relevant to accommodating logistics-related changes and available to policy makers is greater than conventionally thought.* For example, intermodal strategies and increased public-private partnerships in a variety of forms, such as for financing intermodal facilities and promotion (or regulation) of cooperation among modes, appear increasingly viable.

Important questions concerning how government should proceed in efforts to serve industry needs remain unanswered. For example, questions abound regarding the role of government investment in transportation under conditions of restructuring: will it remain as the provider of basic infrastructure, such as a highway network, port facilities, and airports, or will it provide more advanced infrastructure, such as regional intermodal facilities or clearinghouses, where existing rail and truck networks can be linked and freight exchanged? More generally, how does transport investment influence private-sector performance? As with investment, important questions arise about the government's regulatory role: will a governmental return to a more, albeit different, regulatory function in the transportation industry, as was the case before 1980, hamper adjustments in logistics systems? Could the deregulation of the transport sector in the early 1980s have pushed or permitted the changes in production and distribution that occurred later on in the decade? Although it will not be possible to provide complete answers to these and other questions, I will develop a framework to provide at least a starting point for inquiry.

### **AN OVERVIEW**

In order to resolve the research issues I have developed above, I begin with the most general issues and increasingly hone them to more precise concerns. Thus, in the next chapter, I begin with a discussion and definition of the markets for and the objectives behind transportation planning efforts. The selection of markets and objectives directly influences the particular evaluation criteria and procedures to be used.

Following, in Chapter 3 I review past relevant studies that discuss the contributions of transportation to economic performance at all levels of analysis. My purpose in this chapter is not, however, to review all the relevant literature. Rather, I seek to extract the contributions of transportation to economic performance from representative studies of each literature subfield. I

organize and clarify relevant, but differently focused, literature from four areas: (1) Because some analysts have examined the role of transportation in production and distribution at the economy-wide level (be it at the national or regional level), I extract the functions of transportation in the economy, as described by them. I examine studies concerning theories of economic development, location and trade theories, transportation-land-use theories, and long-wave innovation theories. Much of this work emphasizes the importance of reductions in transportation costs, which is a production-cost-reducing function of transportation; (2) I examine analysts who have documented or hypothesized about the spatial behavior of production and distribution processes at the more micro level of an industry or firm, and the role of transportation in this behavior. I draw upon both spatial and aspatial discussions of production, such as Piore and Sabel's (1984) concept of flexible specialization, which somewhat surprisingly makes no mention of transportation's function, as well as the business-case material on logistics changes in firms, which have, in turn, generated analyses of spatial, and thus transportation, impacts; (3) I review transport-policy evaluation methods and transport-planning studies that have considered (or have the potential to consider) relationships between industry and transportation and that document and analyze (or have the potential to document and analyze) the impacts of changing transportation supply on firm behavior, or its converse; and (4) I discuss forward-looking studies that discuss the transportation ramifications of changing production and distribution processes and that call for changes in planning attitudes and efforts.

In Chapter 4, after defining what I mean by the firm and its place in the logistics channel, I introduce and define changing production and distribution processes by organizing the various observations of these changes around the unifying theme of greater control or management of the product channel through supply-chain management. I describe and contrast a supply-chain-

management focus with other ways of organizing production and distribution processes through a discussion of various firm- or industry-level decisions. Much of the restructuring literature is structured in this bimodal style.

I examine the total product channel, which describes the flow of goods from raw-material stage to use by final customer, in as much detail as possible in order to generate a description of relevant firm-level or industry-level decisions under a supply-chain management focus, which I then contrast with the decisions under a traditional focus, such as mass production. Examples of such decisions consist of site selection, production methods and operations (material-resources planning, production schedules or cycles, run-size), distribution-channel selection including logistics considerations (order-size, inventory, and warehousing), and marketing or sales strategies. In this chapter, I utilize some of the sources mentioned above and peruse the business case-study and management literature and existing case studies in order to describe mass-production and restructuring efforts at the industry and firm levels. In way of application of the framework, I include, as an industry example, a discussion of such efforts (or the potential for them) among metalworking firms in Chicago.

In Chapter 5, I examine the role of transportation use in firms, without mention of particular forms of production or distribution. Partly based upon the previous literature review, I provide a novel explanation of why and for what firms utilize the transportation input. I develop at an applied, theoretical (rather than empirical) level, three components of the contribution of transportation to the transformation of inputs to outputs by firms: a production facilitator by altering the location of spatially separated input sources and output markets, a transaction facilitator by ensuring the successful fulfillment of transactions between parties, such as between suppliers and

producers, and an innovation facilitator by improving the previous two functions and diffusing or developing technologies; these three components will be broken down and detailed further.

I then discuss the possibility of describing the transportation input by its attributes (see Quandt and Baumol (1966)) for the original conceptualization and application to planning for urban transport), such as, but not limited to, speed, reliability, flexibility, safety, and information (or tracing), and how different attributes can be matched to the three components of the transportation input. Thus, I establish a three-level (in its most general form) explanation for the use of these transportation characteristics by firms. In later chapters, I show that the contributions of transportation to the above three capacities are a key consideration that needs to be incorporated in transport-planning models and efforts. I access the works reviewed in the previous chapter for discussion of the transformation function and introduce transaction-cost studies and innovation-related studies that provide theoretical background in order to develop the role of transportation in facilitating transactions and innovations.

Chapter 6 features identification of the desired uses and characteristics of the transportation input that are appropriate for firms operating within a logistics-focused environment. In this chapter, I show how transportation is used in the various firm-level or industry-level decisions established in the previous chapter and highlight the changes required under a logistics-focused environment. I utilize the set of characteristics and use capacities from Chapter 5 and match them to the sets (supply-chain management and others) of decisions of Chapter 4. I expect sets to differ among paradigms, with the logistics-focused demands placing greater emphasis on the transaction-permitting aspect of transportation use. Though the work in Chapter 6 involves a blending of the work in the two previous chapters, I supplement the analytical work with an examination of the transportation requirements of mass-production and other industry configurations. As an industry

application of the framework, I also provide survey and interview data to uncover current logistics-related requirements and any potential adjustments (in terms of facility location, production runs, mode choice, shipment data, or any other relevant logistics statistics) due to implementation of supply-chain management (or other) efforts in the metalworking sector of Chicago. Partly based on this metalworking analysis, I provide initial discussion on how transport uses and characteristics may differ depending on the industries and supply chains of interest.

Beginning with this chapter and continuing with the next, I examine the planning implications of the demands specified above. In Chapter 7, I discuss where public-sector and private-sector parties are suited to provide the transportation uses or characteristics established in the previous task and, accordingly, how government must consider these uses and characteristics when deciding if and how to invest in transportation facilities. I discuss, in turn, the major government planning methods (in terms of their inputs, structure, and outputs), such as variants of cost-benefit analysis, involved in making decisions pertaining to supplying this demand. A determination of the public-sector-transport role in accommodating supply-chain management efforts first involves the matching of the transportation requirements (or demand) from the previous chapter, which will differ among industries, with aggregate measures of transportation-system performance or supply characteristics, such as flow, speed, and quality. These supply characteristics can then be cast in terms of general, nondivisible transport-supply options that approximate the demands of firms. For example, levels of reliability of freight shipments can be described in terms of existing transportation-system characteristics, such as speed and presence of congestive network conditions, and solved by different options including public investment in transport facilities or adjustment of shipment schedules by private firms. The remaining structure of this chapter involves a reformulation of existing planning methods and models used in



investment decisions (e.g., Button, 1982; Cohen, Stowers, and Petersilia, 1978) in order to incorporate uses and characteristics that are relevant to firms.

For Chapter 8, I utilize the same method from the previous step to examine government action in regulating any required supplies. As in the previous chapter, I develop a description of how the evaluation of regulatory options or policies should be consistent with the transportation requirements of a supply-chain management focus. I then analyze and reformulate the planning methods and models used in establishing different positions (e.g., Winston, et al., 1990; OECD, 1990; TRB, 1989, 1990a, 1990b). Though the work in Chapters 7 and 8 is entirely analytical, I necessarily access studies that have proposed use of specific models and instances of actual application of different models. I highlight the important separation between state-of-the-art and state-of-the-practice, but my objective in each step remains to find means to reformulate government decision-making tools used to assess regulatory options of both the economic and protective type to eventually enable better practice.

Finally, in Chapter 9, the concluding chapter, I discuss the application of the above framework to investment- and regulation-related planning decisions. I examine, in general, the appropriateness of typical transport options, both investment- and regulation-related, potentially being planned or implemented by policy-makers in terms of the reformulated methods from above, which include supply-chain management considerations. I specify these options under different governance and spatial levels (local, state, and regional/national) to show how planning implications will differ among these levels and demonstrate how the provision of various configurations (in terms of investment and regulation decisions) of the transportation system influences or is an input to production and distribution processes at some firm(s) and industry(ies).

That is, a reconfiguration of the regional transportation system would be translated into industrial-performance impacts, such as reduced transport and inventory costs, increased production-line productivity, and improved employee access. (Note that simple determination of such impacts could prove useful in cost-benefit analyses of infrastructure improvements). These impacts, in turn, could be aggregated into single measures of industrial performance, such as reduced production and transaction costs and increased potential market area. A further step, which I will leave for future research, but will discuss in the concluding chapter, might be to link these single measures into general well-being indicators, such as increases in regional value-added.

Also in the concluding chapter, I provide a summary of the study and its contributions and insights into the hypotheses mentioned earlier. Consequently, I examine the important issue of whether industry needs as regards transport matter enough to warrant strong attention from planners and conversely, whether public-sector action in terms of transport planning matter to industry? Finally, I discuss the benefits and costs of implementing or not implementing the changes recommend in this study and suggest directions for future research.

## **CHAPTER 2**

### **PLANNING MARKETS AND EFFICIENCY OBJECTIVES**

By dissecting the title of this study, one produces three components: (1) changing production and distribution processes (of firms), (2) transportation planning (by the public sector), and (3) implications (for the latter of the former). Leaving the analysis of implications for future chapters, I discuss the definition of the other two components. As will be seen, how one defines these two components influences the perspective and evaluation of transportation planning.

### **CHANGING PRODUCTION AND DISTRIBUTION PROCESSES**

What changes in production and distribution processes exactly mean is far from certain, because the topic is of far-reaching and profound importance to a diverse group of researchers. Although I necessarily develop a structured exposition of these changes later, I provide here a brief introduction. One method of organizing this research is to classify the descriptions of changes in production and distribution processes according to the unit of analysis. On a macroeconomic, top-down level of analysis, analysts have commented on a clear shift in the structure of the economy in much of the industrialized world from a heavy-industry/manufacturing base to a more service-dominated economy and have stressed the rising importance of high-technology and information flows as playing a key role in altering production processes in such a period of structural economic change (e.g., Castells, 1985). Correspondingly, there has been a large amount of research on documenting and exploring the spatial consequences of such changes in the sectoral composition of the economy (e.g., Schoenberger, 1990). I will not directly discuss these macro-level changes. Although important, they have either been studied elsewhere or can be suitably modeled using existing techniques, as will be seen later. Moreover, most of the conclusions of these analysts can be examined using the framework in this study.

On an industry level, individuals have considered changes in the technology of products, as shown by the shift in composition of outputs and inputs and, more importantly, shifts in institutional arrangements within and among industries. Some analysts have concluded that there has been a change in ways of organizing manufacturing activity from a mass-production focus to a different production method, which utilizes high-technology inputs and stresses flexibility in order to adapt to quickly changing market conditions and demands (Piore and Sabel, 1984). Others have stressed adjustments to, rather than a shift away from, mass-production techniques, such as is shown by adoption of lean production and just-in-time (JIT) supply-procurement techniques. Use of these techniques results in increased precision, speed, and flexibility in production of mass-market goods and lower defects and inventory levels (Womack and Roos, 1990). Studies of the spatial consequences or organization of changes in production are also common (e.g., Storper and Walker, 1989; Linge, 1991). Finally, researchers have attempted to develop theoretical frameworks for much of the empirical conclusions of both the aspatial (e.g., Best, 1990) and spatial (e.g., Scott, 1988) work mentioned above.

At the intrafirm level, analysts have concluded that time—in production, distribution, and innovation—is the next source of competitive advantage (Stalk, Jr., 1988). One method used to conserve on time (and the amount of product) in the channel from raw-material procurement to distribution to customers involves development of intercompany operating ties in order to enable more effective control and coordination of the entire product channel (Byrnes and Shapiro, 1991). Unlike much of the work mentioned above, which also shows that increased interaction among firms can help in minimizing “product-time” involved in transactions, this work examines the distribution of output to the customer in addition to production-related ties, such as those between manufacturers and their suppliers. Creation of such ties represents a fundamental internal change to

many companies and is thus related to the notion of re-engineering, which involves changing internal decision processes and functional areas.

### **MARKETS AND OBJECTIVES OF PLANNING EFFORTS**

To be sure, these general restructuring changes at the firm/industry level non-exhaustively described above—namely, greater flexibility in production, increased intercompany operating ties, and a focus on conserving time in the product channel—will have important consequences on, and will be influenced by, the provision and organization of the various inputs used in production, such as transportation. The consequences and relevant public-policy concerns for some inputs, especially those on labor and supplier behavior, have been examined extensively. However, this is not the case for all inputs. Those inputs related to transport, especially regarding government involvement in transport, have not been directly studied in a thorough manner. Thus, the question arises: how can the appropriateness of transportation policies and investments in serving these changes be determined?

Although such a question may provide an initial point for research and discussion, it begets further questions. Particularly, what, from a public-policy perspective, does “appropriate” mean? In answering this latter inquiry, the analyst must determine (1) what ends are to be achieved, (2) for whom these ends are to be achieved, (3) how to determine if these ends have been achieved, and (4) what, if any, negative consequences occur due to achievement of these ends. Leaving aside these two latter items for later discussion, I introduce the first two in this section.

An important starting point for formulating and evaluating policy prescriptions is a determination of the “planning markets” of interest. Although it may be more traditional to start with planning problems and objectives (Dickey, 1983), it is more useful to the objectives of this study to delineate first who or what are the customers of planning efforts in order to situate the

domain of problems, objectives, and even methods. For the current study, it is clear from the previous section and chapter that the planning market is firms and industries that demand transportation services. It is not the macroeconomy, but the interactions of firms within and among themselves. Also, it does not necessarily have a particular spatial context. Firms and industries may exhibit clear spatial relationships, and, as will be discussed later, do so, but, I do not define changing production and distribution processes along spatial lines. Finally, the planning market is not transport suppliers, which includes both carriers and individuals that provide transport services for their own use. Of course, these parties will be the focus of policies and in many cases will have interests that are compatible or identical with the firms and industries towards which their services are directed, but they are not the primary or direct market for the planning efforts described here.

By specifying the planning market in such a manner (with greater detail being better, as will be found in Chapters 4 and 5), determination of objectives becomes less ambiguous. For example, if the public as a whole were the planning market to be served, the planner would need to assure that a great variety of objectives, such as efficiency, equity, safety, and quality of the natural and physical environment, were considered, and because these objectives would conflict, they would also need to be weighted. For the current study, I make the tenable assumption that efficiency (of firms and industries) will be the broad policy objective. Of course, this general objective can be decomposed and analyzed in detail. I elaborate on this objective in the next section and in Chapter 5.

Clearly, the general issue of selecting transportation policies that promote efficiency or, more generally, economic growth is important and, as will be seen in the next chapter, has been the focus of many analysts for quite some time. More importantly, policymakers are becoming increasingly cognizant of the relationship. In the United States, the most recent (soon to be

superseded) major national transportation legislation, the Intermodal Surface Transportation Efficiency Act of 1992 (ISTEA) has the following statement of policy: "...to develop a National Intermodal Transportation System that is economically efficient, environmentally sound, provides the foundation for the Nation to compete in the global economy and will move people and goods in an energy efficient manner (U.S. DOT, 1992)." Although it may be easy to dismiss this type of policy statement as the usual legislative palaver, ISTEA contains the most explicit focus on efficiency of any national legislation to date—"efficiency" is even in the act's title. It will be interesting to assess how the next transportation appropriation legislation (due in 1997) considers efficiency, but a reversal or retreat of position is not expected.

Policymakers and researchers in other parts of the world are also cognizant of the changes facing firms and the need for planning methods to change with them. In an expansive document that gathered opinions from researchers and policymakers from 19 European countries (ESF, 1990), the primary research item from an economic context was the development of a modified theory of the firm under restructuring and a determination of its impacts on the transport sectors. From a Japanese perspective, Kobayashi (1993) recommends a flexible planning schema in order to accommodate increasingly intricate and changing transportation and communication needs. In short, the world economy is becoming increasingly complex, and planning methods must incorporate this complexity.

### **SERVING COMPETITIVE EFFICIENCY**

There are different and numerous ways to define efficiency. Although I discuss this topic in greater detail later, I explain here the definitions I will not use. First, I do not discuss efficiency from a scientific or engineering point of view. Rather, all the efficiency concepts I discuss have economic characteristics of price, cost, and contribution or benefit. Hence, I deal with economic

efficiency. Second, however, I do not use economic efficiency in the economic-science meaning of the term, which holds that situations are efficient when resources are allocated in such a way that no activity can be increased without decreasing some other activity (Nicholson, 1983). By extension, this general definition is then applied to a variety of situations, such as exchange, production, and allocation of resources among firms. For example, production plans (of firms) are efficient when there is no way to produce more output with the same set of inputs or to produce the same output with fewer inputs (Varian, 1984). The meaning is mathematically precise and conveys the important concept of marginality, but it is also abstract and difficult to observe and measure. More importantly, it implies (or necessitates) equilibrium conditions, which I assume (realistically) never hold under the competitive conditions I examine. Indeed, the work in this study seeks ways to establish competitive advantage, by improving customer service at lower costs vis-à-vis other firms, not equilibrium, wherein firms are equally competitive and successful in some form. Thus, although I will examine economic efficiency by including cost (and thus price) considerations, I seek to include competitive and firm-strategy issues in order to investigate, as labeled here, the objective of competitive efficiency.

Finally, it should be noted that I will not define efficiency in terms of policy selection and formation. As will be seen, efficient (in terms of adequate benefit-cost ratios) transportation policies do not always aid the competitive efficiency of firms and industries that use transportation services. I will also not discuss efficiency in policy formation, in the sense of creating and administering institutions. These are, of course, critical tasks, but they can be examined separately from the work in this study and are beyond its scope.



## **EVALUATION OF POLICY ALTERNATIVES AND THE USE OF MODELS**

Given efficiency-related objectives as goals and firms and industries that demand transportation services as the market for policies, the next step is to develop measures or models for use in evaluating how well policies serve the needs of firms. It is useful to consider the steps or components of the planning process as described by Alexander (1992): problem diagnosis, goal articulation, predication and projection, “design” of alternatives, plan testing, evaluation, and implementation. This exposition is, of course, not unique, but it is general enough to use as a frame for this discussion. Button (1982) develops a similar exposition to the urban transport planning process.

The first step, problem diagnosis, has already been discussed above. I assume it to be lost efficiency of firms (and the competitive position of the communities or regions in which they reside) if the changes underlying firms production and distribution processes remain unaccounted-for in planning efforts. This is an assumption, since, depending on one’s perspectives, norms, and ideology, lost efficiency may be of minor concern relative to other problems, such as environmental quality. Furthermore, the objectives are economic-based rather than engineering-based, such as the straightforward objective of improving traffic flow. This is not to say that such objectives should be ruled out, but they, in themselves, will not drive policy considerations.

This assumption also shows my analytical perspective of a researcher interested in transportation and economic models. I assume that the solution to the planning problem lies in the correction or adjustment of models, such as the use of wrong evaluation criteria being used in the selection of policies. On the other hand, other individuals with different analytical perspectives may approach and solve the problem by, for example, examining political considerations and

processes or the performance and organization of planning institutions and suggesting changes in these processes and institutions.

Given the above general problem definition, it is obvious that I will deal with efficiency-related goals. Determination of goals (or objectives) in as much detail as possible is important, because they establish how to proceed in future steps of the planning process. This determination will be featured in Chapter 5 for firms in general and in Chapter 6 for firms undergoing restructuring.

Prediction and projection refers to determination of future states of the domain or environment where the research problem is relevant. Button (1982) describes this step as consisting of an inventory of the existing transport system by, for example, determining current travel patterns, and the simulation of the transport market through the use of mathematical models. This step is not operative for the research problem in this study, since I predict the future as firms undergoing changes in their production and distribution processes. The future is uncertain, of course, but using this as the anticipated future, which will be described in Chapters 4 and 6, aids in the upgrading of planning methods and models to account for demands by firms.

The next two steps, design of alternatives and plan testing, can be considered simultaneously, because plan testing simply refers to determining if the alternatives are feasible and if they are consistent with the objectives. Two groups of policy alternatives will be studied, investment and regulatory, which together define the efficiency-related functions of transportation planning.

Evaluation of alternatives is the next step, which normally involves some variant of cost-benefit analysis. Because I seek to determine how alternative policies can be evaluated in terms of serving firms' competitive efficiency, the real aim of the work in this study will be on the

evaluation step of the planning process and the development of measures that incorporate the relationships between transportation use by firms and industries and transportation policies by government. Finally, as was hinted at above, I will not discuss the implementation step.

### **CONCERNS OTHER THAN EFFICIENCY**

The above discussion has stressed the primary importance of helping the efficiency of restructuring firms. However, this view, is not universal. For example, Harrison (1994) is wary of these restructuring efforts. Although he acknowledges the formation of production networks as a successful strategy in promoting firm-level competitiveness, he is concerned about the negative consequences of this formation on equity, such as increasing inequality of wages among different classes of workers in the same region and among workers across different regions, and the decreasing security of employment. From a social perspective, Langdon (1994) examines the deconcentration or spreading out of residences and firms, which was made possible by specific transport policies, and its negative impacts on family formation, community building, and a sense of belonging. Though these impacts may be important from a comprehensive and long-term view of possible impacts of planning efforts, they are beyond the scope of this study. I mention them only for purposes of demonstrating the possible scope of evaluation considerations and will not consider them when discussing use of coordinated production networks as one of the changes in production and distribution.

Turning to more direct impacts of transportation policies, issues or needs other than efficiency of serviced firms are obviously involved with evaluating transportation-policy alternatives. Prominent examples of such needs (from a public-policy, rather than an individual-consumer, perspective), include equity, public safety, energy use, and environmental quality. In terms of equity, while it has been acknowledged that deregulation of the transportation industry has

had beneficial impacts on the logistics systems of firms (Larson, 1992), there have been concerns that deregulation has also hurt certain segments of the trucking industry, such as less-than-truckload (LTL) operations (Abruzzese, 1990). Moreover, modes with certain characteristics and abilities to serve more advanced transportation demands, such as highway and truck, may be preferred under the efficiency goals discussed above. This concern that highway (which includes auto as a passenger mode) and truck may have inherent advantages in serving future consumption and production demands has alarmed planners and analysts interested in safety, energy use, and environmental quality. The perceived safety problem of increased truck travel and the push to improving truck productivity by increasing the width and length of truck trailers has been the subject of numerous studies (TRB 1986, 1989, 1990a, 1990b). Although, unfortunately, no analyst has explicitly examined the effect of changes in production and distribution on truck safety (probably due to the lack of adequate truck-safety data), the assumed advantages of truck over other modes in serving these changes creates concern.

On the other hand, analysts have examined the effects of these changes on energy use and the quality of the natural environment (ter Brugge, 1991). Cooper (1991a) concludes that despite the commercial benefits of logistics innovations, such as the centralization of inventory and the adoption of just-in-time delivery, these innovations, because of the associated increases in truck travel, are more damaging to the natural environment than the production and distribution methods they have superseded. He also states that any major reduction in potential environmental damage would seem impossible without reversing these innovations. Indeed, the entire issue of considering the gamut of costs and benefits of transportation policies is important, and environmental costs may be an important component of such an analysis. However, analysts also need to be able to

determine the complete efficiency effects of restrictive transportation policies in order to judge the worthiness of these policies.

## CHAPTER 3

### RELATED ANTECEDENTS

As indicated by this chapter's title, the task here is to examine what has come before. The motivation behind this examination of antecedents to the present study is twofold—to demonstrate the context of the present study and to provide important background material for the following chapters. Given the nature of the research question developed in the first chapter, which is concerned with the general relationship between transportation planning (and facilities) and economic growth or development, the relevant literature is vast, but confused. I do not intend to review this massive literature exhaustively or in detail but do intend to organize this literature and extract from it the contributions or functions provided by transportation to firms and industries in relation to the promotion of (and planning for) competitive efficiency. Analysts who have examined the existence of these contributions but who make no behavioral conclusions or otherwise provide no implications for planning efforts are not covered in detail. For example, studies by analysts who use econometric techniques to test the hypothesis that public infrastructure provision, which includes transportation, is associated with economic growth are not very useful for guiding planning efforts except influencing a government's decision in a directional manner to spend more or less on infrastructure. At the same time, although very few analysts have examined the relationship between transportation planning and restructuring efforts of firms and industries, I will discuss them in greater detail because they are central to this study.

Thus, I first review analysts who have examined the relationship between transportation and firm and industry performance from an indirect, economy-wide perspective. Second, I discuss analysts who have examined this relationship more directly at the firm or industry level. The distinction between these two sets of analysts is not precise, because many of the first group

indirectly feature firm-level considerations, but is upheld due to the latter's more explicit focus on firm and industry behavior. Next, I introduce planning methods and models that incorporate some of the conclusions of these two sets of studies. Finally, I summarize the conclusions of analysts who have commented on the transportation requirements of restructuring firms and how to plan for them. Following each of these four sections is a table listing the contributions of transportation to firm efficiency and the measures to estimate this contribution, if any, by source. I conclude with comments concerning these tables.

### **TRANSPORTATION USE AND THE ECONOMY**

Because an investigation of the relationship between transportation and changes in production and distribution processes pertains to the more general issue of the function of transportation in the economy and in economic growth, the extensive literature on this latter topic provides important insights to the current research problem. A useful way to subdivide this literature is to consider the spatial perspective of studies. Therefore, I first discuss analysts who are focused on spatial issues and events (and are usually concerned with regional economic issues) and then discuss aspatially focused studies, which usually feature the nation or some other non-spatially defined area of analysis.

The earliest regional work probably comes from analysts interested in spatial change and location theory that focuses on proximity to production inputs and the importance of transport as a cost of production (Alonso, 1972). Transport costs are assumed (correctly if non-linearities are permitted) to vary with distance and weight, and, maintaining all other input costs and effects constant, these two variables solely determine the location of industry. Location is also affected by terminal costs, which are costs of loading or unloading for any number of reasons, such as change of mode or consolidation or breakup of shipments. Consequently, reductions in transport cost

permit and lead to concentration of activity and differentiation of inferior and superior raw material or market locations. North (1975) notes that improvements in transportation play a key role in regional development because of this enabling effect. More generally, spatial price theorists, who hold that prices will not be equal in equilibrium because of spatial differences, conclude that trade flows improve spatial allocation and that transport costs are a constraint on price equalization among regions (e.g., Richardson, 1979).

Such a constraint relates to issues of uncertainty in production and distribution. Webber (1972) argues that uncertainty affects the spatial distribution of economic activity, scale economies, and transport costs (to firms). In particular, uncertainty reduces plant size and leads to agglomeration in order to reduce risks and take account of external economies. Accordingly, uncertainty is increased with distance. As will be seen later, the ability of improved transportation services to reduce or even eliminate uncertainty and risk is an important input to restructuring firms.

In central place theory, transportation is one of the factors that determines the size of the market (e.g., Heilbrun, 1981). Using the case of an improvement in transport, two effects are noticed: an output effect, whereby market areas shrink because new firms are attracted to production due to extranormal profits, and a substitution effect, whereby market areas become larger, because industry substitutes transport for other inputs (Hoover, 1970). Although such reasoning leads to an ambiguous result, the introduction of production-cost differentials among firms (due to scale economies, for example), introduces additional production-cost competition given the greater number of potential competitors. More generally, a reduction in transport costs benefits low-(production)-cost and large-scale producers relative to high-cost and small-scale ones, and additional reductions imply an ever-increasing size of plant (and market area).



From central place theory, some work branched out and thus is related to growth pole theory (Richardson, 1976) and consequently to an inquiry into the capability of transportation to spread and diffuse the effects of industry. In this theory, the growth-pole process is initiated by the introduction of a innovation, which leads to creation of an activity-generating industry. The industry then disperses activity, thereby creating multiple growth centers to form an industrial complex and eventually spreading innovation to areas not integrated with these centers. As described by Amos, Jr. (1990), transportation plays a key role throughout the process. The formation of the growth pole is due to the concentration effect of minimizing transportation costs with additional transportation improvements occurring within the pole. Expansion of the growth pole to other centers requires development of transportation among and within these centers. Finally, transportation is needed to diffuse innovation from these growth centers to the peripheries. Amos, Jr. expands and develops this growth-pole analysis into a cyclical process of growth by including long-wave theories, which examine temporal (rather than the spatial) relationships of development and are similar to product-(life)-cycle theory (Wells, Jr., 1972). As described above, transportation has important concentration and dispersion functions, which are provided by distinct types of infrastructure (for example, urban transportation as a concentration mode contrasted with limited-access highways as a dispersion mode). Amos concludes that these differences generate long waves of innovation with the depression of one long wave providing the inducement to undertake innovation and thus replicate the growth-pole cycle.

Similar work has been applied to urban areas in investigations of the relationship between transportation and land use (Giuliano, 1989). Location theory has been applied to the problem of industrial location in urban areas, and central-place theory has been applied to the analysis of multiple-center development within urban areas. In addition, traditional land-use theorists, who

originally examined residential location only, have been applied the theory to employment location.

In these theories, transport affects land values with lower transport costs resulting in lower land values at the center and thus greater employment and economic activity at these locations (Solow, 1973).

Other analysts have examined the function of infrastructure, in general, in the economic growth or development of a region, which was usually assumed to be a nation. Beginning with Hirschman (1958) and continuing to the present day with Porter (1990), a great many analysts have examined the extent to which provision of general infrastructure, which includes transportation, aids development of the national macroeconomy as a whole. Some analysts say infrastructure has an extensive and critical importance (e.g., Aschauer, 1990); others argue it only has a supporting importance due to the importance of other factors necessary to sustain economic growth, such as quality of labor pools, availability of capital, or of entrepreneurship (e.g., Montgomery, 1990). Because government can influence infrastructure provision, the discovery of an operational link between this type of government action and economic development is an appealing result. Though much of this literature is not relevant for this study, I briefly mention prominent examples, because these analyses (more than the spatial work previously mentioned) have affected methods used to evaluate transportation projects.

Hirschman (1958, pp. 83-100) is famous for his discussion of social overhead capital (SOC), which includes transportation, and directly productive activities (DPA), which use SOC as a production input. In that discussion, Hirschman mentions that although some SOC is a prerequisite for DPA, for many cases the lack of adequate SOC will just raise the production costs of DPA. Consequently, development through SOC shortage is possible and preferred where motivations for economic growth are scarce because of the incentives and efforts produced to remedy the shortage.

Development through SOC excess, or building before demand, sets up different incentives by permitting greater development and is thus more appropriate where other growth incentives already exist. Thus, Hirschman believes transport is a precondition for growth, but he also states that there is little possibility of evaluating objectively how much SOC is needed.

Rostow (1962), writing at about the same time, stresses the leading-sector, which is a sector that is enjoying greater-than-average (over the entire economy) growth rates and that generates activity in supplemental activities from which it purchases supplies. Rostow concludes that rail is the epitome of a leading sector, because the growth of railroads led to development of modern coal, iron, and engineering industries. He also considers transport as influencing market areas and as a prerequisite for export development, which, in turn, generates capital for internal development.

Important contributions to the role of transportation, specifically, in economic change were also made by Fogel (1964), who provides a good contrast to Rostow's conclusions. While Rostow believes the railroad to be the single innovation vital to economic growth in the United States during the nineteenth century, Fogel associates the growth to the scientific revolution of the previous three centuries and the innovations derived from it. Fogel's treatment was pioneering in terms of its detailed analysis of rail- and canal-transport costs and their impacts on economic growth. Fogel holds that the primary contribution of railroads was to reduce transportation costs. Given that these costs were lower than alternative modes, derived effects followed. These effects included changes in the spatial distribution of economic activity, the mix of final products, and the demand for both skilled-labor and manufactured inputs.

Finally, I mention Porter (1990), who despite being famous for his contributions to the management literature, has also examined the determinants of competitiveness from a nation's perspective and thus is included in the current group of studies. Consequently, he provides a bridge

from the current studies to those of the next section. Porter believes that national competitive advantage and growth derive from industry performance. He considers infrastructure as part of factor conditions, which is one determinant of national advantage, and thus industry performance. Such an analysis forms the basis for traditional neoclassical trade theory. Porter extends this factor-endowment discussion, however, by stating that there is an hierarchy of factors. He distinguishes between basic and advanced factors, where the latter are scarcer and require more investment in human and physical capital, and between generalized and specialized factors, where the latter could be infrastructure with specific properties suited for a particular type of industry. It is the development and use of advanced/specialized factors that promote sustained competitive advantage and thus growth. Porter also states that these categories are ever-evolving with basic factors becoming more advanced and generalized factors becoming more specialized.

According to Porter, this evolution of factors or infrastructure is important, and creation of advanced and specialized factors should be left to the private sector, because it possesses better information about what types of factors are needed. If the government decides to extend its involvement from basic/generalized to advanced/specialized factors, these efforts should be coordinated with industry. Interestingly, Porter concludes his discussion of factors by stating that factor disadvantages can also lead to competitive advantages, a conclusion similar to Hirschman's strategy of development through shortage.

Another important issue is the use of such factors by firms or industries in order to improve their competitiveness, to which I now turn. Table 3.1 summarizes the discussion in this section and will be reviewed in the concluding section of this chapter.

**TABLE 3.1**  
**ECONOMIC AND SPATIAL DEVELOPMENT CONTRIBUTIONS TO TRANSPORTATION'S FUNCTION IN**  
**COMPETITIVE EFFICIENCY**

Field or Author(s)	Contribution	Measures
Location Theory (Alonso, 1972)	Access to raw materials and markets	Minimize transportation cost (weight multiplied by ton-mile rate + terminal costs)
Central Place Theory (e.g., Heilbrun, 1981)	Change in market area or size	Minimize transportation cost
Webber (1972)	Reduction in uncertainty	Agglomeration impacts, transport rates, and scale of production
Growth Pole Theory (e.g., Richardson, 1976)	Improve growth center efficiency; Facilitate dispersion of economic activity	Agglomeration impacts and extent of dispersion to periphery
Growth Pole/Long Wave Theories (Amos, Jr., 1990)	Generation of innovations	Extent of innovation in production
Traditional Land Use Theories (e.g., Giuliano, 1989)	Affects land values and concentration of employment	Change in land value
Hirschman (1958)	Precondition for development	None
Rostow (1962)	Access to areas and products; Widen markets; Prerequisite to development of export sector; Spawn supplier industries	Growth rate of transport; growth in supplementary industries
Fogel (1964)	Change in production potential	Change in total transport costs plus inventory between routes
Porter (1990)	Advanced and specialized infrastructure promotes competitive advantage	Extent of investment and alternate uses

Source: The author.

## TRANSPORTATION USE AND INDUSTRY

Several analysts, who can be divided into two groups, have examined the relationships between the transportation input and firm decisions and performance. The first group consists of analysts who concentrate on behavior (sometimes spatial) of production and distribution processes, usually with the intention of uncovering public-policy conclusions, such as implications for economic development or equity in employment. The second group consists of those analysts who are also concerned with the economic and spatial behavior of firms but who approach these issues from a different perspective, that of private-sector performance. Despite these differing perspectives (and differing backgrounds of the authors), there are startling similarities in the analysts' conclusions concerning the behavior of successful firms.

Within the first group, there are novel, aspatial discussions of production, such as Piore and Sabel's (1984) concept of flexible specialization. Though their analyses and methodology do not involve spatial considerations of the type discussed in the previous section, their conclusions are spatially oriented. They conclude that given the crisis (their word) in the mass-production economy, firms and industrial (public) policy should be geared toward promotion of flexible-specialization strategies, which are locally or regionally focused. Flexible specialization is a craft-based strategy of permanent innovation and is based on "flexible--multi-use--equipment; skilled workers; and the creation, through policies, of an industrial community that restricts the forms of competition to those favoring innovation (p. 17)." Thus, Alfred Marshall's (1919) concept of industrial districts is seen to be reemerging. Moreover, local and regional government will need to be strengthened, and transportation networks will need to be coordinated along with other regional infrastructure, such as training programs and industrial-research efforts.

Harrison (1994) sees a paradigm of “concentration without centralization” as the way to success for many firms, rather than flexible specialization. He believes that firms in local, flexibly specialized industrial districts are only one segment of a geographically extensive production network. He agrees with Piore and Sabel that local-economic-development policy needs to promote strong attractors, such as high-quality transport infrastructure, of economic activity. However, he also feels that the government’s concerns and policies should be driven by an examination of the entire production network. These “production networks”, which Harrison attributes to the work of Powell (1990), are seen to provide greater flexibility in order to account for increasing market fragmentation and uncertainty in demand and supply. This concept appears very similar, if not identical, to the concept of supply-chain management, which predates Powell’s work (e.g., Houlihan, 1985) and will be the focus of Chapters 4 and 5. Harrison does not mention the functions of transport specifically, but transport implicitly serves an important purpose in the logistics activities of these production networks and permits the complex spatial arrangements featured in these networks.

As I mentioned in Chapter 1, these spatial arrangements have been studied by a number of different authors. These impacts on space are technologically and, more importantly, organizationally driven (Walker, 1988). Scott (1988) provides a good summary and framework for these impacts by examining the relationship between industrial organization and urban form. He begins with the location-theory framework of the previous section, but finds it deficient because of its neglect of the locational system (or network) as a whole. Given spatial separation among firms within this system, linkage (or transaction-related) costs occur. And, maintaining the location-theory logic, firms will seek to minimize these linkage costs by either moving and agglomerating to the point of primary economic activity or re-internalizing transactional relations. In essence, firms

co-locate in order to reduce linkage costs. Therefore, it follows that reductions in these linkage costs for any reason, such as improved transport and communication facilities, will lead to or permit decentralization of economic relationships. These linkage costs (interpreted here as transport-related) involve direct interpersonal contact and information exchanges and/or a physical flow of some kind. These costs not only vary with distance and quantity shipped, which Scott labels as simple transport and communication costs; four other attributes are relevant: (1) standardization of goods, (2) stability of linkages, which affect the stability of contacts (and contracts), (3) extent of intermediation needed to complete transactions, and (4) the complexity and difficulty of transacting, such as found in face-to-face contacts between office and service functions.

Much of the business-case material on logistics changes in firms, has also generated analyses of spatial, thus transportation, impacts. This obvious role in linking firms with other firms and customers has been examined extensively in terms of the function of transportation (and communications) in firms' logistics decisions and is found in a number of logistics-management textbooks (e.g., Coyle, Bardi, and Langley, Jr., 1988). Transportation is a necessary part of the logistics system and is seen as a tradeoff with other logistic-system components, namely storage. This tradeoff concept is what distinguishes, from other theories, the view of transportation as a subfunction of the logistics system as a whole and what makes simple minimization of transport costs problematic. Better (and usually more costly) transportation services can reduce the need for inventory and reduce the potential cost of lost sales. Conversely, storage facilities can be substituted for transportation costs by, for example, ordering (and receiving) in larger quantities and storing unused quantities. Thus, transportation provides time and place utility in goods to service the separation among producers and consumers. I discuss the transportation/logistics relationship in greater detail in Chapters 5 and 6.



Analysts have also examined the impacts of changes in the logistics functions in firms on transportation providers. As an example, Colin (1987) discusses the case of France, though his conclusions are applicable to any nation. He sees the focus on logistics as a permanent change in how firms think about their operation. This change provides an increased and more controlled spatial distribution of activities and production/distribution cycle times more correspondent to variations in demand. Thus, the logistics function may not only permit modifications but also motivate them. These modifications will require the transport industry to adjust by adopting a multi-service, amodal transport concept (his phrase), which is structured along the lines of providing general service characteristics rather than mode-specific ones, and applying it to shippers' logistics chains. Thus, there should be, regulations permitting, the birth and growth of transportation firms identified by the service levels they provide through use of any number and combination of modes, than through the currently rigid identification of most transport firms along modal lines.

Finally, though it was not the focus of his study (but was a major component), Chandler (1977) investigates the role of transportation in firm decisions and development from a historical perspective. Chandler's work is especially relevant to this study because of his industry/firm-level, bottom-up approach. He examines the implications of transportation in mass production in considerable detail and in terms of both the technology and institutions involved in production and distribution. For Chandler, advances in transportation (the railroads) and communications (the telegraph), were important to mass production because of their permissive effects on production and distribution processes. These processes depended on the spread, volume, and regularity, which to Chandler is most important, provided by both of these types of (private) infrastructure. In addition, Chandler supports Rostow's idea that leading sectors, such as the railroads, provided

important generators for secondary economic activity (for example, construction and finance), but he extends this analysis to include the impact of railroads' organizational structure on the organization of mass-production enterprises. A new form of business enterprise was needed by railroads because of the careful coordination and control needed to move goods and passengers safely and efficiently over usually large and complex systems.

Table 3.2, on the next page, summarizes the discussion of this section and will be discussed in the concluding section of this chapter.

### **CURRENT PERSPECTIVES AND MODELS IN TRANSPORTATION PLANNING**

Given the rich theoretical possibilities discussed in the previous two sections, I would think that transportation planners would regularly consider the incorporation of the transportation functions described in Tables 3.1 and 3.2 when evaluating policy options. Unfortunately, this is not the case for models and criteria used in both investment and regulation decisions. Here, I will give examples of these models (as well as general perspectives on the types of transportation planning that are considered appropriate), leaving a more detailed discussion for later chapters. Finally, as an introduction, I discuss this literature in search of the state-of-the-art rather than the state-of-the-practice. The discrepancy between the two is real and somewhat significant, but the former is usually included in the latter.

The literature on economic evaluation of transportation investment is vast. Transportation projects tend to be large (both physically and financially) and lofty and thus attract a large following of analysts willing to examine the impacts of these endeavors. Taking a broad, rather complete, view of this literature, I establish five rather distinct perspectives on the evaluation issue: (1) pure cost/benefit analysis, (2) economic efficiency, (3) cost-effectiveness, (4) economic growth and impact, and (5) non-economic-based/multicriteria methods.

**TABLE 3.2**  
**INDUSTRY-RELATED CONTRIBUTIONS OF TRANSPORTATION TO COMPETITIVE EFFICIENCY**

Field or Author(s)	Contribution	Measures
Piore and Sabel (1983)	Assist in industrial-district development	None
Harrison (1994)	Provide regions with access to production networks; Implicit requirement for functioning of production networks	None
Scott (1988)	Permit transactions among spatially distinct firms	Minimize linkage costs (transport costs + transaction-related costs)
Transportation in Logistics (e.g., Coyle, Bardi, and Langley (1988))	Provide time and place utility for goods; Interact with other logistic subfunctions	Minimize logistics costs, given firm's strategic considerations
Colin (1987)	Provide amodal services within a logistics chain.	Minimize logistics costs, given firm's strategic considerations
Chandler, Jr. (1977)	Provide market spreading and volume and regularity of shipments; Lead to development of secondary industries.	Volume, distance, and regularity of shipments.

Source: The author.

The theory and methods of (pure) cost-benefit analysis, in general, have been widely written and applied to a variety of situations. As examples (since this literature is massive), early work in applying the method to highway investment was done by Friedlaender (1965), and Beesley and Walters (1970) for urban-road investment with more recent theoretical expansion found in Jara-Díaz (1986), Williams and Lam (1991), Glazer and Niskanen (1991), and Mohring (1993). As is popularly known, benefits are compared to costs, and feasible (within budget) projects are selected based on the relative difference between benefits and costs. The key, of course, is in determining what to include as benefits and costs.

It is this determination that separates these methods from those of the fourth group, which also considers the benefits and costs of projects or policies. Although economic-impact analysts examine (and have the ability to examine) a wide range of benefits, analysts using pure cost-benefit methods limit the benefit determination to a study of the demand functions for transportation (Viton, 1989). Thus, transport benefits—chief of which is time, which for the average road project accounts for 70 to 80% or more of total benefits (Strand, 1993)—are valued on the basis of users' willingness to pay, which is usually represented by users' income as a proxy. Other benefits include vehicle-related benefits, such as maintenance, fuel, depreciation, and safety benefits. More generally (and abstractly), some analysts calculate changes in users' consumer surplus, a measure of consumer welfare. In both cases, the user or consumer is usually assumed to be an individual passenger. I do not discuss the cost side, because it is more straightforward (largely involving project-related construction costs) and generally does not differ among methods.

Economic-efficiency methods, as they are called here, are related to congestion-pricing studies and have been examined by Walters (1961), Keeler and Small (1977), Small, Winston, and Evans (1989), and Newbery (1989). Similar to the cost-benefit methods, reductions in congestion

(interpreted as time savings) are seen as the primary (and sometimes only) benefit, but the decision rule is different. Investment projects or levels are not selected on the basis of either maximum cost-benefit ratios or of maximum consumer surplus. Rather, investment is pursued until marginal investment cost is equal to the marginal user-cost savings of the investment. Once again, how one values time is of key consequence.

A third group, cost-effectiveness studies, ignore issues of benefit measurement and evaluate investment options based upon cost per some fixed measure of benefit or attainment of some goal. As an example, Johnston and DeLuchi (1989) discuss the procedure used by UMTA (now known as the Federal Transit Agency) to evaluate transit-rail projects. Projects are ranked according to their cost (which includes capital, operating, and travel time costs) per new rider. Although more straightforward than the two previous methods due to the non-quantification of benefits, cost-effectiveness methods do not consider economic-efficiency concerns, such as a more complete and explicit measure of benefits and their overall comparison with costs.

The fourth group of studies holds that transport is a basic requirement for economic growth and development rather than simply treating it like any other product market as found in the two previous sets of studies. Some of these studies, such as Hirschman (1958) and Rostow (1962), have already been mentioned. More recently, there have been efforts to utilize econometric techniques to quantify the relationship between public investment in infrastructure and economic growth (e.g., Duffy-Deno and Eberts (1991)). Conceivably, given the correct causal relationships, planners could just pick the desired investment level (given budgetary constraints) based on the desired (or maximized) amount of economic growth.

More appropriate to the objectives of this study are analysts who examine the economic growth/transportation relationship usually through the use of general-equilibrium models of the

economy. Use of these models not only permits flexibility to examine a variety of situations, but also results in a more comprehensive analysis of the economic impacts of policies. Examples are studies by Huddleston and Pangotra (1990) and Weisbrod and Beckwith (1991). These analysts include a wide range of potential economic impacts for analysis, including direct impacts, such as output generation because of investment expenditures and lower costs of production, and the indirect impacts that result from these, such as new private investment and increased competitiveness of firms.

I label the final group of studies “non-economic based”, because these studies consider resource-allocation issues indirectly, preferring to utilize engineering-oriented measures of performance. Ewing (1995) provides a good summary of this final group. Speed, in terms of roadway levels of service, has been the primary performance measure used by planning agencies and drives investment decisions. As an example, Rathi, et al. (1991) utilize level-of-service considerations (along with forecasted socioeconomic characteristics, such as real income per capita and employment) to forecast highway investment needs for the year 2005. Ewing lists four alternate measures that may be appropriate for measuring transport performance: mobility, accessibility, livability, and sustainability. All four of these involve more complex considerations than just speed of travel. Mobility requires speed but refers more generally to ease of movement, while accessibility encompasses mobility but adds to it the availability of opportunities. Livability and sustainability are not related to promotion of efficiency goals.

An important subset of this group is multicriteria methods. Though application of these methods frequently involves consideration of economic-related criteria, non-economic based criteria tend to dominate. Indeed, these methods are used where the assumptions of the methods of the first four groups from above do not allow measurement of certain events or do not permit

simultaneous evaluation of more than one (conflicting) objective. Giuliano (1985) provides an explanation of these methods for transportation investment planning and applies them to a corridor study where 19 capacity-improving alternatives were evaluated. For each alternative, values for 13 objectives were calculated, then normalized and weighted, and finally ranked. Only 4 of the 13 were cost-related (e.g., maximize cost-effectiveness, minimize operating cost), and others included minimizing noise impacts, maximizing attractiveness to choice riders, and maximizing corridor travel capacity. As can be seen, these methods permit a greater flexibility and complexity in the evaluation process than the other methods but also bring a less formal and structured theoretical framework.

In addition to the transportation-investment side, a number of analysts have evaluated the appropriateness of regulatory actions. This literature is not as vast as the investment-related literature but is nonetheless comprehensive. I establish a organization scheme with four branches: (1) economic surplus; (2) industry structure; (3) change in costs and service; and (4) non-economic-based methods. The first three are applied to problems of economic regulation, while the last set is applied to protective regulation, such as regulation of traffic to analyze problems of congestion, environmental damage, and safety.

Economic-surplus methods are analogous to the second subgroup of the cost-benefit analysis methods featured in the investment discussion above. Winston, et al. (1990) calculated the change in shippers' and carriers' welfare (or surplus) brought about through deregulation by calculating shippers' and carriers' consumer surpluses. These surpluses were calculated by examining changes in mode costs and service rates faced by shippers and in carriers' profits. The general result of these methods is that deregulation has provided, on the whole, positive benefits to shippers and carriers. Friedlaender and Spady (1981) provide an important extension of this work

by utilizing economic surpluses in a general-equilibrium model of the economy in order to examine the impacts on regional output, employment, and income. Hence, the work is similar to the economic growth and impact methods used in the analysis of transport investments. In fact, economic growth and impact analysis can be applied to any of the regulatory planning models. I do not include a separate group, because such applications are rare or use a different theoretical framework than found in the economic growth and impact methods group.

The second type of method uses industry-structure characteristics as the primary evaluation criteria (e.g., Dempsey and Thoms, 1986; OECD, 1990). Use of these criteria in the United States dates back to the origins of state regulation of carriers in 1887, when rates became regulated because of fears of railroads' unfair advantage over some shippers. Regulation of trucks soon followed in order to level the competitive arena among modes. Today, regulations are being dismantled on the same basis, but with reverse conclusions. Various industry-structure measures, such as existence of monopoly conditions, economies of scale, extranormal profits, and concentration ratios, are used to argue for the presence of competitive conditions, and thus deregulation. Of course, in certain sectors of the transport industry, these measures have also shown dangerously strong competitive conditions (in terms of excessively low profit levels) and have led to a call for re-regulation by some. Implicitly underlying deregulatory efforts is the notion that a freely functioning transportation industry will be able to provide better services (in addition to lower costs) than a regulated one.

A third group of methods focuses on improvements in costs and services as motivation for further deregulation. Larson (1992) provides a good survey of these methods and their results. In addition to studies that have examined transportation-cost savings (TRB 1986, 1990b), there have been others that include the more comprehensive notion of logistics costs by including the impacts



of deregulation on inventory carrying costs and order-processing costs. Larson adds to this analysis by examining additional efficiency-related (as well as more general) impacts, such as the increasing interest in logistics strategies, including JIT, and the extent of transportation-service innovations.

This final group of methods, labeled “non-economic-based,” is identical to those described in the investment discussion above. I also include them here, because these methods are frequently applied to traffic-regulation efforts aimed at controlling congestion. Though freight transportation is usually not the focus of these efforts, it is affected directly, through express-lane restrictions on trucks for example, and indirectly, through demand-management efforts such as high-occupancy-vehicle lanes. Freight transportation has been the focus for other protective regulations, primarily those related to safety, such as hazardous-route constraints, noise reduction/avoidance measures, and restrictions on vehicle dimensions. Given the objectives of these efforts, they generally utilize non-economic evaluative criteria, such as maximizing speed of travel and minimizing the negative external effects of transport.

Tables 3.3a and 3.3b, on the next page, summarize this introductory discussion of the various methods used in evaluating policy options. I give a more complete discussion in Chapter 7 for investment-planning models and in Chapter 8 for regulatory models.

### **TRANSPORTATION PLANNING FOR THE FUTURE**

The final group of analysts have examined the impacts of restructuring on transportation (or the opposite). These analysts are futuristic in the sense that they posit, similar to this study, a certain competitive environment or set of conditions that is currently in some incipient stage but that will be the norm, thus requiring change on the part of transportation planners. As expected, the history of this literature is not long which makes the collection of studies eclectic.

**TABLE 3.3A**  
**TRANSPORTATION-PLANNING EVALUATION MEASURES (INVESTMENT)**

Field or Author(s)	Contribution	Measures
Pure Cost-Benefit Analysis	1. Chiefly time benefits; also, vehicle-related savings 2. Change in consumer and producer welfare	1. Willingness-to-pay multiplied by time benefits 2. Change in consumer and producer surplus
Economic Efficiency	Chiefly time-related effects; also, vehicle-related savings	Tradeoff between marginal investment cost and marginal user-cost savings
Cost-Effectiveness	Implicit recognition of time and other (e.g., environmental) benefits	Cost per some benefit measure
Economic Growth and Impact	Direct and indirect economic impacts	Transportation-related and economy-wide measures
Non-Economic-Based/Multicriteria Methods	Not applicable or of primary importance	Maximize speed of travel; Simultaneous satisficing of various non-economic and economic objectives

**TABLE 3.3B**  
**TRANSPORTATION-PLANNING EVALUATION MEASURES (REGULATION)**

Field or Author(s)	Contribution	Measures
Economic Surplus	Change in consumer and producer welfare	Change in consumer and producer surplus
Industry Structure	Implicit cost/service considerations	Criteria for competitive industry
Change in Costs and Service	Improved services; Reduced transportation and logistics costs	Level of services and rate structure, though quality of Service usually dominates and influences logistics costs
Non-Economic-Based	Not or only indirectly applicable	Maximize speed of travel; Reduce adverse, external effects of certain modes

Source: The author.

Policymakers, at least at the macroeconomic, national level, are cognizant of the need to determine transport policies that will support future economic growth and development. There was a large United States-sponsored study that examined the effects of structural change in the United States economy on public works, including transportation (United States Department of Commerce, 1987). Unfortunately, the perspective and conclusions were macroeconomic in nature, using gross-national-product (GNP) data by industry and trends in technology use in production. The analysts did study the shift to a technology-intensive, service-dominated national economy, but conclusions remained at the general infrastructure level in terms of expenditure amounts, rather than in terms of specific policies or investments. For example, they mentioned the increasing use by firms of computer-assisted, flexible-manufacturing techniques and their ability to permit a loosening of production-scale economies as an important trend. Subsequent impacts would include more localized production and increased concentration of these firms, increased economies of scope, and a focus on transport of lighter, high-value products.

The task of speculating about future economic trends and their impacts on transportation has also been the focus of a number of European analysts. As prominent examples, Andersson (1993) and Andersson and Strömquist (1989) comment that a new logistical revolution is coming. This revolution is a departure from Fordism and Taylorism (represented by mass production of uniform products, extensive division of labor, and hierarchical-control systems), which are seen as a consequence of the sparse transportation network of that era. Consequently, this departure will require increasing complexity and complementarity among modes in order to satisfy the ever-increasing demand for mobility and more dense and frequent service and will result in increased flexibility in securing inputs. Given this flexibility, which permits a decreasing plant or (production-facility) size (in the presence of an increasing corporation size in order to explore scale

economies in innovation, diffusion of technology, and marketing), there will be a greater importance attached to the logistics activities within and among firms and across the logistical networks that serve these activities.

A call for a micro-oriented, bottom-up approach, rather than a macroeconomic, top-down one, is featured in Bell and Feitelson (1990, 1991). They first present a description of economic restructuring, which includes (1) changes in production processes to more flexible systems, (2) changes in industrial structure to multinational firms and knowledge-intensive industries, (3) spatial separation of different parts of firms' production processes, which results in regions specializing in functions, such as research and development or administration, rather than sectors, and (4) the rise of the service economy, especially of producer services that serve as intermediary goods. They then discuss, in general terms, numerous effects of restructuring on the demand for, and thus supply of, passenger and freight transportation, focusing on the implications for passenger movement of a shift to a service-dominated economy.

On the goods side, frequency of trips will increase and there will be greater demand for reliability, flexibility, and rapid transport of small quantities of high-value goods. Concerning policy, they see highways and airways as the main modes of travel with increasing emphasis on intermodal connections, and the possible need for regions or jurisdictions to maintain excess highway capacity in order to increase reliability. On the passenger side, a more competitive environment increases the importance of good access to low-wage labor, which coupled with decentralization of firms' functions, leads to an increased imbalance between housing and job locations. Consequently, (passenger) transportation systems need to be oriented to this type of varied travel demand rather than the suburban-to-central-city orientation of many current systems. Increasing differentiation in consumption activities will also lead to these results. Finally, spatial

separation among different parts of the firm and the requirements of high-skill-labor will increase the importance of access to airports and exert pressure to locate where the quality-of-life is high. Needless to say, they view many of these effects as important public-policy issues related to transportation provision and overall economic development that need to be incorporated into decision making by governments.

Toft and Mahmassani (1984) make similar conclusions in their examination of the transportation implications of high-technology development, which they define as the advanced production and processes emerging from industries such as microelectronics, electro-optics, biogenetics, and nuclear materials. These industries require frequent face-to-face contacts for both research and development and business purposes, and feature high-paid, high-skill workers, who attach much importance to time and quality-of-life considerations. In addition, these industries tend to feature high-value, time-sensitive, low-bulk, and fragile shipments. Important transportation implications include provision of air travel for both business passengers and freight, quality journey-to-work options for a white-collar workforce, and site access to major arterials and airports.

Rather than examining sectors by type of output, other analysts have examined the impacts on transportation of changing processes within sectors. Two examples, one from distribution and the other from production, are relevant. Quarmby (1989) examines distribution changes in the British retail market consisting of two trends: (1) a shift away from supplier-controlled distribution networks towards retailer-controlled networks, which results in suppliers' delivery to retailers' distribution centers, which tend to be larger, more regional in coverage, and fewer in number, and (2) a move from own-account operations to contract distribution, which creates an independent market for distribution services and increases potential flexibility of distribution firms to respond to market and network changes. Given these two general trends, predictability of journey times

becomes crucial, which increases the value of time in congested conditions (relative to freeflow conditions). Current policy-evaluation techniques, which value time savings to commercial vehicles as the time costs of vehicle operations (including driver), are seen by Quarmby as underestimating (by 30 to 50%) the benefits brought about by network improvements. This difference relates to additional benefits, such as economies of scale and stock savings due to a reduced number of stocking points.

Fawcett and Vellenga (1992) examine the transportation implications of *maquiladora* operations. Use of *maquiladoras* is a production-sharing strategy whereby certain production activities are shifted to Mexico. This shifting can occur in any country. The proximity and common border between Mexico and the United States reduces the complexity of logistics activities, which become key to reaping the benefits of *maquiladoras*. As expected, due to border delays and the differences between Mexican regulations and infrastructure levels and those of the United States, the authors found that transportation performance (in terms of on-time performance, transit time, and rates/tariffs) suffers in these intercountry operations. Though they concentrate on private-sector efforts to improve this performance, they also mention that increased cooperation between Mexican and U.S. officials to remove the discrepancies (both investment and regulatory) between the two nations' networks would be beneficial.

As another category of changes in production and distribution processes, just-in-time techniques (JIT) have received the most interest. Mair (1993) investigates the local-economic-development potential of JIT. Though he stresses that local governments need to evaluate critically the consequences of JIT, he includes strategies local governments should follow to attract JIT operations. Among these is the importance of extremely reliable logistical links among manufacturers and suppliers and the transportation facilities that support these links.

Other analysts have examined the impacts of JIT on carriers. Lieb and Millen (1990) use survey techniques to investigate how motor carriers are responding to the added requirements of JIT. They find that on-time performance, carrier flexibility, and carrier tracing become key criteria and more important than price in the selection of carriers. Carriers' operating costs increase because of additional start-up (both equipment and training) and monitoring costs. Relationships among carriers and manufactures become longer-term and closer (as found among suppliers and manufacturers), and use of contracts increases. As expected, these types of relationships lead to greater and better information flows within and among firms, which lead, in some cases, to use of more advanced technology, such as electronic data interchange (EDI) equipment.

Higginson and Bookbinder (1990) also examine such impacts but do so from the perspective of railroads, who are not popularly seen as important players in JIT environments. Rather than survey JIT manufacturers and carriers, the authors discuss approaches railroads might use to meet JIT requirements. These approaches include greater use of contracts, and trailer-on-flat-car (TOFC) services, with short truck hauls made possible by more local intermodal facilities. Such facilities would permit fast loading and unloading of trailers. Finally, they mention that use of boxcars, which feature higher profit margins than TOFC, to ship consolidated shipments of small-order quantities is possible but would require regional distribution centers for reloading activities.

Such conclusions regarding intermodal possibilities are compatible with the current national transportation environment in the United States. The 1992 Intermodal Surface Transportation Efficiency Act (ISTEA) has an entire section (title) devoted to discussion of intermodality and proclaims, in 49 United States Code, Section 5001, that the national goal of transport policy is to promote intermodal transportation. Sonstegaard (1992) also begins with this goal of greater use of intermodality, particularly the promotion of greater balance between road and rail use. He argues

that because rail has a lower cost per ton-kilometer and higher optimal speeds on dense-traffic routes than truck, rail should be used (in greater quantities than currently featured) for linehaul services. Sonstegaard adds, however, that rail must first shorten trip time, make it more predictable, and move lading with greater care. He also discusses approaches private and public sectors could take to promote these goals. In terms of public policy, Sonstegaard recommends some regulation of rail routes (due to their monopoly status), centralized dispatching, and public assistance to push nonincremental change in railroad technology, such as changes in gauge and switching design. Sonstegaard mentions that industrial districts provide a practical and useful environment to implement such ideas and that rail-in, truck-out industrial hubs currently perform some of the functions necessary in these districts.

Turnquist and List (1993) not only emphasize the importance of an intermodal (or, in their words, highly integrated) system, but also attempt to substantiate its importance and make more detailed recommendations. They mention the increasing globalization of business and sophistication of manufacturing, as evidenced by JIT, as two trends that raise the importance of an intermodal system. They discuss weakness in four areas of the current system: (1) operational standardization in terms of physical and regulatory standards, (2) information standardization, (3) physical connections between modes, and (4) information connections among carriers, shippers, intermediaries, and government agencies. Given weaknesses in these areas, they specify integration of facilities and equipment, responsiveness to changing demands, and efficient resource utilization as three primary goals to unify the transportation system for better performance. Federal-policy recommendations include an increased effort at constituency building for making such a system politically viable, investment in the transport network, such as intermodal terminals and highway facilities dedicated to commercial traffic, establishment of an “interstate communications network,”



and regulatory loosening to permit increasing coordination among carriers and regulations that promote increased system unification and standardization.

The last group of studies focuses on the establishment of methodologies to examine the relationship between restructuring efforts and transportation. Quarmby (1989), discussed above, also makes conclusions in this area. Lewis (1991), in a federally funded study of methodologies that can be used to analyze the relationship between transport and the economy, establishes a procedure to quantify industry-related productivity benefits associated with major changes in the transportation system. In the same vein as Quarmby, Lewis considers both direct transport costs, such as drivers' wages, fuel, and vehicle-related, and indirect impacts, such as reduced inventory and stocking points, increased application of JIT or some other production/distribution technology, and changes in fleet composition. Such indirect impacts could be included in a more expansive application of cost-benefit analysis.

Rao and Grenoble IV (1991) examine the impacts of traffic congestion on JIT operations from the perspective of the shipper (rather than the carrier or government). They utilize total cost analysis to explore the (short-run) incremental costs of congestion on inventory-holding cost, backorder/stockout/tracing/expediting costs, and in-transit inventory cost. Using numerical examples, they show how changes in transit time and, more importantly, consistency or reliability of service affects logistics performance. Predictability of transit time, therefore, is the key network-related performance measure. They conclude with strategies, such as pooled delivery, consolidated deliveries, computer routing support, off-peak deliveries, relocating facilities, and changing channel structure, to mitigate the negative consequences of congestion on JIT, which can be substantial.

Allen, Baumel, and Forkenbrock (1994) investigate the possibility of adding logistical considerations to current highway-project evaluation techniques. They see current benefit-cost

analyses (discussed above) as inadequate and recommend replacing travel-time savings with a more comprehensive benefit measure that incorporates a micro or firm perspective. Thus, time-related logistical cost savings consist of inventory-cost savings, which include in-transit inventory and safety-stock savings, in addition to the transportation-cost savings that are somewhat captured by traditional methods. They go on to provide more specific guidelines to estimate these savings. In concordance with the conclusions of Rao and Grenoble IV (1991), they recommend such changes in order to consider reliability of transit time, which is seen as the most important characteristic of trucking service but is currently not included as an evaluation measure for highway investments.

Table 3.4 on the next two pages summarizes this section's discussion. I now turn to concluding comments concerning this table and the preceding ones in order to summarize and evaluate how the literature discussed in this chapter is compatible with the work of the study.

### **EVALUATING THE LITERATURE**

By examining the four summary tables collectively, the reader can see that there is a great variety in the types of studies and in the perspectives from which they examine the linkages between transportation and economic performance and how to measure and plan for them. Yet, this examination represents a common thread underlying all of this work, and one sees the progression of ideas from the studies of Table 3.1 to the final study of Table 3.4. This progression is important and needs to continue.

Beginning with the basics, much of the work in Table 3.1 emphasizes the importance of reductions in transportation costs, which is a production-cost-reducing function of transportation. This function is critical, of course, but more has to be said about the role of transport in economic growth. In particular, the influence of transportation, especially in its transaction-cost-reducing role, has not been investigated in detail. This can be attributed to the macro level of detail of much

**TABLE 3.4**  
**FORWARD-LOOKING CONTRIBUTIONS TO TRANSPORTATION'S FUNCTION IN COMPETITIVE EFFICIENCY**

Field or Author(s)	Contribution	Measures
United States (1987)	Not applicable	Not applicable
Andersson (1993)	Increase choices of input sources; Permit smaller plant size; Connect and coordinate spatially-separated units.	Density, frequency, and flexibility of transportation Services.
Bell and Feitelson (1990, 1991)	Permit flexible, precise production of low-volume, high-value products; permit success in a more competitive environment; permit greater amount of interaction.	Frequency of travel and system reliability; (Excess) Capacity of highways and airways; Accessibility of urban transport systems.
Toft and Mahmassani (1984)	Permit greater communication and exchange of information; Permit careful and reliable shipments of high-value goods.	Availability of air service; transport system compatibility and accessibility to quality-of-life conditions.
Quarmby (1989)	Increased Predictability of Trips permits better functioning of depots; Opens up new market potential; Reduces number of depots serving a geographical territory.	Predictability of trips; Increased value of time during congested conditions; Include business-potential benefits in addition to time-savings in project evaluation
Fawcett and Vellenga (1992)	Provide coordination mechanism to tie production-sharing activities across wide geographical areas.	Smoothness of material flows.
JIT and Transportation Planning by Firms	Improve product quality; Reduce inventories; Increase responsiveness to customer needs; enhance production efficiencies.	Reliability of shipments; Efficiency and accuracy in handling; Extent of relationships between carriers, shippers, and intermediaries
Sonstegaard (1992)	Not Applicable	Not Applicable

**TABLE 3.4 (continued)**  
**FORWARD-LOOKING CONTRIBUTIONS TO TRANSPORTATION'S FUNCTION IN COMPETITIVE EFFICIENCY**

Source or Author(s)	Contribution	Measures
Turnquist and List (1993)	Increase industry competitiveness/standard of living; Increase market share for producers; Lower costs; Increase choices for consumers; Aid in JIT production.	Integration, responsiveness, and resource utilization of transportation system
Lewis (1991)	Not applicable	Traditional benefit/cost measures; Also include restructuring-related benefits, such as reductions in inventory/stocking points, introduction of new technology/processes, and change in fleet composition.
Rao and Grenoble IV (1991)	Input to JIT processes.	Predictability of travel times; coefficient of variation (standard deviation / mean) of travel times.
Allen, Baumel, and Forkenbrock (1994)	Component of logistics system.	Inventory cost savings; transportation cost savings.

Source: The author.

of these efforts and, in some cases, the age of these studies, which determines the particular production and distribution processes available and of interest for study. Nevertheless, the studies of Table 3.1 mention important transportation contributions, such as changing market areas, increasing access to inputs, and generating and dispersing innovations to efficiency that should be explicitly considered in transportation planning efforts.

In terms of specific policy or planning recommendations, almost all of the studies are explanatory (and sometimes exploratory) rather than prescriptive in nature, and if public policy is discussed at all, it is at a general level. Porter does make interesting conclusions that are directionally correct, but more detail is necessary. Thus, these studies provide little guidance concerning appropriate types, levels, locations, and control of transportation infrastructure. Finally, the generally macro focus of these studies is problematic to uncovering the transportation-planning implications of restructuring.

The analysts in Table 3.2 correct this last problem by focusing on changes at the firm or industry level. Though Piore and Sabel (1984) do not explicitly discuss spatial change, their study has spawned an extensive literature that examines the occurrence of restructuring and, in some cases, its spatial impacts. The problem with most (if not all) of these studies is that the transportation system itself is essentially assumed and thus not given much, if any, credit for the changes in spatial behavior. Such an assumption disallows any investigation of public-policy issues in transportation. The lack of direct work on the impacts of the restructuring process on transportation, and the converse, is a little perplexing. Even from a casual observation of the changes taking place, it appears obvious that a tighter control over the product channel will undoubtedly influence transportation requirements, since transportation flows (along with information flows) basically link firms and industries together.

On the other side, it appears that transportation has played a critical function in permitting this control to take place. After all, the function of transportation in a production system is clear: to collect and distribute inputs and outputs, which falls under the sphere of the logistics function within firms. The logistics function becomes of central importance to firms that seek to minimize product-time and that heavily interact in terms of buying inputs or selling outputs to other firms that comprise the product channel (Sharman, 1984). The needs of the various logistics functions across firms or industries are served by logistics networks or channels. Logistics networks should be considered in the most general terms as all activities that are directly involved in delivering both inputs and outputs to their users, or the reverse. Andersson and Batten (1988) specify the movement of commodities, information, people, and money to producers and consumers as the function of logistical networks.

Thus, analysts need to examine the logistics function within firms in order to investigate transport-planning implications of restructuring efforts. The literature on transportation use in logistics is vast, but was only briefly mentioned, because the perspective of the studies differs from that of this study. These analysts almost solely discuss logistics and transportation strategies from the perspective of private-sector firms and do not consider public-policy issues. Nevertheless, this work provides important expositions of transportation use by firms, and I return to a discussion of this literature in Chapters 4 and 6.

The third set of studies, transportation-planning and transportation-evaluation methods make assumptions concerning the impacts of transportation on economic performance. Unfortunately, these assumptions usually do not include issues of production and distribution. One reason for this is the lack of knowledge about the impact of transportation-policy decisions on production and distribution at the firm or industry level. In addition, the role of transportation in

production and distribution is perceived as unimportant by policy-makers or as an irrelevant market for planning efforts or overridden by other concerns, such as political concerns or the practical utilization of simple planning methods.

Currently, there is uncertainty from the perspective of the public sector as regards the selection of facilities and policies that are appropriate for supporting or even promoting economic activity or private-sector economic performance. Transport-planning practitioners generally ignore the movement of goods in policy formulation, and planning for passenger transportation does not incorporate private-sector performance measures, such as extent of market areas, access to labor pools, reliability of deliveries, and site access for shipments, instead judging the success of policy and plans on the basis of changes in vehicle miles (or hours) traveled or ridership on public-transport systems. As seen in Table 3.3a, where goods movement is considered, techniques are derived from passenger-transport evaluation and do not incorporate measures related to efficiency in production and distribution efforts; regulation-related studies, Table 3.3b do incorporate such measures to a greater extent.

In sum then, there have been a number of studies that provide relevant insights to the issue of transportation's function in current restructuring efforts but no detailed, structured examinations of the issue. More importantly for the purposes of this study, these issues have not been adequately analyzed from a public-policy perspective, and this literature has not established an effective theoretical framework. The relationship between transportation (and government involvement) and production and thus private-sector performance remains an elusive one, but one that seems reachable. The studies of Table 3.4 provide many important leads into this problem. A comparison of the "Measures" column of this table to those of the previous tables shows an increasing

understanding of transportation's functions in restructuring efforts and provides suggestions on how to model these functions from a public-policy perspective.



## CHAPTER 4

### ADJUSTMENTS WITHIN A PARADIGM

In this chapter, I define and discuss changes in production and distribution processes, which are, in effect, how firms organize, conduct, and control their internal and external business dealings.

As was briefly mentioned in the second chapter, defining “changing production and distribution processes” is not straightforward. Different, and sometimes discordant, answers will result depending on the level of analysis, which can take a number of forms (international, national macroeconomic, inter-regional, interindustry, interfirm, or intrafirm). Answers will also differ on the bases of one’s research objectives and which unit of analysis is of interest. In the examples of Chapter 2, some analysts have examined changing production and distribution processes in terms of their impacts on labor and overall income inequality, while others have examined the role of regional clusters of firms in effecting these changes.

For the current work, the unit of analysis is the supply chain as defined below, along with the spatial transactions among firms that occur within this chain. The paradigm of interest is known as supply-chain management. Supply-chain management (SCM), which can also be described as a coordinated approach to the supply chain, includes many of the principles and concepts that are usually included in discussions of changing or restructuring firm processes and organizes these concepts within a logical framework, hence its use as the model for describing these changes. Two prominent foundations of this paradigm—the term “paradigm” will be used throughout this chapter as simply meaning an observable model or pattern—are its focus on the supply chain, rather than the firm, as the unit over which objectives should be established and its inclusion of coordination over the entire supply chain as the key mission. As will be discussed later, these two factors affect firms’ logistics-related decisions and the transportation characteristics

appropriate to these decisions, thereby necessitating that government transportation policies and planning methods account for these factors.

The reader should note that nothing has been said about the particular products that firms use or sell and thus transport. After all, an analyst could define changing production and distribution processes just in terms of the products or industries involved and examine the effects of such structural-economic changes on transportation use, as was done in a 1987 Department of Commerce study, discussed in Chapter 3. Clearly, the characteristics of the particular products being transported will influence which transport characteristics are demanded. I treat such product-related/technical issues, to be discussed in the next chapter, somewhat independently from organizational issues/institutional. Complete independence is not possible, because not all products may require the same degree of, if any, coordination among the participants in the supply chain. Nevertheless, I make no mention of the suitability of applying to particular products or industries in this chapter's discussion. Thus, rather than draw conclusions for a particular industry or set of industries, I seek to examine the impacts of overall, paradigmatic changes in business practices.

### **DEFINING THE FIRM AND ITS PLACE IN THE SUPPLY CHAIN**

Though I do not want to expend too much time on a formal exposition of the firm as an economic entity, it is important to establish what I mean by a firm. The definition I use throughout is based on that of Dietrich (1994), who stipulates that the core activity of the firm is production and/or distribution activity and thus defines a firm as “an economic unit that transforms inputs into outputs for use by other economic agents (p. 6).” The firm is neither just a resource-allocation unit, which accords institutions no importance as described by traditional neoclassical economics (e.g., Varian, 1984), nor just a collection of individual exchanges as held by transaction-cost theories (Coase, 1993). Thus, this definition holds that the central characteristic of a firm is management of

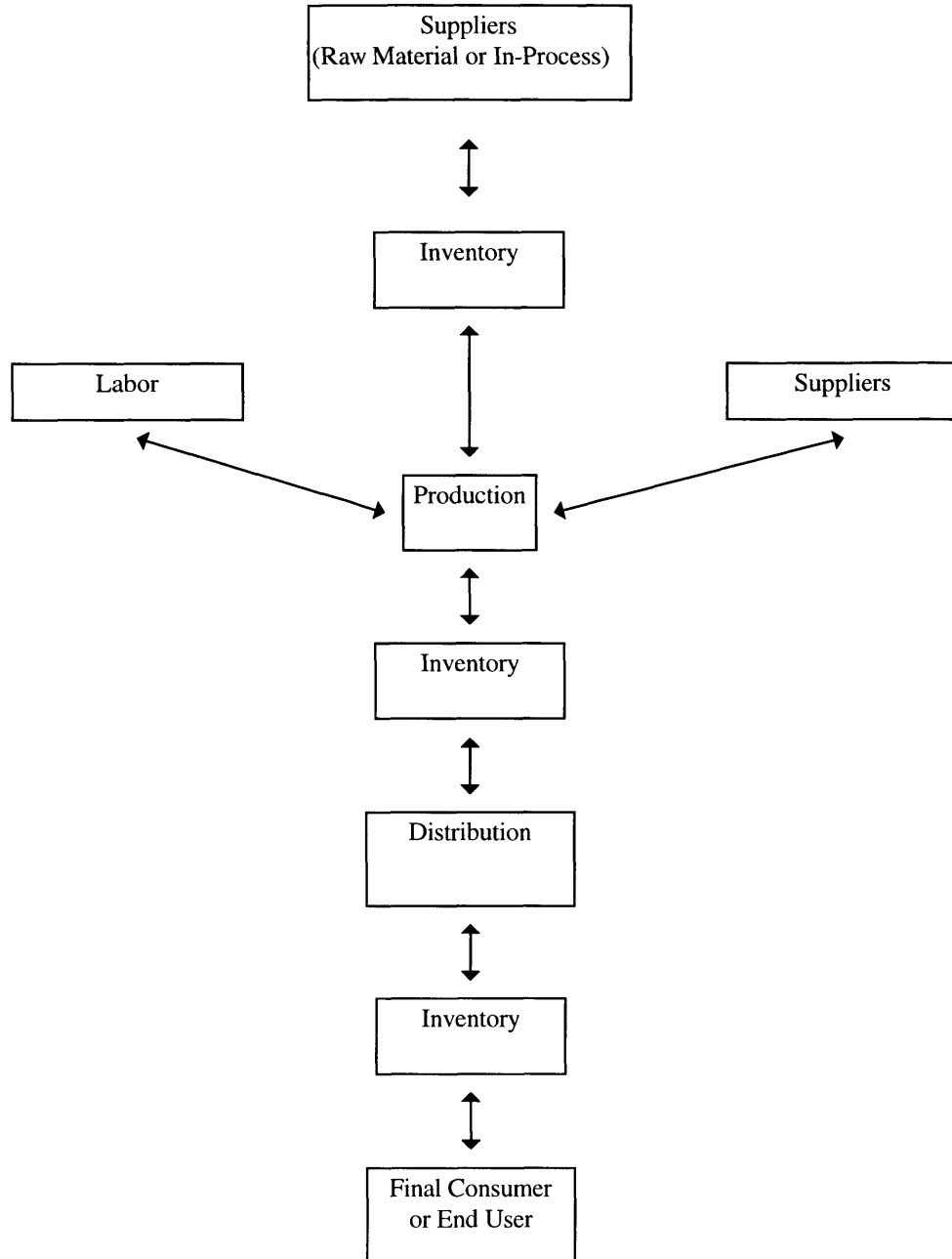
a production-distribution process, with different management or governance structures generating not only a reduction in exchange-related costs (as held by transaction-cost theories), but benefits as well. Dietrich mentions just-in-time (JIT) systems as an example of a benefit-rich governance (as well as production) structure that conforms to neither of the two alternative definitions mentioned above. I return to a discussion of the benefits of a particular governance structure in the next chapter.

For the purposes of the work in this study, I will analyze the performance of management of production-distribution processes by examining the logistics function within firms. To understand how specific transport policies and investments affect firm competitiveness, analysts need to trace how a policy or investment may influence firm-level decisions, and eventually performance. An analysis of the logistics function (as distinct from marketing, finance, human resources, and others) allows me to do this. More generally, the logistics or supply system, also known as the supply chain or channel, can be defined as all activities that make possible the flow of goods (and information) from procurement of raw materials to delivery to final consumers. A comprehensive listing of these activities would include the following: traffic and transportation, warehousing and storage, industrial packaging, materials handling, inventory control, order processing, customer-service levels, demand forecasting, procurement (of inputs), distribution communications, plant- and warehouse-site location, return-goods handling, parts and service support, and salvage and scrap disposal (Coyle, Bardi, and Langley, Jr., 1988). Although information flows can be analyzed in the same way, I concentrate on the supply chain for goods, which is shown diagrammatically in Figure 4.1.

The example of Figure 4.1 is simple, but can be accurate depending on the product and the level of detail of interest to the analyst. The arrows connecting the various boxes represent the

**FIGURE 4.1**

**A SIMPLIFIED EXAMPLE OF THE SUPPLY CHAIN**



separation, both spatial and institutional, among the various production and distribution activities (the boxes in the figure) and thus represent the logistical networks used to overcome this separation. As previously stated, these networks can be interpreted most generally in terms of moving commodities, information, people, and money. Moreover, flows need not pass through all the boxes shown in the figure.

Based upon a study of the Chicago metalworking sector, to which the framework of this study was applied and will be used throughout the current work as an illustration of concepts and techniques, a supply chain in which a metalworking firm operates would feature a number of flows. Steel, as raw materials, and services purchased from other metalworking firms, as in-process supplies, either of which may or may not go into inventory. These inputs along with (usually a relatively large amount of) the labor input feed into the production process. Metalworking products may then be placed in finished-goods inventory or shipped to the end user, such as a machinery producer, who may not be the ultimate consumer of the product, to a final consumer, or to an intermediary, with these latter two being quite uncommon.

I show a two-way flow in the figure (using two headed arrows) largely because of non-transport-related flows, but also because of product returns or recycling and passenger trips. An increased division of labor and task specialization will increase the number of tiers in the functions of Figure 4.1. For example, suppliers of in-process goods may themselves have suppliers, and distributors may sell to sub-distributors, such as wholesalers or retailers. Also, although the boxes in Figure 4.1 can represent individual facilities, it is possible for there to be several production locations and various distribution centers, and other facilities. For much of the metalworking sector in Chicago, as an example, this is clearly not the case. The great majority of metalworking firms combine production and inventory activities for both inbound and outbound needs in one facility.

Nevertheless, in some cases, the supply chain can be very complex if not easily or directly observed. The particular structure of the supply chain will depend on the management strategies adopted by individual firms but, as will be seen later, common elements can be established for portions of the metalworking and other sectors as well. In a later section, I describe, based on survey results, different supply chains found in the metalworking sector.

The above definition of the logistics function is traditional and can be found (with minor alterations) in many sources (e.g., Shapiro and Heskett, 1985; Ballou, 1987; La Londe, 1994). Setting these alterations aside, the key concept underlying the logistics function is the idea of flow or movement. As regards transport, this flow is not only one of goods but of people, since the flow involved in the delivery-to-customer activities implicitly involves movement of customers to goods as well as the reverse. Movement of people as labor providers will also be included as a logistics-related activity. After all, self-transport of workers is just a variant of procurement activity, and access to labor is frequently an important factor in selecting site locations. Furthermore, increased attention to environmental concerns by policymakers may lead to firms monitoring their employees' travel-to-work patterns. For example, certain employers in Southern California are required to develop and implement programs that reduce use of single-occupancy vehicles for drive-to-work trips (SCAQMD, 1990). Therefore, both freight and passenger transportation will be affected by changes in firms' logistics functions.

A single firm can conduct all the logistics activities listed above, but it is also possible (and increasingly common) to have different firms perform particular activities or more than one firm involved in a single activity. For example, a manufacturing firm may purchase supplies, which themselves may be manufactured, from a different firm or set of firms, and sell its goods to independent re-sellers, such as wholesalers and retailers, who will sell the product to final

consumers. At first glance, an analyst may think that use of different firms for various functions would be more costly because of a likely increase in spatial and institutional separation, but this need not be the case. After all, suppliers may locate next to customers, and intercompany-operating ties may permit better performance and information exchange than provided by internal bureaucratic channels.

## **LOGISTICS DECISIONS AND PERFORMANCE MEASURES IN THE SUPPLY CHAIN**

One way to describe the organization, conduct, and control of production and distribution processes is to examine various decisions undertaken (or potentially undertaken) in these endeavors among firms, their suppliers, and their customers. An analysis of decisions is useful, because it allows examination of objectives as well as decision criteria. The decision-making process has already been mentioned, in terms of the planning process, in Chapter 2. The greater the number of steps included and the greater the detail of each step's analysis, the more complete will be the description of a particular planning (interpreted in a broad manner) process. Whatever the level of inclusion and detail, however, an analysis of decisions is a viable way to describe a planning process.

For the current work, these decisions will be made by individual firms but analyzed (if not made) in the context of the supply chain. Only decisions that affect or are affected by transportation choices will be included in this decision set. For example, if one takes a rather complete view of the supply chain by including financial and information flows (in addition to product and people) within the chain, the decision set would need to be expanded to consider the creation and maintenance of systems to manage these flows. Such a view would allow a better comparison-and-contrast analysis of different management paradigms but is not needed for the current work.

However, a quick comparison of the included decisions with the definition given previously shows

that transportation is involved in a great proportion of the logistics system. I now consider how to construct an effective decision set.

The literature reviewed in Chapter 3 can be considered as one source. Most of those studies make at least implicit assumptions about which decisions are relevant to an examination of transport use by firms, though much of this group makes no mention of which management paradigm(s) is (are) at work. The economic- and spatial-development studies (of Table 3.1) mention the following contributions to firm activities: access to raw materials and markets, dispersion/generation of innovations, and changes in production potential. These contributions correspond to the following logistics decision areas: purchasing, facility location, traffic and transportation, production planning, and customer service/distribution. Table 3.2 expands this list by its mention of transportation's influence on logistics costs and other costs related to interfirm transacting. Correspondingly and based on the above description of the logistics function, the following additional decision areas need to be included: inventory control/policy, product design/packaging, demand forecasting, order processing, and supply-chain structure and interfacing. Finally (the studies of Table 3.3 offer no additional contributions), Table 3.4 contains studies that either examine these decisions in greater detail or implicitly analyze them in terms of particular management paradigms.

Organization of this decision set improves it. I order the decisions in the direction of product flow from suppliers to customers in Table 4.1. I also distinguish among inbound, outbound, and within-bound activities of the firm. These categories are straightforward and refer to the direction of product and information flow to and from the firm; however, for purposes of this study, the boundaries on these activities are spatially constrained rather than institutionally constrained. Thus, I confine within-bound activities to activities conducted within a particular plant



or facility, such as materials handling; also, the parties involved in outbound and inbound activities may belong to the same firm.

Some decisions apply to both flow directions, while others either apply uniquely or are not easily categorized as inbound- or outbound-related decisions. Traffic and transportation, inventory management, facility location, and supply-chain structure and interfacing decisions are relevant for both inbound and outbound transactions. Of course, these decision areas, though featured on both sides of the chain, will differ in terms of objectives, performance measures, and decision rules depending on the side to which they pertain. Purchasing and order processing are similar in nature, but serve different, inbound and outbound respectively, sides of the supply chain. Also considered as outbound decisions are customer service, product design/packaging, and demand forecasting. Finally, production planning is considered a within-bound activity.

The ordering is only approximate, because activities may be conducted simultaneously, outbound activities may precede inbound activities, such as when demand-forecasting results influence purchasing arrangements, and different firms will have different ways of conducting their logistics activities.

I discuss these decision areas individually, in general first, then for two categories of various management paradigms (examples of which were discussed in Chapter 3) and for SCM, followed by an application to Chicago's metalworking sector. Both similarities and differences among paradigms are of interest because of the desire to know to what extent SCM is a departure from other paradigms. It should be noted that such discussion of decisions individually does not imply that these decisions are conducted independently. Clearly this is not the case in many instances, and given the definition of SCM, should never be the case.

I analyze the objectives/decision rules and measure(s) of each area in terms of their relevance to transportation planning. That is, I establish relationships between transportation use by firms, as exhibited in the traffic and transportation decision area, and the other logistics decision areas. Other planning or policy areas may feature a slightly different discussion and set of relevant measures. The discussion is derived from a largely common pool of work (Magee, Copacino, and Rosenfield, 1985; Coyle, Bardi, and Langley, Jr. ,1988; Ballou, 1992; Lambert and Stock, 1993) but recast for the purposes of this study; I indicate where findings are attributable to a single source.

**TABLE 4.1**  
**RELEVANT DECISION AREAS FOR PROCESS ANALYSIS**

Decision Area	Shipment Direction
Supply-Chain Structure/Interfacing	Inbound/Outbound
Facility Location	Inbound/Outbound
Purchasing	Inbound
Traffic and Transportation	Inbound/Outbound
Inventory Management	Inbound/Outbound
Production Planning	Within-bound
Demand Forecasting	Outbound
Order Processing	Outbound
Product Design/Packaging	Outbound
Customer Service	Outbound

Source: The author.

*Supply-Chain Structure and Interfacing* comprises decisions regarding the design of the supply chain in terms of the number and characteristics of levels and members. This decision area is relevant both on the inbound side when dealing with suppliers and supplier-related intermediaries and on the outbound side when dealing with customers and customer-related intermediaries. The objective of this decision area is to select or create a supply chain that meets the desired level of functionality in moving goods and information into and from the production process, and the

decision rule is to select the supply-chain arrangement that maximizes (or attains) the desired level. The desired level of functionality is a net (benefits-cost) level and will depend on the objectives of many of the decision areas discussed below, such as facility location and inventory management. Likewise, performance measures can be of the direct kind, such as number of upstream and downstream partners or echelons, the degree of control over partners or echelons, and the degree of interaction among partners or echelons, and of the indirect kind, such as an assessment of the performance-measure values in the decision areas below for alternative supply-chain arrangements.

*Facility Location* refers to deciding where, how many, and which nodes in the supply chain are to be located. While the location/creation of some nodes, such as product-input stores, are clearly inbound-related, the location/creation of others, such as manufacturing facilities located next to customers, may be influenced by outbound considerations. Hence, I wish to distinguish between inbound and outbound locational determinants. On the inbound side, the objectives, performance measures, and decision rules will be based on which specific inbound considerations are important. Examples of these inbound considerations include the favorability of the labor market, proximity to suppliers, resources, and labor, and the availability of adequate transportation and other infrastructure. Outbound considerations are customer-related, such as proximity to current or potential customers.

The particular measures to use in capturing performance of different options will depend on the inbound/outbound consideration(s) of prime interest. For example, if attracting high-skill labor was the prime consideration in locating a production facility, measures might include local quality-of-life environment, home-to-work trip conditions, and proximity to a pool of qualified employees. The decision rule would be to maximize the attainment of such measures, or, where there are two or more different measures, a weighted sum.

*Purchasing* consists of those tasks involved in obtaining or procuring inputs, both goods and services. Labor is also an input but, as indicated above, will be included in the facility-location section. As such, purchasing does not have an outbound component. Purchasing usually includes a number of subtasks, such as determining input needs (in line with production planning guidelines), selecting suppliers, negotiating buying terms and methods, and post-sale monitoring of suppliers. Not surprisingly, purchasing decisions directly affect supply-chain-structure decisions as well. Performance measures can consist of either supplier characteristics, such as production capacity, financial stability, and company history, or product characteristics, such as overall quality and delivered price. Attachment of detail to these measures is possible, of course.

*Traffic and Transportation* corresponds to physical movement of inputs to or outputs from the production (or an intermediary) establishment. The objective of this decision area is to select a transportation strategy that is consistent with the objectives of the firm, as described in other logistics decision areas. That is, the firm's particular inventory policies, purchasing and supply-chain choices, production plans, and customer-service levels will influence which transportation strategies are relevant.

Rather than describe these strategies, as is usual, in terms of management of private fleets or, if not private, modal and carrier choices and in terms of pricing strategies (free-on-board (FOB) origin or destination), I will use the characteristics of transportation service, which are described in the next chapter. Hence, different 'values' for the performance measures, and thus demands, of the other logistics decisions areas will lead to selection of different transport-characteristics sets as strategies. Conversely, the availability and feasibility of characteristics to service these demands will influence the decisions made in other logistics-related areas. A discussion of both these relationships is the topic of a future chapter. Use of such a description permits an analysis of how

transportation-planning efforts may influence transportation strategy and, consequently, the other logistics-decision areas.

*Inventory Management* includes all decisions involved in maintaining inbound and outbound inventories, including warehousing and storage selection and location. The objective of this decision area is to design a inventory policy or system that is consistent with the firm's overall strategic needs. Performance measures used in this design include the general type of inventory system (whether push or pull), the types of inventory to be held, the levels of inventory to be held, and the location and type of facilities where inventory is to be held.

*Production Planning* represents the tasks involved in directly supplying the demand for the firm's products. For the purpose of this chapter, the performance measures of importance include the length of production run (in terms of time or quantity) and the pattern of production over some time period.

*Demand Forecasting* is the determination of future levels of orders, which is an important information input to production-planning decisions. For current purposes, the particular methods used and their accuracy are not important. Rather, the nature of demand or its dependence on certain factors, such as the order pattern of a dominating customer or customers, is critical. The nature of demand does influence the selection of methods and the accuracy of the forecasts, but a more critical performance measure is the importance attached to accurate forecasts or, in other words, the sensitivity of the other logistics decision areas to the demand forecasts.

*Order Processing* consists of tasks involved in starting and completing a customer's order through the production and distribution systems of the firm. Ballou (1992) includes the following activities within this decision area: order preparation, transmittal, entry, filling, and status reporting. At first glance, this decision area may hold more relevance for the planning of information systems

than for transportation planning. However, two points are important. First, a commodity in transport (or transit) is a type of inventory, about which information is needed for the filling and status-reporting activities. Second, the time involved in processing orders is a component of order-cycle time (discussed in the customer-service section below) and interacts with other components, notably delivery time. Consequently, significant measures are the importance (or uses) of having information about products and the time involved in processing orders and its mutability. Transport can also be involved directly in order transmittal, but this function will not be considered critical given the prevalence of electronic options to send and receive orders.

*Product Design/Packaging* decisions determine the dimensions, safety, and other characteristics, such as marketing appeal of the packaging, of shipments to customers. Concentrating on the physical, rather than informational, properties of the design/packaging (even where no packaging is present) or a product, it is clear that they will impact the choice of transportation characteristics and strategies. I wish to examine whether there are product-characteristics-based distinctions among different production/distribution processes. Measures of interest include the extent and importance of protecting packaging and the dimensions of the package or product.

*Customer Service* refers to decisions involved in establishing and delivering levels of firm (and product) quality to customers. Because customer service (at some level), or serving customers, is the goal of all firms, it is determined or implemented by the decisions in the areas discussed above. The objective of this decision area, however, is to establish the overall strategic objectives that will guide action in its component decision areas. Because of the comprehensive nature of customer-service decisions, determining measures to describe customer-service levels must be comprehensive as well.

La Londe (1985) mentions six key customer-service elements: product availability, order-cycle time, distribution-system flexibility, distribution-system information, distribution-system malfunction, and postsale-product support. Coyle, Bardi, and Langley, Jr. (1988) make similar observations and list time, order-cycle dependability, communication, and convenience as key dimensions of customer service. Additional listings can be found, but the important task is to determine whether different paradigms attach greater importance to particular measures either directly through explicit customer-service standards or implicitly through the policies of other decision areas.

Table 4.2 arrays the decision areas of Table 4.1 alongside their relevant measures.

### **Logistics Decisions and Performance Measures Under Two Paradigms**

I now turn to a conceptual discussion of supply-chains and the ways they are managed, maintaining the above framework but not applying it to any particular industry, which will appear below. Before doing this, I discuss categories for classification of paradigms according to the extent of coordination throughout the supply-chain. As such, this is a supply-chain based classification scheme, which may not directly correspond with the management paradigms discussed in Chapters 2 and 3.

For purposes of this chapter, I attach little importance to distinguishing between management paradigms that are focused on or driven by concerns with supply-chain performance and those that are not. Thus, the fact that a paradigm makes little explicit mention of supply chains or logistics does not prevent a determination of its logistics-related implications. This choice of classification scheme is essentially driven by the description of supply-chain management (SCM) at the beginning of this chapter, with the goal being to differentiate the key elements of SCM with those of other paradigms. Accordingly, coordinated intrafirm and interfirm logistics is the category

**TABLE 4.2**  
**PERFORMANCE MEASURES FOR LOGISTICS-DECISION AREAS**

<b>Logistics Area</b>	<b>Relevant Measures</b>
Supply-Chain Structure and Interfacing (Inbound)	-Number of channel partners and echelons
Supply-Chain Structure and Interfacing (Outbound)	-Degree of control over channel partners and echelons -Degree of interaction with channel partners and echelons
Facility Location (Inbound)	-Specific Inbound Considerations
Facility Location (Outbound)	-Specific Outbound Considerations
Purchasing	-Supplier characteristics used in selection -Product characteristics (quality, price, and specifications)
Traffic and Transportation (Inbound)	-Modes, Carriers, Routes, Logistics-Service Providers
Traffic and Transportation (Outbound)	
Inventory Management (Inbound)	-Type of Inventory System
Inventory Management (Outbound)	-Types and Levels of Inventory Held -Types and Locations of Facilities where Inventory is Held
Production Planning	-Length of Production Run -Pattern of Production
Demand Forecasting	-Demand Pattern -Importance and Sensitivity of Demand Forecasts
Order Processing	-Importance or Uses of Product Information -Order Processing Time and Its Changeability
Product Design/Packaging	-Dimensions of Package -Extent and importance of protective packaging
Customer Service	-Customer-Service Criteria

Source: The author

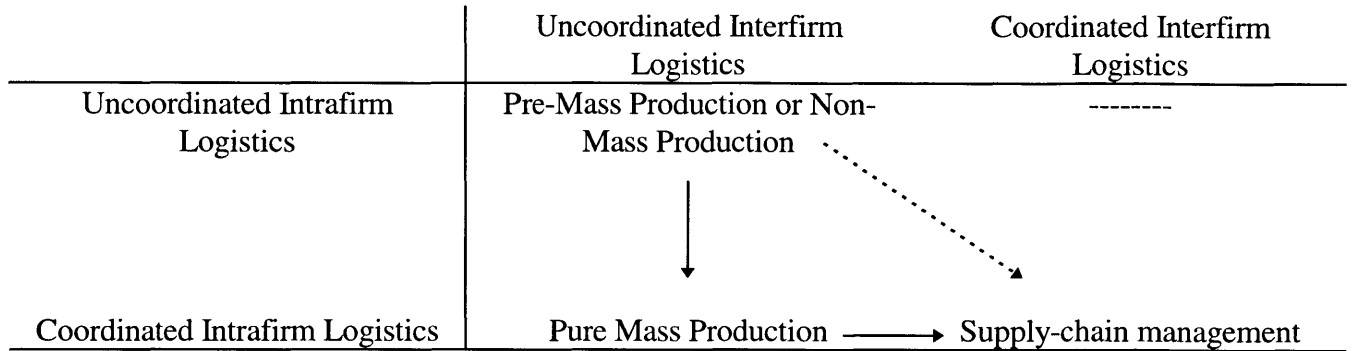


in which SCM is placed and will be examined in the next section. In this section, I jointly discuss (1) non-coordinated intrafirm logistics and non-coordinated interfirm logistics and (2) coordinated intrafirm logistics and non-coordinated interfirm logistics.

I consider these two categories by determining the decision areas and measures of Table 4.2 for both. I am interested in thinking about how the measures for each decision area change when the extent of intrafirm coordination, which refers to coordination of logistics activities with other business processes in the firm, is increased. It should be noted that I assume all factors other than increased coordination remain constant and thus do not impact decision areas and measures. The clearest example of such factors is the industry under discussion, which may alter how firms adjust to the introduction of increased coordination. I illustrate this point when I discuss the metalworking sector and examine which paradigms are at work in the sector.

At this point, it can be noted that another possible category, non-coordinated intrafirm logistics and coordinated interfirm logistics, is also possible. Poist (1986), in work describing the evolution of conceptual approaches to the design of logistics systems, labels this approach as “total channel,” wherein logistics managers look beyond the firm to maximize channel-wide objectives. Intrafirm coordination of logistics systems, in the sense of firm-level goals and strategies guiding the design of logistics systems, is seen as an evolutionary advance to the total-channel approach and is labeled the “total enterprise” approach. Interestingly, Poist does not cover a combination of these two approaches, which would essentially result in a description of SCM. Nevertheless, the important point is that the discussion below is not meant to provide a evolutionary path of logistics systems but just a tool to analyze the impacts of introducing increased coordination of logistics systems, both at the firm and interfirm levels. Figure 4.2 displays the relationships among the various paradigms.

**FIGURE 4.2**  
**Paradigm Classification Scheme**



Source: The author.

As shown in the figure, I classify mass production, where production need not refer exclusively to physical production but also to provision of services, such as finance or retail, as pertaining to the second group and pre-mass production or non-mass production (for current cases of firms that cannot achieve mass-production methods due to reasons such as size or product type) methods as the first group. The arrows are included to show the likely path a firm would follow when shifting from paradigm to paradigm.

The discussion below is derived from secondary sources, notably Chandler (1977), Womack, Jones, and Roos (1990), Best (1990), and Harrison (1994), that provide descriptions of both these paradigms. Though these descriptions are not from a logistics perspective, it is possible to derive conclusions for most of the areas of Table 4.2 based on basic principles and the interdependence among logistics and other firm functions. I begin with the planning of production found in each paradigm.

Production planning is a good place to start, because it essentially is the defining logistics-related area of mass production and drives many of the other logistics decision areas. A rather concise definition of mass production, attributed to Chandler (1977), is the establishment (or use) of technological and organizational innovation, which collectively were responsible for a high rate of

throughput and permitted a small labor force to produce a “massive” output. This high rate of throughput made possible economies of scale not only in production but also in purchasing and distribution. Pre- or non-mass production, on the other hand, is characterized by low volume and speed of production, which together define a low rate of product throughput. Hence, as Chandler (1977) points out, the key is not an increased volume but the speed at which this increased volume is produced. Because of the large capital investment required for this throughput, it is important to maintain as much continuity in the flow of production as possible in order to utilize assets and inputs as fully as possible. This continuity can also be an objective in a pre- or non-mass production setting, but it is not a strict requirement.

Demand forecasting and the more general task of collecting and analyzing data are much more critical to mass-production firms. This is the case because of the need to coordinate the internal functions necessary to produce a high and continuous product flow. Demand forecasting also is important when the holding of inventory is a significant element of assuring reliable supplies, as is the case with mass-production firms.

Order processing is also a decision area that relies on information. Mass-production firms, mostly because of their size, are more likely to have formal management structures to handle this function and, consequently, may attach greater importance to acquiring information. However, this conclusion is not strong, because, as discussed below, mass-production firms usually hold safety buffers to assure adequate delivery of products. In terms of order-processing time, though firms in both paradigms would approve of increased efficiencies in order-processing time, it is not the key goal for firms in either paradigm.

A high rate of throughput also requires an increased level of coordination of the mass-production supply chain, which, in turn, leads to a desire to reduce the number of tiers or

middlemen in the supply chain. This coordination was obtained not by increasing coordination among the firm and existing partners, but by internalizing many functions that were previously left to market transactions and increasing the coordination among these functions. Pre- or non-mass production supply chains have a greater number of tiers, but not necessarily a greater number of supply-chain participants. This statement holds because of (1) these firms' greater dependence on market and price mechanisms than on internal management or integration to manage their supply-chain relationships, (2) the inability to manage a large number of customers or suppliers, which is traced to lack of an organizational structure to conduct this function, and (3) these firms' smaller production volumes. Consequently, mass-production firms require, and are more able to exert, greater control over supply-chain partners. Finally, no clear difference is seen between the two paradigms in terms of the degree or quality of interaction among companies, and the previous statements hold for both the inbound and outbound sides.

Increased coordination of the supply chain through internalization necessitates use of internal management of functions. Purchasing is one such function. Mass-production firms feature formal purchasing organizations in order to assure a continuous and reliable flow of supplies. Consequently, they are more likely to use formal criteria or similar evaluation procedures to select suppliers and are more able to monitor suppliers' performance. The specifics of these criteria will depend on the characteristics of the products or industry, but reliability of delivery will be dominant. Reliability is, clearly, also important to non- or pre-mass production firms, but these firms pay (or are able to pay) less attention to investigating sources of supply instead relying more than mass-production firms on market and price mechanisms.

One way to assure a consistent and reliable flow of supplies is to build storage facilities and maintain inventory. Mass-production firms rely on large inventories of supplies to assure

continuity in production. Non- or pre-mass production firms do not need to hold large inventories in this capacity because their production volumes are lower, which, in turn, reduces the necessity of a continuous flow of supplies. Of course, there are other reasons to maintain inventory, but the holding of buffer stock is a key difference between the paradigms.

Facility location decisions can also influence the ability of firms to assure reliable sources of supply. Co-location with suppliers (or customers) is an alternative to carrying large inventory levels. Mass production firms, with their extensive managerial and organizational resources, are in a better position to evaluate locational options but are more restricted in their locational choices because of the focus on continuous flow and the size of operations. Moreover, the size of operations affects the number of locations (production and distribution, including stocking). Non- or pre-mass production firms, on the other hand are more flexible in their locational choices but may not conduct formal facility-location analyses. It is important to note, however, that facility-location decisions involve a great number of considerations that are unrelated or only indirectly related to the way logistics functions are managed.

Customer-service elements can be similar for both paradigms, but mass production firms, because of their internalization of many marketing and distribution functions, have greater control in establishing and maintaining customer-service elements, both pre- and post-sale. Moreover, if one thinks of customer service as the inverse of purchasing—in the sense of one firm's customer-service levels being another firm's purchasing decisions—non or pre-mass production firms' customer-service elements may not be controllable or may be dictated by the purchasing needs of other firms. In sum, the ability and desire to establish certain customer-service elements differ for firms operating in each paradigm.

Outside of the product design/packaging function, which mostly depends on product or industry characteristics but can influence the rate of throughput, traffic and transportation is the only decision area not yet discussed. For mass-production firms, the focus on a high rate of throughput points to the importance of fast and reliable transport. The costs of not having such transport are great, so much that without it, mass production is just not possible. In addition, the higher production volume found in mass production points to larger shipment sizes (and thus the ability to take advantage of volume discounts) and overall greater use of transport, which is augmented due to mass-production firms ability to receive supplies and serve markets across greater distances. I discuss the traffic and transportation area in detail in Chapter 5.

### **Logistics Decisions and Performance Measures Under a Changed Paradigm** ...

Supply-chain management represents a departure from both paradigms described above, more from pre- or non-mass production. SCM is an extension of intrafirm coordination to the supply chain. Given a large enough firm that controls much of its supply chain, one can, with few differences, also think of SCM at the firm level (Hewitt, 1994). Also, though the literature on SCM is not as extensive or organized as that of mass production, analysts, when documenting SCM efforts, have focused possibly entirely—exceptions may exist—on large firms (e.g., Scott and Westbrook, 1991; Davis, 1993; Abernathy, Dunlop, Hammond, and Weil, 1995). These firms feature or featured many, if not all, of the characteristics discussed above. Hence, as shown by the arrows in Figure 4.2, SCM is a direct extension of mass production, while the path from non- or pre-mass production to SCM is indirect. In general, non- or pre-mass production firms are seen as unable or unwilling to implement SCM, unless some sort of internal coordination and control functions are established or the complexity of their operations makes such functions viable and SCM beneficial. Of course, this is not to say that these firms cannot improve the efficiency of their

logistics activities, which is clearly possible. In addition, though these firms may not initiate or lead SCM efforts, they can clearly be a player, in terms of a supplier or customer to lead firms or firms facing SCM efforts from competitors. Consequently, SCM has the potential to involve a large number of firms with different ways of managing their own logistics operations. Finally, the discussion below includes nothing about the costs, steps, and difficulty involved in implementing SCM, which, like the benefits made possible, can be substantial (Byrnes and Shapiro, 1991).

The conceptual discussion below, which describes SCM in terms of Table 4.2, is derived from an eclectic group of studies. A recent review of the literature shows that a single conceptualization of SCM in terms of economic or management theory is still not available (Franciose, 1995). SCM is a relatively new (compared to discussions of mass production and other management processes, such as just-in-time manufacturing or total quality management) but expanding area in terms of research and analyses. As a possible reason, analysts have viewed the broad perspective and coverage of SCM as obstacles to study (Ellram, 1991). The conceptualization and organization or ideas provided below is not meant to be complete or definitive but to serve the objectives of this study.

Given the initial principle that SCM involves coordination of logistics functions throughout the supply chain as a single process rather than a collection of distinct processes, supply-chain structure and interfacing (inbound and outbound) is the defining logistics-decision area. SCM requires contractual (or binding, in some form) cooperation of chain participants to achieve common goals (Ellram, 1991). The degree of control (usually by a chain leader, who commits managerial and financial resources to the successful implementation of SCM) is greater than the market transactions prevalent in non- or pre-mass production, but less than if internalized within a mass-production environment, though clearly greater than mass-production interfirm relationships.

Consequently, the management efforts involved with this increased level of control motivate a reduction in the number of tiers and participants in the supply chain. Finally, a reduced number of partners and tiers is associated with increased interaction, in terms of closer relationships among chain participants. This increased interaction, which, as described below, takes a number of forms across different logistics areas, brings a number of possible benefits to firms. Such benefits may include (but are not limited to) reduced operating costs for the supplier, customer, and the entire chain, lower inventory levels, lower labor and capital expenditures, more accurate demand forecasts, lower supply prices and overall improved customer service (Byrnes and Shapiro, 1991).

Improved and greater information flows is a key characteristic of SCM, more than in other paradigms. Better information counteracts uncertainty, which is a major problem in the management of supply chains, especially where these chains have become increasingly complex (Davis, 1993). One such flow is reliable information, such as accurate lead-time data concerning availability of supplies. Another is accurate demand forecasts, which then drive production, inventory, purchasing, and other decisions. More accurate demand forecasts are made possible by the sharing of information among customers and their suppliers.

Improvements in production planning are directly tied to the improved quality of demand forecasts and closer intercompany operating ties. Production runs are smoother, thereby improving asset utilization. The smoothing of production, through, for example, the selection of particular customers or markets to serve or the serving of certain portions of a customer base with differently organized supply chains, can also be an end in itself, which essentially results in a reduced dependence on demand forecasts. Finally, SCM (involving suppliers, customers, and carriers) facilitates the adoption of flexible production techniques, which are important in mass production



settings (Womack, Jones, and Roos, 1990). These techniques produce small lot sizes and require short setup times and, usually, adjustments to plant layout (Levine and Luck, 1994).

Not surprisingly, better and closer information flows between firms influences the order processing function. Increased coordination among firms has benefits in terms of lower order-processing costs because of reductions in purchase orders, receiving orders, inspection duties, payment transactions, and sales calls (Landeros and Monczka, 1989). Given enough coordination, ordering costs can be virtually eliminated. Moreover, though any firm, not only those involved in SCM, can improve the quality of their order processing function (Shapiro, Rangan, and Sviokla, 1992), such improvements are crucial to the success of SCM. Increased interaction among suppliers and customers implies a certain dependence and thus requires accurate processing of orders.

Given the above descriptions of interfirm relationships, selection and management of suppliers becomes critical. Firms need to evaluate potential suppliers in light of the requirements of closer and stronger interfirm relationships. Purchasing analyses need to be expanded to consider joint analyses among firms (Cavinato, 1991). Whereas traditional purchasing analyses (as used, for example, in mass-production settings) consist of make/buy comparisons, where the cost of producing supplies in-house is compared to the price of purchasing supplies from outside firms, SCM compares the costs and quality impacts of producing inputs at firms (Burt, 1989). Not surprisingly, a good deal of trust and quality in relationships are needed to assure access to these data. Thus, purchasing decisions need to be expanded to consider a larger, more detailed and complex set of supplier characteristics than in previous paradigms. This expansion may even include the consideration of the characteristics of lower-tier suppliers and their compatibility with SCM objectives. In addition to more detailed analysis, SCM often involves financial

considerations to suppliers (possibly at different tiers), such as purchase guarantees, and the sharing or provision of assets, including technology and research and development, specific to the supplier-customer relationship and of risks, such as when entering new product or geographical markets. Such considerations help establish the strength of relationships, which is necessary for the sharing of information.

Improving or maximizing customer service can (or should) be considered the ultimate objective of any firms' strategy and operations. For SCM, however, improving customer service while reducing costs is the motivating objective and directs the particular strategies implemented. More importantly, improvement in customer-service levels through SCM originates with logistics, which is a relatively new and previously neglected functional area in achieving improved customer service (Sharman, 1984). Logistics-related customer-service improvements made possible by SCM can be classified into four categories: (1) lower costs, which are made possible by changes in other logistics areas, as well as through more efficient provision of customer-service, (2) greater reliability and consistency in customer-service levels and, thus, less rework and rejected shipments (Stalk, Evans, and Shulman, 1992) (3) tailored customer-service levels based on chain characteristics (Fuller, O'Connor, and Rawlinson, 1993), which also impacts a firm's supply side by allocating assets more efficiently, and (4) reduction in cycle-time for both product delivery and development (Stalk, 1988).

Inventory management is another critical decision area. Early analysts' definitions of SCM concentrated on the management of inventory throughout the supply chain (Jones and Riley, 1985). In essence, better information flows among chain participants result in the holding of inventory at locations that are optimal for the chain, rather than for the specific firms involved. Also, optimal levels are interpreted differently in SCM. Inventories are used to make the supply chain more

efficient rather than hide inefficiencies. A prominent example of this is the use of postponement, either on the supplier or customer side of production. Postponement is the holding of inventory (or the postponement of production) at certain places in the supply chain whereby flexibility, and thus the ability to respond to demand changes, is increased. Also, postponement at the supply-chain level can be motivated by the desire of holding inventory at lower levels of value added, which not only increases flexibility but reduces inventory holding costs. Finally, postponement may have scale-economy benefits, resulting in reduced packing needs and shipping costs (Davis, 1993).

Though it is clear that the firm initiating SCM efforts benefit in terms of reduced inventory levels and costs, it is unclear whether this is the case for all firms in the supply chain. Thus, it is important to have quality relationships among suppliers and customers. Reduced inventories at the chain level are possible by providing better matches between suppliers and customers, thus reducing the amount of stock needed to account for uncertainty. Better information permits the pulling (demand-side) of inventories—just-in-time (JIT) manufacturing features a pull system—through the chain rather than using push (supply-side) systems that move inventory from production to distribution, as found in mass production and other settings. Push systems can still be used in SCM because of better information flows and suppliers' financial commitments to customers to counteract negative impacts of supply-demand differences. The increased flexibility gained by improved inventory management among firms may result in shorter, more frequent shipments and thus increased transportation costs (Cooke, 1992).

Facility location decisions clearly involve a large number of factors, but a SCM focus requires that logistics-related factors be given greater weight than in non-SCM analyses. The focus on controlling costs, chief of which are inventory-related, while improving reliability and quality of interaction among suppliers and customers, makes logistics a key consideration. Consequently, the

importance of reducing inventory requirements implies a lower number of stocking points and thus greater consolidation of shipments. On the other hand, greater interaction among customers and suppliers is facilitated by reduced distance—suppliers may even locate within customers' plants—and thus an increased number of stocking points and other facilities. Taken together, analyses will point to a preference for certain locations that support greater and more complex logistical demands.

As discussed in the previous paradigms, product design and packaging decisions are largely influenced by a great number of factors that are not directly related to the objectives of this study. Thus, even though SCM may place added emphasis on reliable product delivery, for some products in certain industries, such as for dies produced by metalworking firms, protective packaging is not relevant. Nevertheless, the emphasis of SCM on customer-service improvements through logistics elevates the importance of this decision area compared to the previous two paradigms. This importance is seen through the interactions between product design/packaging decisions and the functioning of the other logistics areas (Davis, 1993). Thus, in addition to ensuring safe delivery through protective packaging, a focus on reducing lead time may result in an emphasis on designing products or packaging to improve the interface between materials handling and transportation (i.e., loading/unloading) within a plant or facility, which may involve cooperation or intercompany operating ties among firms and carriers.

Given the increased interaction among firms that is necessary for SCM, it would seem logical that the traffic and transportation area would play important indirect (by influencing other logistics functions) and direct (by involving carriers as partners in SCM) roles and thus be a focal point for study. With few exceptions (e.g., Bowersox, 1990), analysis and documentation of this area, however, appears to be more limited than for most of the other logistics functions discussed

above. More recently, analysts have attempted to include and analyze the carrier as an additional participant to customer and suppliers in the supply chain (Carter and Ferrin, 1995; Gentry, 1995). This inclusion can take a number of forms including increased quality emphasis by carriers, cooperation and concessions to accommodate customers' needs, such as more frequent and smaller shipments and more flexible delivery/pickup schedules, and cooperation on cost- and risk-reduction programs. According to these analysts, inclusion of the carrier in SCM had a number of benefits including reduced costs (inventory, administrative, and capital) for all participants and thus for the supply chain, attainment and maintenance of improved supply quality and customer-service levels, reduction in total cycle time, and improved operating performance of carriers. Such benefits are not surprising given the interdependence of the logistics functions. Thus, not only direct impacts, but also indirect impacts of transport should be considered in some form. In addition, impacts should be considered when the carrier is not explicitly included in SCM efforts. In the next chapter, I establish a framework to examine this interdependence and the impacts, and in Chapter 5, I apply this framework to SCM.

Table 4.3, on the next couple of pages, synthesizes the above discussion and highlights important points of, and differences among, the three paradigms. The table should be read from left to right, consistent with the arrows of Figure 4.2, in order to highlight the various shifts in decision areas from one paradigm to the other. Included in the table is a determination of a defining area for each paradigm: facility location for pre- or non-mass production firms, production planning for mass-production firms, and supply-chain structure and interfacing for supply-chain-management firms. Though paradigms are described and determined by a set, if not all, of the decision areas, the defining decision area tends to dominate and provides initial insights into how policymakers should consider establishing and evaluating transportation policy depending on which paradigm is of

**TABLE 4.3**  
**SUPPLY-CHAIN PARADIGMS**

Decision Area	Pre- or Non-Mass Production	Mass Production	Supply-Chain Management
Supply-Chain Structure and Interfacing (Inbound and Outbound)	<ul style="list-style-type: none"> <li>-Simple structure</li> <li>-Small number of fewer tiers and supply-chain partners.</li> <li>-Little or no control over partners.</li> <li>-Can have high or low degree of interaction.</li> </ul>	<ul style="list-style-type: none"> <li>-Complex structure</li> <li>-Large number of partners and tiers</li> <li>-Internalize tiers and partners to increase control</li> <li>-Can have high or low degree of interaction, but low dominates.</li> </ul>	<p><b>Defining Area</b></p> <ul style="list-style-type: none"> <li>-Desire to simplify and manage; reduce number of tiers and partners</li> <li>-High degree of interaction and dependence among supply-chain partners</li> </ul>
Facility Location (Inbound and Outbound)	<p><b>Defining Area</b></p> <ul style="list-style-type: none"> <li>-Can usually select location but does not conduct formal analyses; work within local conditions</li> </ul>	<ul style="list-style-type: none"> <li>-More restricted in locational choices, but will consider formal analyses</li> <li>-Variety of criteria used in location analysis</li> </ul>	<ul style="list-style-type: none"> <li>-Logistics-related factors more critical in locational choices.</li> </ul>
Purchasing	<ul style="list-style-type: none"> <li>-Simple or No formal system used in supplier selection</li> </ul>	<ul style="list-style-type: none"> <li>-Formal purchasing organizations and use of formal criteria</li> <li>-Analysis of input costs is key.</li> </ul>	<ul style="list-style-type: none"> <li>-Evaluation of suppliers is critical</li> <li>-Trust, quality, and compatibility in relationships used in evaluation in addition to costs.</li> </ul>
Traffic and Transportation (Inbound and Outbound)	<ul style="list-style-type: none"> <li>-Basic transportation needs.</li> <li>-Small shipment size.</li> </ul>	<ul style="list-style-type: none"> <li>-Fast and regular transport</li> <li>-Larger shipment size and overall greater use of transport.</li> </ul>	<ul style="list-style-type: none"> <li>-Carrier as key player in management and operations of logistics activities.</li> <li>-Greater sensitivity of logistics activities to transport.</li> </ul>

**TABLE 4.3 (continued)**  
**SUPPLY-CHAIN PARADIGMS**

Decision Area	Pre- or Non-Mass Production	Mass Production	Supply-Chain Management
Inventory Management (Inbound and Outbound)	-Low inventories	-High inventories -Inventories used as buffer to maintain throughput.	-Minimal inventories at supply-chain level -Inventories used as efficiency tool.
Production Planning	-Low throughput of production.	<b>Defining Area</b> -Long runs and high rate of throughput.	-Emphasis on smoothing of production -Maintain flexibility in system to respond to customer needs.
Demand Forecasting	-Demand pattern can be steady or erratic -Demand forecasts not used or important.	-Demand pattern can be steady or erratic -Demand forecasts can be an important informational component.	-Attempt to control demand pattern as steady and consistent. -Reduced dependence on accuracy of demand forecasts.
Order Processing	-Information on customer orders not important. -Order processing time not critical.	-More importance attached to order information. -Order processing time and function receive formalized attention.	-Critical to have access to information concerning customers orders -Quality and efficiency of order processing is important.
Product Design/Packaging	-No significant requirements; product-based.	-No significant requirements; product-based.	-No significant requirements, but greater emphasis on safety of shipment and interface with other logistics areas.
Customer Service	-Not necessarily limited in selection of customer-service elements	-Greater control with establishing customer-service elements and standards.	-Extreme focus on tailoring service levels to customers' needs.

Source: The author.

interest. The local orientation of pre- or non-mass production firms points to a focus on evaluation of local investments and policies in terms of both internal efficiency and more regional connections. For mass production, speed and volume, as well as a degree of reliability, of transportation services are important. Finally, for SCM, reliability is critical, but a more complex understanding of transport is necessary because of the importance of establishing quality relationships among supply-chain partners. The development of this understanding is the focus of the next two chapters.

### **AN ILLUSTRATION OF SUPPLY CHAINS: THE CASE OF CHICAGO'S METALWORKING SECTOR**

Before proceeding with an illustration of supply chains and an industry application of the above framework, I provide a brief background on the study of the metalworking sector in Chicago, which (has been) and will be referred to throughout this study. The work discussed here is only one portion of the larger study (Polenske, McCormick, Pereira, and Rockler, 1996) conducted by the Multiregional Planning Group (MRPG) at the Massachusetts Institute of Technology (MIT), that investigated the interconnections among metalworkers, their customers and suppliers, and the labor force. In particular, the study examined these interconnections in light of pressures and actual instances of restructuring faced by metalworking firms and how various support institutions, both private-sector, such as trade associations, and public-sector, such as infrastructure providers, could assist these firms within the Chicago region.

In that study, the metalworking sector was defined to include various standard industrial classification (SIC) sectors at the four-digit level, mostly in SIC 34, Fabricated Metal Products, but also including sub-sectors of SIC 35, Industrial machinery and related products and a few other selected sectors. Table 4.4, on the next page, lists the sectors used in the study universe by their 3-digit SIC codes. A mail survey, which provides most of the data for this section as well as part of



the next chapter, was conducted from a sample of the 6,575—obtained from a composite industry directory—found in the Illinois portion of the Chicago metropolitan statistical area. The median firm-size of this sample was 10 employees per establishment, with firms having more than 10 employees being classified as large and those with fewer than 10 being classified as small. This value was then used, along with firm location (inside and outside Cook County, which was used to represent the urban core), to stratify the sample into four firm-size/location groups: (1) Cook County/large firms, which accounted for 27% of the mail-survey responses, (2) Cook/small, 26%, (3) Outside Cook/large, 24%, and (4) Outside Cook/small, 23%. This stratification provided approximately the same number of firms in each of the four groups and allowed us to examine various hypotheses according to size of firm, such as differences in management strategies, and location, such as differences in quality of transportation services.

Using Figure 4.1 as a template and the results of the survey instrument, a profile of the industry from a supply-chain perspective is possible. Figure 4.1 can be split into three tiers: (1) a production tier, (2) a supplier tier, and a (3) a customer tier. Also, there is the set of transport connections among the tiers. In this section, I discuss these tiers and their connections and conclude with comments concerning transportation choices based on this initial look at metalworking-sector supply chains.

### **Production Tier**

The production tier consists of all facilities involved in the production of metalworking products, including all facilities where work is produced or stored in anticipation of production or delivery. A great variety of metalworking products, and, potentially, in the production and distribution processes of these firms, is featured in the industry. Table 4.5 displays the distribution of firms according to their three-digit SIC codes that responded to the mail survey.

**TABLE 4.4**  
**SIC-Code Definition for the Metalworking Sector**

3-Digit Code	Description
Metalworking	
339	Miscellaneous Primary Metal Products
341	Metal Cans and Shipping Containers
342	Cutlery, Handtools, and General Hardware
343	Heating Equipment, Except Electric and Warm Air; and Plumbing Fixtures.
344	Fabricated Structural Metal Products
345	Screw Machine Products, and Bolts, Nuts, Screws, Rivets, and Washers
346	Metal Forgings and Stampings
347	Coating, Engraving, and Allied Services
348	Ordnance and Accessories
349	Miscellaneous Fabricated Metal Products
Machinery	
351	Engines and Turbines
354	Metalworking Machinery and Equipment
355	Special Industry Machinery, Except Metalworking Machinery
356	General Industrial Machinery and Equipment
358	Refrigeration and Service Industry Machinery
359	Miscellaneous Industrial and Commercial Machinery and Equipment
Other	
371	Transportation Equipment and Motor Vehicle Equipment
391	Jewelry, Silverware, and Plated Ware

Source: Polenske, McCormick, Pereira, and Rockler, 1996.

**TABLE 4.5**  
**DISTRIBUTION OF SURVEY RESPONDENTS BY**  
**STANDARD INDUSTRIAL CLASSIFICATION (SIC) CODES**

SIC	Number of Firms	SIC	Number of Firms	SIC	Number of Firms
342	1	347	9	356	11
344	9	349	8	358	2
345	6	354	27	359	18
346	5	355	4	<b>TOTAL</b>	<b>100</b>

Source: MIT-MRPG, Chicago Area Survey, 1996

Despite the differences implied by such a listing, the industry is similar enough in many logistics-related aspects to permit categorization into a small number of different supply chains. At the level of detail of this section, there are a number of similarities.

Turning to issues of tier structure, for almost all firms in the metalworking sector, the survey results and detailed interviews indicate that, the production tier consists of a single facility. Only 12% of the survey respondents had additional plants: five percent had additional plants within the Chicago metropolitan area with an average of 1.8 additional plants, and seven percent had additional plants outside the Chicago area with an average of 4.8 additional plants, declining to 2.25 with the removal of a significant outlier.

In terms of inventory facilities, though such definitive statements concerning the number of additional facilities are not possible, there are similar conclusions (Table 4.6). Based on these results, no inventory is held outside of the state of Illinois and the great majority is held within the Chicago metropolitan area. Whether this inventory is held in facilities other than the plant of a particular firm is not observable based on data from the survey; however, it is unlikely that inventory is held in separate facilities. Based on detailed interviews of 13 of the survey

respondents, which are described and largely used in the next section, only one indicated an inventory location other than at the plant and this firm can be considered an outlier in terms of its size.

**TABLE 4.6**  
**INVENTORY LOCATION, 1994**

	Raw Material	Work-in-Progress	Finished Goods
Blank Response or Not Applicable	54%	54%	60%
Local (within Chicago Metropolitan Area)	41%	41%	35%
Rest of Illinois	5%	5%	5%
Outside of Illinois	0%	0%	0%
<b>TOTAL</b>	<b>100</b>	<b>100</b>	<b>100</b>

Source: MIT-MRPG, Chicago Area Survey, 1996

Also indicated by the interviews, inventory appears not to be a great concern to a number of metalworking firms. This is also borne out by the high percentage of firms that either did not respond to the survey question or responded that the question was not applicable. Whatever the reasons for and the effects of this disinterest in inventory management, to be discussed in later sections, it does support the contention that inventory is held only at the plant for a great majority of metalworking firms.

Given these findings, the structure of the production tier in the metalworking sector appears simple. There appears to be little occurrence of intracompany flows among spatially separate facilities of a single firm. Transport connections are thus only relevant to connecting the production tier to suppliers and customers.

### **Supplier Tier**

The supplier tier consists of all suppliers to the metalworking industry. Ideally, this set would include all suppliers backward to the raw-materials source. For this study, however, I examined only direct suppliers. Metalworking firms were asked to list their top three product inputs in terms of value. Table 4.7, on the next page, shows the industry's supplies in terms of the times each was mentioned as the top, second-largest, or third-largest product input. The numbers in the table may not add to 100 because some firms either did not respond or gave two or more responses.

Table 4.7 clearly shows that steel is, by far, the biggest product input of the metalworking sector, being the top supply for 37% of those firms responding. Taking metals (classified in the table with an "M") together, this percentage rises to 63. This dependence is not only important in and of itself but also because of the differing characteristics of the metal-supplying firms. In particular, the large size of these firms has led many metalworking firms (the percentage is not known) to obtain their metal products from distributors, thus adding an additional sub-tier (and cost). The table also shows the intraindustry shipment of products among metalworking firms. Metalworking products (classified in the table with an "MW") were the top supply for 21% of metalworking firms and the second-largest supply for 36% of firms.

Another important piece of information about the supplier tier is the origin of supplies, which provides an idea of the "length" of the transport connections between tiers. Table 4.8 shows the origin of supplies for the metalworking industry.

**TABLE 4.7**  
**METALWORKING SUPPLIES, 1994**

Product Input	Ranked Use by Firm			Product Input	Ranked Use by Firm		
	1st	2nd	3rd		1st	2nd	3rd
Steel (M)	32	19	11	Chicago Tube Iron	0	1	0
Aluminum (M)	6	3	4	Control systems	0	1	0
Metal (M)	5	1	1	Combustion Cont.	0	1	0
Stainless Steel (M)	4	1	0	Components	0	1	0
Brass (M)	3	3	0	Cutting Tools (MW)	0	1	0
Chemicals	3	1	1	Fixtures-Prototypes (MW)	0	1	0
Machined Parts (MW)	3	0	0	Friction Material	0	1	0
Tools/Tooling (MW)	2	9	5	Grinding Wheels (MW)	0	1	0
Molds/Mold Parts (MW)	2	1	3	Hydraulic Parts	0	1	0
Material	2	2	2	Mold Polishing (MW)	0	1	0
Heat Treating (MW)	1	4	4	Polishing Compounds	0	1	0
Tool Steel (M)	1	3	0	Powder Coat	0	1	0
Copper (M)	1	2	3	Precision Assemblies (MW)	0	1	0
Motors (MW)	1	2	2	Prefinished Steel (M)	0	1	0
Pipe & Pipe Fittings (MW)	1	1	2	Compressors (MW)	0	1	0
Screen (MW)	1	1	0	Rivets (MW)	0	1	0
Valves (MW)	1	1	0	Rubber Lining	0	1	0
Die Sets (MW)	1	1	0	Packaging/Boxing	0	0	3
Electronics	1	1	0	Beryllium Copper	0	0	1
Natural Gas	1	1	0	Blades	0	0	1
Cutting Oil	1	0	1	Chromium	0	0	1
Machining (MW)	1	0	1	Color Dyes	0	0	1
Aluminum Casting	1	0	0	Die sinking (MW)	0	0	1
Electricity	1	0	0	Downspouts (MW)	0	0	1
Fabricated Sheet Metal (M)	1	0	0	Evaporators (MW)	0	0	1
Galvanized Steel (M)	1	0	0	Expendable Supplies	0	0	1
Glass	1	0	0	Finishing (MW)	0	0	1
Grinding (MW)	1	0	0	Heating elements	0	0	1
Lathe (MW)	1	0	0	Industrial Supply	0	0	1
Machine Shop Work (MW)	1	0	0	Jig grinding (MW)	0	0	1
Metal Tanks (MW)	1	0	0	Machinery (MW)	0	0	1
Refractory	1	0	0	Machines for Resale	0	0	1
Tin (M)	1	0	0	Manufacturing Supplies	0	0	1
Welding Supplies	1	0	0	Patio Door	0	0	1
Wire	1	0	0	Plastic	0	0	1
Hardware	0	1	2	Plating (MW)	0	0	1
Bearings (MW)	0	1	1	Precision Fabricated Parts (MW)	0	0	1
Castings (MW)	0	1	1	Pumps (MW)	0	0	1
Coatings	0	1	1	Punches (MW)	0	0	1
Paint	0	1	1	Seals	0	0	1
Shop Supplies	0	1	1	Shearing & Forming (MW)	0	0	1
Alum. Hanger mail	0	1	0	Silver Solder & Flux	0	0	1
Aluminum Extrusions	0	1	0	Straps	0	0	1
Bearings sleeves (MW)	0	1	0	Teflons	0	0	1
Clamps (MW)	0	1	0	Tooling Supplies	0	0	1
Contacts	0	1	0	Uniforms	0	0	1
Carbide	0	1	0	Washers (MW)	0	0	1

Source: MIT/MRPG, Chicago Area Survey, 1996; (M) =Metals; (MW) = Metalworking

**TABLE 4.8**  
**ORIGIN OF SUPPLIES, 1994**

% City of Chicago	% Rest of Metro Area <sup>*</sup>	% Midwest U.S. <sup>**</sup>	%Rest of U.S.	% Canada	% Mexico	% Rest of World
26.4 <sup>a</sup>	27.5 <sup>a</sup>	22.7 <sup>a</sup>	22.0 <sup>a</sup>	0.7 <sup>a</sup>	0.0 <sup>a</sup>	0.7 <sup>a</sup>
28.5	39.6	16.2	11.7	1.0	0.1	2.9

<sup>\*</sup> refers to non-Chicago portion of Cook county and DuPage, Grundy, Kane, Kendall, McHenry, and Will counties.

<sup>\*\*</sup> includes Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.

<sup>a</sup>weighted by firms' 1994 employment data; the second line contains the unweighted values.

Source: MIT-MRPG, Chicago Area Study, 1996

The top set of percentages has been weighted using firms' 1994 employment figures, assuming that shipments are related to employment size. The bottom row shows the unweighted values, taking the average for the industry as a whole and assuming equal shipment volumes for each firm. I use the top set of percentages, because they better capture the real differences among large and small firms. Overall, supplies are purchased from relatively local sources. Over half (54%) of all supplies were shipped from within the Chicago metropolitan area, and over three-fourths (77%) were shipped from the Midwest. The non-U.S. share of shipments to metalworking is small (about 1.4% of total shipments). Basically, this geographical distribution can be partly explained by the fact that the major supply to metalworking is a commodity product that can be purchased from anywhere with little noticeable decline in quality. Thus, firms may just be selecting close suppliers to save on transport costs. As will be seen, however, there are additional reasons for preference of local suppliers.

### Customer Tier

The customer tier is defined as all firms that purchase or utilize metalworking products. As with the supplier tier, ideally, all consumers including the final consumer would be included, but

only direct customers were provided by survey respondents. The reader should note, however, that metalworking firms do sell to firms, such as machinery producers and distributors, who then sell to the final user. Thus, some chains do feature an extra tier between metalworking companies and final users. The products shipped to these customers consist, on an industry basis, of a wide range of products, reflected in the SIC listing of Table 4.5. Table 4.9 shows the destination of products for the industry.

The same comments regarding Table 4.8 also apply to Table 4.9. In this case, however, there are more pronounced differences between the two weighting schemes. Overall, the shipment pattern to customers becomes more dispersed when weighted for size of firm (number of employees). In contrast to the inbound side, metalworking firms ship over a wide area. Only 28% of metalworking products are shipped within the Chicago metropolitan area. This figure includes the intraindustry purchase pattern seen in Table 4.7. A majority of metalworking sales (59%) are to firms located outside the Midwest, with nearly one-sixth of this percentage (9%) going to firms outside the United States. Hence, the industry is selling over a fairly wide market area.

**TABLE 4.9  
DESTINATION OF PRODUCTS, 1994**

% City of Chicago	% Rest of Metro Area *	% Midwest U.S. **	%Rest of U.S.	% Canada	% Mexico	% Rest of World
10.2 <sup>a</sup>	16.9 <sup>a</sup>	13.8 <sup>a</sup>	50.4 <sup>a</sup>	2.6 <sup>a</sup>	1.1 <sup>a</sup>	5.0 <sup>a</sup>
17.5	35.7	13.7	29.8	1.4	0.6	1.3

\* refers to non-Chicago portion of Cook county and DuPage, Grundy, Kane, Kendall, McHenry, and Will counties.

\*\* includes Illinois, Indiana, Iowa, Kentucky, Michigan, Minnesota, Missouri, Ohio, and Wisconsin

<sup>a</sup>weighted by firms' 1994 employment data; the second line contains the unweighted values.

Source: MIT-MRPG, Chicago Area Study, 1996



Also complicating the analysis of the customer tier is the number of customers metalworking firms service. Not surprisingly, given the differences among metalworking products, there are significant differences in the customer base for firms. Instead of giving an average customer-base size, Table 4.10, on the next page, shows the frequency of customer-base size for survey respondents.

As shown in the table, over 1/3 (36%) of the firms have extensive customer bases, servicing more than 100 customers; nearly one-quarter (23%) service more than 200 customers. On the other hand, almost 20% have a customer base of less than or equal to 10, and almost half (48%) have 50 or fewer customers. Thus, no general conclusion for the industry is feasible. Some firms feature a smaller customer base, which, generally, is easier to manage and more conducive to closer, more collaborative relationships, and other firms feature much larger customer bases. Though a smaller, more intense customer base appears advantageous, the size of customer bases may not be controllable for some product lines. I return to this point in the later discussion.

**TABLE 4.10  
NUMBER OF CUSTOMERS, 1994**

Size of Customer Base	Metalworking Firms	
	Number	Percentage
Less than or equal to 10	15	18%
11 to 50	25	30%
51 to 100	13	16%
101 to 200	11	13%
201 to 500	11	13%
Greater than 500	8	10%
Total	83	100%

Source: MIT/MRPG, Chicago Area Study, 1996

### Transport Among the Tiers

The above descriptions of the three major supply-chain tiers of the metalworking sector in Chicago provide a background in which to investigate the transportation choices of these firms.

Table 4.11 describes how metalworking firms receive their three largest (value of shipment) product inputs and ship their three largest (value of shipment) products to customers. As can be seen in the table, motor carriage is clearly the dominant mode, accounting for over 95% of the mode choice for firms' top three shipped product inputs or products; the remainder was split into air, ship, and intermodal choices. Though some firms probably use or sell more than three products, it is safe to assume that the lower quantities of these products would probably also result in truck as the mode choice. Breaking down motor carriage, we see that LTL is more prevalent on the outbound than on the inbound side. This is not surprising given the general, commodity-nature of the inbound product, which frequently is steel or some other metal, versus the more differentiable nature of product outputs, such as found in the custom production of many tool and die and machining firms.

There are also distinctions between the inbound and outbound sides in terms of which party provides the transport. The inbound side is dominated by supplier-provided transport. This result is probably due to a greater ability in terms of operating fleets of supplying firms, such as metal distributors. Conversely, except for the third-largest product output, self-transport by firms is the favored option for the outbound shipments. This result is probably due to the desire (and ability due to the small size and destination of shipment) of firms to exert control over the transport of products that are either high-value or under tight delivery-time or -service conditions. The use of self transport and relatively heavy use of small-package carriers for even the largest product output shows that a good percentage of outbound shipments in this sector is of relatively small size. I now turn to a listing and discussion of supply-chain-related decisions faced by firms.

**TABLE 4.11**  
**TRANSPORTATION USE BY METALWORKING FIRMS**

	Inbound	Outbound
<i>Largest Supply or Product (value of shipment)</i>		
Mode Split		
Less-than-Truckload (LTL)	46%	74%
Truck (Truckload or LTL)	49%	24%
Other*	5%	2%
Transport Provider		
Self	13%	39%
Supplier or Customer	46%	13%
Small-Package Carrier	16%	19%
Other Carrier	25%	29%
Shipment Frequency per Week	2.0	2.3
<i>2nd Largest Supply or Product (value of shipment)</i>		
Mode Split		
Less-than-Truckload (LTL)	54%	77%
Truck (Truckload or LTL)	42%	21%
Other*	4%	2%
Transport Provider		
Self	10%	37%
Supplier or Customer	34%	8%
Small-Package Carrier	28%	25%
Other Carrier	28%	30%
Shipment Frequency per Week	1.4	2.0
<i>3rd Largest Supply or Product (value of shipment)</i>		
Mode Split		
Less-than-Truckload (LTL)	62%	74%
Truck (Truckload or LTL)	36%	21%
Other*	2%	5%
Transport Provider		
Self	21%	20%
Supplier or Customer	30%	22%
Small-Package Carrier	33%	30%
Other Carrier	16%	28%
Shipment Frequency per Week	1.5	1.9

\* Includes Air, Ship, and Intermodal

Source: MIT/MRPG, Chicago Area Survey, 1996

## **LOGISTICS DECISIONS WITHIN DIFFERENT SUPPLY CHAINS: THE CASE OF CHICAGO'S METALWORKING SECTOR**

In the metalworking discussion of the previous section, there was some discussion of how metalworking supply chains were managed, but, in the end, supply chains were examined almost entirely from a descriptive perspective. Though such a perspective is informative, it does not provide a detailed picture of how metalworking firms operate their logistics systems.

Consequently, it does not capture the interactions between transportation use by firms and the other logistics areas, which provide important information in terms of determining the impacts of transportation policies and investments. Thus, I apply the framework developed above to the metalworking sector.

The following discussion is based on a review of the survey results and subsequent in-depth interviews with 13 metalworking firms throughout the Chicago metropolitan area. These 13 firms—I originally selected 16, but 3 were either unwilling or able to be interviewed—were chosen from the 100 that returned the mail-survey instrument. Selection of firms was done on two bases: (1) the quality (high or low) of relationships among metalworking firms and their channel partners and (2) the distance (distant or local) over which they operate. Quality of relationship was determined using responses from the survey questions in which firms were asked, for a number of collaborative practices, to provide the percentage of suppliers and customers with which they collaborate; distance was determined by examining the geographical distribution of supplies and markets. Thus, firms were placed in four groups for analysis: high/local, high/distant, low/local, and low distant. The objective behind this placement, which was influenced by the conceptual discussion of the previous section, was to examine differences in the management of logistics, if

any, among firms reporting different degrees of collaboration and interaction with supply-chain partners and how these differences were impacted by the distance between firms.

Applying the set of measures in Table 4.2 to the Chicago metalworking sector results in a number of supply chains, which are differentiable, based on the values for these measures. Unlike the conceptual discussion above, supply chains are classified according to the primary product being supplied to customers of metalworking firms. I return (in the concluding section) to a discussion of which management paradigms are at work in the supply chains of the metalworking sector, but the greatest differences were seen when categorizing supply chains according to the primary product.

To illustrate the framework, I introduce only two supply chains: (1) a custom-built-to-order supply chain (henceforth known as “custom”) and (2) a standardized-process-and-product supply chain (henceforth known as “standard”). There are variations of each, with important differences among these variations, as well as a number of different types of chains, but this dichotomy is useful at a general level. Moreover, this dichotomy is sometimes featured within firms. That is, some firms split their product lines into custom-built and standard products. The important point is that different supply-chain arrangements will have important (different) implications for which types of transport, and other, policies, will be effective. I now turn to the analysis of each of the logistics-decisions areas for both types of chains. Although I discuss each of the decision areas separately, they are strongly interdependent.

*Supply-Chain Structure/Interfacing* on the inbound side is somewhat similar for both types of chain. Raw materials tend to be commodity purchases with few exceptions, an example of which is a custom-to-order supply chain that purchases its major supplies from another custom

shop. Consequently, the degree of interaction and control over inbound partners is very low, and no firm mentioned any interest in lower supply tiers.

The outbound side is somewhat different. Custom supply chains involve more direct contact with customers. Although standard chains usually sell to manufacturers who then sell to other firms or final consumers, custom chains sell directly to final consumers. Thus, the degree of interaction on the outbound side appears more intense and direct.

*Facility Location* decisions, in general, are not of direct importance to transportation policy. First, of the 13 interviewed firms, 10 had always been in the same location. Thus, historical accident appears to be a critical locational determinant. Second, for those firms that were able to identify the reasons for selecting their current location over other relevant sites, geographical (either inbound or outbound) considerations were not mentioned. Rather, issues of property value and land costs were factors. However, it is clear that being within the Chicago metropolitan region conveys certain important benefits (discussed in other decision areas).

*Purchasing* decisions mirror the inbound-supply-chain considerations above with few differences between the two types of chains. Not surprisingly due to the commodity nature of purchases, only 3 of the 13 interviewed firms indicated they had any formal supplier-selection process, all of which were recently started or are not yet fully functioning. These firms tended to be featured in standard chains, but a stronger similarity was a large firm size. Also, use of a number of different suppliers to ensure product availability was common.

*Traffic and Transportation* decisions on a modal level are similar for both types of chains being mostly less-than-truckload shipments on both inbound and outbound shipments with greater prevalence of truckload shipments on the outbound. Generally speaking, metalworking firms do not manage their transportation operations extensively. Direct transport costs were generally less

than 10% of sales; firms involved in custom chains, as a group, featured lower percentages. Firm size is a determinant in this result, because larger firms have more opportunities to reap the benefits of different transportation strategies, such as larger order sizes, consolidation of shipments, and regularly scheduled shipments. Also important, however, is whether the firm is able to forecast demand, and thus plan production operations, input purchases, and overall delivery time to customers. Standard chains, where forecasts appear to be more viable, favor more formalized transportation strategies.

*Inventory Management* conclusions are similar to those of the discussion for transportation. Only 3 of the 13 firms interviewed knew the value of inventory carried, and no firm calculates the costs of carrying inventory. Firm size appears important, given that all 3 were relatively large firms, but more important is whether the firm is custom or standard. Custom firms do not hold finished-goods inventory and do not order to stock. Hence, they rely on good transportation service, with firms stating that 1-2 day delivery of inputs was important and achievable because suppliers were within the Chicago metropolitan area.

*Production Planning and Demand Forecasting* are discussed together because the quality of demand forecasts influences the pattern of production. Firms in custom chains made fewer attempts to forecast demand than those in standard chains, which, in turn, affected the pattern of production and purchase behavior.

*Order Processing* in terms of order-cycle time was significantly different for custom versus standard firms. Lead time for the custom firms was in the range of 6-12 weeks versus 3-5 days to 4 weeks for the standard firms. A more detailed breakdown of standard firms based on where in the supply chain the firm is situated, is recommended, but this difference in lead time is important to determining the sensitivity of firms' operations to transportation strategies. Longer lead times

imply a lower sensitivity. Nevertheless, most of the interviewed firms demonstrated a contraction in lead times, which would increase this sensitivity.

*Product Design/Packaging* was not a major problem area for most firms in either chain. This was mostly due to the nature of the product (usually bulky and not very susceptible to damage) and the small size, which involved little in terms of packaging labor costs. There were exceptions, such as producers of small metal products that goods prepackaged to wholesale distributors, which would be uncovered with a more detailed exposition of the various supply chains.

*Customer Service* elements were somewhat different for the two chains, but a more detailed supply-chain typology is needed. For example, custom firms featured quality (in terms of accurate reproduction of specifications) as the top service element, but there were exceptions according to the customer industry. For some customer industries, price and delivery-time reliability were as important as quality. Standard firms tended to feature price and on-time delivery as the most important element. Overall, customer-service elements are important, because they basically define the firm's niche (or lack of niche) and influence all other logistics decision areas. Table 4.12 summarizes the discussion of this section.

The above sketch of two supply chains is a general cut at the supply chains found throughout the metalworking sector in Chicago and is the initial step in demonstrating how to determine (and thus serve) transportation needs of its metalworking firms. The work of subsequent chapters expands this supply-chain analysis with the addition of the transportation use and characteristics analysis. These analyses will then be matched to currently available and potential transportation-policy initiatives for the Chicago area. In the end, policy conclusions will be based on a detailed examination of firms' transportation use rather than using economy-wide assumptions or no assumptions about transportation use by firms.



**TABLE 4.12**  
**TWO REPRESENTATIVE SUPPLY CHAINS IN CHICAGO'S METALWORKING SECTOR**

Decision Area	CUSTOM	STANDARD
Supply-Chain Structure and Interfacing (Inbound)	Similar -Low interaction with and control over inbound partners -No interest in lower tier suppliers	
Supply-Chain Structure and Interfacing (Outbound)	-More direct contact with customers -More sales to final customers	-Less direct contact with customers -More sales to intermediate producers
Facility Location (Inbound) Facility Location (Outbound)	Similar -- Not directly involved with transportation decisions.	
Purchasing	-Fewer occurrences of formal supplier-selection processes (related to firm size)	-Greater occurrences of formal supplier-selection processes (related to firm size)
Traffic and Transportation (Inbound) Traffic and Transportation (Outbound)	-Modal choices similar (related to firm size) -Favor less formalized transportation strategies	-Modal choices similar (related to firm size) -Favor more standardized transportation strategies
Inventory Management (Inbound)	-Lower inventory held -Generally no formal inventory management process.	-Greater inventory held -Greater (yet not common) use of formal inventory controls
Inventory Management (Outbound)	-No inventory	-Inventory held -Some (yet not common) use of formal inventory controls
Production Planning/Demand Forecasting	-Less forecastable demands and pattern of production	-Greater forecastable demands and pattern of production
Order Processing	-Longer Order Cycle Time	-Shorter Order Cycle Time
Product Design/Packaging	Similar -- Generally not a problem (some exceptions)	
Customer Service	-Usually quality of product as key element (depending on customers)	-Greater occurrence of price and delivery-time reliability as key elements

Source: The author.

## AN ENABLING FRAMEWORK

The framework established in this chapter represents a mechanism by which the linkages between transportation policy and investments and firm can be investigated. Two important components of the framework are (1) the supply chain as the unit of analysis and (2) the logistics function of firms. Consequently, one must think of transport as a major link-provider in the supply chain facing a firm and must consider the interdependence between transport as a logistics decision area and the other main decision areas. It is through these decision areas that one begins to comprehend the varied uses for transport by a firm. In the next chapter, I isolate the transport function and develop an understanding of it in some detail.

This chapter's framework also permits an analysis of differences in the way supply chains are managed. This analysis can be conducted on a number of levels, such as paradigmatic, firm, and sectoral, among others. At the level of paradigms, extent of coordination throughout the supply chain was used as a distinguishing characteristic, and there were more differences than similarities in the logistics decisions areas across different paradigms. In Chapter 6, I examine how transport provides the increased coordination necessary for supply-chain management. At the firm or sub-sector level, the framework was applied to the metalworking sector in Chicago, and two distinct supply chains were evident. Also, in Chapter 6, I examine how transport use differs depending on whether a firm is faced with a custom or standardized supply chain.

Finally, by combining the paradigmatic and metalworking analysis, I am able to comment on which paradigms are prevalent among metalworking firms. Based upon the above description, no metalworking firms practiced SCM. Thus, it may be the case that a certain size threshold has to be reached before SCM becomes either feasible or beneficial. Metalworking firms tended to be relatively small. Consequently, metalworking firms fit into the other two paradigms. Now, there

were instances of metalworking firms feeling SCM-related pressures from other supply-chain partners, usually customers. In addition, there were instances of firms that had implemented efforts similar to many SCM principles, at making their supply chains more efficient. Overall, there appears to be some convergence between metalworking firms functioning in custom supply chains and the pre- or non-mass production paradigm and also between metalworking firms functioning in standardized supply chains and the mass production paradigm. Consequently, the firms in this latter group are expected to have greater need and potential to implement SCM principles. I extend the examination of this convergence in later chapters.

## **CHAPTER 5**

### **THEORETICAL BASIS FOR USE OF TRANSPORTATION BY FIRMS**

The reader may note that transportation has not been the focus of the preceding chapter. In the subsequent discussion, I isolate a single firm and categorize its use of transportation into transformation, transaction, and innovation component or input. Later, I discuss the nature of its particular value-adding function(s) or product(s) in terms of the decision areas of the previous chapter. Thus, the purpose of this chapter is to establish a framework to explain why firms use transportation. Such a detailed look permits analysts to examine how transport affects firm processes and thus performance. These effects are expected to differ based on which production and distribution processes and paradigm are in operation.

Though some of the studies discussed in Chapter 3 provide important insights, they fail to organize these insights in an analytical fashion. Such an organization is an important prerequisite in designing planning systems to successfully serve transportation demands that derive from firm' activities. This view not only applies to planning effectively for goods movement, but also for passenger demands and activities, such as the linking of trips with different purposes, known as trip-chaining, that are becoming increasingly complex.

### **TRANSPORTATION AS A TRANSFORMATION INPUT**

Although production, which changes physical characteristics of goods, is usually considered as the *de facto* transformation function within firms, transportation, in its most obvious use, also transforms inputs and outputs by altering their location and their employability. Input sources and output markets, which were otherwise not relevant because of distance, become integrated with the firm's current production and distribution possibilities and alter the firm's decision calculus with the introduction of transport. Overcoming distance is not costless, however. In addition to the

distance-related costs of the resources (e.g., labor, equipment, and facilities) directly used in transport, there are time-related costs, because travel is not instantaneous. Thus, the tasks of changing time and distance (or location) are intertwined and are commonly referred to as providing time and place utilities, the primary value-adding activities of firms' logistics systems. Because other types of utility, such as possession and quantity, can be analyzed in terms of time and place utilities, I do not discuss them separately.

Place and time utilities thus provide a starting point for examining the contributions of transportation to firm and economy-wide performance. It is clear that as firms (and their concomitant transportation demands) have evolved, there have been changes in the relative importance of each of these two utilities. The shift from the pre-logistics (pre-1950s) era, where the focus was on designing an optimal transport system, to an era where the aim was to design comprehensive logistics systems (Poist, 1986) resulted in increased emphasis on the time utility provided by logistics systems. Accordingly, in terms of the objectives of this study, transport-planning methods also need to adjust by including time-related measures in the evaluation of policies. As was mentioned in Chapter 3, most studies (e.g., Alonso, 1972; North, 1975; Richardson, 1979; Heilbrun, 1981) only consider place utility in an analysis of the contribution of transportation to economic and firm behavior, but some (e.g., Lewis, 1991; Allen, Baumel, and Forkenbrock, 1994) have attempted to include time utility as well. Nevertheless, an analysis at the level of detail and inclusion exhibited by a traditional analysis of time and place utilities, characterized by examining only transportation and inventory-related costs, is not adequate for current purposes.

Each inbound or outbound activity (or function) makes a contribution to firm performance and, thus, eventually to economic development (Table 5.1). Though the motivations and

**TABLE 5.1**  
**TRANSPORTATION AS A TRANSFORMATION INPUT**

Activity (Function) Name	Contribution to Firm Performance
Inbound Activities	
Delivery Of Product Inputs	Permit Production
Permit Shift To Different Product Inputs	Affect Production Costs; Affect Output Quality
Transport Of Labor Input	Permit Production
Permit Shift To Different Labor Inputs	Affect Production Costs; Affect Output Quality
Provide, Or Substitute For, Inventory	Affect Inventory-Related Costs
Influence Stockout Conditions	Affect Production Disturbances and Costs
Permit Shift In Production Run	Affects Output
Outbound Activities	
Delivery Of Goods To Customers	Permit Distribution/Sales
Transport Of Customers To Goods	Permit Sales
Change Service Area	Change Delivered Price/Sales
Provide, Or Substitute For, Inventory	Affect Inventory-Related Costs
Influence Stockouts/Lost Sales/Lost Customers	Affect Sales
Influence Customer Service	Affect Sales
Influence Packaging Needs	Change Packaging/Handling Costs

Source: The author.

organization underlying this table are novel, many of the transport uses mentioned in the table have been discussed by other analysts, many of whom were included in the discussion of Chapter 3. I maintain the distinction among inbound, outbound, and within-bound activities defined in the previous chapter. Thus, for current purposes of examining transportation use by firms, I do not include within-bound activities, such as the transport of inputs within a facility, explicitly in the framework, although I do include the interface between within-bound and inbound/outbound activities.

From the inbound side, transportation provides delivery of inputs and access to supplies of any kind. For this function, supplies can be differentiated along three criteria: (1) whether the supplies refer to goods or labor, (2) the complexity of the supplies (in terms of the inputs' value added) and (3) the specialization of the supplies (in terms of the availability of substitutes). This differentiation is important, because it will determine the particular nature of the transportation service for these demands. Thus, firms receive a number of product inputs, which will range, depending on the particular needs of the firm of industry being examined, from ubiquitous raw materials to in-process or semifinished goods to specialized components or parts. The contribution of this activity is, clearly, to permit production. It is difficult to think of any production/service activity that does not use inputs that have been transported.

One way to express the impossibility of production without transported inputs is to attach an exorbitant or infinite cost to production. An infinite cost would apply to situations where production is technically, rather than financially, infeasible. The introduction of transport alters the cost situation by introducing new input-use possibilities to firm decisions, which will be taken to induce either cost reductions or improvements in product quality. This conclusion applies to any scale shift in input-use possibilities, ranging, as examples, from the birth of new firms due to an

expansion in transport infrastructure to underserved regions to the reduction of production costs of existing firms due to a reduction in transport rates.

The same insights can be applied to the transport of labor, because labor is an input to production. Thus, labor supplies can be differentiated in terms of their complexity and specialization, and the contribution of labor transport to firms is to permit and improve production. On the inbound/production side, a firm uses passenger transport in two general ways: (1) directly, in terms of travel choices that are controlled and paid for by the firm, such as an employee who travels to meet with suppliers or other parts of the firm's supply chain, and (2) indirectly, in terms of travel choices that are not controlled and paid for by the firm, such as home-to-work travel by employees. Unlike other transported inputs, labor introduces the complexity of a decision-making unit, the household or individual traveler, that utilizes different transport-choice considerations, such as quality-of-life measures, which are somewhat independent from those used by a firm. Hence, both sets of decision processes need to be considered when examining transportation use in this capacity.

In addition to delivery of inputs, transport use provides or substitutes for inventory. Inventory costs include carrying (both in-transit and on-site, and warehousing) costs, order/setup costs, and stockout costs. This last inventory-cost category includes not only the costs associated with carrying safety stock in order to avoid stockout conditions, which on the inbound side affects production conditions, such as length of production run, the selection of which can also affect stockout conditions, but also costs associated with disturbances in production, such as idle time due to delays in receiving inputs. Inventory can be held in transport vehicles (either in-transit or on-site), and reduced (increased) inventory levels and costs generally result in increased (reduced) use and cost of transport. This is a general relationship, but an important example is the implementation of JIT, where better (faster and more reliable) transportation is substituted for



reduced inventory levels. Improvements in the transport service will have the same directional effect as increased use of transport. Finally, transportation may also directly affect production by altering the length of production runs.

Turning to the outbound side, the analysis is similar except for the substitution of outputs for inputs. This similarity is expected, because of the fact that the input demands of a firm or production unit are served by the output supplied by other firms. Nevertheless, the perspectives are different, which will influence the nature of the transport used. The basic outbound activity provided by transport is the delivery of goods to customers (say, a manufacturer) or final consumers. As with the case of inputs, outputs can be differentiated according to their complexity and specialization. Moreover, as in the case of labor transport, when considering customers (usually in the role of final consumers) as providing their own transport in order to purchase firms' outputs the introduction of an independent decision-making unit creates difficulties. In addition to the particular characteristics of the output involved, other factors will affect transport choice and sales of firms' output(s).

Transport use not only provides access to a potential customer base but also changes the size of the service or market area. Assuming that the delivered cost (price) is equal to production cost plus transportation costs and ignoring differences in product quality and customer-service considerations, reductions in transport cost will decrease the delivered price for firms' products and increase firms' serviceable area. Inventory held at particular locations can also affect the delivered price of a good and thus the extent of the serviceable area.

Such inventory, being on the outbound side facing customers, is of a different nature than the inbound side and alters the relationship between transport and inventory. As with inbound activities, transport does provide or substitute for inventory on the outbound side of firms' activities

and influences the various inventory-cost categories discussed. Given this function and correlation between higher inventory levels/costs and the level of customer service, transport also affects customer service. Clearly, the occurrence of stockouts (where goods are unavailable for sale), which is influenced by transport, influences the possibility of lost sales and even lost customers. In addition, transport affects the length of order-cycle time, which is the time to deliver a product to the customer from the time of order placement and is analogous to customers' lead time, and the quality of order fulfillment in terms of consistency, safety, accuracy, and flexibility. Finally, based on customer-service needs, transport influences packaging.

### **TRANSPORTATION AS A TRANSACTION INPUT**

Although the transport uses mentioned in the previous section are well-known and have been studied extensively (though not completely incorporated into public-policy planning), the same cannot be said for transportation as a transaction input. Transaction-cost analysis is an area of economic research that is not as formalized as more traditional fields. Given the size and complexity of the area, researchers have concentrated on basic issues that deal with the organization of firms and markets and the institutions or mechanisms that are used in this organization.

Although transportation is one such mechanism, it is clearly not the only one, nor is it necessarily the most important. Others include law, insurance, telecommunications, trade, and finance.

Indeed, the importance of transport in facilitating transactions is easily overshadowed by these transaction-cost-related activities/industries, and analysts have not considered transportation as transaction permitter or facilitator, preferring just to examine its use in transforming production (Wallis and North, 1986), which was discussed in the previous section. The purpose of this section is not to establish the importance of transport vis-à-vis more traditional transaction-influencing activities but to examine whether, or the extent to which, transportation use affects transactions.

To begin, transaction costs, which I define as the activities or costs used to establish, adjust, and monitor relationships, relate (only) to exchange between economic agents, which can be either organizations or individuals. Where there is no exchange (in the case of a single producer who consumes his/her own product), there are no transaction costs. In reviewing Table 5.1, I note some implicit mention of exchange in terms of interactions with suppliers, including employers, and customers. For example, an expansion in the service area in terms of number of potential customers of a supplying firm may also increase competition with existing suppliers and thereby reduce prices. This is a transaction-cost-related effect. I first examine these exchanges from a broad perspective and then discuss how transport influences their operation. Because the following discussion applies equally to inbound and outbound exchanges, I drop the dichotomy of the previous section.

A number of activities are potentially associated with exchanges (or transactions). Williamson (1985) defines these activities as *ex ante* and *ex post* transaction costs, with the temporal descriptors related to the moment of contracting. *Ex ante* costs include the costs of drafting, negotiating, and safeguarding an agreement. *Ex post* costs occur where imperfections arise in the performance of agreements. These include costs to adjust transactions' conditions that have shifted from contracting expectations, haggling costs of efforts to correct such shifts, costs to establish and maintain the governance structures where disputes are referred, and bonding costs of effecting secure commitments. According to Williamson, economic organization, in the form of various governance structures (one of which is market transacting) and other institutions, seeks to minimize both sets of these costs. Different types of organization should be matched to the particular type of transaction under study, which will differ according to various characteristics of the transaction itself. Williamson (1985) lists three: namely, (1) asset specificity, (2) uncertainty,

and (3) frequency. These characteristics provide a way to examine transaction costs, which, in themselves, are difficult to isolate.

Whereas transaction frequency is straightforward, the two other characteristics require clarification. Asset specificity refers to “the degree to which an asset can be redeployed to alternative uses and by alternative users without sacrifice of productive value” (Williamson, 1989, p. 142). Thus, any kind of asset, including both human and capital, may be idiosyncratic to particular relationships among firms/individuals. Uncertainty may occur at all stages of the contracting (or relationship) process and may be due to randomness of particular events or to lack of either deliberate or undeliberate communication among contracting parties.

One problem with Williamson’s framework overall (as indicated by Dietrich, 1994 and, more indirectly, by Powell, 1990) and for the discussion of the previous chapter is that it fails to consider the benefits generated by different forms of economic organization. From this disregard for the benefit side, it follows that forms of economic organization that increase transaction costs are not viable. However, as Harrison (1994) points out, network forms of organization—supply-chain management being a prominent example—which increase transaction costs, exist and proliferate, thus appearing to show that the benefit side is indeed important to firms. These benefits appear in production, because the definition of transaction activities as costs or activities to be avoided precludes any discussion of “transaction benefits”. Dietrich (1994) indicates that these benefits appear as lower production costs and greater revenues. Although such a description might eventually provide an accurate measure of benefits of different economic-organization options, a more detailed typology is needed for current purposes.

Using Table 5.1, I examine four exchange relationships: (1) firm-labor, through the use of transport of labor to firms, (2) firm-supplier, through the use of transport to receive inputs from

supplying parties, (3) firm-customer, through the use of transport to deliver goods to customers or the opposite, and (4) firm-consumer, through the use of transport of goods to final consumers or the opposite. Though implicit to Table 5.1, recalling the discussion concerning inbound, outbound, and within-bound activities, it is important to note that these exchanges, as examined here, involve significant spatial separation. After all, many more transaction types, such as on-site assigning and monitoring of tasks between owners and managers and between managers and employees, exist than are relevant to the current discussion.

Transport will influence these exchanges by effecting changes in the characteristics of the particular transaction. In order to analyze the use of transport as a transaction input, I analyze each group of transactions using the three characteristics mentioned earlier. Transport affects the asset specificity, uncertainty, and frequency of the transactions in two ways. First, transport permits or motivates changes in these characteristics. That is, different types of transactions (as described by these characteristics) will necessitate particular transport services, and, vice versa, the viability of transport services will influence the types of transactions that can take place. In general, the greater the possibility of uncertainty, the greater the asset specificity, and the greater the frequency of transactions, the greater will be the demands on transportation (and on governance structures). Second, transport substitutes for or complements other services used to support these characteristics. These services, some of which have already been mentioned, are used before an exchange (searching and gathering/providing information about goods and buyers/sellers), during an exchange (waiting and negotiating of conditions), and after an exchange (enforcement of agreements and monitoring of quality and performance). Clearly, transportation impacts and transaction characteristics will differ on the basis of the attributes of the goods or individuals transported and the associated demands of the transacting parties, therefore the general exposition

in Table 5.2 is not meant to describe any particular transaction.

The simplest transaction group in terms of transportation's effects is between the firm and consumers. Consumers can be distinguished from other customers on the basis of their not contributing value to, and thereby being the final user of, the product. Many of these transactions are generally market based and thus do not involve use of particular governance structures. Turning to transaction characteristics, asset specificity is generally negligible, thus not affecting transport requirements. On the other hand, transportation may affect uncertainty by altering the conditions of task completion as well as formulation of contracts or relationships through impacts on product delivery. These impacts on uncertainty, in turn, may alter the frequency of transactions. Impacts on frequency may also occur independently of changes in uncertainty.

The transport impacts on the firm-labor transaction group are more interesting and more important. The availability of transportation services may affect (1) the extent to which firms are able to search for and obtain particular labor needs and establish human-asset specificity and, conversely, (2) the extent to which labor is willing to invest in and develop this specificity. Transport may also affect the frequency and uncertainty of completing labor tasks by influencing everyday journey-to-work conditions.

I discuss the final two groups of transactions together, because they essentially pertain to different sides of the decision by a firm on whether to make a product input itself or buy it from (or outsource to) another firm. For each of the two options, firms will examine both the transformation costs involved (production, transport, and research and development) but also transaction costs. The potential for asset specificity is generally the highest for this group of transactions and is affected by transport's influence on uncertainty. Changes in the uncertainty or potential uncertainty of transaction completion affects the willingness to establish asset specificity among firms. Other

TABLE 5.2

TRANSPORTATION AS A TRANSACTION INPUT

Transaction Group	Effects on Transaction Characteristics	Contribution to Firm Performance
Firm-Consumer	<p><u>Asset Specificity</u>: Negligible</p> <p><u>Uncertainty</u>: Change uncertainty in task completion; alter confidence and extent of contract agreements</p> <p><u>Frequency</u>: Permit or change frequency of exchange</p>	Change in search costs may alter potential consumer base; revenues potentially affected by changes in uncertainty and frequency
Firm-Labor	<p><u>Asset Specificity</u>: Permit or change conditions for establishing human asset specificity</p> <p><u>Uncertainty</u>: Affect labor-task completion</p> <p><u>Frequency</u>: Permit or change frequency of labor use</p>	Alter search costs for labor; potential for changes in labor productivity
Firm-Supplier or Firm-Customer	<p><u>Asset Specificity</u>: Permit or change conditions for establishing asset specificity</p> <p><u>Uncertainty</u>: Affect task completion; change or substitute for contingency elements; permit or change confidence and extent of contract agreements</p> <p><u>Frequency</u>: Permit or change frequency of exchange</p>	Influence search costs for suppliers and customers, which may alter potential supplier and customer base; change quality and quantity of exchange-related benefits; alter the occurrence of contingency-related costs

Source: The author.

uncertainty-related impacts include the establishment and completion of the transaction or task and the substitution for contingency elements, such as insurance. Finally, as in the case of consumer exchanges, the frequency of exchanges may be altered.

### **TRANSPORTATION AS AN INNOVATION INPUT**

The final group of transportation impacts consist of the effects on innovation within and among firms. The discussion of this input is necessarily brief, because many of the innovation-related impacts of transport involve altering (nonincrementally) the transport uses of Tables 5.1 and 5.2. Innovation can be defined in terms of altering the “technology set” of a firm, which is the set of production/distribution processes available to a firm (Varian, 1981). This alteration may be a switch or an improvement to a known, existing configuration, which was previously unselected, or just an increase in the number of possible configurations. Traditionally, these alterations have been examined in terms of production/materials innovation and process/system innovations (e.g., Freeman, 1982; Gomulka, 1990). I maintain this scheme. Thus, I consider (1) creation of new processes, (2) creation of new products, and (3) diffusion and adoption of processes or products as the main innovation-related uses of transportation. In the case of transport and the objectives of this study, process innovations are of greater interest.

Creation of new processes is the first use of transportation in an innovation capacity. Changes in public- and private-sector investments and policies may permit or motivate changes in the use capacities designated in Tables 5.1 and 5.2, which essentially refer to processes. Products are involved in these processes, but innovation will rest on how or which products are used rather than on changing the technology of particular products. The difference between classifying a transport use as an innovation or as a transformation or transaction input is the extent of change or improvement in the capacity. Where the process change is incremental or nonexistent, transport is



being used in a transformation or transaction capacity, while if the process change is nonincremental or breakthrough, then transport is being used in an innovation capacity.

An example of a public-sector policy that may have had innovation-related impacts is the national deregulation of transport, specifically the loosening of rules regarding the setting of rates and the selection of services to offer, which, in turn, leads to more flexibility in firms' choices concerning particular production/distribution processes. In terms of private-sector action, Chandler (1977) makes a strong connection between the development of organizational practices within the U.S. railroad industry, which arose because of initial public policies, and the rise of mass production and its modern managerial organization.

Second, transportation may also spur product innovation through two linkages. On the one hand, just because of its large size (both as a sector and of its component firms), transportation provides a large market for innovation. Also, and related, suppliers of transport, such as railroads or trucking companies, can influence the selection of technologies by their customers and suppliers. As examples of the first linkage, Garrison and Souleyrette (1994) mention the development of electronic data interchange (EDI) for use by the railroads and the refinement of mass production by automobile manufacturers. The public sector can also be directly involved in such activities. The most contemporary example of the first linkage is the use of federal funds to research intelligent vehicle highway systems (IVHS). Chandler (1977) provides an excellent example of the second linkage, where suppliers, such as steel, and customers, such as retail, of the railroad industry, pursued innovation in their own products, as well as in their technological and management systems.

A third innovation-related use of transportation involves the diffusion and adoption (rather than the creation, as featured above) of product and process innovations. Despite the spatial and

temporal aspects of the diffusion process—that is, innovating and adopting firms usually are separated in space, and different firms have unequal adoption periods—transportation (as well as communication) capabilities are almost never mentioned as influencing innovation diffusion and adoption rates. Instead, other variables are considered: at the level of inter-firm diffusion, firm size, innovation profitability, firm's growth, profit, and other financial indicators, and firm attitude; at the level of inter-industry diffusion, profitability potential of innovation, size of required outlays, and proportion of firms that have already adopted the innovation; and at the level of inter-country diffusion, profitability of innovation, technological and institutional conditions, and industry characteristics; the costs of and propensity to search are seen as influencing innovation at all levels (Davies, 1979).

By examining this list, it is clear that although transport is not directly mentioned, it is directly involved. For instance, firm size and supplier/customer influence have been already mentioned as two innovation-influencing characteristics of the transport product. Also, the various transformation and transaction capacities of transport (see Tables 5.1 and 5.2) may influence both the setup or search costs and the profit potential of the innovation. In addition to use of such a traditional approach, however, analysts can also examine characteristics of the transport product (rather than the industry) that influence innovation diffusion. As one preliminary example, Amos, Jr. (1990), discussed in Chapter 3, claims that different types of transport will either assist firms in taking advantage of economies that accrue when firms cluster together or will diffuse innovations among spatially separated firms. Clearly, these two different types will feature different characteristics.

I summarize the innovation discussion in Table 5.3.

**TABLE 5.3**  
**TRANSPORTATION AS AN INNOVATION INPUT**

<b>Effects on Innovation Activities</b>	<b>Contribution to Firm Performance</b>
Permit or Motivate Creation of Improved Processes	Sales or Output/Cost Shifts as described in Tables 5.1 and 5.2 but of greater magnitude
Creation of New Products	Sales or Output/Cost Impacts
Diffusion and Adoption of Processes/Products	Improve industry-wide or economy-wide sales or output/costs. Individual firm may or may not realize benefits or disbenefits.

Source: The author

### **THINKING OF TRANSPORTATION IN TERMS OF CHARACTERISTICS, NOT MODES**

The above discussion was intentionally indeterminate regarding what types of transportation perform the functions of transportation use by firms. Though eventually the analyst or planner must describe the supply options in terms of modes, facilities, and regulations, an important prerequisite to this activity is to examine what about the transportation good makes it useful to and utilized by the firm in the ways of the issues discussed in the previous sections. Thus, I examine the demand for transportation services in terms of the characteristics or attributes of the service, rather than the particular transport service or, as traditionally discussed, the mode of transport. Quandt and Baumol (1966), who originally applied such an approach to forecasting intercity-passenger-transportation demand, labeled transport modes described by their characteristics as “abstract modes.” These modes are abstract in the sense that combinations of characteristics at certain values may or may not correspond to existing or future modes of transportation.

The derivation of the general (rather than applied to transport) approach to describing goods by their characteristics was originally designed as an alternative to traditional consumer theory, which posited that goods were the direct objects of utility. This approach can be summarized by three assumptions: (1) it is not the good, per se, that provides utility to the consumer but the

characteristics that the good possesses; (2) in general, a good will possess many characteristics, which may be shared by more than one good; and (3) combinations of goods may possess different characteristics than possessed by those goods separately (Lancaster, 1970).

Clearly, the application of such an approach to transport-demand decisions, be they passenger-travel decisions, to which the theory was originally and continues to be mostly applied, freight-demand decisions, which have received less attention from researchers, or firm-travel decisions, as defined in this study, is appropriate. The first assumption holds strongly for transport use by firms, which is a demand derived from other activities rather than an activity demanded for itself, as is the case with sightseeing or other leisure travel. Turning to the second assumption, the various transportation services, consisting of vehicles, facilities, and policies, available to firms will all possess the same set of characteristics (discussed below), albeit to different degrees. Finally, intermodal options will possess different characteristics than the component modes in isolation. Indeed, the appropriateness of this approach in modeling transportation demand has led to further research including the development of disaggregate (at the level of individuals' or firms' optimization processes) modeling techniques (Quandt, 1976) and discrete-choice analysis of travel demand (Ben-Akiva and Lerman, 1985).

The use of abstract modes in this study can be described by contrasting it to the major applications and extensions that have occurred since the first application to transport by Quandt and Baumol. First, the objectives of the current application are to describe and explain transportation use by firms rather than forecast transport flows, as is the case with almost all variations of the abstract-mode approach. Quandt and Baumol used the approach to forecast the demand for passenger transportation between sixteen city pairs and on three modes, consisting of air, bus, and automobile. They described modes according to their values for two characteristics, travel time and

travel cost. Another characteristic, frequency of departures, was discussed in the theoretical development of the abstract-mode approach but was not included due to its problematic impacts on the statistical estimation of the demand equation. Quandt and Baumol used a gravity-type demand equation, which holds that transport demand is “pushed or pulled” by certain forces, such as size of population centers, and the generally positive regression results led the authors to conclude that abstract modes could be used to estimate the demand for travel.

Although a demand formulation of the issues in this study is possible, it raises a whole host of statistical issues that are beyond the scope of the current effort. Consequently, and as the second contrast to other abstract-mode applications, I will not discuss issues of mathematical formality. These issues are clearly important, but, if taken up now, would cripple the development of the current framework. Available data are not adequate to measure and document statistically the relationships of current interest, and the abstract-mode models that have received the most rigorous attention, discrete-choice models, have a theoretical basis that is inconsistent with the definition of the firm provided in the previous chapter.

Baumol and Vinod (1970) provide an application of abstract modes to freight-transport demand. They defined freight modes by using four attributes or variables: (1) shipping cost per unit, (2) mean shipping time (though which trip frequency was implied), (3) variance in shipping time, and (4) in-transit carrying cost per unit of time. Using an inventory-theoretic approach, they developed a cost function and eventually derived a profit function. Maximizing profit and solving for traffic volume, they derived total volume of shipments as a function of modal attributes. They did not attempt to estimate this demand equation. The perspective of Baumol and Vinod’s work is implicitly that of the firm, and they include inventory-cost considerations in addition to transport cost, but the work is based on a generic-microeconomic profit-maximization model (and firm).

Such an approach makes the mathematical formality of the model tractable, but does not allow for the full range of interactions between transportation and firm activities that were discussed previously.

Third, the broad objectives of the current work encompass both passenger and goods movement. Other analysts deal with one or the other. This is not surprising, because the decisionmakers in each case are completely different entities as traditionally modeled, the individual/household passenger with objectives of maximizing utility contrasted with the individual firm with objectives of minimizing transport/logistics costs.

Finally, my ultimate aim in using the abstract-mode approach is to provide insights to the supply side, which includes both public- and private-sector planning efforts. Thus, I eventually extend the use of characteristics/attributes in describing the demand for the transport product in the three capacities discussed above to allow the inclusion of characteristics in supply models.

In this study, I define 12 characteristics, along with their measures, as relevant to a hypothetical firm's overall transport needs (Table 5.4). A number of comments apply to this table. First, characteristics apply to all modes, freight or passenger, existent or hypothetical. Of course, some characteristics may be irrelevant for passenger movement, such as tracing, and others, such as comfort, may be irrelevant for freight movement. The set as a whole, however, will apply in all circumstances, and distinctions among applications of the set will be based on the various transport uses made by a firm rather than passenger- or freight-mode choices made by that firm. Second, and related, the same "values" for the set may describe different modes, depending on the spatial and temporal qualities of the particular use. Third, the characteristics are somewhat interdependent, but each contributes unique qualities of the transport input. Fourth, some characteristics are easier to quantify than others, while others can only be measured qualitatively. Finally, the particular group

of characteristics is unique to this study but derived from a reading and application of the literature of Chapter 3. Clearly, other combinations of characteristics are also possible and are found in the literature, but this group is necessarily comprehensive and was selected in order to (1) describe both passenger and freight transport and (2) incorporate the perspective of the firm as the decisionmaker.

**TABLE 5.4**  
**ABSTRACT-MODE CHARACTERISTICS AND MEASURES**

<b>Characteristic</b>	<b>Measure</b>
Accessibility (Acc)	Distance to input and customer sources
Comfort (Com)	Extent of passenger amenities
Connectivity (Con)	Extent of separation among transport and logistic-service providers
Coordination (Coo)	Ability to match customer-specific demands
Flexibility (Fle)	Ability and time to adjust to demand changes
Frequency (Fre)	Number of departures/arrivals in specified time period
Intermediacy (Int)	Extent of connections to modes and locations
Price (Pri)	Transport rate or monetary cost of transport
Reliability (Rel)	Standard deviation of travel time
Safety (Saf)	Extent of lost/damaged product
Speed (Spe)	Mean travel time
Tracing (Tra)	Quantity and quality of information flow

Source: The author.

#### **Characteristics Preferences in Chicago's Metalworking Sector**

Similar to work featured in the previous chapter, I applied the above characteristics analysis to the metalworking sector in Chicago. As the first, most direct, measurement of these characteristics, I asked the metalworking firms to rank the above transport characteristics in terms of the importance to their inbound, outbound, and passenger needs. Due to the prior notions concerning differences between inbound and outbound transportation use (as discussed in Chapter 4) and the distinction used in the framework above, I asked firms to answer separately for inbound goods, outbound goods, and passenger transportation use. Figures 5.1a, 5.1b, and 5.1c show the weighted results from the mail-survey instrument. A simple weighting scheme was used, wherein a

characteristic selected as most important would receive a value of 5 and the least important would receive a 1. Different weighting schemes are, of course, possible, but the relative ranking of the characteristics is what is important.

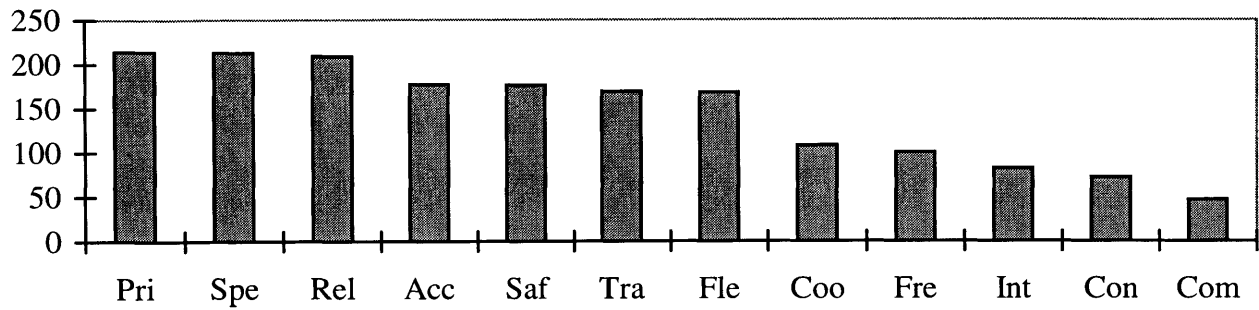
On the inbound side, firms listed the top five demand characteristics as price, speed, reliability, accessibility, and tracing. On the outbound side, they listed the top five demand characteristics as speed, reliability, price, safety, and accessibility. In terms of passenger travel, price, accessibility, safety, speed, and reliability were the top five.

A couple of important points apply to these results. First, the inbound-outbound dichotomy is meaningful. More generally, the supplier side of the metalworking industry involves less complex, less involved demands and relationships than that of the interactions among metalworking firms and their customers. Thus, price (rather than quality considerations) of the transportation service is a slightly more important characteristic on the inbound side, but, equally significant, is the fact that many quality-of-service considerations are deemed to be important. On the outbound side, transport price becomes less important than transportation quality characteristics, such as speed and reliability of shipment. Second, passenger travel appears to be of less interest relative to freight concerns as shown by the number of non-applicable or blank responses received and the subsequent weighted scores of Figures 5.1a-5.1c. This is not surprising, given that most shipments among metalworking firms are goods and not individuals. Nevertheless, the importance of accessibility in passenger needs corroborates the notion (as found from the detailed interviews) that customers like (need) to make personal visits to metalworkers, and vice versa.

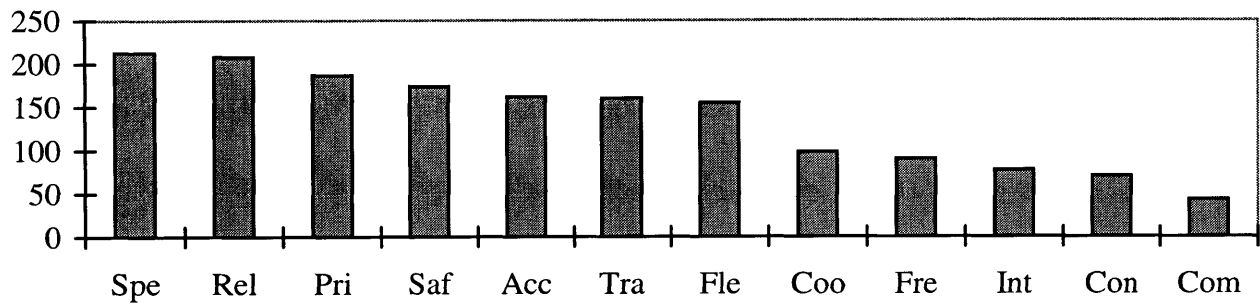
The results can be further examined in light of the supply-chain classification derived from the previous chapter's firm-interviews discussion. Using that classification, whereby two supply-chains, custom and standardized, were developed, the mail survey results reveal that 56% of the



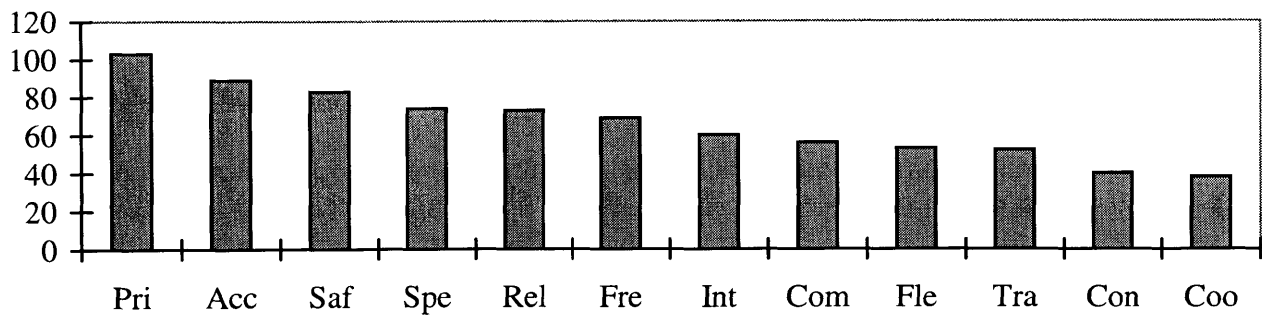
**FIGURE 5.1a**  
**INBOUND CHARACTERISTICS -- WEIGHTED SCORES**



**FIGURE 5.1b**  
**OUTBOUND CHARACTERISTICS -- WEIGHTED SCORES**



**FIGURE 5.1c**  
**PASSENGER CHARACTERISTICS -- WEIGHTED SCORES**



Source: MIT-MRPG, Chicago Area Survey, 1996

respondents faced custom supply-chains and 44% faced standardized chains. Recalling the last chapter, I concluded that there should be standard-chain metalworking firms would be more likely to face pressures to implement supply-chain management principles. Assuming that SCM prefers high-quality transport characteristics, notably reliability and flexibility, a breakdown of the above results according to the two supply-chain types provides partial support for this position. For custom firms, the top 5 inbound characteristics were price, speed, reliability, flexibility, and safety compared to the top five for standardized firms, which were reliability, speed, price, accessibility, and tracing. On the outbound side, the results were not as sanguine in terms of differences with four of the top 5 characteristics identically ranked by firms in either type of supply-chain, which simply may reflect similar customer-service goals among both types of chains.

Metalworking firms were also asked whether the importance of transport delivery time, reliability, and flexibility to, in turn, inbound and outbound logistics needs has changed over the past 10 years. The percentage of firms stating that delivery time has become more important was 23 for inbound and 41 for outbound needs. The corresponding inbound and outbound percentages for reliability were 30 and 38, respectively and for flexibility were 29 and 36. At first glance (without statistical testing of mean differences), transport characteristics have become more important for the outbound side relative to the inbound side. In addition, the large percentage of firms that report no change in importance apparently contradicts the contention that recent supply-chain restructuring efforts have led to additional pressures on metalworking firms to provide speedier, more reliable, and more accurate delivery of products. This finding is not all that startling, depending on the competitive environment and supply chains in which certain firms are embedded.

There are differences when these results are analyzed separately for firms in standardized vs. custom supply-chains. The corresponding inbound and outbound percentages for standardized firms were the following: delivery time, 24 and 45, respectively, reliability, 30 and 41, respectively, and flexibility, 32 and 40, respectively. For custom firms, the corresponding percentages were as follows: delivery time, 21 and 37, respectively, reliability, 30 and 35, respectively, and flexibility, 26 and 33, respectively. It is clear, with the exception of inbound reliability, that there are differences in how firms perceive changing transportation needs depending on the supply chain in which they operate. Once again, this lends credence to the conclusion that standard firms may be facing greater pressures to restructure their logistics and other operations and thus are more likely to implement competitiveness-improving principles related to transportation that are consistent with supply-chain management.

### **Demand and Supply and the Relevance of Certain Characteristics**

The previous results point to clear divisions in the characteristics set. For both inbound and outbound freight transportation, coordination, frequency, intermediacy, connectivity and comfort were the least important characteristics. The result for comfort was not surprising, because it is essentially a passenger-mode-specific characteristic; almost all freight, with very few exceptions, such as the transport of certain live animals, does not require a comfortable mode of travel. The result for the other four characteristics is not as obvious but can be traced to the interpretation that they can be considered as descriptors of supply decisions. Firms, as freight-transport users, may not be interested in the connectivity, coordination, intermediary, and frequency of transport services, but in how decisions made concerning these characteristics translate into system speed, reliability, and accessibility, among others.

Such conclusions cannot be made as strongly for the passenger results. There is not as clear a divergence of results as found for freight demands, and frequency of transport is rated higher for passenger needs. The low result for tracing is, as in the case of comfort for freight needs, not surprising, because tracing is essentially a freight-side characteristic. Flexibility can be considered in a similar manner, since it relates to the ability of transport providers to alter their service provision to meet changes in firms' demands. Firms are less likely to demand or anticipate changes in passenger-travel services in order to accommodate their changing needs, because such changes are out of the control of firms, being controlled by individual passengers or transport providers that will not consider changes on a firm-to-firm basis. Firms did see comfort as an important passenger characteristic. This result can be interpreted as they find current levels as either adequate or irrelevant to their passenger needs, which is not surprising given the labor (low- or craft-skilled) requirements of the metalworking sector. The remaining lowest-ranked characteristics are supply-side.

With the above in mind, some conclusions can be drawn concerning the relevance of certain characteristics. Connectivity, coordination, and intermediacy are clearly supply-side characteristics that do not figure strongly in firms' transportation needs. Frequency can also be considered as supply-side, but, as shown in the passenger results, clearly has importance to demand decisions. The remaining characteristics can also be considered to have such a dual nature. However, the ultimate criterion in deciding if characteristics are directly relevant is whether they describe the role of transportation in firms' production and distribution processes. The remaining nine all have the potential to inform this role and will be used throughout the rest of the study.

## CONCLUDING REMARKS

With this chapter, I have established a rather complete, if at times complex, description of the interface between the transport input and the overall activities of a generic firm. As will be seen in later chapters, this complexity is necessary in order to explain current firm behavior. After all, maximizing profit may not be the only goal of a firm, or it may not be as simple as it appears. Recalling the discussion of Chapter 2, I defined goal articulation as the second of the multi-step transportation planning process and given the problem definition posed in this work, I deemed efficiency-related goals as appropriate. Tables 5.1, 5.2, and 5.3 were created with this perspective in mind and represent a dissection of the efficiency goals as described in Chapter 2. Clearly, the goals described by the framework of this chapter exceed those of the studies reviewed in the previous chapter. Particularly important is the ability of analysts and planners to use the above framework to capture the relationship among changes in the type of economic organization within and among firms and transportation use, not just the technical relationships implied by changes in production and distribution processes.

## CHAPTER 6

### TRANSPORTATION USE IN A COORDINATED-SUPPLY-CHAIN ENVIRONMENT

Given the framework of the previous chapter, one can proceed with a description of how certain firms or industries or even an economy use transportation. For example, if the task were to evaluate the impacts of a transport investment in some region, the analyst could create an inventory or sample of firms in that region (through use of survey data or an application of assumptions and secondary data) and examine the use of transport as specified in Tables 5.1, 5.2, and 5.3 and the discussion of the previous chapter. Economic impacts would take the form of the various use categories found in these tables. Furthermore, this analysis could be extended by matching the extent or range of these economic impacts to certain modal options or, preferably, transportation-characteristics sets.

However, additional elaboration of the framework is needed to make the methodology more precise in terms of planning objectives (and the market for services), evaluation criteria, and impact and criteria measurement, which will be used in the next two chapters covering investment and regulatory policy formulation. In order to maximize the usefulness of the framework, I examine it in light of contemporary changes in the way firms' supply chains are being organized and managed. As already described in some detail, transport (along with communication) essentially provides the means by which supply chains function and, given the greater focus on coordination, the more important become transport and other mechanisms used to organize supply chains. Thus, as management of supply chains changes, so does the role of transport. I illustrate this change by applying the framework of the last chapter (and supporting work from Chapter 4) to supply-chain management (SCM).

Of course, an application need not examine changing production and distribution processes. An application to existing processes is also valid. Indeed, here I describe how I applied the framework to the metalworking sector in Chicago in order to understand how firms in this sector use transport services in terms of the supply chains described in Chapter 4. As was seen in the previous chapter, many firms in this sector did not report, through the mail-survey instrument, an increased importance of transport as a coordinating mechanism, but that does not negate the uses as observed in the case studies. Finally, I include observations, partly based on the different supply chains found in the metalworking sector, on accounting for product and sectoral differences when analyzing transport use.

#### **ANALYZING TRANSFORMATION, INNOVATION, AND TRANSACTION INPUTS IN TERMS OF CHARACTERISTICS**

Though an application can take many forms, Table 6.1, on the next two pages, is a prototype worksheet that can be used to guide analyses. The table is two dimensional with transport inputs/links as the rows and the nine transport characteristics, established in the previous chapter, forming the columns. Moreover, the various transport inputs were organized according to transaction group. Consequently, not all transport inputs or uses were relevant for all four transaction groups. However, the particular structure or form of the table is unimportant.

What is important is to examine, in some (quantitative or qualitative) fashion the transport-use capacities of Tables 5.1, 5.2, and 5.3 according to the characteristics relevant to each capacity. Table 6.1 collects all these capacities as an illustration, but in an actual application not all transport capacities may be relevant to all analysts, and different analysts would examine capacities at different levels of detail. For example, not all transaction groups, such as firm-consumer, are relevant for all firms, which is the case for a large portion of metalworking firms. Regarding level

**TABLE 6.1**  
**CHARACTERISTICS ANALYSIS OF TRANSPORTATION USE—Prototype Table**

Transport Uses/Links by Transaction Type	Characteristics								
	Acc	Com	Fle	Fre	Pri	Rel	Saf	Spe	Tra
<p><b>Firm-Supplier</b></p> <ul style="list-style-type: none"> <li>-Delivery of Product Inputs to Firms</li> <li>-Permit Shift to Different Inputs</li> <li>-Provide, or Substitute, for Inventory</li> <li>-Influence Stockout Conditions</li> <li>-Permit Shift in Production Run</li> <li>-Affect Conditions for Establishing Asset Specificity</li> <li>-Affect Contingency Elements</li> <li>-Influence Confidence and Extent of Contract Agreements</li> <li>-Affect Frequency of Exchange</li> <li>-Influence Innovation in Supplier-Related Processes</li> <li>-Influence Innovation in Supplier-Related Products</li> <li>-Affect Diffusion and Adoption of Supplier-Related Processes</li> <li>-Affect Diffusion and Adoption of Supplier-Related Products</li> </ul>									
<p><b>Firm-Labor</b></p> <ul style="list-style-type: none"> <li>-Transport of Workers</li> <li>-Permit Shift to Other Labor Pools</li> <li>-Affect Conditions for Establishing Human-Asset Specificity</li> <li>-Affect Labor-Task Completion</li> <li>-Affect Frequency of Labor Use</li> </ul>									
<p><b>Firm-Customer</b></p> <ul style="list-style-type: none"> <li>-Delivery of Goods to Customers</li> <li>-Transport of Customers to Goods</li> <li>-Change Service Area</li> <li>-Provide, or Substitute, for Inventory</li> <li>-Influence Stockouts/Lost Sales/Lost Customers</li> <li>-Influence Customer Service</li> <li>-Influence Packaging Needs</li> <li>-Affect Conditions for Establishing Asset Specificity</li> <li>-Affect Contingency Elements</li> <li>-Influence Confidence and Extent of Contract Agreements</li> </ul>									



Transport Uses/Links by Transaction Type	Characteristics									
	Acc	Com	Fle	Fre	Pri	Rel	Saf	Spe	Tra	
<ul style="list-style-type: none"> <li>-Affect Frequency of Exchange</li> <li>-Influence Innovation in Customer-Related Processes</li> <li>-Influence Innovation in Customer-Related Products</li> <li>-Affect Diffusion and Adoption of Customer-Related Processes</li> <li>-Affect Diffusion and Adoption of Customer-Related Products</li> </ul>										
<p><b>Firm-Consumer</b></p> <ul style="list-style-type: none"> <li>-Delivery of Goods to Consumers</li> <li>-Transport of Consumers to Goods</li> <li>-Change Service Area</li> <li>-Provide, or Substitute, for Inventory</li> <li>-Influence Stockouts/Lost Sales/Lost Consumers</li> <li>-Influence Customer Service</li> <li>-Influence Packaging Needs</li> <li>-Affect Certainty of Sale</li> <li>-Influence Confidence and Extent of Agreements</li> <li>-Influence Innovation in Consumer-Related Processes</li> <li>-Influence Innovation in Consumer-Related Products</li> </ul>										

Note: Acc=accessibility, Com=Comfort, Fle=Flexibility, Fre=Frequency, Pri=Price, Rel=Reliability, Saf=Safety, Spe=Speed, and Tra=Tracing.

Source: The author.

of detail in the analysis, some firms may not feature enough goods/inputs (or goods/inputs may not require significantly different transport characteristics) to warrant a detailed breakdown of the transport uses or characteristics of Table 6.1. Given that the objectives of this study are to develop a framework for examining any firm and apply this framework to public-policy planning decisions, I will consider all these transport uses and characteristics to be potentially relevant and will examine how they are affected by changes brought about by SCM efforts.

Eventually, also depending on the perspective of the analyst, the demand characteristics of Table 6.1 would be compared to existing supply options. These supply options would be selected on the basis of some decision rule, whereby the benefits—measured either directly by a change in the characteristics of the transport product or indirectly through a standardized metric, such as effect on costs—of altering transport choices would be maximized. On the other hand, and especially in the case of firms' decision processes, analysts may wish to examine the impacts of altering policies, which influence the transport input in order to determine the feasibility of these alterations and their effects on firm performance. Once again, based on the objectives of this study, I wish to examine the efficiency-related impacts of changing transportation choices through public-policy actions.

### **THE ROLE OF TRANSPORTATION USE IN FIRM DECISIONS IN A COORDINATED-SUPPLY-CHAIN ENVIRONMENT**

The set of logistics decision areas of SCM can be examined in terms of Table 6.1. Where possible, I determine the relevance or importance of each transport use and the importance of each product characteristics to the uses. The basic procedure is to match the relevant transport uses and characteristics to SCM by examining how the different logistics decision areas and their measures interact to require particular uses and characteristics. Because I wish to examine SCM at a conceptual level, I do not point out differences at the level of a specific industry or firm. Not all

transaction groups will be relevant for certain industries. Specific industries or sectors may also differ in terms of the uses and characteristics found within each group. These differences will be highlighted in the metalworking discussion at the end of this chapter.

### **Firm-Supplier**

As with other paradigms (and probably for all firms in the contemporary economy), transport is used for delivery of goods (or the firm's outputs) from suppliers in order to permit production to take place. This is transport's most direct and visible role for this transaction group and, as will be discussed below, will differ according to the complexity and specialization of the product input being transported and, more importantly, the characteristics of the supply chains under study. One way to examine this direct role is to investigate the type of service that carriers are required to provide to firms involved in SCM arrangements. But, this kind of analysis only uncovers the direct transportation needs and uses of firms. As already elaborated, firms' other logistics activities also need to be included in order to account properly for transport's role in production and distribution processes. It is through this inclusion that the influence of SCM can be analyzed.

With a transport network in some form and a firm in place (in contrast to undeveloped areas, where this use would not apply), firms may face the necessity or desire to acquire additional or different inputs. Given the focus of SCM on a continuous search for improvement and quality, and thus a search for inputs and suppliers that are well suited to its demands, access to a large pool of potential suppliers is important. Countervailing this finding is the importance of long-term, stable relationships with a reduced supplier base. For firms already involved in these types of relationships, wide access may not be as critical. Consequently and given this caveat, the important characteristics for this use are accessibility and price, which may tradeoff with one another. Price is

probably not a critical characteristic but is clearly always an important consideration. That is, SCM firms will not be willing to pay any price for additional services and characteristics. However, the need for other characteristics may reduce the relative importance of price.

Substitution for inventory is, possibly, the most important transport use for firms involved in SCM, because inventory reductions may be the largest benefit due to SCM. If transport cannot adequately service a firms' needs, inventory levels must necessarily be kept high and inventory-related benefits of SCM simply cannot be achieved across great distances. Important characteristics for this use are both accessibility and speed, but these have to be considered in conjunction with the needs of the next transportation use.

Consequently, transport plays a key role in influencing stockout conditions, which given the requirements of SCM, have extremely ill effects. Given the reduced levels inherent in a SCM arrangement, transport plays a key part in assuring that supplies are received, because they cannot be drawn from inventory. In addition, avoiding stockout conditions clearly becomes more important in the presence of closer relationships with fewer suppliers and fewer supply tiers (discussed below). Reliability of shipment is thus a key characteristic along with safety, which, when lacking, can also induce stockout conditions, and tracing.

Flexibility in production can be an important need for some firms. Though SCM prefers production schedules that are consistent (with few seasonal peaks and valleys in production), the focus on maximizing customer-service and needs may require abrupt shifts in production runs. Indeed, some SCM systems operate on a make-to-order basis, which may feature extreme variance in demand. Such shifts, in turn, may require flexibility in delivery of inputs. Other important characteristics include, speed, accessibility, and, possibly, frequency. Also, permanent shifts in

production, possibly due to innovation in processes or products would require a similar set of characteristics.

The next three transport uses—namely, those related to transportation as a transactional facilitator—are the most intriguing and, quite possibly, the most important under SCM. Transport influences the particulars and thus appeal of any potential SCM arrangement, notably the extent of common assets and other interests among firms and their suppliers and the recurrence of transactions. Within SCM, closer relationships with fewer suppliers not only results in greater dependence among firms but also allows firms to enter into complex, recurring transactions, both of whom require reliable transport. This reliability has a number of important influences, notably (1) accuracy in lead time and more generally in the availability of supplies and (2) accuracy in delivery, in terms of receipt of correct product inputs. Thus, a high degree of certainty is necessary for SCM transactions, because of the lack of contingency elements. Of course, where this certainty cannot be achieved, contingency elements and costs are necessary, which results in fewer benefits from SCM implementation.

High-quality transport will be necessary due to the high degree of asset specificity and frequent exchanges among firms in SCM arrangement. Transport affects the likelihood that the investments in the relationship will be recovered and, thus, eventually generate benefits. Consequently, the type of transport (among other factors) available to firms will also affect the probability that firms and their suppliers will seek to enter into SCM arrangements. Important transportation characteristics thus include accessibility, reliability, and safety of shipment.

Because SCM is a logistics-based restructuring paradigm, there is great potential for innovation in processes and, somewhat less, which will depend on the particular firm or industry of interest, in products. Thus, a change in transport possibilities, through either a private or public-

sector initiative, may permit significant changes in the production and distribution processes of a firm. These process impacts may, in turn, also affect the creation of products, or they may be motivated by such creation.

The diffusion and adoption of product and process innovation are heightened under SCM arrangements because of the close relationships among firms and their suppliers. Thus, the effects are interconnected and cumulative. The availability of high-quality transport, as noted above, influences the likelihood that such relationships will be possible and thus establish, which, in turn, affects the extent of innovation and may create additional opportunities for SCM implementation. Firms, which usually are large, initiating SCM efforts usually require changes on the part of suppliers in terms of their processes. Transportation characteristics of interest would be similar to the set necessary for successful establishment and completion of transactions.

### **Firm-Labor**

The firm-labor group needs to be determined in a more indirect fashion, because SCM is a logistics-related paradigm, concentrating on coordination of product and information flows. Other paradigms (discussed briefly in Chapters 2 and 3), such as flexible specialization or downsizing, examine the labor component by specifying and focusing on the impacts of new management practices or market conditions on labor. SCM also has such direct impacts, especially at different levels of management (Byrnes and Shapiro, 1994), but what is of interest here is the way, in terms of uses and characteristics, labor transport is affected or affects SCM.

Ideally, an analyst wishes to determine the link between labor productivity (measured in terms of output or sales per unit of labor) at work and the quality of journey to work, but this direct linkage is not known and would involve analysis beyond the scope of this study. Rather, some of the uses found below may eventually be used in such a determination.

As with the case of other inputs, transport is involved in transport of workers. What is of interest are the shifts in labor use due to the implementation of SCM in an existing firm or, less likely, the use of labor in a new SCM-practicing firm. SCM, in particular, influences or requires labor transport in certain ways. First, the facility location decision, which may be driven by labor concerns but also may be affected by logistics concerns, favors locations where many of the SCM-related benefits described above can be achieved. In the case of re-location, firms will have to search for additional labor pools. These locations may not be next to large sources of labor and thus may involve significant search, including re-locating, costs. In addition, with a focus on controlling costs, firms may be unwilling or unable to compensate employees for increased travel time, due to distance or other impediments, such as traffic congestion. Important characteristics from the perspective of firms, but also from the perspective of the work or individual traveler are accessibility, speed, price, and comfort.

Second, given the quality focus of SCM, firms will seek to expand their access to necessary labor sources, which may include both low-cost labor and specialized labor. Firms may be interested in developing human-asset specificity with certain sections of their labor force or at some basic level with their entire workforce, in terms of company-wide training or orientation. Some segments of the labor force, such as high-skill labor, prefer high-quality of life, thus requiring comfort and safety in transport conditions. At the same time, SCM's focus on flexibility in production leads to a desire to have some flexibility in labor utilization—whether this flexibility actually occurs is dependent on a variety of factors, such as union presence, that are beyond the scope of the work here—and thus in transport behavior and provision. Taken together, important characteristics will be accessibility, flexibility, frequency, price, and speed.

The remaining use, labor-task completion, is related to labor productivity at the work site, but the transport impacts are unknown. In so much that SCM requires greater and more accurate completion of tasks from all its inputs, a more accurate and incident-free journey to work, measured by values for comfort, speed, reliability, and safety, may be preferred.

### **Firm-Customer**

The analysis of this group is similar to the firm-supplier group at the conceptual level, with the major difference being the direct influence of customer-service provision and levels. Transport is used for the delivery of outputs to customers (and customers to the output source) much in the same fashion that these outputs are delivered as inputs to firms. Therefore, many of the conclusions made in the firm-supplier discussion can be transferred to this group. However, various uses discussed above, such as use of transport to influence the likelihood of stockout conditions, does not affect customer service indirectly through impacts on production, as would be with the case with the firm-supplier interface. Rather customer-service levels are directly affected.

Thus, in this section I concentrate on how transportation uses and characteristics are affected by the changes for the two remaining—product design/packaging and demand forecasting were indirectly discussed above—outbound-only logistics decision areas, namely order processing, which under SCM places a greater focus on tracing of shipments, and customer service. Customer-service levels in SCM are especially affected because the improvements to customer service originate with logistics decisions.

Transport is used both for delivery of goods to customers and transport of customers to goods, but as was done in the firm-supplier case, characteristics determination can be conducted by examining the remaining uses that support these. As with the importance of permitting shifts to different inputs and other labor pools, SCM seeks to expand the potential customer base not only



for reasons of compatibility in interfacing with other firms but also because of production planning reasons. Hence, the important characteristics for this use are accessibility and price, which may once again tradeoff with one another.

The substitute-for-inventory and stockout-influencing uses of transport are also relevant with the latter having different, more important impacts than its inbound version. Instead of disrupting production and inducing costs related to idle production, the potential here is loss of customers. And, if these customers are involved in a SCM arrangement, losses additional to sales or revenues, such as investments idiosyncratic to a relationship, may be borne. Important characteristics include speed and accessibility for the inventory-substitution use, and, for assuring customers receive their products in an adequate fashion, reliability, safety, and tracing, which may be required by customers who wish to have a report on the status of their inputs.

Establishing high-quality customer service involves all facets of operations, but transport use directly affects the quality (and consequently, the ability to provide a wider range) of customer-service elements. Customer-service improvements through SCM depend on efficient logistics operations. In way of a brief review, four customer-service streams were discussed in Chapter 4: (1) lower costs, (2) greater reliability in customer service and delivery, (3) customer-specific service levels, and (4) cycle-time reduction. Taken together, and influenced by discussion elsewhere, important transportation characteristics include price, reliability, flexibility, and possibly frequency, safety, tracing, and speed.

The final firm-customer uses are either simple or have been discussed before. In the first category is the influence on packaging needs. Packaging, similar to inventory, is a safety feature to ensure accurate delivery of products. As such, it is also a cost. Safer transport can substitute for

more extensive packaging and costs. The remaining transaction- and innovation-related uses can be analyzed in the same way as was done for the respective uses in the firm-supplier group.

### **Firm-Consumer**

As in the pairing of the firm-supplier and firm-labor groups, there are a number (more for this latter pairing) of similarities between the firm-customer and firm-consumer groups. Of course, there may be variance in transportation use and characteristics due to the customer, in this case, being the final user of the good, but the major, and only ones to be discussed here, are differences between consumers and customers occur in the cases where consumers are individuals. For these cases, passenger transport of individual consumers needs to be considered. The important exception to this statement is direct home delivery of goods to consumers, which is increasingly expanding to a wider variety of products and arrangements. Passenger transport choices and demands include an additional decision-making unit and, thus a comprehensive discussion of the passenger side is beyond the scope of the current work. But, it is possible, as in the discussion of the labor input above, to examine briefly how SCM principles affect this transaction group.

I isolate the customer-service-influencing use, because outside of the transaction-input-related uses, which require a little more elaboration, the uses are quite similar. For that group, I have to generalize the SCM arrangements, which are usually between and among firms, to a firm-consumer relationship. That is, though asset specificity and contingency elements are not relevant, transport conditions and related search costs, among other factors, certainly may influence the certainty of sale and the likelihood that the consumer will show product loyalty to the firm. Important transport characteristics thus include accessibility, safety, and comfort of travel, among other characteristics that are important to the well-being determination of the individual traveler.

Table 6.2, on the next few pages, summarizes this section. With few exceptions, which were mostly due to overlap, I include all the transportation uses of the previous table. This is expected, because SCM, when compared to other paradigms, places greater and more varied demands on transportation. Taken together, these demands point towards use of modes or combination of modes that provide a high level of accessibility, reliability, and safety of shipment, and less importantly, a number of other characteristics. At first glance, such a conclusion might seem trite and uninteresting, but this is not the case for two reasons: first, it points to the importance of transport characteristics other than speed and price of travel, thus expanding the understanding of how time is used and valued; and second, it is explained (and thus supported) by the variety of transportation uses relevant to SCM arrangements.

Starting with the firm-supplier transaction group, transport has the potential for a variety of impacts related to these uses due to (partial or complete) implementation of supply-chain-management principles: (1) Transport is used to increase the availability of inputs to a firm. Use of such inputs may open up opportunities to reduce costs or improve output quality. These cost/output impacts should be considered. (2) Transport substitutes for inventory. Such substitution will result in reduced inventory-holding costs, as well as the possible elimination of facilities and the associated costs, both of which should be analyzed. (3) Intertwined with this, reduction of stockout conditions is a necessary use under SCM. Given reduced inventories, stockouts become more probable. Where transport cannot assure reliable delivery of inputs, there will be increased costs associated with implementation of SCM, or SCM will not be possible. Hence, opportunity costs may be suffered by firms. (4) Transport permits smaller and more flexible production runs, through increased frequency, flexibility, and reliability of shipments. The ultimate impact of this shift is an

**TABLE 6.2**  
**CHARACTERISTICS AND USE ANALYSIS—SUPPLY CHAIN MANAGEMENT**

Transportation Uses	Relevant Characteristics	Contributions to Firm Performance
<b><u>Firm-Supplier</u></b>		
-Permit Shift to Different Inputs of More Variety	Acc, Pri	Production Cost; Output Quality
-Provide, or Substitute, for Inventory	Acc, Spe	Inventory-Related Costs
-Reduce Stockout Conditions	Rel, Saf	Production Disturbances and Costs
-Permit Shift to Smaller, More Flexible Production Runs	Acc, Fle, Fre, Spe	Production Run Shifts; Output and Inventory Levels
-Motivate Conditions for Establishing Asset Specificity	Acc, Rel, Saf	Exchange-Related Investments and Benefits; Search Costs
-Reduce Contingency Elements	Acc, Rel, Saf	Costs of Contingency Elements
-Increase Confidence and Extent of Contract Agreements	Acc, Rel, Saf	Exchange-Related Investments and Benefits; Search Costs
-Increase Frequency of Exchange	Acc, Rel, Saf	Exchange-Related Investments and Benefits; Search Costs
-Increase Innovation in Supplier-Related Processes	Acc, Rel, Saf	Output and Sales/Cost Impacts
-Increase Innovation in Supplier-Related Products	Acc, Rel, Saf	Output and Sales/Cost Impacts
-Expand Diffusion and Adoption of Supplier-Related Processes	Acc, Rel, Saf	Output and Sales/Cost Impacts
-Expand Diffusion and Adoption of Supplier-Related Products	Acc, Rel, Saf	Output and Sales/Cost Impacts

Transportation Uses	Relevant Characteristics	Contributions to Firm Performance
<b><u>Firm-Labor</u></b>		
-Permit Shift to or Use of Other Labor Pools	Acc, Com, Pri, Spe	Production Costs; Output Quality; Search and Relocating Costs
-Motivate Conditions for Establishing Human-Asset Specificity	Acc, Fle, Fre, Pri, Spe	Production Costs; Output Quality; Search and Relocating Costs
-Increase Labor-Task Completion	Com, Rel, Saf, Spe	Production Costs; Output Quality; Search and Relocating Costs
-Increase Frequency of Labor Use	Acc, Fle, Fre, Pri, Spe	Production Costs; Output Quality; Search and Relocating Costs
<b><u>Firm-Customer</u></b>		
-Increase Service Area	Acc, Pri	Delivered Price; Sales
-Provide, or Substitute, for Inventory	Acc, Spe	Inventory-Related Costs
-Reduce Stockouts/Lost Sales/Lost Customers	Rel, Saf, Tra	Sales
-Improve Customer Service	Fle, Fre, Pri, Rel, Saf, Spe, Tra	Sales
-Reduce Packaging Needs	Saf	Packaging/Handling Costs
-Motivate Conditions for Establishing Asset Specificity	Acc, Rel, Saf	Exchange-Related Investments and Benefits; Search Costs
-Reduce Contingency Elements	Acc, Rel, Saf	Costs of Contingency Elements
-Increase Confidence and Extent of Contract Agreements	Acc, Rel, Saf	Exchange-Related Investments and Benefits; Search Costs
-Increase Frequency of Exchange	Acc, Rel, Saf	Exchange-Related Investments and Benefits; Search Costs
-Increase Innovation in Customer-Related Processes	Acc, Rel, Saf	Output and Sales/Cost Impacts

Transportation Uses	Relevant Characteristics	Contributions to Firm Performance
-Increase Innovation in Customer-Related Products	Acc, Rel, Saf	Output and Sales/Cost Impacts
-Expand Diffusion and Adoption of Customer-Related Processes	Acc, Rel, Saf	Output and Sales/Cost Impacts
-Expand Diffusion and Adoption of Customer-Related Products	Acc, Rel, Saf	Output and Sales/Cost Impacts

**Firm-Consumer**

-Increase Service Area	Acc, Pri	Delivered Price; Output
-Provide, or Substitute, for Inventory	Acc, Spe	Inventory-Related Costs
-Reduce Stockouts/Lost Sales/Lost Consumers	Rel, Saf, Tra	Output
-Improve Customer Service	Acc, Com, Saf	Output
-Reduce Packaging Needs	Saf	Packaging/Handling Costs
-Increase Certainty of Sale	Acc, Com, Saf	Output
-Increase Confidence and Extent of Agreements	Acc, Rel, Saf	Exchange-Related Loyalty and Benefits
-Increase Innovation in Consumer-Related Processes	Acc, Rel, Saf	Sales/Cost Impacts
-Influence Innovation in Consumer-Related Products	Acc, Rel, Saf	Sales/Cost Impacts

Note: Acc=accessibility, Com=Comfort, Fle=Flexibility, Fre=Frequency, Pri=Price, Rel=Reliability, Saf=Safety, Spe=Speed, and Tra=Tracing.

Source: The author.

increased responsiveness to customer demands and thus improved service, or preceding this, a reduced level of input inventories to meet these demands.

(5) Transport increases the ability or likelihood of firms to enter into high-quality, long-term relationships or contract agreements, which feature investments to ensure mutual benefits to firms. These benefits can be examined directly in terms of these investments or through ultimate impacts in terms of cost savings due to, for example, elimination of redundant activities, or improved products. Also, search costs for suppliers are reduced when firms are assured of adequate supplies.

(6) Related, increased interaction also reduces the need for contingency elements that are used to account for instances where supplier transactions fail or become unreliable. Inventory is a production-related contingency element, but other contingency-related costs, such as insurance and information-gathering about suppliers, will also be reduced. (7) A final transaction-related effect is to increase the frequency of exchange between parties, which, depending on the nature of the relationship, will feature all or some of the impacts mentioned in (5) and (6).

(8) Changes in transport options available to a firm may result in substantial reconfiguration of logistics and related processes, described by changes in the production- and transaction-facilitating uses mentioned above. Innovation in products due to transport is less likely but possible, especially given the close relationships involving transport carriers as suppliers and the importance attached to logistics activities by SCM. (9) Accordingly, diffusion and adoption of processes and products will be expanded due to the increased transaction-related uses of transportation.

The firm-labor group features similar impacts to the firm-supplier group but with a different set of relevant transport characteristics: (1) Much in the same way that shifts in product inputs are permitted, transport increases the ability of firms to use other labor pools and thereby reap benefits

in terms of reduced labor and search/re-locating costs and, ultimately, increases in output quality; (2) Also, transport can motivate the establishment and maintenance of labor skills specific to firms (in terms of specific labor tasks or sections of firms' operations); (3) On the other hand, where this specificity is not desired or necessary, flexible use of transport is also permitted. Both this use and the previous one will have similar impacts to use (1); (4) Finally, there may be labor-task completion impacts, but these are less well-known and possibly more difficult to substantiate and measure.

Turning to the firm-customer group, transport will have similar impacts on the inbound side but will feature additional impacts related to the customer-facing side: (1) Expand the service area of a firm through reductions in delivered prices and, ultimately, increases in sales; (2) Reduction in outbound-inventory-related costs; (3) Avoidance of lost sales or customers due to stockouts; (4) Improved customer service (and thus sales possibilities) in terms of reliability, time, and flexibility at a lower price; (5) Reduced packaging needs and costs; and (6) Transaction- and innovation-related uses similar to those discussed for the firm-supplier group except for the involvement of customers than suppliers.

The final group, firm-consumer, is a specialized instance of the firm-customer and thus will not be summarized in detail. This group features the inclusion of an additional decisionmaker (as well as an additional stakeholder in policy formation). The above discussion was conducted from the perspective of firms but can also be conducted from the perspective of individual consumers (or travelers). Thus, one could think of the individual traveler as an entity with suppliers and customers and different uses and impacts of transportation, such as reduced prices, greater choices, reduced search costs, and reductions in packaging/handling costs. But, leaving this for future work and maintaining the perspective of firms, there are slight differences in the transportation characteristics



of this group with that of the firm-customer group, but relevant uses and impact measures are similar.

In sum, the above use and characteristics analysis also provides explanations and support for increased frequency and length of travel. That is, the increase in both passenger and freight travel per output or gross national product (U.S. DOT, 1994) can be interpreted as a more complex use of transportation than in the past. Of course, statistical analysis would have to be conducted to make this statement definitive, but the work provided here, at least, provides a qualitative explanation and description of the linkage between increased transport use and more complex economic activity. The total possible impacts of a change in the transport configuration facing a firm or sector will depend on the specifics of the parties affected. Also, one has to be careful not to double-count impacts. I discuss such issues, related to application of the above table, in the next two chapters.

As in Chapter 4 for the logistics decision areas, it is also possible to determine the key transportation uses and characteristics for different paradigms, and, accordingly, for different industries and supply chains as well. In the concluding section of this chapter, I provide this and a brief discussion of what Table 6.2 would look like for the other two main paradigms (pre- or non-mass production and mass production) developed in the previous chapter. The same statements apply to transportation characteristics. Finally, Table 6.2 includes a third column specifying the contributions to firm performance (developed in Chapter 5) as applied in the above summary discussion, which along with the transportation characteristics, can be interpreted as measures of the transportation use. As introduced above, I utilize this last column, along with the uses and characteristics, in the models and methods discussion of the next two chapters.

## **THE ROLE OF TRANSPORTATION USE IN CHICAGO'S METALWORKING SECTOR**

As noted earlier, I used this framework to analyze the metalworking sector. Based on the interview and survey data, I was able to determine the various uses of transportation and how this use differs based on which chain is being examined. Ideally, I wished to use the metalworking sector as a case study of the conclusions made above and supported by the work in the previous two chapters. Unfortunately, supply-chain management, as described above, was not practiced by any of the case-study firms that were visited and interviewed. There was, however, partial implementation of SCM principles and the potential for greater implementation of these principles. This potential applies to both types of supply chains (custom and standard) established in Chapter 4, but as explained below and supported by the case-study work of that chapter and the characteristics analysis of Chapter 5, is greater for firms operating in standardized chains. These firms tend to be larger and more geared to mass-production principles and thus more able to implement and benefit from SCM.

### **Firm-Supplier**

Using Table 6.1 as a guide, delivery of product inputs obviously is important for both types of chains, but, despite the differences in product output between the two chains, it is also similar. Major product inputs to both chains (Table 4.7) are generally non-specialized, non-complex supplies that, except for the size of product lots purchased and shipped, feature the same transport requirements. Many of these supplies are locally purchased and are thus shipped within the metropolitan area (Table 4.8).

As expected, there are exceptions to this result, where specialized materials are used and necessarily obtained from distant sources. For these cases, the transport requirements will differ because of the longer distances involved. For firms that are involved in the custom chain, the extra

monetary and non-monetary costs involved will not be critical due to the extra lead time involved for delivery to customers. These costs will be higher for firms involved in standard chains, who will attempt to compensate by either purchasing from local sources or increasing the local, on-site stock of inputs. However, none of these firms reported any particular problems in bearing related costs, despite the tendency for these costs to increase due to customers' pressures. For both types of chains, network-wide, at the metropolitan-area level and beyond, improvements will expand the input possibilities to firms.

Turning to inventory, metalworking firms, especially in the custom chain, use transport to substitute for inventory (and its associated costs). Almost all firms in custom chains reported the lack or near lack of inbound-related inventory, which was made possible by the speed (1 or 2 days) in obtaining steel and other supplies. As consequences, stockout conditions are minimized, and smaller production runs, which were especially relevant for firms in custom chains, are made possible.

The firm-supplier group, because of the nature of metalworking's major supplies, does not feature extensive or complex transaction-related effects.

Given the above analyses of metalworking's use of transportation in transformation and transaction capacities, it is not surprising that firms in standard chains would have a greater potential for innovations in processes and products due to changes in transport use. Firms in standard chains also tend to be larger with more formal logistics strategies and functions, which increases the probability of using transportation in these capacities. Although no metalworking firms reported recent transport-induced innovation, no definitive statements about their occurrence in metalworking firms is possible because of lack of historical information. For example, while some standard-chain respondents reported significant changes in processes after the mode shift

from rail to truck, others could not recall if any changes had occurred since then. Although less likely and not reported by any firms, product-related innovations are a possibility, because the various transportation industries are customers of the metalworking sector.

### **Firm-Labor**

The same approach can also be applied to the labor input, of which firms in both chains reported a difficulty in acquiring an adequate amount. Firms in custom chains tend to have more complex, specialized labor needs, which, in general, would have to be obtained from a larger labor-source area. Also, this type of worker may prefer the perceived quality-of-life conditions outside the central metropolitan area. Indeed, one custom-good producer, located outside the central city area, proclaimed the preference of his labor force for high-quality-of-life residential locations to be an important determinant to attracting labor. However, no firm reported any commuting difficulties for their labor force, but this may be just a reflection of the travel characteristics of their current labor force, thus excluding potential employees, or it may be a management, rather than a labor, view. Finally, the travel of employees to meet with customers and other parties was minimal.

The transaction-related uses of this group are interesting with the most potential and important effects for the metalworking sector, especially for the custom chain. Labor in these firms probably has a higher asset specificity than in standard-chain firms, though asset specificity can be high for standard-chain firms that feature extensive training programs or other types of firm-idiosyncratic investments in their workforce. The performance of the intraurban or metropolitan transport network (or those sections relevant to a particular firm) will (1) influence the ability of firms to attract workers and conversely, and (2) influence the ability of workers to seek opportunities at different firms.

### **Firm-Customer/Firm-Consumer**

Because the metalworking sector in Chicago is in the intermediate-to-back end of the complete supply chains to the final consumer, the firm-consumer transaction group is not relevant. Almost no metalworking firms sell to individuals and for those that do, such as chrome platers, consumer sales consist of a small part of the firm's revenues.

One innovation-related use, related to diffusion and adoption, is intriguing. With a dispersing customer base, which as the outbound side is the more relevant part of metalworking firms' operations for innovation, it appears that the transport network will diffuse innovations rather than permit innovation through cluster-related effects, such as face-to-face communications among firms. Either these types of practices are becoming less important, or firms are willing to continue these practices under more dispersed, thus, usually, more costly, conditions.

In addition to the complexity and specialization of the metalworking product, the amount of time to fulfill customers' orders, will influence the nature of firms' transport use. Longer lead times are generally related to more complex and specialized products and are featured in the custom chains of the metalworking sector. With longer lead times, time utilities of the transport good become less important to firms' logistics systems. Some custom firms did report that the reliability of lead (or delivery) time was becoming increasingly important as a component of customer service, but with longer lead times, other components of lead time, notably manufacturing, become more prominent. Hence, transport will be more important and able to affect the market area, extent of stockouts, and customer-service levels for those metalworking firms with shorter lead times, which tend to be found in standard chains. Finally, metalworking's use of relatively safe (only air is safer) transport modes, such as less-than-truckload and self-delivery in autos or trucks, made packaging-related problems or costs minimal.

As with the outbound-transformation activities, lead time also is an important factor in metalworking-firm-customer-firm transactions. Thus, despite the occurrence of high asset specificity among custom-chain metalworking firms and their customers, it is unlikely that transport will have a major effect because of the relatively small part it plays in total lead time. Moreover, this part will also be small in causing uncertainty to occur in transactions. For firms with shorter lead times, on the other hand, transport will have important effects on the success of transactions and on the possibility of establishing complex governance structures, as found in restructuring effort.

Table 6.3 on the next page, summarizes this discussion. I also include the top 5 characteristics, from the results of the previous chapter, in this table. A few comments pertain to this table. First, the metalworking sector, as broken down into these two general chains, does not feature as an extensive use of transport as shown by the SCM analysis of Table 6.2. Exceptions do exist on a firm-by-firm basis, with larger firms generally featuring more extensive use. This points to the fact that though the SCM analysis of above assumes certain behavior on the part of firms, actual behavior may diverge, in some cases substantially, from an assumed pattern. Clearly, this divergence will occur on a supply-chain level, where different competitive pressures and product characteristics will influence the different logistics decision areas. However, this divergence may be due to decisions made by firms that are inconsistent with expected behavior. Second, standardized firms, which are also larger than custom firms, feature more complex use of transportation. Once again, exceptions exist, but this further supports the contention found in Chapter 4 that standardized firms are more likely and able to implement SCM strategies. Third, there were differences between the reported importance of certain characteristics by firms and the findings of Table 6.2. Notably, accessibility was not as prominent a characteristic, which is

**TABLE 6.3**  
**USE AND CHARACTERISTICS ANALYSIS--CHICAGO METALWORKING SECTOR**

Transportation Uses		Five Most Important Characteristics (as reported by firms)	
<u>Firm-Supplier—Custom</u>	<u>Firm-Supplier—Standardized</u>	<u>Firm-Supplier—Custom</u>	<u>Firm-Supplier—Standardized</u>
<ul style="list-style-type: none"> <li>-Delivery of Product Inputs (Both common and specialized)</li> <li>-Large Use of Transport to Substitute for Inventory</li> </ul>	<ul style="list-style-type: none"> <li>-Delivery of Product Inputs (Both common and specialized)</li> <li>-Less Use of Transport as Substitute</li> <li>-Some Use of Stockout-Influencing Use</li> <li>-Innovation-Related Uses (process) are possible</li> </ul>	<ul style="list-style-type: none"> <li>-Price, Speed, Reliability, Flexibility, and Safety</li> </ul>	<ul style="list-style-type: none"> <li>-Reliability, Speed, Price, Accessibility, and Tracing</li> </ul>
<u>Firm-Labor—Custom</u>	<u>Firm-Labor—Standardized</u>	<u>Firm-Labor—Custom</u>	<u>Firm-Labor—Standardized</u>
<ul style="list-style-type: none"> <li>-Provide Wide Area for Selection of Specialized Labor</li> <li>-Motivate High Level of Human-Asset Specificity</li> </ul>	<ul style="list-style-type: none"> <li>-Provide Wide Area for Labor Pools</li> <li>-Motivate Moderate Level of Human-Asset Specificity</li> </ul>	<ul style="list-style-type: none"> <li>-Price, Accessibility, Safety, Speed, and Reliability</li> </ul>	<ul style="list-style-type: none"> <li>-Price, Accessibility, Intermediary, Frequency, Safety/Comfort</li> </ul>
<u>Firm-Customer—Custom</u>	<u>Firm-Customer—Standardized</u>	<u>Firm-Customer—Custom</u>	<u>Firm-Customer—Standardized</u>
<ul style="list-style-type: none"> <li>-Some Use of Increasing Service Area (Among Larger Custom Firms)</li> <li>-Minor Affects on Customer Service</li> <li>-Choice of Mode Minimizes Packaging of Shipment-Safety Problems</li> </ul>	<ul style="list-style-type: none"> <li>-Increase Service Area</li> <li>-More Substitution for Inventory</li> <li>-Reduce Stockouts/Lost Sales/Lost Customers</li> <li>-Expand Diffusion of Innovation (Process and Products)</li> <li>-Innovation-Related Uses</li> <li>-Motivate Confidence and Extent of Agreements</li> </ul>	<ul style="list-style-type: none"> <li>-Speed, Reliability, Price, Safety, and Accessibility</li> </ul>	<ul style="list-style-type: none"> <li>-Speed, Reliability, Price, Safety, and Tracing</li> </ul>

Source: The author.

possibly due to its composite nature of incorporating some of the other characteristics, such as speed, reliability, price, and frequency or due to firms' preferences for these characteristics directly. Passenger-transport characteristics were also featured less prominently in the reported results, which may be due to firms' belief that work-to-travel choices and conditions are the domain of the individual traveler and not the firm.

## **ACCOUNTING FOR CHANGES IN PRODUCTION AND DISTRIBUTION PROCESSES**

The framework used in this chapter's analysis is useful because of its ability to account for a wide variety of production and distribution processes. This ability was developed because of the selection of the paradigm used to develop the framework. Supply-chain management places entirely new demands on transportation that may not be found in other paradigms and thus a comprehensive framework is necessary to examine these demands, which run a gamut of uses. Examining Table 6.2, it is clear that reliability and accessibility are the key transportation characteristics. Much of this is motivated by the importance of maintaining a high level of quality and coordination in supply-chain relationships with both supplier and customer firms.

Other paradigms, such as mass-production and pre- or non-mass production will feature different demands. Pre-or non-mass production firms generally face simple transportation demands. Consequently, relevant uses may be limited to the basic uses from each transaction group, such as delivery of product inputs and outputs and labor. The key characteristic is probably price, but as shown by the metalworking-sector results, even non- or pre-mass production firms may desire a more complex and advanced set of characteristics.

Mass-production firms, on the other hand, face much more complex transportation needs. Most of the uses of Table 6.1, with the exception of the uses of transportation as a transaction-input, are relevant to mass-production firms. Their level of importance for some uses, such as substitution



for inbound or outbound inventory, may not be as critical, but it is likely that firms would benefit from improved transportation services that would allow or motivate improvements in production and distribution, such as greater innovation among firms and their suppliers. In terms of transport characteristics, reliability is also a key characteristic for mass-production firms but speed may be even more critical. Of course, as mass producers begin to restructure their operations to approximate SCM, reliability may become more critical.

In addition, I used the framework to examine an industry example, which showed that differences exist not only among different types of supply chains but also among firms within the same supply-chain type. In some ways, the metalworking sector is not the best industry to apply the framework. As previously stated, implementation of SCM principles was not found. On the other hand, the examination of the metalworking sector emphasized that not all of the characteristics and uses developed in the previous chapter will be relevant for all industries. Consequently, analysts should be cognizant of the industrial composition of the jurisdiction or planning domain under study. For adjustment to models, featured in the next two chapters, I return to using supply-chain-management in order, once again, to make the framework as applicable as possible.

## CHAPTER 7

### SUPPLYING DEMAND

Though improved logistics will become increasingly critical at the firm level if supply-chain management (SCM) is applied more thoroughly throughout the economy, there will (or should) also be interest at the government level. First, governments at all levels want to see “their” firms succeed. Second, government plays a direct role in the two critical components of the modern logistics function: transportation, which coordinates physical goods flow, and telematics, which coordinates information flows. For purposes of this study, I have ignored the government function with regard to the latter sector but acknowledge that many important questions remain to be resolved in determining appropriate government policies or attitudes towards the informatics/telecommunications sector. Currently, transport and information policies tend not to be coordinated. A pursuit of synergy between these two is an important goal but is beyond the scope of the present study.

In the next two chapters, I apply the framework and conclusions reached in this study to public-policy decisions and models as regards transportation. That is, given the exposition and description of production and distribution processes (and changes therein), I wish to determine the implications for transportation planning of including (or ignoring) these processes in policy analyses and evaluation. A number of steps are implied by this statement. I first briefly describe investment (or the supplying of firms’ demands) as one of two overall domains of planning. I then discuss the various models and techniques used or proposed for use in making investment-related decisions. Throughout this discussion, the focus will be on the state-of-the-art, as defined by published studies, rather than the state-of-the-practice, because implementation of state-of-the-art techniques is a complex issue that can be handled separately. In addition, there may be instances of

practice that differ from the studies that determine the state-of-the art, but it would be impossible to examine or find all such instances. I will thus assume that the state-of-the art at least informs, if not represents, planning practice, given that many of the studies were motivated by, or describe, actual planning efforts.

Third, and most important, I reconsider these models and techniques in light of the conclusions of the previous chapters. In particular, I evaluate how well the various models account for the supplying of demands generated by firms' production and distribution processes. It should be noted that I will make no significant attempt to determine where government should be involved in relation to the private sector. As discussed in Chapter 2, while promotion of competitive efficiency, which may or may not justify grounds for privatization, is assumed to be the overall goal of planning efforts directed at firms, transportation planning frequently has other goals, such as maintenance of public safety and welfare, income distribution, and appeasement of certain groups for political reasons. The inclusion of other such goals will clearly influence both the selection of particular evaluation models and the manner in which model results are examined. Models with these goals will only be discussed and evaluated in terms of their efficiency-related implications. Fourth, I introduce necessary adjustments to these models in order to incorporate firm-level demands.

### **INVESTMENT AS A MAJOR GOVERNMENT FUNCTION**

Investment is the first major domain of transportation planning. Public funds may be used for a number of purposes: upgrading or maintaining of existing facilities, which may be necessary to harmonize conditions with other parts of the network, expanding capacity of facilities, and constructing facilities, which may serve public or joint needs, such as distribution or intermodal-transfer centers.

Public investment, in general, is important to the logistics function in four ways. First, some necessary infrastructure is provided by the public sector that is not provided by the private sector. Transport infrastructure usually involves large initial capital expenditures and a long stream of uncertain returns. Of course, public-private financing partnerships are possible, but a government presence may be necessary to reduce risks. Second, much of the existing basic infrastructure is owned by the public sector; in the absence of complete privatization, the government will still be a provider of infrastructure. Third, government investment may be justified on the basis that it accounts for negative and positive externalities that would not appear in firms' or individuals' decisions. As examples, negative externalities consist of noise and air pollution, traffic congestion, and safety; positive externalities may include engagement in basic research (such as telematics applications in the freight sector) or coordination of cooperation among competing firms or competing modes to provide more efficient service at the system-wide level. Finally, there may be other public concerns, such as improving conditions of local firms vis-à-vis competitors, that may require government investment in some form.

Public investment in transport facilities is commonplace and has a long history. Of course, the extent and type of government involvement (past and present) in transport provision will differ according to the particular region and time period under study, which importantly affect the goals or values that direct policy. For example, postwar government involvement in public transportation has been greatest in Japan, the United Kingdom, and West Germany and less so in France and, especially, the United States (Akaha, 1990). Moreover, there may be differences among regions within countries, such as among states, provinces, or metropolitan areas. It is important, therefore, to describe planning in general-enough terms for broad applicability to a number of different settings.

To begin, it is useful to consider that investment can occur in fixed facilities, which includes all the different manifestations of transportation terminals and links among these terminals, and in the vehicles that use these fixed facilities. Two obvious (and popular) approaches to organizing government policy towards both types (facility or vehicles) of transport investment are (1) by what (either passengers or freight) is being transported and (2) by mode of travel. The first is essentially a demand-side distinction, though probably formulated more in terms of political demands rather than economic demands. The second is a supply-side distinction. Given the discussion of Chapter 5, a modal approach will not be used initially. Eventually, policy affects modes, but it is more fruitful to first think of modes in an abstract manner by using product characteristics. Thus, rather than supplying particular modal facilities or services, a basket of characteristics is being provided for a number of uses. The freight/passenger policy distinction will be maintained.

Investment can be further described by its temporal and spatial characteristics or impacts, and thus adding a jurisdictional component, and the extent of public involvement relative to the private sector. On the temporal side, investment can be one-time, as in the purchase and installation of facilities and vehicles, or it can be ongoing in terms of the maintenance and operation of facilities and vehicles. Spatially, investment can be locally oriented or network-wide. Taken together, spatial and temporal qualities, which can affect the overall size of the investment, influence jurisdictional decisions regarding investment provision. Finally, as indicated above, the extent of public involvement (and thus the extent of private-sector participation) will differ depending on the circumstances under investigation, ranging from complete public ownership and operation to only minimal public investment.

Table 7.1 summarizes the above discussion. Investment planning is thus portrayed as having six dimensions: (1) system, pertaining to whether investment occurs in facilities or vehicles,

(2) product, pertaining to the product being produced by the investment, (3) time, pertaining to the length of investment impacts and involvement, (4) space, pertaining to the geography of investment impacts, (5) jurisdiction, pertaining to the level of government responsible for the investment activity, and (6) participation, pertaining to the level of private-sector participation.

Not surprisingly, the dimensions are somewhat interdependent with “values” for one or some dimensions implying other dimensions’ values. The clearest example of this interdependence is between space and jurisdiction where more spatially expansive impacts implies higher levels of jurisdictional responsibility. Another example is the link between time and participation, where the long life of some investments (and the concomitant time to recapture the investment expenditures) implies small or no private-sector involvement. In essence, these dimensions represent a set of decisions or a checklist to be used in developing public-sector investment strategies. I now turn to a discussion of models used in the evaluation of these decisions.

**TABLE 7.1 -- TRANSPORTATION-INVESTMENT-PLANNING DIMENSIONS**

Dimension	Values
System	Facilities/Vehicles
Product	Demand Characteristics and Uses
Time	Duration of impacts; Number of time periods
Space	Project-level/Network-wide
Jurisdiction	Town or City/Metropolitan Area/County/State or Province/Multi-state or -province/National/International
Participation	% private-sector expenditures of total

Source: The author.

### **MODELING AND EVALUATING PUBLIC-INVESTMENT DECISIONS**

In order to incorporate the findings discussed earlier concerning firms’ production and distribution processes, I introduce a multi-step validation procedure. This procedure will be applied in two stages: (1) in this section, as an application to existing investment planning and evaluation

models, techniques, and methods, which were touched upon in Chapter 2, in order to determine how well existing devices account for the findings of the previous three chapters and (2) in the next section, as a framework to guide recommended changes to these devices.

The first step of the procedure is to determine the overall objective(s) of the models in terms of which of the dimensions of Table 7-1 are covered by the models. In other words, what are the models trying to answer? Ideally, models used to assist in the evaluation or creation of investment policy alternatives would be able to calculate all of the above dimensions for a particular situation. In actuality, models have been developed to cover only some of the dimensions. Second, given a listing of the purposes behind the modeling effort, I examine who or what is the functioning party in the model, and their decision processes. Possible options include individual travelers (passenger or freight), vehicles, households, firms, governments, and different levels of the macroeconomy.

Third, I determine what type of decision is being made with use of the model (rather than the parties in the model) in evaluating different policies. This includes determining the function of the decision (e.g., maximize, minimize, satisfice, approximate) as well as any transformation of the inputs to the model. Consequently, I discuss the inputs utilized by the model user and thus the data collected. Finally, I discuss the output measures used in the final evaluation step.

In order to make this discussion tractable—the literature on transportation investment is enormous—I maintain the categorization of Chapter 3 and conduct the analyses for each of the groups. As developed in that chapter, investment planning models and methods were categorized into 5 groups: (1) pure cost/benefit analysis, (2) economic efficiency, (3) cost-effectiveness, (4) economic growth and impact, and (5) non-economic based/multicriteria methods. It should be noted that there may be examples of studies within groups that have slightly different conclusions for each step than portrayed for the group. In addition, there may be examples of practice that

feature such differences. These exceptions are real, but unavoidable, when attempting to describe transport planning as a unified field. In addition, I apply the framework described above in order to describe, but not detail, the particular methods. Such work is useful but beyond the scope of the current study.

As stated in the introduction, I am interested in providing a description of the state-of-the-art. However, based on the literature review and other sources, I provide general indications here and in the next chapter concerning which models are used in the evaluation of investment and regulatory decisions. Leaving regulatory decisions for the next chapter, evaluation of investments is commonly done using cost-benefit (simple applications dominate), cost-effectiveness, and non-economic based methods. Economic-efficiency methods are frequently ignored by practitioners because of the unlikelihood, due to political reasons, that policy recommendations from these models would be implemented. Finally, economic growth and impact models are usually not used, but there are isolated examples of their use, and trends, based on personal observation, appear to favor greater use of these methods.

In addition, as with the case of the metalworking firms, I met with public-agency representatives in Chicago to attempt to uncover how officials at different levels (City of Chicago, Chicago metropolitan area, and the State of Illinois) of government conduct analyses of transportation policy with the objective of serving industry needs. Because the interviews produced no additional models or methods or innovative uses of the models and methods described below, I do not discuss the methods used by planners throughout the Chicago Metropolitan Area and the State of Illinois.



### Cost-Benefit Analysis

Cost-benefit analysis (CBA), interpreted in general, can be applied to either facilities or vehicles, but has been applied mainly to evaluation of facilities. These facilities can serve either passengers or freight, or both, and thus CBA can be applied toward planning for passenger or freight transport. CBA does not usually measure impacts—which mostly apply to the benefit side, since costs usually refer to the costs involved in construction and other areas—in terms of transport characteristics or uses, such as substituting for inventory. Such uses are seen as small compared to other costs, such as driver and vehicle. Rather, utility and the concepts of consumer and producer surpluses for passenger and freight analyses, and cost (or profit) for freight analyses are used. In the most advanced applications, characteristics and uses can be determining variables but are not usually directly used as measures. I return to a discussion of utility measures below.

Turning to measurement of temporal and spatial impacts, CBA can be applied across time periods and to project- or network-level investments. Finally, CBA cannot determine the relevant jurisdiction and levels of private- versus public-sector participation but can analyze options with different values for these levels and jurisdictions. Taken together, all dimensions can be analyzed and determined by CBA as long as policy or investment options are defined in an adequate fashion.

The functioning agent in the model can be either individual travelers or firms, who are affected by the change in transport through the supply and demand curves faced by each and attempt to maximize their consumer surplus or producer surplus. Thus, inputs to the model consist of an individual travelers' or firms' supply and demand curves for transportation. Unfortunately, these demand curves are difficult to measure and establish, so proxies are used for the changes in surplus, notably changes in travel time and travel-associated costs.

### **Economic Efficiency**

The methods of economic efficiency (EE) have the same origins in neoclassical economic theory as CBA methods, but there are slight differences. In terms of the objectives of the models, EE methods are applicable to investment levels in facilities only. The product dimension is interesting because this group of methods does not consider the benefits of transport, such as the uses developed in Chapter 5. Rather, negative economic impacts (costs) and externalities, such as congestion and damage to the facility, are considered. These economic impacts can be determined across time and at both the project or network level, which will determine the jurisdiction. Finally, the participation dimension is not relevant and not determined by the model, because EE methods presuppose some level (usually 100 percent) of public-sector involvement.

The functioning parties with this group of methods are individual travelers, either passenger or freight, but the model considers these travelers on a vehicle basis. Thus, costs and damages are measured per vehicle. The basic decision rule of the model is to approximate or attain equilibrium between congestion and damage charges and the capital cost of the facility (which serve as the inputs to the model) in order to determine the optimum level of transport investment, which is the output of the model.

### **Cost-Effectiveness**

Cost-effectiveness studies (CE), like the previous group, ignore the benefit side but do so in a different way. Instead of attempting to compensate or pay for the disbenefits associated with transport, these methods fix some benefit or other performance measure, such as passenger trips, to project or policy alternatives. Conceivably, any sort of benefit measure, such as transport characteristics and uses, could be used, but I did not encounter much innovation in the selection of benefit measures. Rather, benefits included such measures as number of riders, which is frequently

used in the evaluation of public-transit projects, and vehicle-miles for highway-investment analysis. This benefit analysis (and the calculation of costs) can be applied to facilities or vehicles, for any number of periods, and on any spatial level. Because these methods are project or policy-based, the jurisdiction and participation are not determined by the model but can be evaluated by examining alternative configurations of the project or policy.

The analysis of the functioning party is interesting because it features two parties with different interests. One is passengers, usually individuals, who are assumed to utilize the facility and thus reap its benefits. Another is the government, who through use of different configurations in their project and policy selections attempts to minimize costs of implementing and maintaining the investment. This bifurcation is not surprising, given the nature of the models, and affects the models' inputs, which are the levels of transport benefit or product attainment and the costs associated with the project. The decision rule is to select that project or policy with the highest effectiveness per cost ratio (maximize) or the lowest cost per effectiveness (minimize).

### **Economic Growth and Impact**

Economic growth and impact (EGI) models are more eclectic, because they do not derive from a common and extensively studied theoretical basis, such as found in CBA and EE methods, and often possess different objectives. Consequently, only EGI studies that were or can be directly used in evaluation of transportation investment, not work that has supported such evaluation analysis (as found in Table 3.1), will be included.

The variation in theory and objectives of these methods does have advantages, notably an increased modeling flexibility and capability. Consequently, all the investment dimensions except for jurisdiction and participant can be directly evaluated at some level by these methods. The two exceptions can be indirectly evaluated by examining alternative options with differing values for

these dimensions. There is also flexibility in the selection of functioning party in the model, whereby any party can be examined given the correct definition of alternatives.

The inputs, outputs, and decisions made by any specific EGI model will depend on the specific purpose intended for the model. Most of these models were designed and created in order to be applicable to any number of policies. Thus, they require that inputs be in some, usually traditional, economic measure, such as firms' production costs or individuals' consumption expenditures. For these models, if the user were interested in evaluating a policy's impact or affect in terms of the uses or characteristics of Chapter 6, he would first have to translate the uses or characteristics to some economic measure. By including this translation step, any of the transport-product dimensions could serve as inputs. Turning to the output side, given the name of the EGI models, outputs are some form of economic performance. Within this group, there are a number of possible options, which will depend on the functioning party in the model, but the decision of the model is always to maximize economic performance.

### **Non-Economic Based**

This final group of investment-planning methods is also eclectic, mostly due to the grouping adopted in this study but also to the nature of the models. These models, unlike the other groups, do not have some underlying theoretical underpinning but are more methodology-focused and were developed primarily for non-economic evaluation of transport policies or projects. Within the two subgroups developed in this study—engineering-oriented and multicriteria—models feature a common evaluation methodology and thus will be discussed separately.

Engineering-oriented measures can be applied to either facilities, such as road or transit links, and vehicles, such as transit operations, and have been applied to both groups with some regularity. The transportation uses developed in this study are not considered, because these

methods do not directly consider economic uses of transportation. Instead, they concentrate on transportation characteristics, notably, and usually only, speed, which is commonly cast in discrete level of service (LOS) gradations. Conceivably, any characteristic or set of characteristics could be used, but speed dominates.

Turning to the remaining dimensions, LOS evaluations can be conducted across time and for different project levels, but the jurisdiction and, especially, participation dimensions are not usually determined or evaluated by the models. LOS methods are frequently applied by governments at particular jurisdictions, thus rendering these two dimensions irrelevant. The issues of whether inclusion of the private sector or, less strongly, other jurisdictional levels may influence the LOS evaluation is assumed away.

The functioning party in models that use LOS criteria is the vehicles using the particular facility being analyzed or, in the case of evaluation of vehicles, the passengers being transported or the vehicles themselves. The evaluating decision made by the model is to select that investment level or option that maximizes or simply attains the desired LOS. Consequently, the inputs to the model consist of a desired LOS, which may be based upon existing levels and thus serve as additional inputs to the model. The output of the model is just a comparison of desired to existing levels of service.

The other subgroup of non-economic-based methods, multicriteria (MC) methods, offer the greatest amount of flexibility because their lack of theoretical foundation allows application to a wide variety of issues and situations. MC methods can also be used in evaluation of regulatory policies (discussed in the next chapter) but are included in here because all the applications I investigated are of an investment nature. These methods evaluate a set of alternatives based on the achievement of certain objectives or criteria. Criteria can be economic-related, which can include

the measures of the previous methods, such as maximizing consumer welfare and cost-effectiveness or minimizing project costs, but non-economic criteria, such as minimizing negative environmental impacts and use of land, tend to dominate. Thus, in terms of the dimensions of Table 7.1, all the dimensions can be evaluated, depending on how one defines the alternatives for analysis and the objectives to be reached.

The functioning party in the model will depend on the objectives but will almost always be multifarious in nature. That is, there may be a wide range of groups on whom impacts will occur and be evaluated, such as the individual traveler or firm, the general public, and certain communities and sectors. The decision of the model is to maximize (or minimize, depending on the normalization procedure) a weighted, which describes the preferences of analyst, average of the normalized measures of each criteria or objective. The investment alternative with the highest weighted average is selected. Inputs consist of the normalized measures for each objective and a set of weights. The output is some weighted combination of the normalized measures. There are versions of MC methods that feature different decisions and outputs and involve additional transformations of the inputs, but the general technique of evaluating weighted measures for certain criteria remains the same.

### **REMODELING AND RE-EVALUATING PUBLIC-INVESTMENT DECISIONS**

In this section, I reconsider the above planning models and methods in light of the supply-chain-management conclusions of the previous chapter. The methods described above were not developed to account for SCM, or for any production/distribution process or paradigm. They each are deficient in some way. In this section, I set out an “ideal” modeling framework, in terms of incorporating SCM but without concern about the costs of model development, testing and data collection, using Table 7.1. I then discuss, in turn, how the above groups can, if at all, incorporate

the transport-product dimension. Alteration of the other dimensions for each group to incorporate SCM is not as involved or necessary and can be deduced somewhat from the adjustments to the transport-product dimension and, thus, will be left for future work.

The ideal model would determine both passenger and freight transport on vehicles and facilities. Supply-chain management (SCM), despite being a paradigm that has many implications for freight transportation does have implications for passenger transport use as well. And, of course, both vehicles and facilities are used by firms.

Economic impacts should be modeled over time. A fine level of detail in terms of discrete units is not critical; what is more important is the ability of the model to capture a wide range of impacts, some of whom may not surface for a long length of time. The spatial and jurisdictional elements of the model are likewise important. Different impacts of transport investments and regulations, as measured in Table 6.2, will vary across space and jurisdictional levels.

The functioning party in the model is the supply chain. Ideally, an analyst would attempt to model the supply-chain as a single unit with a singular decision process, but this is difficult. What is important is to realize that impacts of transport policies and investments on a firm may be transferred in some form to that firm's suppliers and customers and thus their decision processes also need to be considered. Thus, depending on the domain of analysis, import and export of benefits and costs to other regions have to be considered. Finally, the models should consider changes in production and distribution processes, in some form, as inputs. Outputs can be contributions to firm performance, as was given in Table 6.2 or they can be more general economic measures.

Adjustments can be made to the model in order to incorporate the transport-product dimensions of SCM, as given in Table 6.2. As will be seen for both investment and regulatory-

planning models, groups are not equally capable of modeling the transport product. Some groups may already model some of the uses and characteristics in an adequate fashion, others may require different degrees of adjustments to permit modeling of uses and characteristics, and still others may not be able to model certain uses or characteristics, without destroying the model structure.

The most suitable investment-model group is the EGI models. Depending on the particulars of the specific EGI model, all the transportation uses, and indirectly through them, the characteristics, can be modeled. Thus, given a transportation policy and the correct definition of the transportation uses, contributions to firm performance in terms of sales, costs, and output changes are enabled. More difficult is modeling the transaction- and innovation-related transportation uses, which usually are not directly considered by these models. For these uses, an analyst would have to determine independently the impacts of these two types of uses and either feed them into the model or consider them in addition to, but independently of, the EGI analysis. The other transportation uses can be modeled using some variation of cost or sales with minimal assumptions.

Cost-effectiveness, although not the best choice for modeling firm demands, can be modified to provide adequate answers. The major modification would be to select a benefit measure (or measures) that describes firm performance. This measure could be a transportation use or characteristic or composite of the two. Selection and establishment of these measures may involve significant background work but is the only way to make this model group usable for current purposes.

Cost-benefit analysis and economic-efficiency methods both suffer because of their insistence on strict economic theory and equilibrium conditions, which were not developed to account for the imperfectly competitive conditions of SCM arrangements. The valuation of benefits is based on surplus, which derives from demand curves and willingness-to-pay. Supply-



chain-management, however, considers transport factors and uses in addition to simple quantity and price of products, which for application to transport-investment evaluation is usually linked to the time utility provided by transport. Use of CBA models may thus understate benefits. Simply including a wider range of benefits improves use of these methods, but the question arises whether such a modification changes the model type, in effect, approximating the EGI methods above. Another type of modification is to forego completely the measurement of surplus and directly consider the factors that may affect the measurement of a demand curve for transport services as evaluative criteria.

Economic-efficiency methods are especially problematic because they maintain competitive equilibrium as a decision to determine investment levels. Clearly, the major disbenefit of these models, traffic congestion, has dire consequences on firms, especially those under SCM, which require high levels of reliable transport. The model, therefore, may be directionally correct even if, given the above conclusions for CBA models, benefits to SCM are understated. However, supply-chain-management seeks to capture benefits through non-competitive arrangements involving close relationships with suppliers, customers, and carriers. Thus, an analyst would have to use a measure of marginal benefit that incorporates the characteristics and uses involved.

The engineering-oriented subgroup of the non-economic based methods do not consider transportation uses directly and thus prohibit an estimate of the benefits or costs of specific policies, but these models can be adjusted to incorporate firms' demands. In relation to supply-chain management, instead of focusing on speed as a characteristic, reliability should be the single-most important characteristic. Additional characteristics should also be used.

Finally, the multicriteria group, as expected, is fully capable of evaluating the impact of transportation investments on firms. Of course, a great deal of background work is necessary to

adjust these models. In particular, objectives would have to be selected either in terms of providing the characteristics of Table 6.2 or maximizing the contributions to firm performance directly or, given a description of a relationship between firm performance and transportation use, indirectly in terms of uses.

Table 7.2, on the following page, includes the adjustments for each model group in order to account for the supply-chain-management uses developed in Chapter 6. However, these adjustments are not recommended just for analysis of impacts on firms implementing or having the potential to implement SCM. Rather, these adjustments improve the model groups in terms of their ability to consider firm-level impacts of transport investments for any type of firms, with the caveat about transport uses differing according to the specific supply-chain under study. The table also includes additional tasks that are needed to apply each method group to the evaluation of a transport investment. Of course, the tasks and adjustments found in the table can be broken down in greater detail.

In way of illustration, I elaborate the application (with adjustments) of the EGI group of methods. For sake of completeness, all groups should be formally discussed and adjusted, but this will not be done here. Such work is important and interesting but is beyond the scope of the work in this study and can be handled elsewhere given the work of the previous two chapters as background. For current purposes, I discuss the steps involved in a possible application of the framework, utilizing EGI methods. These methods were selected as the most suitable of the investment-planning groups for considering the findings of the previous chapter and for providing the most information to policy makers.

**TABLE 7.2**  
**SUPPLY-CHAIN-MANAGEMENT ADJUSTMENTS TO INVESTMENT-PLANNING**  
**MODELS AND METHODS**

<b>Adjustments</b>	<b>Additional Tasks</b>
<u>Cost-Benefit Analysis</u>	
-Expand range of considered benefits; -Or, Consider demand for different attributes other than price and speed; Analyze surplus for each attribute individually or collectively	-Inventory of Affected Firms -What-If Scenario Analysis/Survey Work -Formulation and Estimation of Additional Demand Curves
<u>Economic Efficiency</u>	
-Include transport uses in valuation of congestion disbenefit per road length or other supply measure (e.g., rather than simply lost time per km, use increased inventory per km)	-Inventory of Affected Firms -What-If Scenario Analysis/Survey Work -Valuation of Uses and Conversion to per-mile or other supply-measure basis
<u>Cost-Effectiveness</u>	
-Change effectiveness measure from physical operational measure to firm-level measures, such as output/sales or cost changes	-Inventory of Affected Firms -What-If Scenario Analysis/Survey Work -Determination of relevant uses -Weighting of uses or selection of primary use
<u>Economic Growth and Impact</u>	
-Include transport uses (through contribution measures) as inputs to economic model where appropriate (some models already calculate sales/output impacts)	-Inventory of Affected Firms -What-If Scenario Analysis/Survey Work -Distinguish between direct inputs to model (e.g., cost impacts) and indirect (e.g., additional sales generated by increased competitiveness).
<u>Non-Economic Based</u>	
-Use additional characteristics as LOS measure (e.g., standard deviation of travel times on a corridor/route or network basis as reliability measure)  -For multicriteria models, utilize maximization/minimization of transportation uses (or more indirectly in terms of contribution measures) as objectives	-Inventory of Affected Firms -What-If Scenario Analysis/Survey Work -Selection of characteristics and measurement of them from supply perspective -For multicriteria models, selection and weighting of objectives

Source: The author.

The first step in an application is to conduct an inventory of affected firms or firms of interest. Prior or concurrent to this, the analyst has to delineate the relevant planning domain or jurisdiction in which impacts are to be measured. Impacts can be determined for firms in a localized area, such as in an industrial park or along a specific transport corridor, or on a region-wide basis, such as at the level of a metropolitan area, state, or even a nation. The selection of the domain of analysis will usually influence the inventory of affected firms, but this need not be the case. Using the Chicago metalworking study as an example, one could evaluate how the effects of changes in transport policy on metalworking firms would ultimately impact the metropolitan-area economy. Thus the inventory of affected firms can either be selected as all those firms within the impact-measurement area or certain sector or firms of interest.

The second step, which along with the first are common to all the methods of Table 7.2, is conduct survey work or what-if analysis to determine the quantitative linkages between transportation investment policy and the uses of Table 6.2. That is, an analyst wants to determine the sensitivity, preferably in terms of the contributions to firm performance, of the transportation uses to changes in transportation supply. For certain changes, such as minor alleviation of traffic congestion through either investment or regulation efforts, the sensitivity and impacts may be negligible and possibly zero; for other changes, such as the extension of the road network to previously underserved areas or the reducing of bridge clearances, may be significant. This task involve use of additional models—logistics and transportation models—and assumptions—grouping of sectors according to similarities in their supply chains—in order to reduce the reliance on and cost of collection of primary data.

With these two steps complete, the various model groups will differ in subsequent steps. For EGI models, the critical next step is to develop the linkages between the particular variables in

the economic model and the transport uses/contributions of Table 6.2. Recalling that discussion, the following measures were seen as relevant and can be used, either directly or indirectly, as linkages: change in production, inventory, and packaging/handling costs, changes in exchange-related investments, changes in search and contingency-related costs, changes in quantity of output and sales, and changes in delivered price. Ideally, these impacts would be broken down by the transportation uses of Table 6.2 in order to trace the different types of impacts, but an aggregation of measures is also possible. The development of linkages is important, because some models may already calculate some impacts internally, such as sales and output impacts due to increased competitiveness that is a result of reduced costs. Thus, the analyst has to be careful not to double-count or consider the same impacts more than once. Finally, results have to be compiled and analyzed for different policy (or regulatory for the next chapter's topic) options. The same caveat concerning double-counting applies to this step.

In conclusion, the adjustments and additional steps necessary to account for production and distribution processes in the evaluation of transportation investments are minor compared to the background work featured in previous chapters. That work was necessary to understand the functions of transport in the economy, as utilized by firms, and thus provide the important linkages between the transportation and economic/business systems that need to be modeled. In addition, the adjustments to the preferred group of models, EGI models, are not entirely new, in that these steps are usually featured in other types of investment-evaluation analyses.

Though a comprehensive review of investment-evaluation methods was presented, transportation investments should be considered in an EGI-type framework, not only for the purpose of accounting for effects on supply-chain management efforts, for which these models are best, but to also develop an understanding of the impacts of transportation on a region's economic

well-being. On the other hand, the increased complexity (and generally costs) of these models needs to be considered, and careful attention is necessary when applying them and analyzing their results. Because of this, analysts with backgrounds or interests other than economics or examining relatively small transportation investments, may prefer one of the other model types, with the recommended adjustments of this chapter.

## **CHAPTER 8**

### **REGULATING SUPPLY**

The objective of this chapter is to apply the analysis and methods of the previous chapter to the regulatory domain of government. Consequently, the components of the two chapters are similar. I first describe regulation as the other major domain of planning. This domain not only includes policies to regulate, but also to deregulate transportation in some form. I then discuss the models or techniques used to evaluate regulatory decisions, maintaining the focus on the state-of-the-art. Third, I evaluate how well the various models supporting these decisions consider the impacts of regulating or deregulating transport on firms' production and distribution processes. As before, I am concerned with efficiency-related impacts as defined for this study. Most regulation-related policies have primarily non-efficiency objectives, notably the maintenance of public safety and welfare, but efficiency effects are frequently considered in the evaluation of policies. In fact, the move toward de-regulation was motivated by efficiency concerns. In the final section, I introduce adjustments to these models in order to incorporate firm-level demands as specified in previous chapters.

### **REGULATION, DEREGULATION, AND RE-REGULATION AS MAJOR GOVERNMENT FUNCTIONS**

Regulation, or the setting of rules or standards, is the second major domain of governmental planning or policy. As such, it includes deregulation, in order to improve, as assumed, efficiency of transport services, and re-regulation, which may be used to compensate for any negative effects of a deregulated environment. Concerns with environmental degradation and decreases in safety both originate in greater volume of truck (and auto) travel, which may be a consequence of deregulation

(Cooper, 1991b). Taken together, regulatory rules or standards influence the functioning of transport markets in terms of what types of behaviors are permitted or motivated.

It is useful to consider three types or functions of (de)regulation: economic, protective, and operational, listed in the order of their prominence and commonality. Economic deregulation, the current trend--because of the consensus among shippers that the efforts of the late 1970s/early 1980s have had positive impacts (in terms of reduced costs and better and more variety of service) on the logistics function (Delaney, 1991)--involves liberalization of the transport sector in some form related to market participation and behavior and, as examples, includes abolishing rate controls, permitting freer entry to and exit from the market, and allowing mergers. Protective regulation, which involves the control of negative transportation impacts, includes, as examples, limits on truck access or size and capacity, monitoring of drivers' hours and training, and setting of emissions and other environmental standards; deregulation of protective measures is also possible. Operational regulation involves the setting of rules or standards governing the efficiency of transport operations, both publicly and privately owned. Examples include the control of highway-traffic flows to reduce congestion and the management of public transit.

As with the investment function, government regulation of transportation will differ according to the particular region and time period of interest. In terms of current trends, there is a clear direction to reduce the government role in transportation. However, outside of this basic objective, deregulation will differ across countries. Cooper (1991b) compares the deregulation process in the United States, the United Kingdom, and Australia and finds considerable differences in the processes among the three countries. In addition, in countries with a strong federal tradition, such as the United States, there are considerable regulatory differences among sub-national regions (TRB, 1990). Thus, as with the previous chapter, I wish to examine regulation efforts in general.



Following Table 7.1, regulation can be applied both to facilities and vehicles, but, as hinted to in the examples above, most regulation affects vehicles (and their related organizations or operators). In terms of product, regulation does not supply transport but does affect it, by altering the available supply of transport characteristics and uses to which this supply is applied, both passenger and freight. Of the final four dimensions, only participation (amount of private sector) is not necessary. Table 8.1 shows the regulatory dimensions of transport planning.

**TABLE 8.1 -- TRANSPORTATION-REGULATION-PLANNING DIMENSIONS**

Dimension	Values
System	Facilities/Vehicles
Product	Demand Characteristics and Uses
Time	Duration of impacts; Number of time periods
Space	Project-level/Network-wide
Jurisdiction	Town or City/Metropolitan Area/County/State or Province/Multi-state or -province/National/International

Source: The author.

### **MODELING AND EVALUATING REGULATION DECISIONS**

For the regulation models and methods, I use the multi-step validation procedure (and associated caveats) of the previous chapter, which involved the identification of model purposes, functioning parties, decision processes, inputs, and outputs. I introduced four groups of models in Chapter 3: (1) economic surplus, (2) industry structure, (3) change in costs and service, and (4) non-economic-based methods. As before, the objective of this section is to provide an overview of each of these groups, not individual studies or applications within the groups.

In terms of differences between the state-of-the-art and the state-of-the-practice, methods used in the analysis of regulatory policy, unlike the investment-planning models, lean more heavily toward the first group. Practitioners and planners tend not to conduct regulatory-type of analyses,

and if they do, it is frequently concentrated on use of non-economic-based methods. This may be due to the necessity of these models to consider private-sector behavior, but also may be due to the fact that many regulatory-related decisions are outside the domain of traditional transportation planners.

In terms of applicability, economic-surplus methods have been or are used in the evaluation of de-regulatory decisions directed towards freight transport but also passenger-transport-related regulatory decisions. Industry-structure methods have generally been used to argue for regulation, but, more recently they have been used to reverse this argument. Models that examine costs and service are used to establish arguments for deregulation, with non-economic-based methods used to establish regulations. It should be noted that combinations of methods may be used (one for regulatory and another for deregulatory arguments) for analysis of the same policy. In addition, different models may provide outputs to evaluate the same policy option. For example, an evaluation of safety regulations on trucks may use both non-economic based methods and a cost and service determination.

### **Economic Surplus**

The methods of economic surplus (ES) used in evaluation of regulation decisions are analogous to the (pure) cost-benefit analysis (CBA) methods of the previous chapter. The term “economic surplus” is used, because, given the nature of regulation decisions, the cost side is not directly related to the expenditures of policy, which under regulation are basically ignored. This ignorance is interesting, because the costs of maintaining institutions to establish, monitor, and enforce regulations can be substantial. Of course, negative economic impacts (which can be interpreted as costs, but better thought of as disbenefits in order to avoid confusion with CBA

terminology) can be and are analyzed by these methods, in terms of changes in consumer or producer surplus of those parties negatively affected by regulation or de-regulation.

Beginning with the dimensions of regulatory planning, ES models can be potentially applied to either facilities or vehicles, but, in actuality, are mostly used to examine regulation of vehicles and the firms that employ them. As in the case of CBA, these vehicles can contain either passengers or freight, or both, but ES models are largely used in the evaluation of regulatory policies toward freight carriers. Where these models are applied to passenger transportation, for example in the evaluation of traffic regulations to control urban-transportation congestion, they usually use time savings as a proxy for passenger surplus and thus as an evaluative measure. For freight-transportation analyses, more complex measures approximating the actual surplus are used, and this surplus is measured for a variety of groups, including shippers and carriers, and, through use of proxies, related parties, such as labor force and communities served, are also examined. It is interesting that economic-surplus methods when applied to regulatory decisions consider a greater variety of impacts. This is possibly due to the greater likelihood of planners using these methods to investigate investment decisions but not regulatory ones.

Though these methods do not directly measure the transportation product through uses and characteristics, uses and characteristics can be used to estimate the demand functions behind the surplus measurements. Hence, changes in characteristics can influence the measurement of surplus and thus be indirectly evaluated. ES methods can be applied to various time periods, but, usually feature before-and-after analyses of regulatory policy rather than evaluating impacts through time periods. In terms of space, certain spatial levels are irrelevant, notably the evaluation of project-level regulation of freight transport. Even in the case of regulation of passenger travels along

certain routes, which can be interpreted loosely as project-level, network-level impacts are frequently determined. Finally, these methods do not determine the jurisdictional dimension.

The particular functioning parties in the model will depend on the selection of surpluses that are measured. Hence, in the example from above, four types of functioning parties, shippers, carriers, the labor force, and communities, were specified. Each of these would attempt to maximize their surplus and may be differentially affected by regulatory changes because they face different demand and supply curves. Thus, where effects may be benefits to some parties, they actually might be costs to others. Inputs to the model include the change in surpluses, which usually require demand and supply curves, any factors used in estimation of these curves, such as transport uses and characteristics or proxies, and usually some monetary-conversion factor in order to translate surpluses to monetary values. The decision made by the model is to maximize the total surplus, which is the model's output, in order to inform the selection of regulatory policy or direction.

### **Industry Structure**

Though the previous group of methods have a strong foundation in economic theory and thus feature consistency among applications, industry structure (IS) methods do not have a common theoretical base and thus may feature greater variety in application. This variety is due to the type of evaluative criteria ultimately used, which derive from legal theory and wording, such as the promotion of public convenience, necessity, or interest, and national transport policy. Different interpretations of such wording leads to latitude in the selection and use of evaluation methods. As might be expected, a wide range of arguments, many of which are not efficiency- or economic-based, can be used either to support or counter arguments to regulate or deregulate that initially

derive from examining industry characteristics. Nevertheless, it is still possible to determine the basic manner in which these methods evaluate regulatory decisions towards transportation.

In terms of the system dimension, these methods are only applied to vehicles indirectly by examining the characteristics of the firms that employ them. The transport product frequently is not the focus of study and, when analyzed, it is not in terms of transport uses or characteristics but rather in amount and cost of transport, as affected by various industry-structure measures and behavior. These measures, which are used to demonstrate the lack, or more recently the existence, of competitive markets, include large economies of scale, unfair or destructive competitive advantages and practices, extranormal profits, barriers to entry, and high concentration ratios. As with ES methods, time is usually handled in a before-and-after examination of impacts, and spatial analysis is only relevant at the network-wide level. Jurisdiction is not determined by these methods.

The functioning party in these methods is the transportation carriers. Decision processes and behaviors on the part of transportation firms are assumed to be competitive, and, as stated above, are the focus of these methods.

Given the various measures used to describe carriers' behavior and the objectives behind the use of IS methods, establishing a concise and consistent description of the evaluative decision made by these methods is not straightforward. Generally speaking, these methods attempt to minimize adverse competitive conditions, and consequently, the adverse impacts on the economy and groups, such as the public, within the economy. This decision is usually evaluated using transport availability (or amount) and price as outputs and examining how the industry-structure measures of above, which serve as inputs, affects these.

### **Costs and Service**

The third group of methods is related to the CBA methods of the previous chapter and the ES methods discussed above in that they examine the benefits and costs, in terms of changes in costs and service (CS) and their impacts, to the different parties affected by the regulation. The main differences lay in the extent of theoretical rigor. CS methods are not as rigorous, in terms of adhering to an elegant or set theory, as the CBA and ES methods, but this lack of rigor permits a great deal more flexibility in deciding what should be included or excluded from the benefit-and-cost determination. I examine this benefit-and-cost determination using Table 8.1.

Beginning with dimensions, CS methods seek to evaluate the impacts of regulation, which affect carriers, on vehicles. These methods are not used in the regulation of facilities. In addition, these vehicles mostly pertain to freight transportation. These methods can be used for passenger travel (for example, in terms of modeling transport-mode-split decisions due to increased regulation for purposes of reducing congestion), but for purposes of this study, the freight application is more relevant. Maintaining this freight focus, the transport product is measured using a logistics-based framework, such as utilized in Chapter 4. Hence, these models include some of the transport uses developed in Chapter 5, and, by association but not directly, the characteristics as well.

In terms of passenger applications, CS models can also include transportation uses and characteristics, but these are usually done with the individual passenger, who has different objectives than firms, as the functioning party in the model and thus feature a different set of characteristics. Economic impacts can be evaluated across time, and spatial impacts are usually measured at the network, or at least the corridor, level. Finally, jurisdiction is not evaluated by these methods.

Turning to the functioning party, for these models it will be the user of transport, which will either be the firm (mostly for freight but some passenger use) or the individual (mostly for passenger but some freight use). The decision process for each is assumed to be minimization of “total” logistics cost (or maximization of profit) and maximization of utility, respectively.

The decision of the model is to minimize the negative (or maximize the positive) impacts of regulation, depending on the perspective of the functioning party. The outputs, of course, are these impacts and consist of some measure of total cost or profit for firms and utility for individuals.

Assuming shipping and receiving firms as users, inputs consist of firm-level metrics that capture the uses and characteristics of Chapter 5, such as inventory-carrying cost, transportation rates, and order-processing costs. These metrics are similar to the contributions to firm performance developed in Tables 5.1, 5.2, 5.3, and 6.2. For individuals as passengers, inputs could consist of a similar set of metrics that measured contributions to passenger utility.

### **Non-Economic Based**

In terms of economic theory, all regulation is necessary for two basic reasons: (1) there are questions of equity, which is usually outside the domain of market forces, that need to be considered and (2) there are market failures or externalities, both beneficial and damaging, that market signals are unable to take into account. Both these reasons were featured as background to the regulatory policies in the discussion of the above models.

For this group of methods, the regulations that are evaluated are primarily used to combat market failure and negative externalities from the direct operations of transportation rather than the economic organization, as was the case above. One exception is the regulation of congestion, which was cited in the ES methods above, but traffic regulation efforts are frequently evaluated using non-economic-based methods. These methods either use operational or actual measures of

the externality to evaluate regulatory policy. As in the case of IS methods, other types of arguments, such as a determination of economic impacts of different regulatory policies, can be used, but non-economic-based criteria take precedent.

Using Table 8.1, IS methods can be applied to both regulation of vehicles, such as controls on truck weights and dimensions, and facilities, such as design specifications of roads and bridges. In terms of transport product, these methods either ignore economic-related impacts of transportation, use outputs from other methods, such as changes in transport cost, as a measure of product, or use level-of-service type criteria, such as volume or speed of travel. The remaining dimensions are similar to the previous methods group.

The functioning party in the model can be either freight or passenger vehicles and the individual or firms responsible for the movement. The parties are assumed to act in a traditional fashion (as in the previous group of methods), with the model evaluating the consequent externalities. The objective of the models is to minimize externalities and other adverse impacts, with possible constraints being the costs or impacts of achieving this minimum. Outputs can just be a selection of policies according to externality levels, which themselves are usually outputs from separate models that are beyond the scope of the present work, or a comparison of these externality levels with the economic costs of regulation. Consequently, inputs consist of levels of externalities and the impacts or costs of regulation.

### **REMODELING AND RE-EVALUATING REGULATORY DECISIONS**

For this section, I maintain the steps of the corresponding section of the previous chapter. Thus, I will utilize the ideal situation as set out previously. Similar to the investment models, the above regulation models and methods were not designed with SCM in mind but some of the groups were designed to evaluate impacts on firms. Consequently, these models, as a whole, are more



able, as is, to investigate and plan for SCM but still need some adjustments. As before, I only discuss major modifications to the transport-product dimensions, which does imply certain values for the remaining dimensions.

The best group of models, and thus the group that requires the least amount of adjustment, is the cost-and-service group. These methods use a logistics perspective and thus are able to capture most of the uses, and the related characteristics, of Table 6.2. In order to accommodate SCM principles, additional transaction-input measures, including the extent of exchange-related investments and benefits and reductions in search costs, and innovation-input measures, such as subsequent sales and cost impacts, need to be included. Furthermore, the impacts on labor are usually disregarded by these models. Regulation of passenger facilities and vehicles may indeed have labor-related impacts that also need to be modeled.

Industry-structure methods have the potential to feature many of the considerations above and thus may feature minor modifications. However, traditional IS analysis, which solely considers industry-structure metrics as evaluative criteria, needs significant adjustments. Though the focus on the carrier might be wise from an economic analysis of whether an industry should be regulated, the ultimate customer of these regulation efforts is forgotten in such an analysis. The only impact that can be measured is that greater freedom of operations, as befits a competitive industry, will translate to greater efficiency of carriers' ability to fulfill supply-chain-management demands. Although such a result is directionally correct, it does not inform all the applications of regulatory policy. Thus, if only directional advice is necessary, these methods are accurate, but if a more comprehensive notion of the impacts of regulatory decision is desired, this group of methods needs to incorporate some sort of additional analysis, similar to the cost-and-service determination above.

The same basic conclusions apply to non-economic-based methods. These methods have purposes different from serving competitive efficiency, and thus cannot be used in an effective manner to examine the economic impacts of changing production and distribution processes. However, in addition to the measurement of the economic impacts of regulatory policy on externalities, these models should also consider the complete cost (or in the case of supply-chain-management, loss of potential benefits or opportunity cost) of the regulation on firms. Such a consideration involves including the modified version of the cost-and-service analysis discussed above. For those NEB models that use only speed as a level-of-service determinant, use of additional characteristics, such as reliability and accessibility at a minimum, is necessary to incorporate the effects of firms' production and distribution processes. This applies to both freight-and passenger-transportation analyses.

The final group of methods, economic surplus, has similar problems to its investment counterpart despite the ability of these methods to incorporate different transportation characteristics and uses. The evaluative measure still remains a non-monetary surplus unit that is then converted to a monetary measure. Adjustments take the same form as presented in the previous chapter, or a minor modification would be to use the transportation characteristics and use analysis directly. This, in effect, changes the structure of these models, but there are serious questions concerning the advantages of measuring the impacts of regulatory and other transportation policies using surplus measures.

Table 8.2, on the next page, highlights the recommended adjustments and additional tasks to the regulatory-planning models. As with the investment side, additional subtasks and more detailed adjustments are possible, and one could re-develop and reformulate each of groups to account better for production and distribution processes, including SCM. For regulatory models,

**TABLE 8.2**  
**SUPPLY-CHAIN-MANAGEMENT ADJUSTMENTS TO REGULATORY-PLANNING**  
**MODELS AND METHODS**

<b>Adjustments</b>	<b>Additional Tasks</b>
<u>Economic Surplus</u>	
<ul style="list-style-type: none"> <li>-Expand range of considered benefits; Consider transport uses or characteristics directly;</li> <li>-Or, Consider demand for different attributes other than price and speed; Analyze surplus for each attribute individually or collectively</li> </ul>	<ul style="list-style-type: none"> <li>-Inventory of Affected Firms</li> <li>-What-If Scenario Analysis/Survey Work</li> <li>-Formulation and Estimation of Additional Demand Curves</li> </ul>
<u>Industry Structure</u>	
<ul style="list-style-type: none"> <li>-For traditional analysis, only direct use of group is relevant to evaluation needs.</li> <li>-Inclusion of an examination of relationships between a more efficient (in terms of competitive behavior) transport industry ad performance of transport-service users</li> </ul>	<ul style="list-style-type: none"> <li>-Inventory of Affected Firms</li> <li>-What-If Scenario Analysis/Survey Work</li> <li>-Statistical Analysis to Link Objectives or Decision Rules of IS Models to SCM transport framework</li> </ul>
<u>Costs and Service</u>	
<ul style="list-style-type: none"> <li>-Inclusion of transaction-facilitating uses (e.g., increased investments, reduced costs due to elimination of redundancies)</li> </ul>	<ul style="list-style-type: none"> <li>-Inventory of Affected Firms</li> <li>-What-If Scenario Analysis/Survey Work</li> <li>-Possible Use of Economic Models to Account for Indirect Impacts on Firms</li> </ul>
<u>Non-Economic Based</u>	
<ul style="list-style-type: none"> <li>-Include analysis of costs and service impacts in addition to non-economic impacts (i.e., externalities)</li> </ul>	<ul style="list-style-type: none"> <li>-Inventory of Affected Firms</li> <li>-What-If Scenario Analysis/Survey Work</li> <li>-Estimation of Cost and Service Impacts and Comparison with Non-Economic Impacts</li> </ul>

Source: The author.

the adjustments are not as dramatic, especially for the cost-and-service group. By augmenting the work of this method group, the illustration of the EGI method of the previous chapter can also be applied to regulatory decisions in much the same way.

## **CHAPTER 9**

### **CONCLUSIONS**

The purposes of this chapter are (1) to bring adjournment to the current study and, consequently, (2) to suggest areas where continuance of this study may occur. This study was not intended as a final word on the topic of how public-sector involvement and policy, as exhibited in the modeling and planning of transportation, and private-sector behavior, as shown by changing production and distribution processes, can achieve convergence. Rather, this was only the overall idea of the study and was comprised of a number of sub-goals. A great deal of background and development was involved in order to achieve these goals.

In this chapter, I review this background by providing a summary of previous chapters and highlighting important contributions, findings, and insights. Next, I provide general policy suggestions, which differ for different jurisdictional levels and point to the importance of higher jurisdictions or at least a strong level of cooperation and coordination among lower jurisdictions. This study not only recommends changes to current planning methods, but also provides an initial understanding of what type of transport facilities and policies are consistent with the goals of supply-chain management and other firm-based paradigms. Conclusions specific to the metalworking sector help to inform both of these sections and thus are dispersed among them.

I then discuss possible answers to whether evolving industry needs due to changing production and distribution processes are important and thus whether the public sector is important in serving these needs. I close with thoughts on the benefits and costs of making the adjustments suggested in the previous chapter and suggestions for resuming this work in terms of future research directions and topics.

## A SUMMARY

This study began with the notion that production and distribution processes are changing and that public-sector transportation planners need to be aware of these changes. I took the first part of this notion as an assumption, but I examined the latter part as an issue. I then placed this examination in a value-laden framework, notably the consideration of competitive efficiency as the focus of public policy. Other objectives are clearly important and may outweigh efficiency, but that was the assumption used throughout this study.

Given this goal, I deemed the evaluation step of the planning process and the models that inform or support public-policy decisions, subsequently defined as consisting of investment and regulatory roles, as the domain of the study. Thus, I sought to draw implications for transportation planning of changing production and distribution processes from the additional considerations and adjustments to models in order that they may better inform evaluative policy-related decisions.

Subsequently, I reviewed the literature both to gauge, at a superficial level, the effectiveness, which was found lacking in many aspects, of the currently available literature to examine the relationships between industry needs and transportation provision and regulation by the public sector, and to provide input to future sections of the study. In way of understanding a massive literature, I classified, unique to work found here, studies into four categories: (1) examination of the roles of transportation in the macroeconomy, (2) investigation of these roles at the industry level, (3) evaluation and planning of transportation investments and policies, and (4) accounting, in a more direct fashion than the previous three groups, for changes in production and distribution processes in the formulation of transportation policies. This last group of studies is the most related to the current study, but also requires additional conceptual and theoretical development, to which the current study should contribute. Likewise, the comprehensiveness of the

literature review of this study, in terms of compiling and classifying studies that have examined the linkages between transportation and industry, has not been featured elsewhere.

Aside from establishing a literature on this subject, I found a clear (and important) progression of ideas from the oldest, most basic studies--in terms of the current study's objectives--of the first category to the most current and relevant work of the fourth category. In particular, additional transport characteristics, besides price, and transport uses, besides influencing location decisions, become increasingly important and examined. Despite this progression, however, the literature was found lacking a consistent theoretical framework to examine the relationships between transportation policy and the effects on industry and the economy.

As a starting point for this framework, I defined the supply chain as the unit of analysis, and I used the logistics function within firms that comprise the supply chain as the mechanism by which the public-sector role in transportation could be examined. Though the selection of this function may seem obvious and unremarkable, I know of no study that has examined transportation planning issues by analyzing how the overall logistics function (not just individual components, such as inventory management) in firms, and thus the supply chain, may be affected. I found that the selection of the logistics function (within a supply chain) provided a pragmatic means by which policy impacts on firms could be examined.

I then analyzed the logistics function for different management paradigms and for the metalworking sector. This analysis was conducted by examining various decision areas in order to determine how transport policy may eventually impact logistics and, thus, firms' operations. Once again, though it is well-known that transport is an important input to logistics operations, the comprehensive decoupling of transport from other logistics areas found here is unique to this study. In particular, I developed a number of measures for each logistics area that could be used to

differentiate among types of supply chains and their associated transportation uses and characteristics. I chose supply-chain management (SCM) as the paradigm to describe changing production and distribution processes and contrasted it, in terms of logistics decision areas, with two other paradigms, mass-production and pre- or non-mass production. A comprehensive description and analysis of mass-production, albeit in a different form, does exist, but this is not the case for the other two paradigms, and the contrast is new.

For both the paradigm and industry applications, I found different types of supply chains to have significantly different logistics systems. Facility location was found as the defining logistics-decision area for pre- or non-mass production firms; production planning was the most relevant area for mass-production firms; and supply-chain structure and interfacing was the most important for SCM. I showed that these differences, in turn, affected the particular uses of the transport input and characteristics desired in different systems. Collectively, these uses and characteristics impact the importance of transport policies to firms, which will differ according to supply-chain characteristics. The local orientation of pre- or non-mass production firms stresses the importance of local investments and policies both to improve the internal efficiency of the local transportation system and to provide it with more regional connections. The key transport characteristic for these firms is price, but there is still need for additional characteristics. For mass-production, speed and volume, as well as a degree of reliability, of the transportation are important. These firms face a more complex set of transportation uses, similar to SCM with the possible exception of transaction-related uses. Finally, SCM firms face the most complex and varied set of transportation uses, and accessibility and reliability of the transportation system are required at high levels because of the importance of high-quality interfirm transactions. Such relationships among supply-chain characteristics and transport demands and uses expand previous analyses, which primarily



accounted for differences in transport sensitivity or importance among industries by establishing and comparing some variant of value-weight ratios or some other simple measure of sector or product delineation.

In order to examine these differences in more detail, which was required for SCM, I then isolated the transportation component of the logistics function and devised a theoretical framework to explain the use of transportation by firms in terms of the underlying characteristics of the transport product. This framework featured the splitting of the transportation input into three use categories: a production facilitator, a transaction facilitator, and an innovation facilitator. Though the transformation and innovation uses have been examined elsewhere and were adapted for this study's framework, the development of transportation as a transactional facilitator is novel.

Then, I presented results for the Chicago metalworking sector that supported that price of transport may not be the single-most important transport characteristic, an assertion that is found throughout the economic and transportation-planning literature. My results also showed that the more complex the logistics demands in this sector, the greater pressure to restructure and implement supply-chain management principles, which in turn leads to a more complex set of uses for transportation. I established two basic supply chains, a custom chain, which features the production of custom-made goods and simple logistics demands, and a standard chain, which features large production runs of more standardized products and more complex logistics demands.

Finally, I made suggestions to improve existing investment- and regulatory-planning models based on an application of the entire framework to supply-chain management. The tasks of describing and organizing planning methods and models are not trivial because of the number and variety of methods, but five model groups were established for the investment side and four on the regulatory side. Adjustments to the groups differed on the basis of each group's current ability to

consider production and distribution processes in terms of the expanded set of characteristics and uses that were deemed important.

### **GENERAL POLICY SUGGESTIONS**

Several important findings and policy recommendations result from the analysis. I first present five general recommendations, because there is the larger question concerning how should policymakers establish transport policy that explicitly considers private-sector needs, not only of those firms that are undergoing changes or restructuring of their production and distribution processes. I then discuss policy recommendations for both investment and regulatory functions of government in general and those that were established for the metalworking study.

First, planners and policymakers need to be aware of the “markets” for their actions. That is, they need to determine who will be served by specific investment and regulatory policies and realize that private industry (not just the traveling public) is an important user of and market for public policy. As highlighted above, there are some important caveats to this statement. At the project level, this means knowing the local industries (and other residents not considered in this report) that will be affected. At the network, metropolitan (and higher) level, this means knowing the sectoral composition of the economy, and how supply chains differ based on this composition.

Second, policymakers should be cognizant of the supply-chain perspective. Industries do not operate in isolation, rather they have important connections to other industries and firms. Thus, while transport policies may appear to influence only certain firms and industries, other firms and industries are also indirectly affected.

Third, policy choices need to be examined with a spatial (and thus jurisdictional) dimension. Policies at different spatial and governmental levels will have different levels of

effectiveness, and jurisdictions should work together to create a unified policy that provides maximum benefit to the firm under study.

Fourth, transport policies should influence, and analysts should evaluate them on the basis of, transport-product characteristics other than just transport cost, which essentially is an amalgam of price and speed. In addition, typical planning metrics, such as travel-time measures or volume-to-capacity ratios do not adequately capture the reliability, in terms of deviations from expected travel times, of the transport system, which was seen as critical to changing production and distribution processes as defined by supply-chain management.

Fifth, policymakers should realize the importance of the various motor-carriage modes, such as truckload, less than truckload, and small-package delivery, to industry needs. These modes provide more complex and multifarious set of transport characteristics, including, but not limited to, accessibility, reliability, flexibility, and speed, that is needed to serve contemporary travel demands. This is especially true for firms with high-quality logistics needs.

This last general finding concerning mode choices leads to the discussion of appropriate types of investment and regulatory policies. In the United States, the Intermodal Surface Transportation Efficiency Act of 1992 (ISTEA) transferred much decision-making power to local bodies at the metropolitan level, which might hinder a more global view of the transportation service as required under changed production and distribution processes. With the increased emphasis on reliability and predictability of shipments, federal (or some higher-level jurisdiction) investment in increased highway capacity that is more far-reaching than a system with a central-city focus appears necessary.

In addition, government investment or subsidy is appropriate for construction of intermodal facilities in the instances where carriers, either from the same or different modes, may be unable to

agree or invest in common facilities. Higher-level participation may also be appropriate, because many of these facilities serve more than one state or metropolitan area. One related occurrence has been the strategy of states (and sub-state regions) to offer benefit packages, which include infrastructure facilities, to attract large industrial complexes. This has been the case of the Japanese automobile-industry transplants and the General Motors Saturn plant. Both these sets of facilities feature many of the SCM principles mentioned in previous chapters and rely on high-quality connections between producers and suppliers, thus requiring complex infrastructure. This type of regionalized infrastructure focus may actually lessen the importance of government investment at the national level relative to state or lower levels. However, these production and distribution systems also rely heavily on inbound and outbound corridors that extend far beyond any state boundaries.

Finally, public investment may be used to improve system performance and account for negative externalities. Options such as special-use freeway ramps, highway facilities dedicated to commercial or truck traffic, rail-to-water links, and non-public highways that provide connections between water and rail and between rail and trucking terminals are candidates for improving system efficiency. Though not the objective of the methods developed in this study, investment may be used to control negative efficiency-related externalities. An investment policy to motivate shippers to switch to or use more environmentally sound modes--which would also speak to financing-inequities--such as rail, will require improvements or subsidies given the benefits that arise to certain firms from use of high-quality transport. Provision of subsidies to carriers, such as rail, may also be advisable in order to permit non-incremental development and purchase of technology and equipment in order to address these inequities.

In terms of re-regulation, there are issues of reduced safety and environmental quality (for air, noise, and visual) that may increase due to a focus on serving changing production and distribution processes and its concomitant increases in highway travel. Once again, higher-jurisdiction regulation may carry increased weight for the same reasons given above. And, as was discussed in Chapter 2, major reductions in negative environmental impacts appear not possible without reversing logistics-related practices to some degree. Investment to upgrade more environmentally sound modes to provide better service (discussed above) or providing service guarantees to shippers may be the only types of options that would not have a negative efficiency effect.

Turning to de-regulation, there is agreement that federal deregulation of the transportation sector has benefited shippers. However, these efforts did not completely deregulate the transportation industries. For example, rates still need to be submitted to the Interstate Commerce Commission (ICC), and carriers do not have complete pricing freedoms. Increased deregulation in terms of fewer rate-reporting requirements to the ICC, greater freedom to price different services, and removal of regulations that require contracts to include a discussion of how the charged rate was determined would all benefit carriers. In addition, legislation should be revised to allow greater cooperation among firms both within and across modes in order to promote service flexibility and reduce costs of providing broader, high-quality service.

It is expected that higher-jurisdiction involvement in economic regulation will increase relative to state involvement. Intrastate regulation place carriers operating in a regulated state at a competitive disadvantage and may prompt motor carriers to leave. This movement of carriers should be exacerbated because of the emphasis on flexible methods, an increased competitive environment, and an emphasis on demand for broader, higher-quality services. However, higher

jurisdictions have to remain vigilant in assuring that the financial, long-term health of the deregulated transportation industries is sound. This is especially true for parts of the trucking industry, such as the less-than-truckload sector, which have suffered drops in profitability and much exit by firms. Failure of transportation firms creates more of a problem when supplier bases are reduced, and when firms are more closely linked and dependent on each other's performance. On the passenger side, traffic-regulatory strategies that reduce congestion through reduction in passenger accessibility to a wide area should be avoided, since greater accessibility and mobility of passengers are becoming more important to metropolitan economies.

Finally, two overall policies are recommended. First, jurisdictions should promote greater standardization of regulations and requirements, such as for vehicle dimensions and design, access, safety-compliance measures, and fuel taxes, vehicle registration, and other fees or reporting requirements. Such standardization among jurisdictions becomes indispensable to providing a quicker, flexible, and more reliable service as well as saving carrier costs. Second, government can serve as an arbiter and contingency builder among different parties, including different modes, shippers and labor. Table 9.1, on the next page, summarizes the policy implications derived from an analysis of changing production and distribution processes.

In terms of the metalworking sector, from transportation and logistics perspectives, inbound and outbound shipments differ. Inbound shipments tend to be more intraurban and local and feature simple commodity products, such as metal; outbound shipments tend to be much more dispersed and feature more complex and differentiated products. These differences, in turn, affect other areas, such as the extent of interface with companies (more interface on the outbound side), transportation-mode choice (the outbound side has more use of modes providing smaller, more frequent, and faster transport), and inventory management (raw-materials considerations on the

**TABLE 9.1**  
**TRANSPORT-POLICY IMPLICATIONS OF**  
**CHANGING PRODUCTION AND DISTRIBUTION PROCESSES**

Investment

- Provide increases in highway (and other non-central-city-oriented) capacity where congestion and other bottlenecks occur and promotion of air service, as well as intermodal connections between these modes.
- Investment in new intermodal terminals that are accessible by anticipated production-distribution complexes and that serve more than one state or metropolitan area.
- Investment in special facilities to improve system performance or account for negative externalities

Re-regulation

- Increased environmental regulations, which may be seen as necessary, will tend to hamper logistics-improving changes
- Increased protective regulation, such as limits on truck access or dimensions, may become increasingly ineffectual at the state level, thus prompting involvement at higher levels.
- Provide service guarantees to shippers for switching to more environmentally sound options.

Deregulation

- Economic deregulation at the national level has been seen by shippers as supportive of logistics
- Further deregulation may be necessary to take advantage of the anticipated efficiencies promoted by changes in production and distribution processes.
- Revise antitrust legislation to allow more cooperation among firms within and across modes
- Any economic re-regulation will necessarily be at the national level rather than at lower levels
- Jurisdictions (probably higher-level) will need to remain vigilant in monitoring the health of transportation industries, such as the LTL trucking sector, because costs of failure are higher

Other

- Promote greater standardization of regulations and taxes among jurisdictions
- Promote more dialogue among shippers, carriers, and other parties

inbound side versus finished-goods-inventories considerations on the outbound side). Such differences were also found in the comparison of supply chains at the paradigm level.

The varying nature of inbound and outbound transport needs means that distinct policies need to be directed at different levels of the chain. Related to this fact, policies at different spatial (and jurisdictional levels) will have unique effects. Metropolitan-level policies will have greater and more direct effects on metalworking firms' inbound activities than policies directed at transport facilities at the state level and beyond; on the other hand, outbound-side activities require policies at regional, national, and international levels. Thus, all levels of government should be involved in transport policy toward metalworking firms in order to service not only local metalworking connections but also the external (to the Chicago metropolitan area) connections metalworking firms have with their suppliers and, especially, customers.

In terms of transportation strategy of the metalworking sector, motor carriage is practically the only mode used (directly) by firms. Indirectly, of course, other modes, possibly intermodal (i.e., trailer-on-flat-car) and some rail, are used because of metalworking's increasingly wide shipment pattern to customers and backward connections to more-probable users of rail, such as the various metal producers. Moreover, shipment size tends to be small, thus favoring less-than-truckload shipments; many firms provide their own transport, largely in small-ton trucks, vans, and automobiles, as well.

Consequently, highway-related regulatory and investment policies at the network level will have the most direct impacts on metalworking performance. In order for policy directed at other modes to have any effects, they will have to be at a multistate or national level. Also, the negligible effects of potential project-level improvements aimed at metalworking firms, such as raising of viaducts, improving turning radii, or regulating local traffic flow, on firm performance means that



regular efforts to maintain and expand the regional highway network and its connections to the national system will suffice.

In sum, the varied uses of transportation as highlighted above for the metalworking sector and in previous chapters for supply chain management, points to the need for innovation in policy formation. Both passenger and freight need to be considered. In addition, public-private partnerships, not only for financing, but also for transport policy and product development may improve policy formulation and effectiveness. The public-sector should consider being a more active partner in the supply-chain through closer relationships and consultations with their “customer firms.”

### **DO CHANGING INDUSTRY NEEDS MATTER?**

In Chapter 1, I established the hypothesis that transportation has played and is playing an important part in the changes occurring in distribution and production processes and that lack of public-sector action to accommodate these changes can be problematic. As seen in previous chapters, this is only partially true. It depends on the supply chain under study. In terms of SCM, which was used as the descriptor of changing production and distribution processes, the servicing of industry needs through transportation is important.

For parts of the metalworking sector, monitoring changing production and distribution processes in terms of transportation is not important. Although there are a number of different production/distribution processes in Chicago's metalworking sector, for an analysis of logistics systems, two general supply chains are evident: a "custom" chain, which features a producer of a custom good, such as tools, dies and molds, and a “standard” chain, which features a producer of a relatively standard good, such as hardware and containers. In terms of the paradigm discussion,

custom firms were similar to pre- or non-mass production firms, and standard firms were similar to mass-production firms.

Although the research does not allow us to recommend a comprehensive transport policy for the Chicago metropolitan region or its sub-regions, it does show that the effects of transport policy will differ based on the types of supply chain (or logistics arrangements) affected. In particular, standard metalworking chains will have a greater sensitivity than custom metalworking chains to transport policies. The effects of transport policies in terms of alterations in the time or accuracy in receiving or sending shipments will not have to be as large for these firms to realize meaningful benefits. That is not to say that firms in custom chains will not be affected, rather that the effects are more indirect and of lower magnitude. Policymakers thus need to recognize the type of logistics systems to be affected when designing policies. Many firms do not perceive the logistics function to be vital to their everyday operations. This was conveyed by respondents during the process of completing the survey form, with common sentiments that many of the transportation and logistics questions were not that applicable and that transport was a minor part of the firm's business. The fact that none of the 13 firms I interviewed calculated inventory-related costs (a basic and necessary measure of logistics-system performance) also indicates a disinterest with logistics activities.

Clearly (as stated above), firms in different chains will differ in recognizing the importance of logistics to their everyday operations. Besides this factor, however, some firms may not feel that the benefits of diverting attention from other facets of their business to logistics operations will be worth the costs. For some metalworking firms, this may be a wise decision; however, for others, especially those in standard chains, there will be real benefits, such as lower inventory levels, lower and more reliable lead times, and improved customer service, from re-evaluating their current

logistics practices. Policymakers can identify, using supply-chain analysis and cost analysis of different areas throughout the chain, those firms that may benefit from such a re-evaluation and recommend changes in business practices.

For the metalworking sector as a whole, about two-thirds of firms report that the importance of transport delivery time, reliability, and flexibility (which collectively should become more important under restructuring conditions) have not changed over the past 10 years for their inbound and outbound logistics needs. Some of this result is due to a disinterest or inability on the part of firms to optimize the logistics functions, but some is also due to the nature of the supply chains in which these firms operate. The custom chain features, among other things, longer lead times, lower inventory levels, fewer forecastable demands, and fewer formalized transportation and logistics strategies. Those in custom chains, while also feeling the demands of restructuring, are somewhat shielded from making many logistics-related adjustments due to chain characteristics, such as long lead times and almost zero inventory levels. On the other hand, about a third (greater for outbound, less for inbound) of firms report that the importance of these transport-service characteristics has changed.

In sum, then firms that are under restructuring pressures, notably those firms that approximate the mass-production or supply-chain management paradigms, need more attention from policymakers. Certain firms, notably in the pre- or non-mass production group, to which many of the metalworking firms belong, will not be affected by increased attention to their logistics and transportation needs.

### **BENEFITS AND COSTS OF READJUSTING PLANNING MODELS**

It is clear from the discussion of the previous three chapters that current transportation-planning models, especially if one judges the state of the practice and not the state of the art, are

inadequate to incorporate supply-chain-management issues. Failure to consider these issues may result in policies or investments that are inadequate to meet firms' needs and thus potentially hamper the competitiveness of the planning region. On the other hand, one has to consider the costs involved in developing and maintaining a modeling framework and comparing them to the benefits generated. Consequently, one needs to consider the particular types of firms and supply chains that are the targets of policy.

With the previous section's conclusion in mind, I found that even metalworking firms do not only use transportation for delivery of inputs and outputs. Other uses, such as (but not limited to) substitution for inventory on the inbound side and expansion of firms' market areas on the outbound side are also important.

In addition, metalworking firms require transport-service characteristics other than price and speed. Metalworking firms did rank price and speed as important characteristics, but reliability and accessibility were also highly ranked. Reliability was especially important on outbound shipments to customers.

Policymakers thus need to consider a wider range of effects, such as changes in inventory-related costs, production costs, delivered prices, and sales, when evaluating investment and regulatory policies toward metalworking firms. In addition, the reliability (in terms of travel-time deviations and shipment safety) and the accessibility (in terms of the distance between metalworking firms and their customers and suppliers) of the transport system need to be considered in policy-evaluation efforts.

Methods could be changed or should be changed for accuracy purposes but will not make difference to firm's performance for certain firms, especially those firms in custom or uncoordinated chains and for pre- or non-mass production firms. For these instances, the costs may

outweigh the benefits of increased accuracy. Use of existing methods with minor or partial implementation of the adjustments presented in Tables 7.2 and 8.2 may be adequate.

### **FUTURE RESEARCH DIRECTIONS**

The number of future research directions is virtually endless, but I only discuss three categories. First, there is the issue of what to do with this elaborate framework. In the current study, it was applied to inform policy formation toward the metalworking sector and how policies and planning will differ based on the supply-chain under study. Additional applications may be conducted for other sectors, in way of establishing a “database” of policy implications for different industries. That is, the use-and-characteristic determination could be determined for a number of industries or supply chains. Given this database, or preceding it, another application may be to conduct a region-based study that compares regions according to how well firms are being served by transportation facilities and policies. One interesting extension of such a regional study is to inform policy in areas that seek to attract industry or particular forms of industry. These areas could be developing countries or developing regions within countries. The work in this study shows that the attractiveness of low-wage labor found in developing regions is clearly not the only, and possibly not the most important, factor that may influence the retention, attraction, and growth of industry in regions.

Second, the supply-chain framework can be used to establish an overall framework for a variety of public policies or concerns, not just transportation policy with the goal of promoting competitiveness or economic development. Policies toward the environment and labor may be good candidates because they are directly impacted. Environmental impacts have already been discussed from a transport perspective, but there can be additional impacts related to increases or

redistribution of output along the supply chain to other firms and regions. The analysis of other externality-related impacts, such as safety, is also important.

Likewise, the impacts on labor can be examined in light of the competitive pressures described in this study. That is, the paradigm shift described in Chapter 4, though originating in logistics-related considerations, will have clear impacts on labor needs as well. These impacts will have clear implications for the workers themselves, thus pointing to the fact that individuals—in whatever guise, such as workers, travelers, consumers, or simply member of the general public—are stakeholders in public policy as regards transport whose perspectives should be examined in addition to those of firms. Of course, as highlighted in the second chapter, defining these groups and common objectives and interests to achieve is more difficult but is, nonetheless, important.

Such an analysis points to the importance of considering equity impacts as a force that countervails the efficiency-laden perspective of this study. Distribution of SCM benefits among various groups—labor force and the firm, small firms and large firms within or across supply chains, and among regions or jurisdictions—is also an important policy concern.

In total, the focus on policy prescriptions directed toward transport could be examined in light of additional focus in other areas, such as financial or educational assistance to certain firms, upgrading and education of the labor force, and promotion of a more equitable distribution of benefits. Transport could be considered only one component, and possibly compared to other components, within a package of policy options.

Third, more analytical work in various aspects of the framework can be conducted. Additional work could concentrate on formally, where applicable, incorporating the observations derived from examining transportation use by firm into the various planning model groups. As an example, a more formal examination of the valuation of travel time is possible. Devising a more

detailed implementation scheme for the adjusted methods, especially in terms of the data collection and statistical work, is also possible. Finally, the analytical work of this study can be extended to models or research with other purposes, such as an examination or explanation of the productivity of transport as a service sector and the contribution of public investment and policy in transportation towards economic development.

## REFERENCES

- Abernathy, F.H., J.T. Dunlop, J.H. Hammond, and D. Weil. 1995. "The Information-Integrated Channel: A Study of the U.S. Apparel Industry in Transition." *Brookings Papers on Microeconomic Activity*.
- Abruzzese, L. 1990. "Motor Carriers Ask ICC to Set Minimum Rates." *Journal of Commerce*, April 12, 1990.
- Akaha, T. 1990. "Introduction." in *International Handbook of Transportation Policy*, ed. T. Akaha. New York: Greenwood Press.
- Alexander, E.R. 1992. *Approaches to Planning: Introducing Current Planning Theories, Concepts and Issues*. Second Edition. Philadelphia: Gordon and Breach Science Publishers.
- Allen, B. J., C. P. Baumel, and D. J. Forkenbrock. 1994. "Expanding the Set of Efficiency Gains of a Highway Investment: Conceptual, Methodological, and Practical Issues." *Transportation Journal*, Vol. 34, No. 1, pp. 39-47.
- Alonso, W. 1972. "Location Theory." in *Readings in Urban Economics*, ed. Edel and Rothenberg. New York: Macmillan.
- Amos, Jr., O. 1990. "Growth Pole Cycles: A Synthesis of Growth Pole and Long Wave Theories." *The Review of Regional Studies*, Vol. 20, No. 1, pp. 37-48.
- Andersson, Å. 1993. "Infrastructure and the Transformation to the C-Society." In *The Future of Transportation and Communication*, ed. R. Thord. Berlin: Springer-Verlag, pp. 11-26.
- Andersson, Å., and D. Batten. 1988. "Creative Nodes, Logistical Networks, and the Future of the Metropolis." *Transportation*, Vol. 14, pp. 281-293.
- Andersson, Å, and U. Strömquist. 1989. "The Emerging C-Society." In *Transportation for the Future*. Berlin: Springer-Verlag, pp. 29-39.
- Aschauer, D. A., 1990. "Public Capital Investment: Rx for Productivity? Yes." *The Public's Capital*. Vol. 1, No. 3, pp. 4-6.
- Ballou, R. H. 1987. *Basic Business Logistics*. Second Edition. Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Ballou, R.H. 1992. *Business Logistics Management*. Third Edition. Englewood Cliffs, NJ: Prentice-Hall, Inc.
- Baumol, W. J., and H. D. Vinod. "An Inventory Theoretic Model of Freight Transport Demand." *Management Science*, Vol. 16, No. 7, pp. 413-21.



- Beesley, M.E., and A.A. Walters. 1970. "Some Problems in the Evaluation of Urban Road Investments." *Appl. Econ.*, Vol. 1, pp. 241-59.
- Bell, M., and E. Feitelson. 1990. "Bottlenecks and Flexibility: Key Concepts for Identifying Economic Development Impacts of Transportation Services." *Transportation Research Record 1274*. Washington, D.C.: TRB.
- Bell, M., and E. Feitelson. 1991. "U.S. Economic Restructuring and Demand for Transportation Services." *Transportation Quarterly*, Vol. 45, pp. 517-538.
- Ben-Akiva, M., and S. R. Lerman. 1985. *Discrete Choice Analysis*. Cambridge, MA: The MIT Press.
- Best, M. H. 1990. *The New Competition: Institutions of Industrial Restructuring*. Cambridge, MA: Harvard University Press.
- Bowersox, D.J. 1990. "The Strategic Benefits of Logistics Alliances." *Harvard Business Review*, Vol. 68, No. 4, pp. 36-45.
- Byrnes, J., and R. Shapiro. 1991. *Intercompany Operating Ties: Unlocking the Value in Channel Restructuring*, Harvard Business School Working Paper No. 92-058.
- Byrnes, J., and R. Shapiro. 1994. "Focused Human Resources Management." In *The Logistics Handbook*, ed. J.F. Robeson, W.C. Copacino, and R.E. Howe. New York: The Free Press.
- Burt, D.N. 1989. "Managing Suppliers Up to Speed." *Harvard Business Review*, Vol., 67, No. 4.
- Button, K.J. 1982. *Transport Economics*. Aldershot, England: Gower.
- Carter, J.R., and B.G. Ferrin. 1995. "The Impact of Transportation Costs on Supply Chain Management." *Journal of Business Logistics*, Vol. 16, No. 1, pp. 189-212.
- Castells, M. 1985. "High Technology, Economic Restructuring, and the Urban-Regional Process in the United States." In *High Technology, Space, and Society*, ed. M. Castells. Beverly Hills, CA: Sage Publications, pp. 11-40.
- Cavinato, J.L. 1991. "Identifying Interfirm Total Cost Advantages for Supply Chain Competitiveness." *International Journal of Purchasing and Materials Management*, Vol. 27, pp. 10-15.
- Chandler, Jr., A. 1977. *The Visible Hand. The Managerial Revolution in American Business*. Cambridge, MA: The Belknap Press.
- Coase, R.H. 1993. "The Nature of the Firm (1937)." In *The Nature of the Firm*, ed. O.E. Williamson and S.G. Winter. New York: Oxford University Press.

- Cohen, H.S., J.R. Stowers, and M.P. Petersilia. 1978. *Evaluating Urban Transportation System Alternatives*. Washington, D.C.: U.S. Department of Transportation.
- Colin, J. 1987. "France (country report)." In *The Role of Shippers and Transport Operators in the Logistics Chain*, Report of the Seventy-Sixth Round Table on Transport Economics. Paris: European Conference of Ministers of Transport, pp. 5-49.
- Cooke, J.A. 1992. "Supply Chain Management 90's Style." *Traffic Management*, May, pp. 57-59.
- Cooper, J. 1991a. "Innovation in Logistics: The Impact on Transport and the Environment." In *Freight Transport and the Environment*, ed. M. Kroon, R. Smit, and J. van Ham. Amsterdam: Elsevier Science Publishers B.V., pp. 235-253.
- Cooper, J. 1991b. "Lessons for Europe from Freight Deregulation in Australia, the United Kingdom and the United States of America." *Transport Reviews*, Vol. 11, No. 1, pp. 85-104.
- Coyle, J.J., E.J. Bardi, and C. J. Langley, Jr. 1988. *The Management of Business Logistics*. St. Paul, Minnesota: West Publishing Company.
- Davies, S. 1979. *The Diffusion of Process Innovations*. London: Cambridge University Press.
- Davis, T. 1993. "Effective Supply Chain Management." *Sloan Management Review*, Vol. 34, No. 3, pp. 35-46.
- Delaney, R.V. 1991. "Trends in Logistics and U.S. World Competitiveness." *Transportation Quarterly*, Vol. 45, pp. 19-41.
- Dempsey, P.S., and W.E. Thoms. 1986. *Law and Economic Regulation in Transportation*. Quorum Books: New York.
- Dickey, John W. 1983. *Metropolitan Transportation Planning*. Second Edition. New York: Hemisphere Publishing Corporation.
- Dietrich, M. 1994. *Transaction Cost Economics and Beyond: Towards a New Economics of the Firm*. London: Routledge.
- Duffy-Deno, K.T., and R. W. Eberts. 1991. "Public Infrastructure and Regional Economic Development: A Simultaneous Equations Approach." *Journal of Urban Economics*, Vol. 30, pp. 329-343.
- Ellram, L.M. 1991. "Supply Chain Management: The Industrial Organization Perspective." *International Journal of Physical Distribution & Logistics Management*." Vol. 21, No. 1, pp. 13-22.
- ESF (European Science Foundation). 1990. *Euromobile: Transport, Communications and Mobility in Europe*, ed. P. Nijkamp, S. Reichman, and M. Wegener. Aldershot: Avebury.

- Ewing, R. 1995. "Measuring Transportation Performance." *Transportation Quarterly*, Vol. 49, No. 1, pp. 91-104.
- Fawcett, S., and D. Vellenga. 1992. "Transportation Characteristics and Performance in Maquiladora Operations." *Transportation Journal*, Vol. 31, No. 4, pp. 5-16.
- Fogel, R. 1964. *Railroads and American Economic Growth*. Baltimore, MD: Johns Hopkins Press.
- Franciose, M.M. 1995. *Supply Chain Integration: Analysis Framework and Review of Recent Literature*. Unpublished Thesis, Department of Civil Engineering, Massachusetts Institute of Technology. Cambridge, MA.
- Freeman, C. 1982. *The Economics of Industrial Innovation*. Second Edition. Cambridge, MA: The MIT Press.
- Friedlaender, A. F. 1965. *The Interstate Highway System*. Amsterdam: North-Holland Publishing Company.
- Friedlaender, A.F., and R.H. Spady. 1981. *Freight Transport Regulation: Equity, Efficiency, and Competition in the Rail and Trucking Industries*. Cambridge, MA: The MIT Press.
- Fuller, J.B., J. O'Connor, and R. Rawlinson. 1993. "Tailored Logistics: The Next Advantage." *Harvard Business Review*, Vol. 71, No. 3, pp. 87-98.
- Garrison, W. L., and R. R. Souleyrette II. 1994. "The Relationship Between Transportation and Innovation." *Transportation Quarterly*, Vol. 48, No. 2, pp. 257-65.
- Gentry, J.J. 1995. *Role of Carriers in Buyer/Supplier Strategic Alliances*. Tempe, AZ: Center for Advanced Purchasing Studies.
- Giuliano, G. 1985. "A Multicriteria Method for Transportation Investment Planning." *Transportation Research A*. Vol. 19A, No. 1, pp. 29-41.
- Giuliano, G. 1989. "Research policy and review 27: New Directions for Understanding Transportation and Land Use." *Environment and Planning A*, Vol. 21, pp. 145-159.
- Glazer, A., and E. Niskanen. 1991. "Measuring the Benefits Derived From a Transportation Investment—A Comment." *Transportation Research B*, Vol. 25B, No. 6, pp. 413-419.
- Gomulka, S. 1990. *The Theory of Technological Change and Economic Growth*. London: Routledge.
- Harrison, B. 1994. *Lean and Mean: the Changing Landscape of Corporate Power in the Age of Flexibility*. New York: Basic Books.

- Heilbrun, J. 1981. *Urban Economics and Public Policy*. Second Edition. New York: St. Martin's Press.
- Hewitt, F. 1994. "Supply Chain Redesign." *International Journal of Logistics Management*, Vol. 5, No. 2, pp. 1-9.
- Higginson, J., and J. Bookbinder. 1990. "Implications of Just-In-Time Production on Rail Freight Systems." *Transportation Journal*, Vol. 29, No. 3, pp. 29-35.
- Hirschman, A. 1958. *The Strategy of Economic Development*. New Haven, CT: Yale University Press.
- Hoover, E. M. 1970. "Transport Costs and the Spacing of Central Places." *Papers of the Regional Science Association*, Vol. 25, pp. 255-74.
- Houlihan, J.B. 1985. "International Supply Chain Management." *International Journal of Physical Distribution and Materials Management*, Vol. 15, No. 1, pp. 22-38.
- Huddleston, J.R., and P.P. Pangotra. 1990. "Regional and Local Economic Impacts of Transportation Investments." *Transportation Quarterly*, Vol. 44, No. 4, pp. 579-594.
- Jara-Díaz, S. R. 1986. "On the Relation Between Users' Benefits and the Economic Effects of Transportation Activities." *Journal of Regional Science*, Vol. 26, No. 2, pp. 379-391.
- Johnston, R.A., and M.A. DeLuchi. 1989. "Evaluation Methods for Rail Transit Projects." *Transportation Research A*, Vol. 23A, No. 4, pp. 317-25.
- Jones, T. C., and D.W. Riley. 1985. "Using Inventory for Competitive Advantage through Supply Chain Management." *International Journal of Physical Distribution and Materials Management*. Vol. 15, No. 5, pp. 16-26.
- Keeler, T. E., and K.A. Small. 1977. "Optimal Peak-Load Pricing, Investment, and Service Levels on Urban Expressways." *Journal of Political Economy*, Vol. 85, No. 1, pp. 1-25.
- Kobayashi, K. 1993. "The Emerging New Arena of Transportation and Communication in Japan," in *The Future of Transportation and Communication*, ed. R. Thord. Berlin: Springer-Verlag.
- La Londe, B. J. 1985. "Customer Service," Chapter 11 in *The Distribution Handbook*, ed. J. F. Robeson and R. G. House. New York: The Free Press.
- La Londe, B. J. 1994. "Evolution of the Integrated Logistics Concept." In *The Logistics Handbook*, ed. J.F. Robeson, W.C. Copacino, and R.E. Howe. New York: The Free Press.
- Lambert, D. M., and J. R. Stock. 1993. *Strategic Logistics Management*. Third Edition. Homewood, IL: Irwin.

- Lancaster, K. J. 1970. "A New Approach to Consumer Theory," in *The Demand for Travel Theory and Measurement*, ed. R. E. Quandt. Lexington, MA: Heath Lexington Books, D.C.
- Landeros, R., and R.M. Monczka. 1989. "Cooperative Buyer/Seller Relationships and a Firm's Competitive Posture." *Journal of Purchasing and Materials Management*. Vol. 25, No. 4, pp. 9-18.
- Langdon, P. 1994. *A Better Place to Live: Reshaping the American Suburbs*. Amherst, MA: University of Massachusetts Press.
- Larson, P.D. 1992. "Transportation Deregulation and Logistics Costs." *Transportation Quarterly*, Vol. 46, No. 2, pp. 261-278.
- Levine, A.S., and J. Luck. 1994. *The New Management Paradigm: A Review of Principles and Practices*. Santa Monica, CA: Rand.
- Lewis, D. 1991. *Primer on Transportation, Productivity and Economic Development*. NCHRP Report 342. Washington, D.C.: TRB.
- Lieb, R., and R. Millen. 1990. "The Responses of General Commodity Motor Carriers to Just-In-Time Manufacturing Programs." *Transportation Journal*, Vol. 30, No. 1, pp. 5-11.
- Linge, G.J.R. 1991. "Just-In-Time: More or Less Flexible?" *Economic Geography*, Vol. 67, No. 4, pp. 316-332.
- Magee, J. F., W. A. Copacino, and D. B. Rosenfield. 1985. *Modern Logistics Management: Integrating Marketing, Manufacturing, and Physical Distribution*. New York: Wiley.
- Mair, A. 1993. "New Growth Poles? Just-in-time Manufacturing and Local Economic Development Strategy." *Regional Studies*. Vol. 27, No. 3, pp. 207-221.
- Marshall, A. 1919. *Industry and Trade*. London: Macmillan & Co.
- Mohring, H. 1993. "Maximizing, Measuring, and *Not* Double Counting Transportation-Improvement Benefits: A Primer On Closed- And Open-Economy Cost-Benefit Analysis." *Transportation Research B*, Vol. 27B, No. 6, pp. 413-24.
- Montgomery, W. D. 1990. "Public Capital Investment: Rx for Productivity? Maybe." *The Public's Capital*. Vol. 1, No. 3, pp. 4-6.
- Newbery, D.M. 1989. "Cost Recovery from Optimally Designed Roads." *Economica*, Vol. 56, pp. 165-85.
- Nicholson, W. 1983. *Intermediate Microeconomics and Its Application*. Third Edition. Chicago: The Dryden Press.

- North, D. C. 1975. "Location Theory and Regional Economic Growth." In *Regional Policy*, ed. J. Friedman and W. Alonso. Cambridge, MA: The MIT Press.
- OECD. 1990. *Competition Policy and the Deregulation of Road Transport*. Paris: Organisation for Economic Co-operation and Development. Committee on Competition Law and Policy.
- Piore, M., and C. Sabel. 1984. *The Second Industrial Divide*. New York: Basic Books.
- Poist, R.F. 1986. "Evolution of Conceptual Approaches to Designing Business Logistics Systems." *Transportation Journal*. Vol. 26, No. 1, pp. 55-64.
- Polenske, Karen R., Lynn E. McCormick, Alvaro E. Pereira, and Nicolas O. Rockler. 1996. "Industrial Restructuring, Infrastructure Investment, and Transportation in the Midwest." Prepared for the Joyce Foundation, Chicago Manufacturing Center, and National Institute for Science and Technology.
- Porter, M. 1990. "Determinants of National Competitive Advantage." Chapter 3 in *Competitive Advantage of Nations*. New York: Free Press, pp. 69-129.
- Powell, W.W. 1990. "Neither Market nor Hierarchy: Network Forms of Organization." In *Research in Organizational Behavior*, ed. B.M. Straw and L.L. Cummings. Greenwich, CT: JAI Press, pp. 295-336.
- Quandt, R., and W. Baumol. 1966. "The Demand for Abstract Transportation Modes: Theory and Measurement." *Journal of Regional Science*, Vol. 6, pp. 13-26.
- Quarmby, D. A. 1989. "Developments in the Retail Market and Their Effect on Freight Distribution." *Journal of Transport Economics and Policy*, Vol. 23, No. 1, pp. 75-87.
- Rao, K., and W. L. Grenoble IV. 1991. "Modelling the Effects of Traffic Congestion on JIT." *International Journal of Physical Distribution & Logistics Management*, Vol. 21, No. 2, pp. 3-9.
- Rathi, A. K., S. Miaou, F. Southworth, and H. Caldwell. 1991. "Highway Needs for the Year 2005." *Finance, Planning, Programming, Economic Analysis, and Land Development 1991*. Washington, D.C.: TRB.
- Richardson, H.W. 1976. "Growth Pole Spillovers: The Dynamics of Backwash and Spread." *Regional Studies*, Vol. 10, pp. 1-9.
- Richardson, H.W. 1979. *Regional Economics*. Urbana, IL: University of Illinois Press.
- Rostow, W.W. 1962. *The Process of Economic Growth*. Second Edition. New York: W.W. Norton & Company, Inc.

- SCAQMD. 1990. "Regulation XV." Los Angeles: South Coast Air Quality Management District.
- Schoenberger, E. 1990. "New Models of Regional Change." In *New Models in Geography*, ed. R. Peet and N. Thrift. London: Unwin Hyman, pp. 115-140.
- Scott, A. J. 1988. *Metropolis: From the Division of Labor to Urban Form*. Berkeley, CA: University of California Press.
- Scott, C., and R. Westbrook. 1991. "New Strategic Tools for Supply Chain Management." *International Journal of Physical Distribution and Logistics Management*, Vol. 21, No. 1, pp. 23-33.
- Shapiro, B. P., V. K. Rangan, and J. J. Sviokla. 1992. "Staple Yourself to an Order." *Harvard Business Review*. Vol. 70, No. 4, pp. 113-22.
- Shapiro, R.D., and J.L. Heskett. 1985. *Logistics Strategy: Cases and Concepts*. St. Paul, MN: West Publishing Company.
- Sharman, G. 1984. "The Rediscovery of Logistics." *Harvard Business Review*, Vol. 62, No. 5, pp. 71-79.
- Small, K. A., C. Winston, and C. Evans. 1989. *Road Work: A New Highway Pricing and Investment Policy*. Washington, D.C.: Brookings Institution.
- Solow, R.M., 1973. "On Equilibrium Models of Urban Location," In *Essays in Modern Economics*, ed. J.M. Parkin. Essex: Longman.
- Sonstegaard, M. 1992. "Balance and Coordination for Road and Rail." *Transportation Research A*, Vol. 26A, No. 1, pp. 419-432.
- Stalk, Jr., G. 1988. "Time—The Next Source of Competitive Advantage." *Harvard Business Review*, Vol. 66, No. 4, pp. 41-51.
- Stalk, G., P. Evans, and L.E. Shulman. 1992. "Competing on Capabilities: The New Rules of Corporate Strategy." *Harvard Business Review*, Vol. 70, No. 2, pp. 57-69.
- Storper, M., and R. Walker. 1989. *The Capitalist Imperative: Territory, Technology, and Industrial Growth*. Oxford, UK: Basil Blackwell.
- Strand, S. 1993. "Time in Transport: A Perverted Problem? Arguments for a Fresh Look at Time Utility Research and Its Application." *Transportation Research Record 1395*. Washington, D.C.: TRB.
- ter Brugge, R. 1991. "Logistical Developments in Urban Distribution and Their Impact on Energy Use and the Environment." In *Freight Transport and the Environment*, ed. M. Kroon, R. Smit, and J. van Ham. Amsterdam: Elsevier Science Publishers B.V., pp. 331-341.

- Toft, G., and H. Mahmassani. 1984. "Transportation and High Technology Economic Development." *Transportation Research Record 984*. Washington, D.C.: Transportation Research Board.
- Transportation Research Board. 1986. *Twin Trailer Trucks*. Washington, D.C.: TRB, National Research Council. TRB Special Report 211.
- Transportation Research Board. 1989. *Providing Access for Large Trucks*. Washington, D.C.: TRB, National Research Council. TRB Special Report 223.
- Transportation Research Board. 1990a. *Truck Weight Limits -- Issues and Options*. Washington, D.C.: TRB, National Research Council. TRB Special Report 225.
- Transportation Research Board. 1990b. *New Trucks for Greater Productivity and Less Road Wear*. Washington, D.C.: TRB. TRB Special Report 227.
- Turnquist, M., and G. List. 1993. "Charting a Course For Intermodal Policy and Research." *Transportation Quarterly*, Vol. 47, No. 2, pp. 257-280.
- United States. Department of Commerce. 1987. *Effects of Structural Change in the U.S. Economy On the Use of Public Works Services*. Final Report to the National Council on Public Works Improvements. Washington, D.C.: Department of Commerce.
- United States. Department of Transportation. 1992. *Intermodal Surface Transportation Efficiency Act of 1991: A Summary*. Washington, D.C.: Department of Transportation.
- United States. Department of Transportation. 1994. *Transportation Statistics, Annual Report*. Washington, D.C.: Bureau of Transportation Statistics, Department of Transportation.
- Varian, H.R. 1984. *Microeconomic Analysis*. Second Edition. New York: W.W. Norton, Inc. & Company.
- Viton, P.A. 1989. "Economic Contributions to Transportation Planning I." *Journal of Planning Literature*. Vol. 4, No. 2, pp. 137-153.
- Wallis, J., and D. North. 1986. "Measuring the Transaction Sector in the American Economy, 1870-1970." In *Long-Term Factors in American Economic Growth*. Ed. S. Engerman and R. Gallman. Chicago: University of Chicago Press, pp. 95-148.
- Walker, R. 1988. "The Geographical Organization of Production-Systems." *Environment and Planning D: Society and Space*, Vol. 6, pp. 377-408.
- Walters, A. A. 1961. "The Theory and Measurement of Private and Social Costs of Highway Congestion." *Econometrica*, Vol. 29, pp. 676-99.



- Webber, M.J. 1972. *Impact of Uncertainty on Location*. Cambridge, MA: MIT Press.
- Weisbrod, G.E., and J. Beckwith. 1991. "Measuring Economic Development Benefits for Highway-Decision Making: The Wisconsin Case." *Transportation Quarterly*, Vol. 46, No. 1, pp. 57-79.
- Wells, Jr., L.T. 1972. "The Produce Life Cycle Approach." In *The Product Life Cycle and International Trade*, ed. L.T. Wells Jr. Cambridge, MA: Division of Research, Graduate School of Business Administration, Harvard University, pp. 3-33.
- Williams, H.C.W.L., and W. M. Lam. 1991. "Transport Policy Appraisal with Equilibrium Models I: Generated Traffic and Highway Investment Benefits." *Transportation Research B*, Vol. 25B, pp. 253-79.
- Williamson, O.E. 1985. *The Economic Institutions of Capitalism*. New York: The Free Press.
- Winston, C., T.M. Corsi, C.M. Grimm, and C.A. Evans. 1990. *The Economic Effects of Surface Freight Deregulation*. Washington, DC: The Brookings Institution.
- Womack, J., D. Jones, and D. Roos. 1990. *The Machine That Changed the World*. New York: Rawson Associates.