Facility Location and the Theory of Production

Facility Location and the Theory of Production

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To Florence, Vicki, and Michael for
making it all worthwhile.

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Preface

The design and location of production facilities are important aspects of corporate strategy which can have a significant impact on the socio-economy of nations and regions. Here, these decisions are recognized as being interrelated; that is, the optimal plant design (input mix and output level) depends on the location of the plant, and the optimal location of the plant depends on the design of the plant. Until the late 1950s, however, the questions of where a firm should locate its plant and what should be its planned input mix and output level were treated, for the most part, as separate questions, and were investigated by different groups of researchers. Although there was some recognition that these questions are interrelated [e.g., Predohl 1928; Hoover 1948; Isard 1956], no detailed analysis or formal structure was developed combining these two problems until the work of Moses [1958]. In recent years scholarly interest in the integrated production/locaton decision has been increasing rapidly.

At the same time that research on the integrated production/location problem was expanding, significant related work was occurring in the fields of operations research, transportation science, industrial engineering, economics, and geography. Unfortunately, the regional scientists working on the production/location problem had little contact with researchers in other fields. They generally publish in different journals and attend different professional meetings. Consequently, little of the recent work in these fields has made its way into the production/location research and vice versa.

The primary purpose of this book is to bring together in a single coherent volume all of the work previously published on the integrated production/location problem. This book is intended to provide a complete and rigorous treatment of the topic; proofs are given for major results and

references are provided for relevant details. At the same time, in order to develop an understanding of the current state of the art in production/location research, it is necessary to explore how this work contributes to and draws upon work in other disciplines and other problems. This exploration is pursued throughout the book.

In addition to providing a unified presentation on production/location theory and its relationship to work in other disciplines, this volume makes several other specific contributions.

1. Given the prominent role of both national and local governments in the market economy, models that facilitate the evaluation of government policies in terms of their effects on the economic units of the economy are increasingly necessary. For many years economists have been studying the effects of public policies such as taxation, incentives, and regulations on the economic behavior of the firm. However, they have paid little attention to the locational or spatial aspects, especially when the policies are administered in a spatially uniform manner. Many government policies, even those that are not primarily meant to be economic (e.g., pollution regulations), affect both the production decisions (e.g., input mix) and location decisions of firms. In fact, the effect of public policies on a firm's plant location decision is often *through* their effect on the production process. Consequently, an integrated model of the firm's production and location decisions provides a better framework for analyzing the (sometimes subtle) effects of government policy. The integrated production/location model provides a format for simultaneously evaluating the technological, production, and locational effects of taxes, incentives, and regulations. In recent articles [e.g., Martinich and Hurter 1985] we have illustrated the policy analysis potential of these models, especially stochastic forms of the model. That work is expanded here, and the general issues of using taxes and incentives to influence locational decisions is examined in light of the model. We devote two full chapters to this topic.

2. Production/location research has been criticized for its abstract, theoretical nature. The resulting models exhibit a degree of mathematical complexity which makes it difficult to obtain mathematically precise results that are both instructive and general. The complexity, abstractness, and mathematical sophistication employed has undoubtedly limited access to the more recent work on production/location problems, and limited its application in fields such as public policy. We have attempted to improve the accessibility and clarity of the models by including many numerical examples to motivate and illustrate the theoretical results. These numerical examples make it possible for readers to understand the essence of the

theorems without mastering the mathematical details. In addition, numerical illustrations are used to demonstrate conjectured relationships that are not readily provable because of the mathematical complexity of the problem. This approach may not be satisfying to mathematical purists, but it greatly expands the insight that can be drawn from these models and increases their potential application.

3. Parametric uncertainty and risk preferences were first incorporated into the production/location problem only recently [Mai 1981; Martinich and Hurter 1982]. This book includes extensive discussion of the published work on the stochastic production/location problem, and presents new, previously unpublished work. The addition of uncertainty makes the problem more realistic (and complex), and takes advantage of recent research on economics under uncertainty.

4. In order to develop an understanding of the interaction among the producton decision, the location decision, and the problem parameters, extensive sensitivity analysis is necessary. Very little sensitivity analysis has appeared in the literature, so we have devoted considerable space to this topic.

5. The published work on production/location theory has dealt almost exclusively with one-facility models because the mathematical complexity of the production/location problem often makes multifacility models analytically intractable. Multifacility models are presented in this book, however, to highlight their computational complexity; to compare them with other more common location models; and to show under what conditions the problems may be tractable, at least with approximation methods.

6. Little attention has been given in the literature to the solution aspects of production/location problems. For each of the major categories of models, solution procedures are presented; and, where appropriate (e.g., multifacility problems), they are compared to algorithms that have been developed for other location problems, such as the Steiner-Weber problem and the fixed-charge problem. Some new algorithmic results are presented along with numerical illustrations.

Our overall goal in writing this book was to provide an integrated presentation of the state-of-the-art in production/location research. Further, we have attempted to present the material in such a manner that it is of interest and accessible to potential readers with a variety of backgrounds. A knowledge of microeconomics and calculus, and in some cases, probability theory, is necessary to follow the formal proofs and the more technical results. Nevertheless, we believe that our exposition and numerical examples should make the essential features and potential appli-

cations of the theory understandable to those without such a background. Our approach makes the book usable for special courses that cover production/location problems, as well as a research reference for regional scientists, economists, industrial engineers, operations researchers, and policy analysts.

We would like to acknowledge the support of The Technological Institute of Northwestern University, the School of Business Administration and the Office of Research of the University of Missouri–St. Louis, the School of Business Administration of Washington University, and the National Science Foundation, which supported much of the underlying research on which this volume is based. Special thanks for invaluable assistance in preparing the manuscript are due to June Wayne, George Mach, and Mary O'Brien.

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