

This PDF is a selection from an out-of-print volume from the National Bureau of Economic Research

Volume Title: A Disequilibrium Model of Demand for Factors of Production

Volume Author/Editor: M. Ishaq Nadiri and Sherwin Rosen

Volume Publisher: NBER

Volume ISBN: 0-870-14261-5

Volume URL: <http://www.nber.org/books/nadi74-1>

Publication Date: 1974

Chapter Title: Front matter, preface and introduction

Chapter Author: M. Ishaq Nadiri, Sherwin Rosen

Chapter URL: <http://www.nber.org/chapters/c0571>

Chapter pages in book: (p. -25 - 0)

A Disequilibrium Model of Demand  
for Factors of Production

M. ISHAQ NADIRI

National Bureau of Economic Research and  
New York University

AND

SHERWIN ROSEN

National Bureau of Economic Research and  
University of Rochester



National Bureau of Economic Research

NEW YORK

1973

Distributed by Columbia University Press

NEW YORK AND LONDON

Copyright © 1974 by National Bureau of Economic Research  
*All rights reserved*

Library of Congress card number: 73-81541

ISBN: 0-87014-261-5

Printed in the United States of America

15972

A Disequilibrium Model of Demand  
for Factors of Production

NATIONAL BUREAU OF ECONOMIC RESEARCH  
NUMBER 99  
GENERAL SERIES

## NATIONAL BUREAU OF ECONOMIC RESEARCH

### OFFICERS

Arthur F. Burns, *Honorary Chairman*  
Walter W. Heller, *Chairman*  
J. Wilson Newman, *Vice Chairman*  
John R. Meyer, *President*  
Thomas D. Flynn, *Treasurer*  
Douglas H. Eldridge, *Vice President-Executive Secretary*

Victor R. Fuchs, *Vice President-Research; Co-director, NBER-West*  
Edwin Kuh, *Director, Computer Research Center*  
Hal B. Lary, *Vice President-Research*  
Robert E. Lipsey, *Vice President-Research*  
Sherman J. Maisel, *Co-director, NBER-West*  
Geoffrey H. Moore, *Vice President-Research*  
Edward K. Smith, *Vice President*

### DIRECTORS AT LARGE

Atherton Bean, *International Multifoods Corporation*  
Joseph A. Beirne, *Communications Workers of America*  
Arthur F. Burns, *Board of Governors of the Federal Reserve System*  
Wallace J. Campbell, *Foundation for Cooperative Housing*  
Erwin D. Canham, *Christian Science Monitor*  
Emilio G. Collado, *Exxon Corporation*  
Solomon Fabricant, *New York University*  
Eugene P. Foley, *Montrou Securities, Inc.*  
Eli Goldston, *Eastern Gas and Fuel Associates*  
David L. Grove, *International Business Machines Corporation*  
Walter W. Heller, *University of Minnesota*  
Vivian W. Henderson, *Clark College*

John R. Meyer, *Harvard University*  
J. Irwin Miller, *Cummins Engine Company, Inc.*  
Geoffrey H. Moore, *National Bureau of Economic Research*  
J. Wilson Newman, *Dun & Bradstreet, Inc.*  
James J. O'Leary, *United States Trust Company of New York*  
Alice M. Rivlin, *Brookings Institution*  
Robert V. Roosa, *Brown Brothers Harriman & Co.*  
Boris Shishkin, *Washington, D.C.*  
Arnold M. Soloway, *Jamaicaway Tower, Boston, Massachusetts*  
Lazare Teper, *International Ladies' Garment Workers' Union*  
Donald B. Woodward, *Riverside, Connecticut*  
Theodore O. Yntema, *Oakland University*

### DIRECTORS BY UNIVERSITY APPOINTMENT

Moses Abramovitz, *Stanford*  
Gardner Ackley, *Michigan*  
Charles H. Berry, *Princeton*  
Francis M. Boddy, *Minnesota*  
Otto Eckstein, *Harvard*  
Walter D. Fisher, *Northwestern*  
R. A. Gordon, *California*  
Robert J. Lampman, *Wisconsin*

Maurice W. Lee, *North Carolina*  
Almarin Phillips, *Pennsylvania*  
Lloyd G. Reynolds, *Yale*  
Robert M. Solow, *Massachusetts Institute of Technology*  
Henri Theil, *Chicago*  
William S. Vickrey, *Columbia*  
Thomas A. Wilson, *Toronto*

### DIRECTORS BY APPOINTMENT OF OTHER ORGANIZATIONS

Eugene A. Birnbaum, *American Management Association*  
Thomas D. Flynn, *American Institute of Certified Public Accountants*  
Nathaniel Goldfinger, *American Federation of Labor and Congress of Industrial Organizations*  
Harold G. Halcrow, *American Agricultural Economics Association*  
Walter E. Hoadley, *American Finance Association*

Philip M. Klutznick, *Committee for Economic Development*  
Roy E. Moor, *National Association of Business Economists*  
Douglass C. North, *Economic History Association*  
Willard L. Thorp, *American Economic Association*  
W. Allen Wallis, *American Statistical Association*  
Robert M. Will, *Canadian Economics Association*

### DIRECTORS EMERITI

Percival F. Brundage  
Frank W. Fetter  
Gottfried Haberler

Albert J. Hettinger, Jr.  
George B. Roberts

Murray Shields  
Joseph H. Willits

### SENIOR RESEARCH STAFF

Gary S. Becker  
Charlotte Boschan  
Phillip Cagan  
Stanley Diller  
Solomon Fabricant  
Milton Friedman  
Victor R. Fuchs  
J. Royce Ginn  
Raymond W. Goldsmith

Michael Gort  
Michael Grossman  
F. Thomas Juster  
John F. Kain  
John W. Kendrick  
Irving B. Kravis  
Edwin Kuh  
William M. Landes  
Hal B. Lary

Robert E. Lipsey  
Sherman J. Maisel  
Benoit B. Mandelbrot  
John R. Meyer  
Robert T. Michael  
Jacob Mincer  
Ilse Mintz  
Geoffrey H. Moore  
M. Ishaq Nadiri

Nancy Ruggles  
Richard Ruggles  
Anna J. Schwartz  
Robert P. Shay  
Edward K. Smith  
George J. Stigler  
Victor Zarnowitz

RELATION OF THE DIRECTORS  
TO THE WORK AND PUBLICATIONS  
OF THE NATIONAL BUREAU OF ECONOMIC RESEARCH

1. The object of the National Bureau of Economic Research is to ascertain and to present to the public important economic facts and their interpretation in a scientific and impartial manner. The Board of Directors is charged with the responsibility of ensuring that the work of the National Bureau is carried on in strict conformity with this object.

2. The President of the National Bureau shall submit to the Board of Directors, or to its Executive Committee, for their formal adoption all specific proposals for research to be instituted.

3. No research report shall be published until the President shall have submitted to each member of the Board the manuscript proposed for publication, and such information as will, in his opinion and in the opinion of the author, serve to determine the suitability of the report for publication in accordance with the principles of the National Bureau. Each manuscript shall contain a summary drawing attention to the nature and treatment of the problem studied, the character of the data and their utilization in the report, and the main conclusions reached.

4. For each manuscript so submitted, a special committee of the Directors (including Directors Emeriti) shall be appointed by majority agreement of the President and Vice Presidents (or by the Executive Committee in case of inability to decide on the part of the President and Vice Presidents), consisting of three Directors selected as nearly as may be one from each general division of the Board. The names of the special manuscript committee shall be stated to each Director when the manuscript is submitted to him. It shall be the duty of each member of the special manuscript committee to read the manuscript. If each member of the manuscript committee signifies his approval within thirty days of the transmittal of the manuscript, the report may be published. If at the end of that period any member of the manuscript committee withholds his approval, the President shall then notify each member of the Board, requesting approval or disapproval of publication, and thirty days additional shall be granted for this purpose. The manuscript shall then not be published unless at least a majority of the entire Board who shall have voted on the proposal within the time fixed for the receipt of votes shall have approved.

5. No manuscript may be published, though approved by each member of the special manuscript committee, until forty-five days have elapsed from the transmittal of the report in manuscript form. The interval is allowed for the receipt of any memorandum of dissent or reservation, together with a brief statement of his reasons, that any member may wish to express; and such memorandum of dissent or reservation shall be published with the manuscript if he so desires. Publication does not, however, imply that each member of the Board has read the manuscript, or that either members of the Board in general or the special committee have passed on its validity in every detail.

6. Publications of the National Bureau issued for informational purposes concerning the work of the Bureau and its staff, or issued to inform the public of activities of Bureau staff, and volumes issued as a result of various conferences involving the National Bureau shall contain a specific disclaimer noting that such publication has not passed through the normal review procedures required in this resolution. The Executive Committee of the Board is charged with review of all such publications from time to time to ensure that they do not take on the character of formal research reports of the National Bureau, requiring formal Board approval.

7. Unless otherwise determined by the Board or exempted by the terms of paragraph 6, a copy of this resolution shall be printed in each National Bureau publication.

*(Resolution adopted October 25, 1926 and revised February 6, 1933,  
February 24, 1941, April 20, 1968, and September 17, 1973)*

## Contents

|  |     |
|--|-----|
| Preface  | xv  |
| Introduction   | xix |
| <i>1. Nature of the Problem and Relation to the Literature</i> | 1   |
| A. General Considerations                                      | 1   |
| B. Time-Series Employment Models                               | 2   |
| C. Investment Models   | 6   |
| i. Output and Interest Elasticities                            | 6   |
| ii. The Neoclassical Model of Investment                       | 7   |
| D. An Example  | 10  |
| <i>2. The Structure of the Model</i>                           | 13  |
| A. Input Demand Functions                                      | 13  |
| i. Specification of Input Prices                               | 16  |
| ii. The Long-Run Demand Functions                              | 19  |
| B. Short-Run Adjustments                                       | 24  |
| i. Costs of Adjustment: Theoretical Considerations             | 25  |
| ii. Some Qualifications  | 27  |
| iii. Characterization of Disturbances                          | 29  |
| C. Restrictions on Adjustment Coefficients                     | 32  |
| D. Dynamic Properties of the System                            | 34  |
| E. Comparison with Other Models: Theoretical Considerations    | 36  |
| <i>3. Characteristics of the Data</i>                          | 40  |
| A. Construction of the Variables                               | 40  |
| i. Labor Variables   | 42  |
| ii. Capital Stock  | 42  |
| iii. Rental Prices   | 42  |
| iv. Inventories  | 42  |
| v. Utilization Rates   | 42  |
| B. Properties of the Data                                      | 43  |
| <i>4. Estimation of the Model: Total Manufacturing</i>         | 55  |
| A. Problems of Estimation                                      | 56  |
| B. Structural Estimates  | 58  |

|  |     |
|--|-----|
| C. The Goodness of Fit and Forecasting Performance   | 68  |
| D. Response Characteristics of the Model   | 73  |
| i. Computational Methods   | 73  |
| ii. Stability  | 78  |
| E. Long-Run Response   | 78  |
| 5. <i>Experimentations in Specification</i>  | 81  |
| A. Sensitivity of Structural Estimates to Specification  | 81  |
| B. Analysis of Residuals: Cross Correlation  | 91  |
| C. Reduced Form Estimation   | 94  |
| 6. <i>Disaggregated Results</i>  | 101 |
| A. Structural Estimates  | 101 |
| i. Overview  | 101 |
| ii. Short-Run Elasticities   | 132 |
| iii. Own Adjustments   | 134 |
| iv. Cross Adjustments  | 136 |
| B. Dynamic Properties  | 139 |
| i. Distributed Lags  | 139 |
| ii. Long-Run Elasticities  | 154 |
| C. Summary   | 159 |
| 7. <i>Further Observations, Summary, and Conclusions</i>   | 160 |
| A. Interindustry Differences   | 160 |
| B. Comparisons with the Literature: Empirical Results  | 162 |
| C. Summary and Conclusions   | 167 |
| Appendix A. Industrial Classification  | 175 |
| Appendix B. Descriptive Statistics of Quarterly Time Series for<br>Individual Industries and Industry Aggregates | 177 |
| Appendix C. Estimated Structure of the Model   | 184 |
| Appendix D. Glossary of Important Symbols  | 189 |
| Appendix E. References   | 191 |
| Index  | 197 |

## Tables

|   |  |     |
|---|--|-----|
| 3.1   | Description of Data: Seasonally Adjusted Quarterly Averages for Total Manufacturing  | 44  |
| 4.1   | Estimated Structure of Model (4.1) for Total Manufacturing   | 59  |
| 4.2   | Direction Effect of Exogenous Variables and Adjustment Coefficients  | 66  |
| 4.3   | Forecast Performance Indexes for Model (4.1) for Total Manufacturing   | 69  |
| 4.4   | Long-Run Elasticities for Total Manufacturing  | 79  |
| 5.1   | Regression Results of Auxiliary Equations (5.1), (5.2), and (5.3) for Predicting the Level of Sales of Total Manufacturing | 84  |
| 5.2   | Matrix of Simple Correlation Among Current and Lagged Residuals of Equation (2.3)  | 92  |
| 5.3   | Regression Results of Cross Correlation of Residuals of Model (4.1)  | 93  |
| 5.4   | Lag Distribution from Time Domain Regressions of the Dependent Variables on Past and Current Values of Sales               | 96  |
| 5.5   | Lag Distribution from Time Domain Regressions of the Dependent Variables on Past, Current, and Future Values of Sales      | 98  |
| 5.6   | Lag Distribution from Time Domain Regressions of the Dependent Variables on Current and Future Values of Sales             | 99  |
| <i>Estimated Structure of Model (4.1) for Individual Industries, 1954I-1967IV, and Industry Aggregates, 1948I-1967IV:</i> |  |     |
| 6.1   | Total Durables   | 103 |
| 6.2   | Primary Iron and Steel   | 104 |
| 6.3   | Primary Nonferrous Metal   | 105 |
| 6.4   | Electrical Machinery and Equipment   | 106 |
| 6.5   | Machinery Except Electrical  | 107 |
| 6.6   | Motor Vehicles and Equipment   | 108 |
| 6.7   | Transportation Equipment Excluding Motor Vehicles  | 109 |
| 6.8   | Stone, Clay, and Glass Products  | 110 |
| 6.9   | Other Durables   | 111 |
| 6.10  | Total Nondurables  | 112 |
| 6.11  | Food and Beverages   | 113 |

## Tables

*Estimated Structure of Model (4.1) for Individual Industries, 1954I-1967IV, and Industry Aggregates, 1948I-1967IV (cont.):*

|      |   |     |
|------|---|-----|
| 6.12 | Textile Mill Products   | 114 |
| 6.13 | Paper and Allied Products   | 115 |
| 6.14 | Chemical and Allied Products  | 116 |
| 6.15 | Petroleum and Coal Products   | 117 |
| 6.16 | Rubber Products   | 118 |
| 6.17 | Other Nondurables   | 119 |
| 6.18 | Own-Adjustment Coefficients of Dependent Variables in Individual Manufacturing Industries                     | 135 |
| 6.19 | Frequency of Statistically Significant Cross Effects of Model (4.1) for Individual Manufacturing Industries   | 138 |
| 6.20 | Largest and Smallest Characteristic Roots of $(I - \beta)$ Matrix, by Industry                                | 155 |
| 6.21 | Long-Run Price Elasticities, by Industry  | 156 |
| 6.22 | Long-Run Trend Elasticities, by Industry  | 157 |
| 6.23 | Long-Run Sales Elasticities, by Industry  | 158 |
| 7.1  | "Short-Run" Scale Effects, Production Worker Employment, and Hours of Work in Total Manufacturing, Full Model | 165 |

*Descriptive Statistics of Quarterly Time-Series Data, 1953I-1967IV:*

|     |  |     |
|-----|--|-----|
| B.1 | Total Durables, Primary Iron and Steel, and Primary Nonferrous Metal                               | 178 |
| B.2 | Electrical Machinery and Equipment, Machinery Except Electrical, and Motor Vehicles and Equipment  | 179 |
| B.3 | Transportation Equipment Excluding Motor Vehicles; Stone, Clay, and Glass; and Other Durables      | 180 |
| B.4 | Total Nondurables, Food and Beverages, and Textile Mill Products                                   | 181 |
| B.5 | Paper and Allied Products, Chemical and Allied Products, and Petroleum and Coal Products           | 182 |
| B.6 | Rubber Products and Other Nondurables  | 183 |
| C.1 | Predictive and Structural Tests of Model (4.1), Total Manufacturing, 1948I-1967IV and 1968I-1970II | 184 |

*Estimated Structure of Model (4.1), Total Manufacturing Sector:*

|     |  |     |
|-----|--|-----|
| C.2 | With Forecasted Sales Variable         | 185 |
| C.3 | Without Utilization Rate               | 186 |
| C.4 | With Forward Values of Sales and Wages | 187 |
| C.5 | With Forward Values of Sales           | 188 |

## Charts

### *Quarterly Data, 1947I-1970II:*

|      |   |    |
|------|---|----|
| 3.1  | Stock of Production Workers ( $Y_1$ )                           | 46 |
| 3.2  | Hours of Work per Week of Production Workers ( $Y_2$ )          | 47 |
| 3.3  | Deflated Capital Stock ( $Y_3$ )                                | 48 |
| 3.4  | Utilization Rate ( $Y_4$ )                                      | 49 |
| 3.5  | Manufacturers' Total Inventories in Constant Dollars ( $Y_5$ )  | 50 |
| 3.6  | Stock of Nonproduction Workers ( $Y_6$ )                        | 50 |
| 3.7  | Deflated Shipments ( $S$ )                                      | 51 |
| 3.8  | Hourly Earnings per Week of Production Workers ( $w$ )          | 51 |
| 3.9  | User Cost of Capital ( $c$ )                                    | 52 |
| 3.10 | Relative Prices ( $w/c$ )                                       | 52 |
| 3.11 | Manufacturers' New Orders in Constant Dollars ( $N$ )           | 53 |
| 3.12 | Manufacturers' Unfilled Orders in Constant Dollars ( $ou$ )     | 53 |
| 3.13 | Ratio of Manufacturers' Unfilled Orders to Shipments ( $ou/S$ ) | 54 |

### *Quarterly Data, 1948I-1967IV:*

|     |   |    |
|-----|---|----|
| 4.1 | Actual and Estimated Values of the Stock of Production Workers                      | 60 |
| 4.2 | Actual and Estimated Values of Hours of Work of Production Workers                  | 61 |
| 4.3 | Actual and Estimated Values of Deflated Capital Stock                               | 62 |
| 4.4 | Actual and Estimated Values of the Utilization Rate                                 | 63 |
| 4.5 | Actual and Estimated Values of Manufacturers' Total Inventories in Constant Dollars | 64 |
| 4.6 | Actual and Estimated Values of the Stock of Nonproduction Workers                   | 65 |

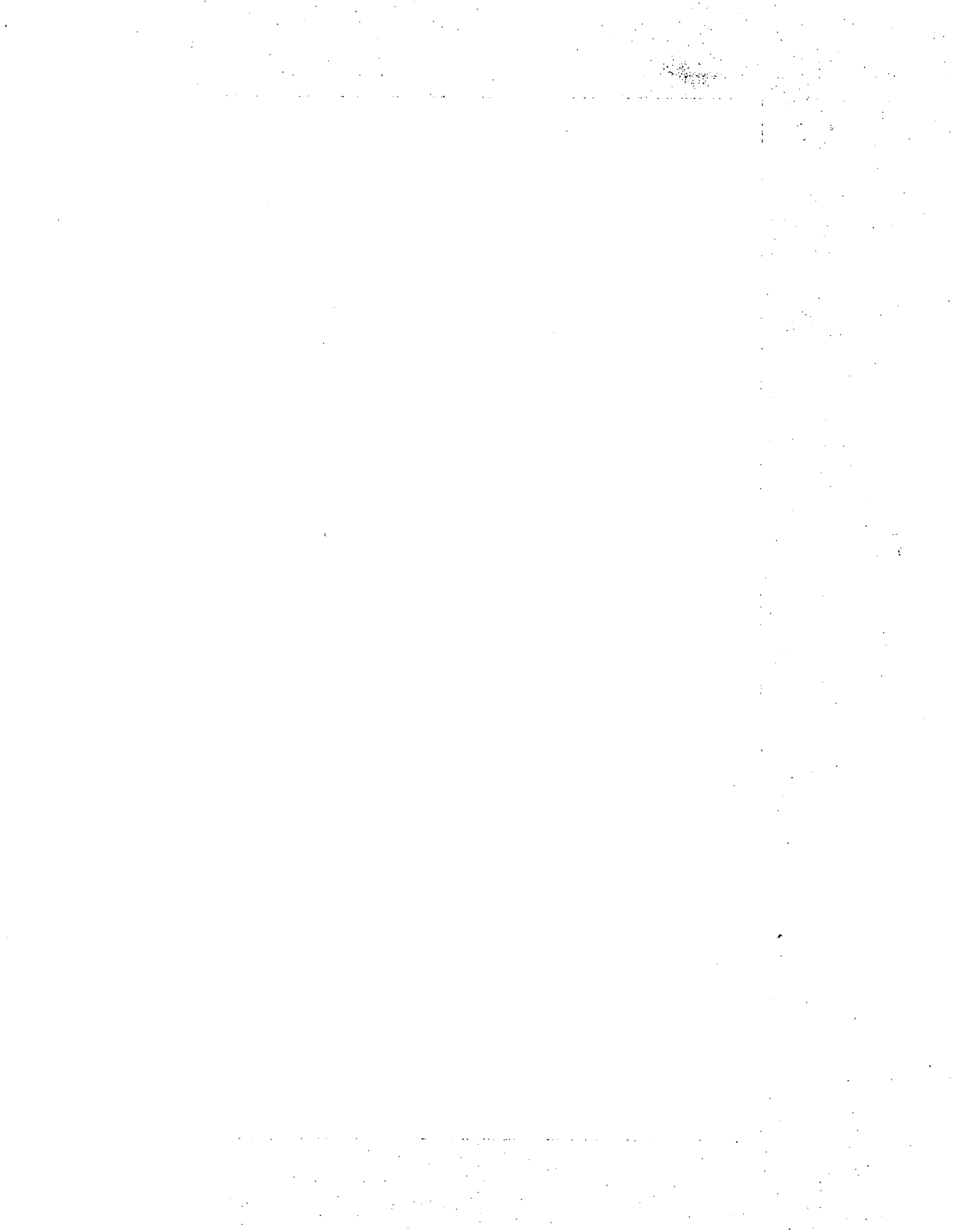
### *Quarterly Data for Total Manufacturing, 1968I-1970II:*

|     |  |    |
|-----|--|----|
| 4.7 | Actual and Forecast Values of the Stock of Production Workers, Weekly Hours, and Capital | 71 |
|-----|--|----|

|      |   |     |
|------|---|-----|
|      | <i>Quarterly Data for Total Manufacturing, 1968I-1970II (cont.):</i>  |     |
| 4.8  | Actual and Forecast Values of the Utilization Rate,<br>Total Inventories, and the Stock of Nonproduction<br>Workers | 72  |
|      | <i>Total Durables, Quarterly Data, 1948I-1967IV:</i>  |     |
| 6.1  | Actual and Estimated Values of the Stock of<br>Production Workers   | 120 |
| 6.2  | Actual and Estimated Values of Hours of Work of<br>Production Workers   | 121 |
| 6.3  | Actual and Estimated Values of Capital Stock  | 122 |
| 6.4  | Actual and Estimated Values of the Utilization Rate   | 123 |
| 6.5  | Actual and Estimated Values of Total Inventories  | 124 |
| 6.6  | Actual and Estimated Values of the Stock of<br>Nonproduction Workers  | 125 |
|      | <i>Total Nondurables, Quarterly Data, 1948I-1967IV:</i>   |     |
| 6.7  | Actual and Estimated Values of the Stock of<br>Production Workers   | 126 |
| 6.8  | Actual and Estimated Values of Hours of Work<br>of Production Workers   | 127 |
| 6.9  | Actual and Estimated Values of Capital Stock  | 128 |
| 6.10 | Actual and Estimated Values of the Utilization Rate   | 129 |
| 6.11 | Actual and Estimated Values of Total Inventories  | 130 |
| 6.12 | Actual and Estimated Values of the Stock of<br>Nonproduction Workers  | 131 |

## Figures

|      |   |     |
|------|---|-----|
| 1.1  | Untitled  | 11  |
| 4.1  | Implied Distributed Lag Responses to a Unit Sales Impulse, Based on Model (4.1) | 76  |
| 5.1  | Implied Distributed Lag Responses to a Unit Output Impulse, Based on 1969 Model | 82  |
|      | <i>Implied Distributed Lag Responses to a Unit Sales Impulse:</i>               |     |
| 5.2  | Based on Model (5.1)  | 86  |
| 5.3  | Based on Estimates Untransformed for Serial Correlation                         | 87  |
| 5.4  | Based on Model (4.1), Omitting the General Utilization Rate                     | 88  |
| 5.5  | Based on Actual Current and Future Sales  | 89  |
|      | <i>Distributed Lag Responses to a Unit Sales Impulse:</i>                       |     |
| 6.1  | Durable Goods   | 140 |
| 6.2  | Nondurable Goods  | 141 |
| 6.3  | Primary Iron and Steel  | 143 |
| 6.4  | Primary Nonferrous Metal  | 144 |
| 6.5  | Electrical Machinery and Equipment  | 145 |
| 6.6  | Machinery Except Electrical   | 146 |
| 6.7  | Motor Vehicles and Equipment  | 147 |
| 6.8  | Stone, Clay, and Glass Products   | 148 |
| 6.9  | Other Durables  | 149 |
| 6.10 | Textile Mill Products   | 150 |
| 6.11 | Paper and Allied Products   | 151 |
| 6.12 | Petroleum and Coal Products   | 152 |
| 6.13 | Other Nondurables   | 153 |



---

## PREFACE

---

THE behavior of capital investment and employment patterns in time-series data has been an active area of research in economics for many years, undoubtedly because of the importance of these phenomena for understanding and controlling business cycles. Research in the area has intensified in the past decade, with the emergence of better data and the realization that investment and employment variations may be best understood in terms of a modification of the theory of the firm. The modification largely consists of explicit recognition that there are costs associated with changes in the stocks of inputs as well as with changes in the intensity of their use. Under these circumstances, rational decision-making requires taking into account the effect of current decisions on future events, for there are strong incentives to minimize costs of change through production smoothing, reducing the period-to-period variance of input stocks by spreading out such changes over an extended horizon. By providing a link between present and future, this approach introduces a dynamic element into the theory of the firm that the static constructs of short- and long-run cost functions lack. It focuses attention away from the question of which inputs are to be regarded as fixed or variable over the period spanned by the data, and toward the role of inventories of both output and inputs and of utilization rates, and the dynamic linkages between input changes during the adjustment process. We hope to have provided new evidence on these important and interesting relationships in this study.

A great deal of research under the auspices of the National Bureau has pointed toward the development of dynamic models of the variety illustrated in this monograph. In particular, mention must be made of

Wesley Mitchell's<sup>1</sup> view of the behavior of costs in the generation of business cycles and empirical work by Thor Hultgren<sup>2</sup> in documenting that behavior for the case of labor costs. Further work by Hultgren<sup>3</sup> and also by Solomon Fabricant<sup>4</sup> traced systematic patterns of productivity over the course of business cycles and raised questions difficult to resolve on the basis of the customary distinctions between the short run and the long run. Finally, Gerhard Bry's<sup>5</sup> investigation of variations in the length of the work week naturally lead toward input inventory and capacity considerations in the theory of demand for factors of production. Though sometimes only implicitly, elements of all these works are to be found in our model, and our research certainly could not have proceeded as it did without them.

Our collaboration began in 1967-68, when we both held research fellowships at the National Bureau and decided to pool our efforts. From the beginning, many persons contributed to the completion of this volume, and we are greatly indebted to all of them. Geoffrey Moore, then director of research, and Victor Fuchs, then in charge of the fellowship program, gave much encouragement to our initial plans. At a later stage John Meyer made a number of important suggestions regarding model design. George Borts, Solomon Fabricant, Robert Lucas, Marc Nerlove, Arthur Treadway, and Neil Wallace offered many useful suggestions and criticism of the work at various times. A staff reading committee consisting of Robert Eisner, Franklin Fisher, and Christopher Sims provided a volume of constructive criticism that materially improved the manuscript. Robert Lipsey was also very helpful in this connection. We are also thankful for the valuable comments of the Board of Directors' reading committee: Otto Eckstein, Nathaniel Goldfinger, and Robert M. Solow. Our thanks also are due to Emilio G. Collado for his observations on the manuscript.

This study benefited greatly from highly competent assistance. Most of

1. Wesley C. Mitchell, *Business Cycles: The Problem and Its Setting*, New York, NBER, 1927.

2. Thor Hultgren, *Changes in Labor Cost During Cycles in Production and Business*, Occasional Paper 74, New York, NBER, 1960.

3. Thor Hultgren, *Cost, Prices, and Profits: Their Cyclical Relations*, New York, NBER, 1965.

4. Solomon Fabricant, *Basic Facts on Productivity Change*, Occasional Paper 63, New York, NBER, 1959.

5. Gerhard Bry, *The Average Workweek as an Economic Indicator*, Occasional Paper 69, New York, NBER, 1959.

the data processing and computations were supervised admirably by Veena Bhatia, Morris Harf, and Susan Johnson. They were assisted at one time or another by Margaret Crump, Jennifer Michaels, and Selma Seligsohn. Rose Ferro provided very efficient and conscientious typing and secretarial assistance. We are very grateful to Ester Moskowitz for editing the manuscript. H. Irving Forman's expert draftsmanship contributed immeasurably to the presentation of the material in this book.

Financing for the study was provided partly from grants to the National Bureau by the Alfred P. Sloan Foundation and the Alex C. Walker Educational and Charitable Foundation for the Bureau's studies on productivity, employment, and price levels, and partly from the general funds of the National Bureau.



---

## INTRODUCTION

---

THE purpose of this volume is to present a systematic investigation of investment, employment, utilization rates, and inventories in manufacturing industries over the post-World War II period. The focus of the study is on the dynamic interrelationships among these variables that arise from changing demand and market conditions. Costs associated with changes of these variables, absent in a static world, significantly affect the outcome in a dynamic setting. These costs provide a link between present and future profits and consequently require firms to take explicit account of the effects of current decisions on future profits.

In a changing world, the firm is faced with three basic options regarding production and input. It can perfectly synchronize input and output decisions without holding any inventories. It can hold inventories of output to meet changing demand and stabilize employment of its capital stock and labor force. Finally, it can hold the equivalent of inventories of inputs, not smoothing production perfectly but changing the intensity of use of existing resources. The first strategy is unlikely to be pursued because there are natural delays in production and because rapid acquisition and change in the utilization of inputs is costly. The typical policy for most firms is to follow a mixed strategy of holding some inventories of output and some of input. The combination is determined by an interrelated set of implicit cost trade-offs which are, in turn, determined by the technological and market conditions under which the firm operates.

The forces underlying these trade-offs are very complex, and lead to a network of interrelated decisions. Changing the levels of output inventories, input utilization rates, or additions to input stocks all involve

costs which vary according to the type of adjustments, the length of time, and the decisions made about the other inputs and outputs. These events, in turn, lead to a pattern of intertemporal substitutions among these variables. Costs of altering input utilization rates include overtime wage payments to labor and accelerated depreciation of capital equipment because it is used more intensively. Finally, changing the labor force involves search, hiring, and training costs, and acquiring new capital goods entails order delays, installation costs, etc.

Some simple examples will illustrate the nature of the response mechanisms involved. Suppose a firm expects a permanent increase in sales, which will eventually make an expansion of its productive capacity advantageous. To meet new demand in the short run requires, because of adjustment delays in the acquisition of new capital goods, increasing utilization of existing capacity by adding overtime and additional labor and by running down existing inventories. Current costs are thereby increased temporarily. As capital expansion proceeds, these costs are slowly reduced to more normal levels. In certain cases, the firm may be additionally constrained by labor market conditions. Current unavailability of skilled labor at or near existing wage rates leads to the postponement of capital expansion plans and greater reliance on more intensive utilization of existing resources. In situations where increased sales are not considered permanent, costs of temporary changes of plant capacity may be so large that new investments are precluded. The firm increases utilization of existing stocks and may temporarily increase its labor force as well. As sales fall to their prior levels, utilization rates taper off, inventory-sales ratios slowly increase to their desired levels, and temporary labor acquisitions are reduced.

It is important to take account of these interrelationships and feedbacks in the adjustment process, both from a purely scientific point of view and also for policy prescriptions. The scientific contribution lies in a more complete description and analysis of production decisions. Taking account of these dynamic constraints provides an opportunity to predict more accurately the production and factor employment behavior of firms. This point is illustrated by a survey of the literature on investment and employment functions. Existing time-series employment studies assume fixed capital stock. Yet estimated labor stock adjustment periods are so long as to place this assumption in serious doubt. On the other hand, most investment studies treat labor as a completely variable factor even

though employment studies indicate otherwise. Furthermore, few of these investigations have made adequate allowance for variations in utilization rates of labor and capital, and the estimates often are difficult to interpret.<sup>1</sup>

The relationships among input and output decisions have important policy implications. For example, a policy designed primarily to influence investment behavior may have unintended spillover effects on employment and utilization decisions. Policies aimed at one market do not in fact remain confined to that market. An important consequence is that program monitoring of fiscal and monetary policies is rendered more difficult. Because of the complexity of the response networks involved, the immediate response and the evolution of the system can be very different from that intended. It therefore becomes very important to be able to predict how these response patterns will evolve. For example, as will be seen below, employment response to expansionary fiscal policy may exceed its ultimate equilibrium value for some period of time after the stimulus because of the feedback and cross-adjustment mechanisms involved. In terms of employment objectives, the policy temporarily may look better (or worse) than it will ultimately be.

An attempt has been made in this study to develop and estimate a model which takes explicit account of these interrelationships. The theoretical structure is based on the neoclassical theory of production in the presence of costs of changing input levels. The model and estimates of it provide a unified framework for analyzing input demand functions over time. The inputs considered are production and nonproduction labor, capital stock, and inventories. The role of utilization rates in these functions and variations in utilization rates are also analyzed. The model is estimated for total manufacturing and its component sub-sectors—durables, nondurables, and fifteen individual industries—using quarterly data over the 1947–69 period.

The main contribution of this study lies in four areas:

1. We have tested for the existence of cross-adjustment or feedback effects among input decisions and have found them to be present in all industries studied. Quarterly changes in each input are found to be

1. Some studies use man-hours rather than employment stock but do not determine the division between employment and hours of work. Two exceptions are Black and Kalejian [1970] and Kuh [1965a]. Nadiri [1969] explicitly takes into account capital utilization in his investment function, but it is exogenous to the model.

significantly affected by the position and adjustment response of other inputs. The results verify the generality of the model, which includes existing employment and investment models as special cases.

2. The existence of cross-input adjustment effects implies patterns of responses to changing conditions which are in marked contrast to results reported in previous studies. Two outstanding general features of the results are as follows: First, dynamic responses of utilization rate variables and, very often, employment variables overshoot their ultimate equilibrium values very soon after the adjustment process begins. These results cannot be obtained (by construction) in traditional employment and investment function studies, which exclude feedback effects from one input to the other. Second, there are systematic differences in the timing and speed of response among inputs. Utilization rates respond very quickly to changes in demand, followed by production employment and inventory variables. Nonproduction worker employment and especially capital stock respond very sluggishly. Moreover, the average lags in the system tend to be shorter than those found by previous investigators, who have ignored interaction effects. It should be emphasized that those variables which overshoot their ultimate equilibria are also the quickest to respond to external stimuli. They act as buffers, taking up the slack imposed by the slower-adjusting inputs such as capital. This result justifies the cross-adjustment specification of the model.

3. The analysis permits separation of sales and relative input price responses, and these are systematically different in all industries studied. The sales effects are much larger than the price effects, which tend to be very small in magnitude and often indiscernible in these data.

4. There are systematic differences across industries, both in speed of response of inputs to sales and prices and in the ultimate effects of these variables. Input responses are much more rapid in durable goods industries than in nondurables, and long-run responses are also smaller.

The material in this volume is presented as follows: Chapter 1 contains a discussion of the general setting of the problem and illustrations of some conceptual issues. The complete model is presented and elaborated in Chapter 2. The nature of the data and some preliminary observations are discussed in Chapter 3. Structural estimates, distributed lags, and long-run elasticities for total manufacturing and their interpretation are presented in Chapter 4. Results of various experiments with alternative

forms of the model for total manufacturing are found in Chapter 5. The complete results for individual industries are presented in Chapter 6. In Chapter 7, the empirical results obtained in this study are used to answer some heretofore unresolved questions about the estimation of short-run employment and investment functions, and a summary and conclusions are also given. Appendixes and references are included at the end of the volume.

For those readers interested only in the essential theoretical and empirical results of this volume, we recommend Chapter 2 for theoretical development and Chapters 4, 6, and 7 for empirical application.



A Disequilibrium Model of Demand  
for Factors of Production

