INVESTMENT IN THE IRON AND STEEL INDUSTRY
OF THE UNITED STATES, PHASE II

CONDITIONAL FORECASTS AND SUPPLY OF FUNDS MODEL

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

by

Institute for Research on Human Resources
The Pennsylvania State University
University Park, Pennsylvania   16802

ANNUAL REPORT (July 1, 1975-June 30, 1976)

on

Contract No. JO255006
Capital Requirements in the U.S. Iron and Steel Industry

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The views and conclusions contained in this document are those of the
author and should not be interpreted as necessarily representing the
official policies or recommendations of the Interior Department's
Bureau of Mines or of the U. S. Government.

Acknowledgments

PREFACE

The basic objectives of this report are: (1) to provide updated forecasts of the physical capital investment process in the iron and steel industry, including forecasts under various assumptions about federal tax policy; and (2) to develop a model of the financial aspects of the investment decision in the iron and steel industry. The first objective is the subject of Chapter 2 of this report. Chapters 3-9 develop a model of the supply of and demand for investment funds in the United States iron and steel industry for the period 1960-1973.

A number of federal tax policy alternatives are examined, including an investment tax credit of 10 or 12 percent, a reduction in the corporate income tax to 42 percent, and reductions in the capital recovery period for depreciation purposes to ten years or five years. In addition, the forecasts incorporate the latest revisions of data for such variables as the level of steel output (seasonally adjusted) and the price index of investment goods. The latest revisions in the level of gross investment in iron and steel plant and equipment are also incorporated for short-run forecasting purposes.

A comparison of the forecasted level of physical capital investment through 1980, considering various policy alternatives, leads to a conclusion that federal tax policy alone will be insufficient to close the capital shortage gap in the iron and steel industry. This conclusion rests on a comparison of conditional forecasts using the physical capital investment model (Phase I model) with the American Iron and Steel Institute's target of $2.9 to $3.5 billions of investment expenditures (in 1973 dollars) per year through 1980. The report then briefly explores the economic reasons for the relative ineffectiveness of federal tax policy in closing the capital shortage gap in the iron and steel industry. Among the reasons suggested are the relative inflexibility of the steel production process, the long lead times needed to plan and construct facilities, and the minor role given to supply of funds considerations in the physical capital investment model.

The bulk of this report (Chapters 3-9) is devoted to the specification and estimation of a model which attempts to portray the financial aspects of the investment decision in the iron and steel industry. An attempt is made to trace the flow of funds through the business firm in terms of: (1) the level of profits and gross cash flow (before taxes); (2) the division of net cash flow into retained earnings (internal funds) and dividend payments to stockholders; (3) the impact of gross retained earnings (retained earnings plus depreciation allowances) on the timing of physical investment expenditures; and (4) the financing of the remainder of investment funds requirements through the acquisition of long-term debt (external finance). The overall model consists of eight

equations, of which five are behavioral (stochastic) and three are accounting indentities. It should be noted that Chapters 3 - 9, except for introductions and summaries, are written in the specialized language of the econometrician and, as such, are not intended for wide general readership.

It is our considered judgment that the model developed in this report will serve as a sound theoretical and empirical basis on which to examine the questions of the supply of and demand for investment funds in the iron and steel industry, including both replacement investment and net, new investment (modernization). Furthermore, the model of the capital expenditure decision incorporates such variables as the wage demands of labor, capacity utilization, and foreign imports of steel. It is our intention, therefore, to integrate our earlier research results reported under Phase I and explore the following issues:

1. The future levels of physical capital investment in the iron and steel industry, under different assumptions and scenarios, giving explicit attention to the effects of public policy decisions on investment.

2. The role of financing of capital expenditures in meeting these requirements in order to assess the possibilities of a shortage of capital funds.

These issues will be the subject of our future research for which we have contracted with the Bureau of Mines.

Jacob J. Kaufman
Director

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CHAPTER 1

INTRODUCTION AND SUMMARY

Introduction

During the ten-year period from 1965 to 1974, total cumulative capital consumption in the United States economy doubled to $1.5 trillion relative to 1955-64. For the period 1975-84, some projections place cumulative capital consumption at $4.4 trillions of current dollars, or an 8.7 percent compound annual rate of growth.[1] The implications of this rate of growth are many, but to some observers it has suggested the picture of an economy beset by a capital shortage gap of substantial and perhaps growing proportions, in which economic growth occurs in a series of prolonged recessions and abortive recoveries.

The reasoning leading to this dismal prediction is roughly as follows:[2] First, as a consequence of a series of "credit crunches" suffered in 1966, 1969-70, and 1973-74, physical investment in plant and equipment in the private sector has been inadequate over the past decade. Second, it is said that both the public and private sectors are too profligate in consuming rather than saving, and will therefore put too high a price on capital. Finally, it is argued that inadequate past and future capital investment will not enable the U.S. to meet commonly accepted goals for economic growth and total employment. As a consequence, a capital shortage could mean:[3]

- The financial markets would be chronically unable to provide the necessary flows of funds to finance the economy's expenditures at rates of interest that anyone could afford.

- The U.S. economy would suffer from chronic shortages of goods and from continued high inflation because capital expenditures would be insufficient to generate capacity to meet demand at reasonably stable prices.

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[1]See A. Sinai and R. E. Brinner, The Capital Shortage (Lexington: Data Resources, Inc., 1975), pp. 33-5.

[2]The analysis of the capital shortage debate follows that contained in W. J. Vaughan, C. S. Russell, and H. C. Cochrane, Government Policies and the Adoption of Innovations in the Integrated Iron and Steel Industry (Washington, D.C.: Resources for the Future, Inc., May 1976), pp. 87-91 passim.

[3]"Capital Crisis: The $4.5-Trillion America Needs to Grow," Business Week, September 22, 1975, p. 42. See also "Where is the Capital Spending Boom?", Business Week, September 13, 1976, p. 64.

- The business cycle profile would consist of prolonged recessions and short, feeble recoveries along with constant upward pressures on interest rates and prices.

- The corporate structure would be altered toward a greater concentration of production in the hands of a few large firms with the very highest credit ratings.

- Social unrest and class conflict would become endemic because real income gains would be marginal or nonexistent.

The overall problem of a capital shortage in the economy[4] can be distinguished from--although not entirely separated from--the problem of capital shortages in certain sectors or industries.[5] In the iron and steel industry, the short supply of investment funds is related in part to a historically low rate of return relative to other manufacturing industries. For example, during the period 1965-73, the steel industry's average rate of return on stockholders' equity (net worth) was 7.4 percent compared to 12.7 percent for forty manufacturing industries.[6] The industry's low rate of return creates problems in raising external debt or equity capital while at the same time it limits the internal supply of retained earnings. Thus, while the general problem of a capital shortage lends credence to some of the proposed solutions to the steel industry's potential capital shortage, it must be recognized that the two problems do spring from somewhat different causes and involve somewhat different perspectives. For example, while the iron and steel industry is certainly an important basic manufacturing industry, it is difficult to imagine widespread social unrest if a steel capital shortage alone were to go unabated. Nevertheless, some

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[4] For analysis of the overall capital shortage problem see B. Bosworth, J. S. Duesenberry, and A. S. Carron, Capital Needs in the Seventies (Washington, D.C.: The Brookings Institution, 1975); A. Sinai and R. E. Brinner, The Capital Shortage (Lexington, Mass.: Data Resources, Inc., 1975); B. M. Friedman, "Financing the Next Five Years of Fixed Investment," Sloan Management Review, 16 (Spring 1975), pp. 51-74; and P. Wachtel, A. Sametz, and H. Shuford, "Capital Shortages: Myth or Reality," Journal of Finance, 31 (May 1976), pp. 269-86; P. L. Bernstein, "Capital Shortage: Cyclical or Secular," Challenge, 18 (November 1975), pp. 6-11; and D. Ignatius, "The Capital Crisis," Washington Monthly, 7 (November 1975), pp. 16-22.

[5] Vaughan, Russell, and Cochrane, op. cit., p. 88.

[6] Fordham University, Financial Study of the United States Steel Industry, COM-75-11191. (Springfield, Va.: National Technical Information Service, August 1975), p. 65.

of the proposed policy alternatives for dealing with the overall capital
shortage and with a possible steel capital shortage are the same, e.g.,
investment tax credits and elimination of double taxation of dividends.[7]

For both the overall capital shortage and the steel capital shortage,
there is a problem, however, of defining exactly what is meant by the
term "shortage." One view is that a shortage cannot exist, at least in
the long run, so long as interest rates and other prices are free to
fluctuate and find the level that clears the markets in question. Indeed,
this is the position taken by many economists who question the validity
of the debate in general. A second view is to posit certain commonly
accepted goals--such as a 4 percent unemployment rate and a 3 percent
rate of inflation. The question then is, given these goals, will the
economy generate sufficient capital investment to meet them?

A third view of the shortage problem--that put forward by the
iron and steel industry--involves parts of both of the above arguments.
It is argued that there is or will be a shortage of domestic steel
production capacity due to:[8]

1. Direct and indirect government involvement in most
   foreign steel industries in the areas of investment,
   rationalization of facilities, pricing, distribution
   and international trade. As a consequence, the growth
   in steel demand in the U.S. has been largely filled by
   increased steel imports.

2. The need for a domestic steel industry of sufficient size
   to generate a favorable trade balance, provide for national
   security, assure price stability, provide employment
   opportunities, and meet projected future domestic demand
   without undue reliance on unreliable foreign producers.

The first point implies a lack of a free market in the international
trade of steel while the second point places heavy emphasis on the
more normative "needs" or "goals" view of a shortage.

The steel industry has provided estimates of the size of the
capital shortage which are summarized in Table 1. These estimates
are the basis for a number of proposed federal tax policy changes
favorable to steel profits and have provoked a lively debate over the

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[7]For analysis of the latter proposal in the context of the steel
industry see Vaughan, Russell, and Cochrane, op.cit., pp. H71-86. One
important difficulty in analyzing the impact of this policy is that it
is unlikely to be of a partial equilibrium nature. Both the model used
by Vaughan, Russell, and Cochrane and the model developed in this report
ignore general equilibrium considerations.

[8]American Iron and Steel Institute, op.cit., pp. 15-18.

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TABLE 1.1

THE STEEL INDUSTRY'S ANNUAL CAPITAL TARGET
(Billions of 1973 Dollars Annually 1974-1980)

	Case 1	Case 2
Investment Requirements:[a]		
Additional Capacity	$1.15	
Maintenance of Existing Capacity	1.75	
Pollution Abatement Facilities	0.40	
Miscellaneous	0.20	
	$3.50	
Sources of Funds:[b]	Case 1	Case 2
Retained Earnings and Depreciation	$2.0	$2.4
Long-term Borrowing	0.4	0.4
	$2.4	$2.8
Short Fall	$1.1	$0.7

[a]Source: American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy (Washington, D.C.: February 1974), p. 27.

[b]Source: American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy (Washington, D.C.: June 1975), p. 25. See also W. J. Vaughan, C. S. Russell, and H. C. Cochrane, Government Policies and the Adoption of Innovations in the Integrated Iron and Steel Industry (Washington, D.C.: Resources for the Future, Inc., May 1976), p. 89, on which our table is based.

Case 1 used the average results of 1973 and 1974 while Case 2 uses only 1974. In both cases, the numbers have been deflated by a factor of 0.7 to be consistent with the investment requirements projection, i.e., both investment requirements and sources of funds are expressed in constant 1973 dollars.

accuracy of the potential steel capital shortage gap.[9] In this report, we do not examine the relative merits of the views held or numbers proposed by the debaters (a critique is planned for the Phase III report). Rather, we simply summarize the steel industry's recommendations for government policy changes designed to relieve the capital shortage, leaving open to question the exact size of the shortage. The steel industry urges that government policy should:[10]

· Avoid the formal and informal price controls imposed upon it for most of the period since the early 1960's (emphasis in the original).

· Promptly and effectively offset the questionable trade practices of foreign steel producers and their home governments.

· Provide sound, realistic and consistent environmental policies which effectively equate the benefits being sought with their total economic impact.

· Encourage capital formation through reductions in the portion of profits and internal cash flow which is devoted to income tax burdens, and increase the incentive to invest in the productive facilities required.

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[9]See, for example, Council on Wage and Price Stability, A Study of Steel Prices (Washington, D.C.: July 1975); Morgan Guaranty Trust, The Domestic Steel Industry, Outlook and Financing Implications (New York: June 1975); W. T. Hogan, et al., Financial Study of the United States Steel Industry: Analysis of Capital Needs and Financial Condition, COM-75-11191 (Springfield, Virginia: National Technical Information Service, August 1975); Arthur D. Little, Inc., Steel and the Environment: A Cost Impact Analysis, C-76482 (Cambridge, Mass.: May 1975); American Iron and Steel Institute, Financing Capital Expenditures--A Critical Concern of the American Steel Industry (Washington, D.C.: October 30, 1975); P. F. Marcus, Observations and Commentary on the Council on Wage and Price Stability's Steel Price Study (New York: Mitchell, Hutchins, Inc., October 29, 1975); Temple, Barker and Sloane, Inc., The Economic Impact of Environmental Regulation on the Iron and Steel Industry (New York: April 1976); P. Marshall, Summary of Comments from the Council on Wage and Price Stability's Symposium on Steel Prices, CWPS-144 (Washington, D.C.: Council on Wage and Price Stability, April 27, 1976); and C. J. Loomis, "Steel's Not-So-Solid Expansion Plans," Fortune, January 1976, p. 106.

[10]American Iron and Steel Institute, Steel Industry Economics, op. cit., (June 1975), p. 35. See also Vaughan, Russell, and Cochrane, op.cit., pp. 95-6.

Specific recommendations are provided by the American Iron and Steel Institute (AISI) with regard to the last proposal. It is recommended that:[11]

1. A major long-term goal of Federal income tax policy should be the enactment of a simplified and flexible capital recovery system which will permit the cost of all productive facilities to be recovered over a period as short as 5 years.

2. The full investment tax credit should be retained as a permanent provision of the Internal Revenue Code...The Tax Reduction Act of 1975 provides for a temporary two-year increase in the rate of investment credit to 10 percent. We [AISI] further recommend that the rate be permanently established at 12 percent, but, at a minimum, the 10 percent rate be made permanent.

3. A long-term goal of Federal income tax policy should be a substantial reduction in the corporate tax rates combined with some efforts to eliminate the double taxation of corporate dividends.

Objectives of the Report

The objectives of this report may be summarized as follows:

1. To quantify the AISI proposals with regard to depreciation allowances, investment tax credits, and the corporate income tax.

2. To develop and estimate a quantitative model which considers both the supply of and demand for investment funds in the iron and steel industry.

Chapter 2 examines a number of alternative forecasts of future investment expenditures in the iron and steel industry under alternative assumptions about policy variables. These forecasts permit us to quantify the AISI proposals and determine the extent to which these proposals will: (a) increase investment expenditures relative to the no-change or do-nothing alternative; and (b) close the capital shortage gap relative to the AISI-stated requirements. It should be noted that these forecasts are conditional on other assumptions about the future level of steel ingot output, the wholesale price index for iron and steel products, the GNP implicit price deflator for nonresidential fixed investment, the interest rate (corporate industrial bond yield) and the estimated rate of economic depreciation for iron and steel producing facilities. The conditional forecasts in Chapter 2 are based

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[11]American Iron and Steel Institute, Steel Industry Economics, op.cit. (June 1975), pp. 36-9. See also Vaughan, Russell, and Cochrane, op.cit., pp. 95-6.

on the investment demand model developed in Phase I of this project[12] and ignore, therefore, the supply of funds for investment.

Chapters 3-9 develop the empirical model of the supply of and demand for investment funds. The empirical model in this report is composed of five behavioral (stochastic) equations and three identities.[13] The basic dependent variables, i.e., those variables which are being explained, are:

1. Gross cash flow (before tax profits plus depreciation allowances);
2. Corporate taxes paid;
3. Net cash flow (after tax profits plus depreciation allowances);
4. Dividends paid;
5. Gross retained earnings (net cash flow minus dividends);
6. Gross investment expenditures on fixed plant and equipment (replacement investment plus net, new investment);
7. Capital stock;
8. Long-term debt stock.

Each behavioral equation incorporates several independent or ex-planatory variables, i.e., those variables whose purpose is to explain variations in the dependent variable in question. Among the major in-dependent variables are current and lagged sales revenue from steel products, raw steel capacity utilization, price index of steel mill products, steel import penetration, raw steel output, user cost of capital, the wage rate, and the actual and the desired stocks of capital. Each behavioral equation involves several parameters (regression coefficients) which are numbers expressing the change in the level of the dependent variable associated with a unit change in the independent variable in question. These parameters are estimated using statistical (econometric) procedures and include, for example, the dividend payout ratio, the marginal tax rate, the capital-output elasticity, the capital-relative factor price elasticity, and the debt-to-capital ratio.

It is our judgment that the model developed in this report will serve as a sound theoretical and empirical basis on which to examine questions of the supply of funds for investment in the iron and steel

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[12]G. R. Neumann, Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975-1980, Final Report to the U.S. Bureau of Mines Under Grant No. GO244006 (University Park, Pa.: Institute for Research on Human Resources, December 1975). Here-after this report is referred to as the Phase I report. Copies are on file at the U.S. Bureau of Mines or available from the Institute for Research on Human Resources, 409 Kern Building, University Park, Pa. 16802

[13]Some changes in our model are planned for Phase III, especially in terms of the treatment of profits, depreciation, and taxes. The initial model estimated in this report is designed to establish the overall framework necessary to explore the forecasting questions of interest, and determine the necessary econometric procedures.

industry relative to the demand for funds. In particular, the model
does not require that the supply of funds always be instantaneously
equated with the demand for funds. We thus allow for temporary
imbalances between supply and demand for investment funds--shortages
(or surpluses) in a positive sense. The model may still be used to
examine the more vexing question of shortages in a normative sense,
i.e., the projected level of investment expenditures relative to the
AISI statement of needs or requirements.

Finally, it should be noted that the investment demand equation
developed in this report is similar to, but not identical with, the
investment demand model from the Phase I report. For purposes of
long-range forecasting, either model would probably be adequate,
especially if supply of funds problems were expected to be minimal.
We demonstrate in Chapter 7 that the Phase II investment equation
can outperform the Phase I model when forecasting short-term invest-
ment expenditures, i.e., during the period 1974-1975. Furthermore,
we suggest that the improvement in short-term forecasting is in large
part due to the incorporation of supply of funds considerations in
the Phase II investment equation.

We turn now to a summary of the basic results of this report,
beginning with a summary of the conditional forecasts of future
capital expenditures under various policy alternatives and a comparison
of these forecasts to the AISI projection. Following this, a non-
technical summary and description is presented for the eight-equation
recursive model. The chapter concludes with a general discussion of
the limitations of our work to date and a statement of our future
intentions and plans.

Summary of the Conditional Forecasts

The basic mechanism by which tax policy alters investment ex-
penditures is as follows: If capital services cost less as a result
of tax incentives, businessmen will employ more of them, other things
being equal. In general, investment in any time period depends on
the capital stock on hand at the beginning of the period and on changes
in the desired or target level of capital in previous periods. The
form of the gross investment relationship also depends on the form of
the distributed lag structure, i.e., on the timing of net investment
expenditures, and on the rate of replacement investment due to economic
depreciation. The desired level of capital depends on the level of
steel output, the price of output, and the rental price of capital
services.

Tax policy affects investment expenditures through the rental price
of capital services. This price depends in turn on the price of
investment goods, the cost of capital, the tax rate, the rate of
economic depreciation, the several formulas for calculating the depre-
ciation allowances for tax purposes, and the level of the investment
tax credit. A change in tax policy changes the rental price of the
capital input and consequently the desired level of capital. An in-
crease in the desired capital stock generates net investment. If the
cost of capital and all other determinants of desired capital remain
constant, net investment will eventually decline to zero as the capital
stock approaches its desired level. However, a change in tax policy
will continue to affect gross investment through replacement requirements

for a permanently larger capital stock. If the desired capital stock is decreased by tax policy, these effects are precisely reversed.

To evaluate the effect of a specific tax policy, all determinants of investment spending except the tax policy parameters are held equal to their current or projected values. The impact of tax policy is then captured by substituting the parameters of the tax structure appropriate to the policy alternative in question. The difference between investment forecasts resulting from no change in current tax policy and investment forecasts that are dependent on alternative tax incentives is a (partial equilibrium) quantitative measure of the impact of federal tax policy on steel industry economics. If our interest is solely in this differential, then no great precision is required in the projections of other investment determinants. That is, the estimates of the differential impact of alternative policies do not depend critically on the assumed level of investment, although gross investment expenditures do depend on the level of replacement expenditures and the forecasted stock of capital.

Chapter 2 includes a number of alternative forecasts for steel investment expenditures. In order to summarize the forecasts, it is useful to think of the problem in terms of four scenarios. These are:[14]

1. The Do-Nothing Scenario--the price of steel products and the price of investment goods both increase at equal rates, so that the relative price ratio is constant and equal to its 1974-IV value (see Figure 2.4). The interest rate is approximately constant through 1980 and equal to its 1974-IV value of 9.34 percent per annum (see Figure 2.5).[15]

   The investment tax credit is set at 10 percent for 1975 and 1976, and 7 percent thereafter. The corporate income tax rate and capital recovery periods are unchanged from their present values of 48 percent and 14.5 years, respectively.

2. The Most Likely Future--The rate of inflation is assumed to gradually decline, affecting prices of steel products and investment goods equally, so that the relative price ratio is constant through 1980. Tight monetary policy is assumed to keep interest rates high and approximately equal to the 1974-IV value of 9.34 percent per annum.

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[14]Our nomenclature is taken from Vaughan, Russell, and Cochrane, op.cit., pp. 107-20. Also the content of our scenarios closely parallels that found in their report, which uses linear programming to examine several steel public policy issues, including energy, environmental and financial policies.

[15]The actual values of the interest rate during the four quarters of 1975 were 9.39 percent, 9.49 percent, 9.50 percent, and 9.49 percent, respectively. The interest rate during the first quarter of 1976 was 9.13 percent.

Some assistance is extended to business. The investment tax credit is set equal to 10 percent through 1980. Some changes are made in depreciation rules but these are so minor as to not affect the rental price of capital. There is no change in the corporate income tax rate of 48 percent.

3. <u>A Helping Hand to Business</u>--The price of steel products grows 2 percent faster than the price of investment goods during 1976-77. From 1978-80, the relative price ratio remains constant at its 1977 level. Tight monetary policy is assumed to keep interest rates high and approximately equal to the 1974-IV value of 9.34 percent per annum.

   Major changes in tax policy are instituted. The investment tax credit is increased to 12 percent; the corporate income tax rate is reduced to 42 percent; the period allowed for capital recovery is reduced from 14.5 years to 10 years.

4. <u>Return to Prosperity</u>--The price of investment goods grows 2 percent faster per year than the price of steel products during 1976-77. From 1978-80, the relative price ratio is constant at its 1977 level. Interest rates gradually decline as tight monetary controls are relaxed. The corporate industrial bond yield reaches 8.00 percent by 1977-IV, 7.00 percent by 1979-II, and 6.00 percent by 1980-IV (see Table 2.4).

   The investment tax credit is set at 10 percent for 1975 and 1976, and 7 percent thereafter. The corporate income tax rate and capital recovery periods are unchanged from their present values of 48 percent and 14.5 years, respectively.

The forecasts for average annual gross investment expenditures are presented in Table 2 for each of the four scenarios. Two alternative assumptions are presented for the projected rate of growth of steel production. In the first case, steel production is assumed to grow at a rate of 2.5 percent per annum for 1975-80. The 2.5 percent growth rate is a consensus figure used by many steel analysts[16] and implies raw steel production of about 167.3 million tons during 1980 (see Table 2.2). In the second case, production grows at a rate determined by the historical relationship between annual raw steel output and annual real GNP (see n.8, Chapter 2). Under this assumption, raw steel production reaches 165.6 million tons in 1980 (see Table 2.3).

Table 2 indicates that the Helping Hand Scenario would increase investment expenditures by between $0.106 to $0.111 billion (constant 1973 dollars) per year relative to the Do-Nothing Scenario, depending

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[16]American Iron and Steel Institute, <u>Steel Industry Economics</u>, <u>op. cit.</u> (June 1975), p. 22.

TABLE 1.2

SUMMARY OF CONDITIONAL FORECASTS:
AVERAGE ANNUAL GROSS INVESTMENT
EXPENDITURES IN STEEL TO 1980
(Billions of 1973 Dollars)

Steel Output Assumption	Scenario[a]			
	Do-Nothing	Most Likely	Helping Hand	Prosperity
2.5 Percent Growth	$2.228	$2.246	$2.339	$2.292
GNP-based Growth	$2.118	$2.135	$2.224	$2.179
Percent Change in Rental Price of Capital[b]	--	-4.9%	-16.8%	--

Target Expenditures: $2.9 - 3.5 Billions of 1973 Dollars per annum.[c]

[a]See Tables 2.11, 2.12, and 2.13.

[b]The percentage changes in the rental price of capital are relative to an investment tax credit of 7 percent in 1977. Figures in Table 2.12 are relative to an investment tax credit of 10 percent in 1976.

[c]Source: American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy (Washington, D.C.: February 1974), p. 27.

on which output assumption prevails. The Most Likely Scenario increases expenditures by only $0.017 to $0.018 billion per year. In the Helping Hand case, tax policy reduces the rental price of capital by 16.8 percent relative to 1977, while in the Most Likely case the implied reduction is 4.9 percent relative to 1977.

Using the AISI target expenditure level of $2.9 to $3.5 billion per year, it must be concluded that tax policy alone will be insufficient to attain this level. For example, under the Helping Hand Scenario, using a 2.5 percent growth rate for steel production, annual expenditures would average about $2.3 billion per year. This implies a capital expenditure shortfall of between $0.6 and $1.2 billion per year in constant 1973 dollars.[17]

The relative ineffectiveness of tax policy implied by these forecasts can be attributed to several economic factors. First, the role of relative prices is reduced in this model since the estimated elasticity of substitution among factors is considerably less than unity ($\sigma = 0.4$). This implies that the technological steel production process is characterized by relative inflexibility in terms of the businessman's ability to substitute capital for other factor inputs such as labor or energy (this is a prediction of the model, not an assumption). Second, the steel investment process is characterized by a long lag structure (24 quarters or 6 years) so that the full effect of tax policy will extend somewhat beyond 1980. This implies that changes in the desired capital stock which lead to net investment are distributed over a number of future periods, roughly 1977-1982, for policy changes instituted in 1976 (this is a prediction of the model, not an assumption). Finally, we present some evidence in Chapter 7 that the Phase I model may understate the impact of tax policy in the steel industry. Specifically, the estimated elasticity of factor substitution is somewhat higher than noted here (about -0.8), although the lag structure is still 24 quarters. The Phase I model also omits any effects of the supply of funds on the level and timing of investment. Revised conditional forecasts for tax policy are planned for Phase III of this project.

Summary of the Recursive Model

Chapters 3 - 9 of this report are devoted to the specification and estimation of an econometric model of the supply of and demand for investment funds in the iron and steel industry. By and large, these chapters are written in the arcane language of the econometrician and, except for introductions and summaries in each chapter, are not intended for wide general readership. Consequently, our intent here is to summarize these chapters in as brief and nontechnical a fashion as possible.

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[17]Due to differences in the data series employed, the Commerce Department's series on investment expenditures in iron and steel may bias our forecasts downward relative to the AISI series. The amount of the bias is probably not more than eight percent per year (see Table 2.14).

The essence of the model developed in these chapters is an attempt to trace the flow of funds through the business firm in terms of: (1) the level of gross cash flow (before-tax profits plus depreciation allowances); (2) corporate tax payments on earnings; (3) the division of after-tax profits into dividend payments and retained earnings; (4) the impact of gross retained earnings (after-tax profits plus depreciation allowances minus dividends) on the timing of gross investment expenditures; and (5) the stock of long-term debt required or permitted by the stock of capital resulting from the investment process. In short, the model attempts to determine the amount of internal funds available for investment, the level and timing of investment expenditures, and the level of external funds (long-term debt issues) that the internal decision process will sustain. A schematic summary of the model is presented in Figure 1 and the eight equations which make up the model are summarized in Table 3.

Furthermore, the model is recursive rather than simultaneous. This means that the decision process can be thought of as a series of discrete, individual steps rather than a grand overall system with feedbacks or simultaneity from later decisions (e.g., the level of investment expenditures) to earlier decisions (e.g., the division of after-tax profits into retained earnings and dividends). Although every effort is made to determine if any simultaneity is present, statistical tests and procedures always dictated the superiority of the recursive model. Thus, in Figure 1, each block may be thought of as an individual decision and the causal flow is always from the northwest corner of the diagram to the southeast corner.

Among the more important implications of the recursive view of economic decisions is the absence of strong equilibrium assumptions in the model. For example, in the typical economic model of a market, supply and demand are generally assumed to be equated within the time period in question. This implies the simultaneous determination of price and quantity for both supply and demand. In a recursive model, however, strong equilibrium assumptions are absent. It is possible for the supply of internal and external funds to be insufficient to finance the level of investment expenditures determined by the demand equation. Thus, it is quite possible to have temporary shortages or surpluses (in a positive sense) in a recursive model, two real world phenomena which are absent from simultaneous equation supply and demand models.

To complete this summary, we briefly survey the independent (explanatory) variables which are incorporated in each of the five behavioral (stochastic) equations in the recursive model. In each case, the list of independent variables serves to explain statistically the observed variation in the dependent variable in question. Equation 1 in Table 3 indicates that gross cash flow is hypothesized to be a function of steel product sales revenue, lagged sales revenue, capacity utilization, and an import penetration index. The lagged sales term enters this equation as a proxy for the wage demands of labor. In Equation 2, the amount of corporate taxes is determined, where the sole independent variable is gross cash flow before taxes. Equation 3 is an accounting identity from which net cash flow (gross cash flow minus taxes) is calculated.

FIGURE 1.1

SCHEMATIC VIEW OF THE PHASE II RECURSIVE MODEL

(1)

Sales revenue, lagged
sales revenue, capacity
utilization, price
change, import pene-
tration
- - - - - - - - - - - - -
GROSS CASH FLOW

Error
Term
$\bar{U}_1$

(2)

Gross cash flow
- - - - - - - - - - - - -
TAX PAYMENTS

Error
Term
U_2

(3)

Compute net
cash flow as
gross cash
flow less
tax payments

(4)

Lagged net
cash flow,
lagged divi-
dends
- - - - - - - - -
DIVIDENDS

Error
Term
U_3

(5)

Compute gross
retained earnings
as net cash flow
less dividends

(6)

Change in permanent output,
change in permanent relative
factor prices, change in lagged
gross retained earnings, lagged
gross investment
- - - - - - - - - - - - - - - - - -
GROSS INVESTMENT

Error
Term
U_4

(7)

Compute capital stock
as beginning of period
capital stock minus
economic depreciation
plus gross investment

(8)

Capital stock,
lagged long-
term debt
- - - - - - - - -
LONG-TERM DEBT

Error
Term
U_5

Legend:

Explanatory
Variables
- - - - - - -
Dependent
Variable

Behavioral
Equation

Computation
Instructions

Identity

14

TABLE 1.3

SUMMARY OF THE RECURSIVE MODEL

Dependent Variable		Explanatory Variables
(1) GCF_t'	$=$	$f_1(TR, TR_{-i}, CU, \Delta p, IMP, U_1)$
(2) TAX_t	$=$	$f_2(GCF, U_2)$
(3) NCF_t	$\equiv$	$(GCF - TAX)/\text{PRICE DEFLATOR}$
(4) DIV_t	$=$	$f_3(NCF_{-i}, DIV_{-i}, U_3)$
(5) GRE_t	$\equiv$	$NCF - DIV$
(6) I_t	$=$	$f_4(\Delta Q'_{-i}, \Delta(c/w)'_{-i}, \Delta GRE_{-i}, I_{-1}, U_4)$
(7) K_t	$\equiv$	$(1-\delta) K_{-1} + I$
(8) LTD_t	$=$	$f_5(K, LTD_{-i}, U_5)$

Notation: GCF = gross cash flow; TR = sales revenue; CU = capacity utilization index; Δp = change in price index of steel mill products; IMP = import penetration index; TAX = taxes paid; NCF = net cash flow; DIV = dividends; GRE = gross retained earnings; I = gross investment; $\Delta Q'$ = change in permanent level of raw steel output; $\Delta(c/w)'$ = change in permanent relative factor prices where c = user cost of capital and w = wage rate; K = capital stock; δ = rate of economic depreciation; and LTD = long-term debt. The terms $U_1, \ldots, U_5$ are the stochastic error terms.

The subscripts -i refer to lagged values of variables or lagged values of changes in the level of variables. Unless otherwise indicated, the time period of explanatory variables is the current period t.

Equations (1) and (2) are in current dollars while Equations (3) - (8) are in constant 1973 dollars. The primes in Equation (6) indicate long-run or permanent values.

Equation 4 is a behavioral equation for the level of dividends. The independent variables are lagged net cash flow and lagged dividends. It is hypothesized that there is an i-period decision lag in the calculation of the permanent or expected level of net cash flow. In effect, information in the current period on financial flows is not available, has not yet been fully digested, or is otherwise irrelevant to the dividend payout decision. Equation 5 is an identity from which gross retained earnings (after-tax profits plus depreciation minus dividends) is calculated.

Equation 6 is the investment demand function and the most important relationship in the model. Gross investment expenditures are hypothesized to be a function of the permanent or expected growth of raw steel production, changes in relative input (factor) prices for capital and labor, and the growth of gross retained earnings relative to "the investment requirement," i.e., the investment requirement is the difference between the desired and actual capital stock. The first two variables are based on the economic theory of factor demand and serve to determine the current conception of the optimal or desired stock of capital. Changes in gross retained earnings, however, enter the demand equation primarily as a determinant of the timing of investment expenditures. If the level of available internal funds is high, then the gap between the actual and desired capital stock will be closed more rapidly than would otherwise be the case. Changes in gross retained earnings enter the investment demand function with a lag reflecting conditions of information and uncertainty.

Equation 7 is an identity from which the end-of-period capital stock can be calculated. Finally, Equation 8 is a behavioral equation for the level of long-term debt or external finance that is permitted or required by the internal decision process relating investment and retained earnings. The level of external financing is constrained by an optimal or desired debt-to-capital stock ratio. The independent variables in Equation 8 are the current value of capital stock and lagged long-term debt.

As indicated, it is quite possible, in any single period, for the level of internal funds plus external funds to be insufficient to finance the predicted level of gross investment expenditures. That is, it is possible for gross retained earnings (GRE) determined by Equations 1 - 5 plus the change in long-term debt (ΔLTD) determined in Equations 7 - 8 to be insufficient to finance the level of gross investment expenditures (I) from Equation 6. When investment is greater than new debt plus retentions, the resulting difference may be termed a "shortage" in a positive sense. Thus, while it would be possible to close the model with a fourth identity, $I \equiv \Delta LTD + GRE$, this constraint has not been imposed on the model, leaving the question of a shortage an empirical issue rather than a statistical artifact or mathematical impossibility.

Chapters 3 and 4 are devoted to a general discussion of the model and a survey of the econometric literature on iron and steel investment. Chapter 5 develops a theoretical equation for iron and steel profits and estimates this equation using quarterly data for the period 1960-1973. Forecasts of profits are also presented for 1974 and 1975. These forecasts, while less than completely satisfactory, do suggest that 1974 and 1975 are years with a substantial transitory component in profits or gross cash flow. Chapter 6 repeats the same process for iron and steel dividends and highly accurate forecasts are presented for dividends in 1974 and 1975.

Chapter 7 presents an investment demand equation which incorporates a timing mechanism that is dependent on the level of internal funds. The equation is estimated using quarterly data for 1960 - 1973 and the estimated equation provides accurate short-run forecasts for 1974 and 1975. Chapter 8 presents equations for the stock of long-term debt and the level of tax payments. Accurate forecasts for 1974 and 1975 are presented for both long-term debt and tax payments.

Chapter 9 compares several alternative statistical procedures for estimating the recursive model. In Chapters 5 - 8, ordinary least squares with adjustment for serial correlation (Cochrane-Orcutt technique) is used to estimate each of the five behavioral equations and to prepare forecasts for 1974 and 1975. In Chapter 9, we then compare ordinary least squares estimates with two-stage least squares estimates and with estimates using Zellner's seemingly unrelated regression method. It is concluded the best estimation method is ordinary least squares, with adjustments for serial correlation (generalized least squares).

Concluding Comments and Future Plans

As is the case with all partial equilibrium empirical models, the recursive model developed in this report makes certain assumptions about the real world, abstracts from some real world details while emphasizing others, and treats some variables as exogenous to the system of equations under consideration, i.e., some variables are taken as given and determined outside of the system rather than as an outcome or prediction of the model. This section discusses each of these aspects of the model and concludes with a brief statement of future plans for Phase III.

<u>Model Assumptions</u>. Among the more important assumptions of the model are the following:[18]

1. Economic rationality is assumed; long-run profit is maximized.

2. The rate of economic depreciation is constant for long periods.

3. The before-tax discount rate is constant in any given period.

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[18] The assumptions contained in the recursive model are probably less stringent than those contained in the strict neoclassical model of investment demand. For a discussion of this issue, see L. R. Klein and P. Taubman, "Estimating Effects within a Complete Econometric Model," in G. Fromm (ed.), <u>Tax Incentives and Capital Spending</u> (Washington, D.C.: Brookings Institution, 1971), pp. 199-207.

First, although we assume that firms maximize long-run profits, we do not assume that firms consider each and every nuance of product demand and production cost that will potentially lead to greater profits. For example, our calculations for the rental price of capital do not include state and local taxes, accelerated amortization provisions, and capital gains due to accelerated depreciation. It is our judgment that these omissions are of a second-order of importance relative to those factors which are included in the rental price formula.

Second, the estimated rate of economic depreciation for iron and steel plant and equipment increased somewhat during the time periods 1958-1965 and 1966-1973.[19] Our model estimates and forecasts, however, assume a constant rate of economic depreciation for 1966-1973 and 1974-1980, respectively. Increases in the rate of economic depreciation during the 1960s reflect changing market conditions (e.g., growth of the Chicago market), adoption of the basic oxygen furnace, and other important innovations such as improved rolling and finishing mills. It is unlikely that any development in the future will affect the industry to such an extent, and thus the assumption of a constant rate of economic depreciation seems reasonable. An important implication of this assumption is that the mix of technology in the steel industry is assumed to be relatively constant through 1980.[20]

Third, Harberger has argued that equity capital as a factor of production bears a greater than proportional burden of the corporate income tax due to the tax exempt status of income-producing capital used in unincorporated enterprises and corporate capital financed by debt.[21] As a consequence, once general equilibrium considerations are accounted for, the assumption of a constant before-tax discount rate is unrealistic since decreases (increases) in the corporate tax rate will tend to increase (decrease) the after-tax rate of return on corporate equity capital.

The assumption of a constant before-tax discount rate tends, therefore, to exaggerate the effect of tax stimuli upon investment due to the indirect influence of tax policy upon the interest rate. This effect is reinforced if tax incentives are restricted to certain sectors of the economy or types of investment and thus cause a shift of capital spending from noncovered to covered sectors.

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[19]Neumann, op.cit., p. 21.

[20]For some related evidence, see Vaughan, Russell, and Cochrane, op. cit., p. xiii.

[21]A. C. Harberger, "Discussion", in G. Fromm (ed.), Tax Incentives and Capital Spending (Washington, D.C.: Brookings Institution, 1971), p. 259. See also L. R. Christensen, "Tax Policy and Investment Expenditures in a Model of General Equilibrium," American Economic Review, 60 (May 1970), pp. 18-22.

To the extent that other economic factors alter rates of return on iron and steel capital relative to other industries, general equilibrium considerations may again alter or even negate any particular conclusions reached with regard to tax policy alone. Only a complete econometric model of the economy, broken down by sectors and industries, would be sufficient to answer these important and far-reaching questions.

Major Included Variables. The number of major variables included in the recursive model is quite limited relative to the number of economic magnitudes which are potentially of some importance in explaining iron and steel investment spending. The major variables included are:

1. Endogenous Variables

    a. gross cash flow (before-tax profits plus depreciation);
    b. corporate tax payments;
    c. dividends;
    d. gross investment expenditures;
    e. long-term debt stock.

2. Exogenous Variables

    a. sales revenue (current and lagged);
    b. capacity utilization;
    c. changes in the price index for steel mill products;
    d. import penetration;
    e. raw steel output;
    f. rental price of capital services;
    g. price deflator for nonresidential fixed investment.

In addition, accounting identities allow us to calculate the endogenous values for net cash flow, gross retained earnings, and the capital stock.

The list of exogenous variables is constrained by our interpretation of the current body of economic theory relating to the endogenous variables. Of course, alternative models of these decisions are available, and the theories we draw on do tend to ignore entirely certain economic variables of potential importance. Inventories, for example, are completely absent from the recursive model. The gross profit and gross cash flow equations do not explicitly consider changes in profits arising from volative production cost items like coking coal and steel scrap. A rationalization is presented for these exclusions (see n.3, Chapter 5), and it is our current judgment that it is more important to treat labor and capital costs in some depth.

As a third example, consider the fact that equity capital is entirely absent from the recursive model as a source of new investment financing. This omission, which is not an oversight, is dictated by the complete absence of historical data or other information on steel equity financing of capital expenditures. During the past twenty-five years, none of the major steel companies used equity financing. During 1976, seven of the eight largest steel companies made or scheduled public securities offerings, including two offerings which

involved equity. On March 30, 1976, Inland Steel announced an offering of new common stock, while on June 22, 1976, U. S. Steel announced an offering of convertible subordinated debentures.[22]

It is possible, therefore, that additional equity financing will take place in the future on the part of steel producers. Our model cannot predict the size or timing of these offerings, except perhaps as a residual where the recursive model predicts a shortage between the amount of physical investment expenditures and the available amount of internal funds and new long-term debt.

Partial Equilibrium. The recursive model treats only a part of reality and explicitly assumes that certain variables are determined outside of the equation system under consideration. This partial equilibrium approach, which is quite standard in applied econometrics, has well-known limitations.[23] Some of the implications of the partial equilibrium approach with respect to steel output and investment are discussed in this section. Specifically, we ask the following questions:

1. If output is considered predetermined (exogenous), does this not imply that investment expenditures and capital stock are known as well?

2. Are not the decisions to produce a given level of output and invest in a given stock of capital simultaneously determined?

Answers to both of these questions require a careful examination of the overall rationale of the model, especially the investment function developed in Chapter 7. The first question implies a fixed technological relationship between output and capital. Such a fixed relationship is embodied in the well-known simple accelerator model of investment. The investment model developed in Chapter 7 assumes no such fixed relationship; it instead postulates a general production function in which

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[22]See Business Week, April 19, 1976, p. 145; and "U.S. Steel's $400 Million of Convertible Debt is Expected to Bear a 6% Yield, Sell Out Fast," Wall Street Journal, June 3, 1976. See also "U.S. Steel Plans $400 Million Sale of Debentures," Wall Street Journal, May 26, 1976; "Two Steelmakers Join Other Producers Seeking External Sources of Financing," Wall Street Journal, July 15, 1976; and "Steel Industry Regains Generally Good Health After Years of Troubles," Wall Street Journal, August 28, 1976.

[23]As previously noted, the recursive model, while partial in nature, does not contain strong equilibrium assumptions. Whether or not this is a virtue or limitation of our work to date is an empirical issue we intend to explore in Phase III.

steel firms may choose between various combinations of capital and labor to produce a given level of output. We then provide estimates of the elasticity of factor substitution. The estimated elasticity is about -0.8 whereas the fixed capital-output ratio model implies a zero elasticity of factor substitution. Thus, our empirical results, which are quite general, contradict the assertion that capital is used in direct, constant proportions relative to output.

As further evidence on this point, we have calculated an annual capital-output ratio from our data for the period 1960-1975. This ratio is presented in Table 4. If we look at the last five years, the range of the ratio is between 0.1114 in 1971 and 0.0820 in 1973, a difference of 0.0294, or about 36 percent relative to the lower value. We conclude that the empirical evidence is inconsistent with a simple accelerator model of iron and steel investment. The capital-output ratio is not constant, the elasticity of factor substitution is not zero, and relative factor prices as well as output are an important determinant of investment.

The second question is whether or not output is an endogenous variable. If it is, then simultaneous equation bias must be guarded against. Several points can be made regarding this question.

First, the output term appears in the investment equation with a lag and thus may be thought of as an instrumental variable representation for the true output term. However, simultaneous equation bias cannot always be overcome by the use of short lags, especially if the error term is autocorrelated.

Second, the derivation of the investment equation is based on short-run cost minimization. Product prices are taken as given so that given the firm's marginal cost schedule, output will be pre-determined. The primary economic decision is, what quantities of labor and capital should be employed to produce this output? Cost minimization, at least in the short run, makes considerably more sense in an oligopoly such as the steel industry where product prices are "sticky" and administered by a complex inter-firm process.

Third, every effort is made to determine if simultaneity can be detected through statistical tests, although we recognize the informality of these tests. The statistical tests include: (a) the incorporation of endogenous variables on the right-hand side of the dividend, investment, and long-term debt equations; and (b) an examination of the cross-equation residual correlations. No evidence of important simultaneity is exposed via these tests. Moreover, since raw steel output is more highly correlated with gross cash flow ($r = 0.876$)

TABLE 1.4

IRON AND STEEL CAPITAL-OUTPUT RATIO FOR 1960-1975

Year	Average Capital Stock[a] (millions of 1973 dollars)	Raw Steel Output (thousand net tons)	Capital-Output Ratio x 10^3
1960	$11,842	99,282	.1193
1961	11,756	98,014	.1199
1962	11,269	98,328	.1146
1963	10,885	109,261	.0996
1964	11,060	127,076	.0870
1965	11,564	131,462	.0880
1966	12,129	134,101	.0904
1967	12,750	127,213	.1002
1968	13,336	131,462	.1014
1969	13,753	141,262	.0974
1970	13,751	131,514	.1046
1971	13,416	120,443	.1114
1972	12,839	133,241	.0964
1973	12,369	150,799	.0820
1974	12,265	145,720	.0842
1975	12,660	116,642	.1085

[a]Average value for the four-quarters in each year.

Sources: Capital stock series from G. R. Neumann, Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975-1980 (University Park, Pa.: Institute for Research on Human Resources, December 1975), pp. 20-1. Output series is from American Iron and Steel Institute, Annual Statistical Report (Washington, D.C.: various annual editions).

than with gross investment expenditures (r = 0.402),[24] we might expect that any simultaneity between output and investment would be revealed by a statistically significant, contemporaneous residual correlation between the gross cash flow equation and the gross investment equation. Table 9.1 indicates that the residual correlation for these two equations is not significantly different from zero.

Finally, if output is regarded as exogenous, how can we be certain that forecasted investment and capital stock will be sufficient to produce the projected level of output which, after all, underlies the investment forecast? An answer to this question requires a careful examination of the output term which is incorporated in the investment equation. The output observations can be thought of as "planned" or "expected" output since the output data series is based on a complex quarterly, moving average process (see Appendix C). Following standard economic practice, the smoothed output series is referred to as "permanent" output and the variable incorporated in the investment equation is the change in permanent output. On the basis of this model, we believe that the investment and capital stock forecasts should prove sufficient to meet the projected level of output, especially since the steel industry has almost always operated at less than 100 percent of rated raw steel capacity.[25] That is, it is likely that the regression coefficient estimates for output and/or the constant term incorporate a "cushion" reflecting a permanent or desired level of excess capacity. Market structure considerations tend to reinforce these arguments, since excess capacity can be used as a means by which market shares or product prices can be stabilized.

While the simultaneity issue is potentially important, we believe that our statistical tests and _a priori_ reasoning suggest that this

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[24]The corresponding simple regressions are:

$$\hat{I}_t = 203.957 + 7.701 \, Q_t \; ; \; R^2 = 0.101$$
$$\qquad\qquad (3.128)$$

$$\hat{GCF}_t = -174.955 + 30.614 \, Q_t \; ; \; R^2 = 0.617$$
$$\qquad\qquad\quad (3.281)$$

where I is quarterly, seasonally-adjusted gross investment expenditures in millions of 1973 dollars, Q is quarterly, seasonally-adjusted raw steel output in millions of net tons, and GCF is quarterly, seasonally-adjusted gross cash flow in millions of current dollars. All data are for the period 1960-1973 and standard errors are reported parenthetically.

[25]Table 7.3 shows that the average annual operating rate for raw steel capacity was 78.4 percent for the period 1960-1975. The normal or desired operating rate in the steel industry is frequently placed at between 85 and 90 percent of capacity. It is possible that steel executives place more emphasis on peak periods of production than is implied by our moving average calculations. However, we are not aware of any evidence that would indicate that this is the case.

problem, if it exists at all, is of a second-order of importance. A simultaneous equation model considerably more elaborate than the model developed in this report is required if _all_ aspects of steel demand and supply are to be examined. We believe it is more important to emphasize those endogenous variables which are most closely related to the investment decision, i.e., gross cash flow, dividends, gross retained earnings, and long-term debt.[26]

Thus, while we recognize that the recursive model has certain shortcomings, it is our considered judgment that the model developed in this report will serve as a sound theoretical and empirical basis on which to examine questions about the supply of and demand for investment funds in the iron and steel industry through 1985. Moreover, the model can be used to forecast both replacement investment and net, new investment (modernization) and can be used to examine the effects of foreign steel imports, capacity utilization, etc., insofar as they affect the capital expenditure decision. It is our intention, therefore, to integrate our earlier research results reported under Phase I and explore the following issues:

1. The future levels of physical capital investment in the iron and steel industry, under different assumptions and scenarios, giving explicit attention to the effects of public policy decisions on investment.

2. The role of financing of capital expenditures in meeting these requirements in order to assess the possibilities of a shortage of capital funds.

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[26]The most elaborate econometric model of the steel industry of which we are aware is C. I. Higgins, "An Econometric Description of the U.S. Steel Industry," in L. R. Klein (ed.), Essays in Industrial Econometrics, Vol. II (Philadelphia: Economics Research Unit, University of Pennsylvania, 1969), Chapter 1. Higgins notes (page 26) that his investment equation is not very satisfactory, in part because of the use of annual data.

See also S. Kinoshita, "An Econometric Analysis of the Steel Industry of the United States, 1950-1970," paper presented at the Third World Congress of the Econometric Society, Toronto, Canada, August 22-26, 1975.

CHAPTER 2

CONDITIONAL FORECASTS OF FUTURE
EXPENDITURES FOR PLANT AND EQUIPMENT
IN THE IRON AND STEEL INDUSTRY: 1975-1980

Introduction

The purpose of this chapter is to present a series of conditional
forecasts using the model developed and estimated in Phase I. In the
Phase I report, a series of thirty-six forecasts were presented which
depended on alternative assumptions about relative prices for steel
products and capital equipment, interest rates, and physical output
levels of steel products. These forecasts did not account for varia-
tions in several parameters of investment behavior, including invest-
ment tax credits, corporate income tax rates, and depreciation-service
life guidelines. Instead, the forecasts in Phase I examined the effect
of market forces alone on investment levels in iron and steel, while
holding constant those parameters which are under the direct control
of policy makers.[1] These forecasts do not necessarily assume an active
role for policy makers who wish to predict or abate possible capital
shortages. That is, given a target level of capital expenditures in
iron and steel, the question of a capital shortage could be answered
with a simple "yes or no" response.[2]

The forecasts to be presented in this chapter do, however, assume
an active role for policy makers. Conditional forecasts are implied
by questions of the following sort, "If the investment tax credit is
increased from 7 percent to 12 percent, what will be the impact on
investment spending in iron and steel for the period 1975 to 1980?"
Forecasts which can be characterized in this manner are conditional--
i.e., conditioned upon the formulation and realization of specified
economic policy--and may be compared either to market determined values
or target values of the dependent variable.

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[1]This is not to say that monetary and fiscal policy do not have
an impact on investment spending. Changes are effected indirectly,
however, through fluctuation in output demand, market prices, and in-
terest rates. Policy instruments such as tax credits have a direct,
although possibly lagged, effect on investment incentives and spending.

[2]This is somewhat oversimplified since all forecasts based on
regression models imply probabilistic statements about expected values
of the target variable.

Conditional Forecasting: An Analytical Framework

The quality of a conditional economic forecast depends on the quality of the body of economic theory upon which the forecasts are based and on the thoroughness with which this theory has been related to empirical evidence concerning the structure and performance of the economic subsystem in question. The process of relating economic models to economic policy can be divided into three interrelated parts:[3]

1. Characterization of the policy problem: specification of the preference function, the quantitative model and the constraints or boundary conditions.

2. The selection problem: classification of variables by their properties, such as randomness, direct or indirect controllability, and time-dependence.

3. The steering problem: derivation of optimum decision rules and determination of the flexibility of optimal decision-making procedures under changing conditions associated with risk, uncertainty, and the sequence of new information.

Although no attempt is made here to specify a preference function for policy makers, the policy problem can be characterized by the following question: Given specified values of policy parameters (tax credits, corporate tax rate, depreciation guidelines), what will be the resulting level of capital expenditures in the iron and steel industry relative to market determined (unconditional) levels and target levels? The quantitative model to be employed is the neoclassical model of investment behavior which was specified and estimated in the Phase I report. In addition, boundary conditions will be specified for the policy parameters in question (e.g., the investment tax credit is between 7 and 12 percent, or the corporate income tax rate is between 42 and 48 percent). This implies that the conditional forecasts do not attempt to determine the changes in policy parameters necessary to fully attain the target levels of investment. Boundary conditions may exist either because the target levels are flexible rather than fixed, or because the policy parameters enter the preference function of the policy makers.

The selection problem may be characterized as follows: Given a preference function for the policy makers, which is a function of I target variables y_i, and J instrument or policy variables z_j, a

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[3]K. A. Fox, J. K. Sengupta, and E. Thorbecke The Theory of Quantitative Economic Policy (Amsterdam: North-Holland, 1966), p. 11.

quantitative empirical model is constructed. The quantitative model postulates an empirical relationship or relationships between the I target variables, J instrument variables, K other exogenous variables u_k (not subject to control by the policy makers), and S other endogenous variables x_s (side effects in which the policy maker is not interested and which do not enter his preference function). These relationships are summarized schematically in Figure 1.

Using the model of investment behavior from Phase I, the selection problem is summarized in Table 1. The target variable is the level of investment expenditures in the iron and steel industry in constant 1973 dollars. Conditional forecasts of this variable may be expressed in quarterly, annual, or cumulative terms for gross investment, net investment, or the stock of capital equipment. The instrument or policy variables are: the investment tax credit, the corporate income tax rate, and the service life of capital equipment for depreciation purposes. The definitions and projections of the other exogenous data are the same as for the Phase I forecasts. Each forecast series contains eighteen forecasts based on nine alternative projections for interest rates and relative prices and two alternative projections for output growth.

Conventional economic theory takes the values of the instrument variables to be given and analyzes their economic effects, whereas conditional forecasting (at least in a fixed-target model) takes the desired values of the target variables to be given and calculates the constellation of values of the instrument variables required to attain the given targets. This inverse relationship, in the case of flexible targets, gives rise to the so-called steering problem. That is, if targets are flexible, how shall policy makers achieve a constellation of values of the economic variables which approximates one that has been recognized as an optimum constellation? Some aspects of the steering problem will be indicated below and incorporated in the forecasts. Any comprehensive solution to this problem, however, is beyond the scope of this report.

An Overview of the Projections and Forecasts

We turn now to an overview of the conditional forecasts for iron and steel investment expenditures. From the Phase I report,[4] the preferred empirical model of gross investment behavior I_t is given as

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[4] G. R. Neumann, Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975-1980, (University Park, Pa: Institute for Research on Human Resources, December 1975), Table 4.7, p. 48.

FIGURE 2.1

ANALYTICAL MODEL OF CONDITIONAL
FORECASTING AND ECONOMIC
POLICY [a]

Exogenous Variables	System of structural relationships connecting all variables: The "model"	Endogenous Variables	Utility, welfare or "objective function"

Policy Instruments

Goals or "target variables"

$$\begin{bmatrix} z_1 \\ z_2 \\ \vdots \\ z_j \end{bmatrix}$$

$$\begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_i \end{bmatrix}$$

$$W$$

"Data" or noncontrollable factors [b]

Side-effects or "irrelevant variables"

$$\begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_k \end{bmatrix}$$

$$\begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_s \end{bmatrix}$$

[a] Classification of variables based on J. Tinbergen.
[b] Not subject to control by the policy-maker or level of government that sets the goals and uses the policy instruments in question.

Source: K. A. Fox, J. K. Sengupta and E. Thorbecke, The Theory of Quantitative Economic Policy (Amsterdam: North-Holland, 1966), p. 21.

TABLE 2.1

DESCRIPTION OF VARIABLES IN THE
CONDITIONAL FORECASTS

Variables	Description/Boundaries
Target	
Investment expenditure I_t	Gross and net quarterly, annual, and cumulative expenditures in 1973 dollars.
Instrument	
Investment tax credit k	Rate of investment tax credit against corporate income taxes; maximum 12 percent and minimum 7 percent.
Corporate income tax rate w	Statutory corporate income tax rate; maximum value 48 percent and minimum value 42 percent.
Discounted value of depreciation per dollar gross investment z	Present value of depreciation per dollar gross investment; maximum service life of 14.5 years and minimum five years.
Exogenous Data	
Raw steel production Q	Quarterly rate, seasonally adjusted, in thousands of net tons. Projected at two alternative rates.
Relative price ratio P/q	Wholesale price index for iron and steel products divided by the GNP implicit price deflator for nonresidential fixed investment. Projected at three alternative rates.
Interest rate r	U. S. corporate industrial bond yield. Projected at three alternative rates.
Rate of economic depreciation δ	Quarterly rate of economic depreciation. Assumed fixed at a value of 0.0363.
Endogenous Side-effects	
None	

$$(2.1) \quad \hat{I}_t = b_o + \sum_{i=1}^{24} b_i \, \Delta[(\tfrac{P}{c})^{.4} Q]_{t-i} + b_{25} K_{t-1}$$

where the elasticity of substitution, σ, is equal to 0.4, $b_o = -0.11410$, and $b_{25} = 0.04385$. The lag structure is twenty-four quarters and the Almon lag parameters have values of 0.02688×10^{-5}, 0.44470×10^{-5}, and 0.45987×10^{-5}, respectively. The relative price of capital services, P/c, is given by the expression

$$(2.2) \quad \frac{P}{c} = \frac{P}{q} \left[\frac{(1-w)}{(\delta+r)\,(1-k-wz)} \right]$$

where P is the wholesale price index of iron and steel products and c is the net user cost (rental price) of capital services. With this model the effectiveness of tax policy in altering investment expenditures can be stated essentially as follows: If capital services cost less as a result of tax incentives, businessmen will employ more capital services. While this statement is not entirely free of technical ambiguities,[5] the model of investment behavior in Equations 1 and 2 does permit quantitative answers to the important questions of economic policy: How much investment and when will it occur?

The mechanism by which changes in tax policy are translated into increased spending may be furhter described as follows: Investment in period t depends on the capital stock at the beginning of the period (K_{t-1}) and on changes in the desired level of capital in previous periods. The form of the relationship depends on the form of the distributed lag structure, i.e., on the timing of net expenditures, and on the rate of replacement investment. The desired level of capital depends on the level of output (Q), the price of output (P), and the rental price of capital services, c, where

$$(2.3) \quad c = q(\delta+r) \left[(1-k-wz)/(1-w) \right]$$

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[5] See, for example, P. A. Samuelson, "Tax Deductibility of Economic Depreciation to Insure Invariant Valuations, *Journal of Political Economy*, 72 (December 1964), pp. 604-06.

Tax policy affects investment expenditures through the rental price of capital services. This price depends in turn on the price of investment goods (q), the cost of capital (r), the tax rate (w), the rate of economic depreciation (δ), the several formulas for calculating depreciation allowances for tax purposes (z), and the level of the investment tax credit (k). A change in tax policy changes the rental price of the capital input and consequently the desired level of capital stock. An increase in desired capital stock generates net investment. If the price of capital services and the other determinants of desired capital remain constant, net investment declines to zero as the capital stock approaches its desired level. However, a change in tax policy will continue to affect gross investment through replacement requirements for a permanently larger capital stock. If desired capital stock is decreased by tax policy, these effects are precisely reversed.

To evaluate the effect of a specific tax policy, all determinants of investment spending except tax policy parameters are held equal to their actual or projected values. The impact of tax policy is then measured by substituting the parameters of the tax structure--tax rate, depreciation formulas and lifetimes, tax credit--appropriate to alternative tax policies. The difference between investment forecasts resulting from present tax policy and investment forecasts that would have resulted from alternative tax policies is a partial equilibrium measure of the impact of tax policy. If this differential alone is of interest, then no great precision is required in the projections of other determinants. The estimates of the _differential_ impacts of alternative policies do not depend critically on the assumed level of investment, although gross investment estimates do depend on the level of replacement expenditures.

In order to use this model for forecasting, projections are required for three exogenous variables: the relative price term, P/q, where q is the GNP implicit price deflator for nonresidential fixed investment (1973 = 100); the level of raw steel output Q; and the interest rate r. Schematic views of past quarterly values of P, q, P/q, r and Q are given in Figures 2-6, respectively. Discussion of the projections for P/q and r are found in the Phase I report,[6] and will be briefly summarized below.

Projected values for output Q are based on the same assumptions as for Phase I. The first output series assumes that the demand for domestic iron and steel products will grow at an average annual rate

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[6]Neumann, _op. cit._, pp. 64-8.
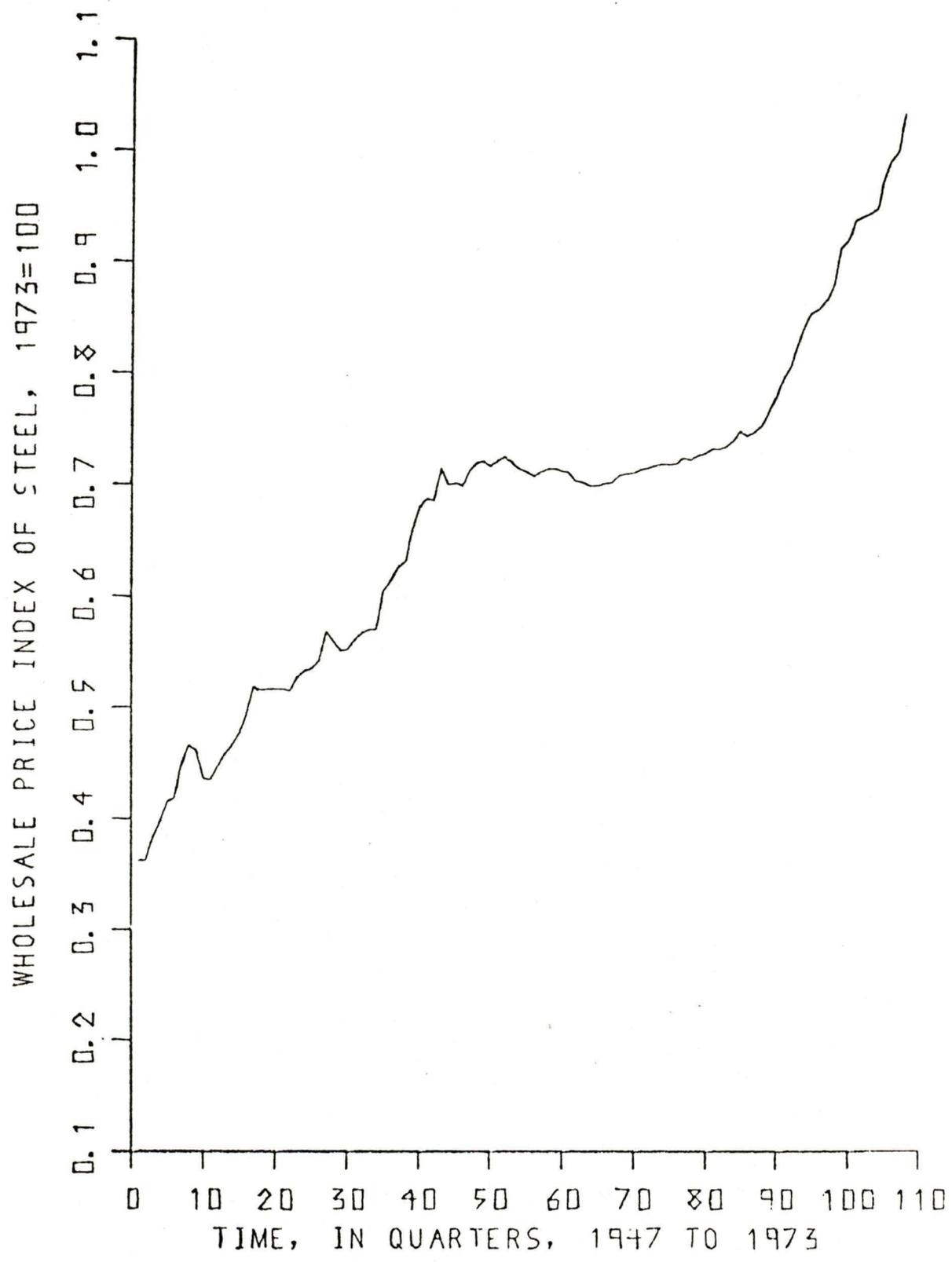
FIGURE 2.2 Wholesale Price Index of Iron and Steel, 1947–1973, quarterly (1973=100).
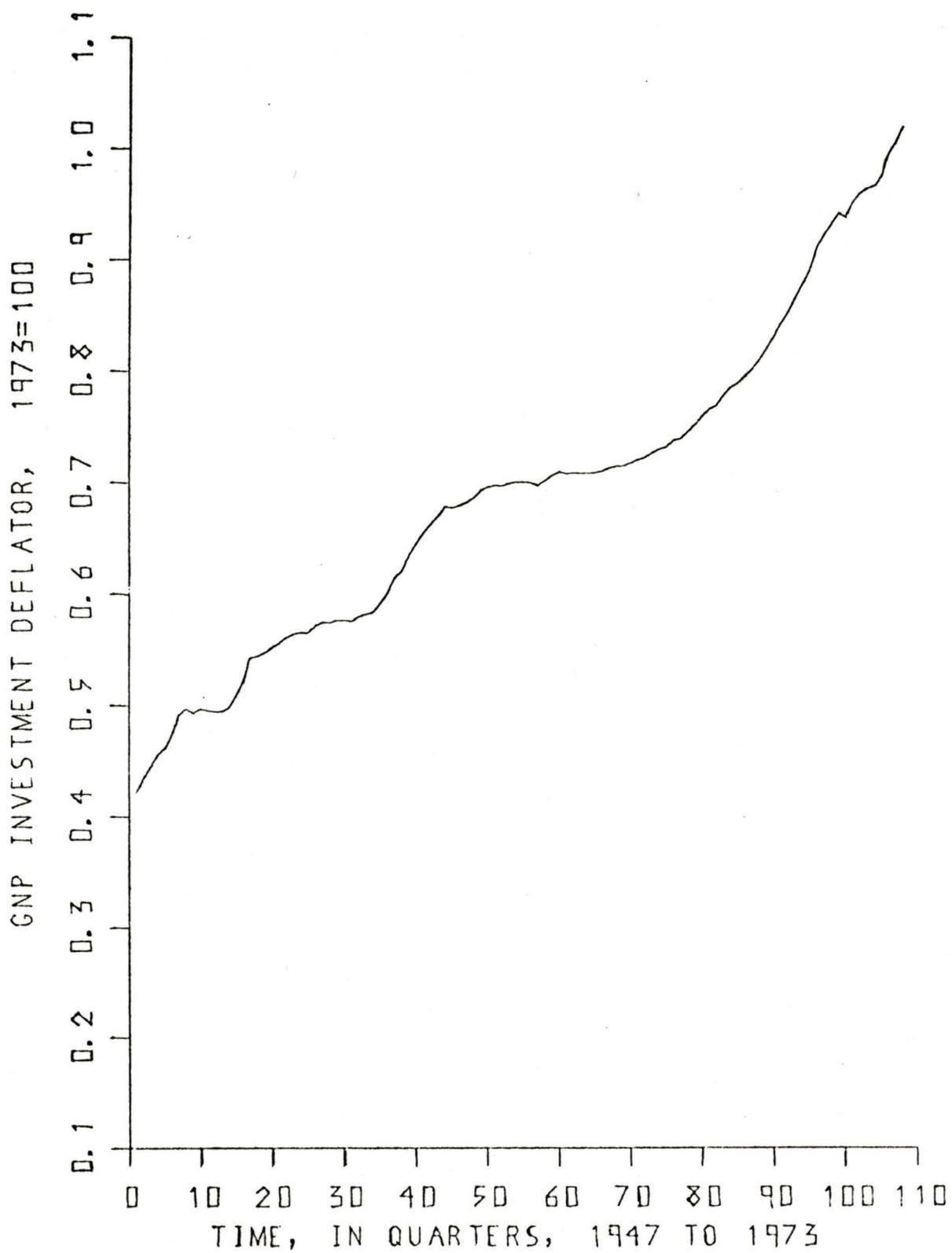
FIGURE 2.3   GNP Investment Deflator, 1947–1973, quarterly
(1973=100).
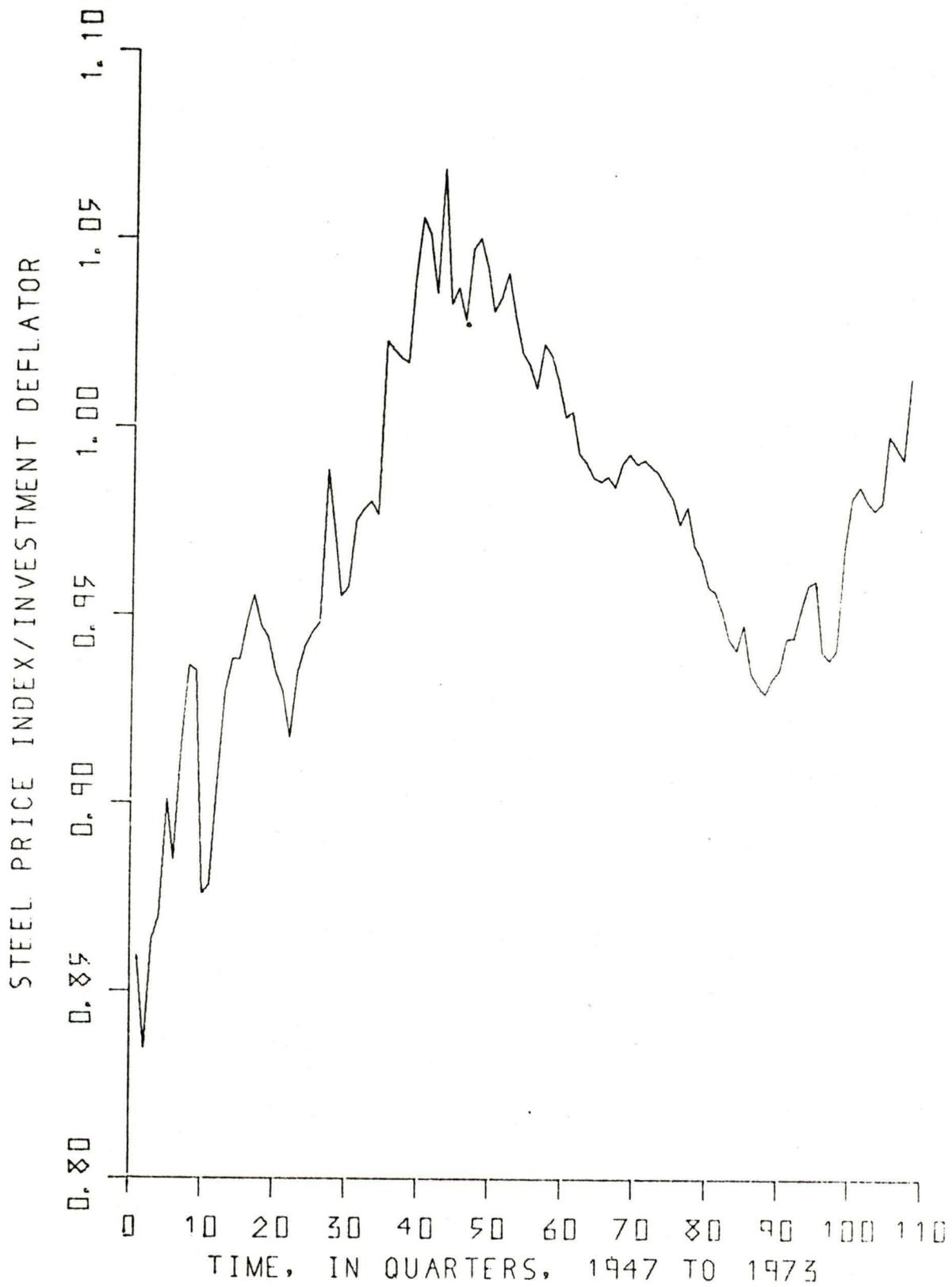
FIGURE 2.4 Ratio of Wholesale Price Index of Iron and Steel to GNP
Investment Deflator, 1947-1973, quarterly (1973 = 100).
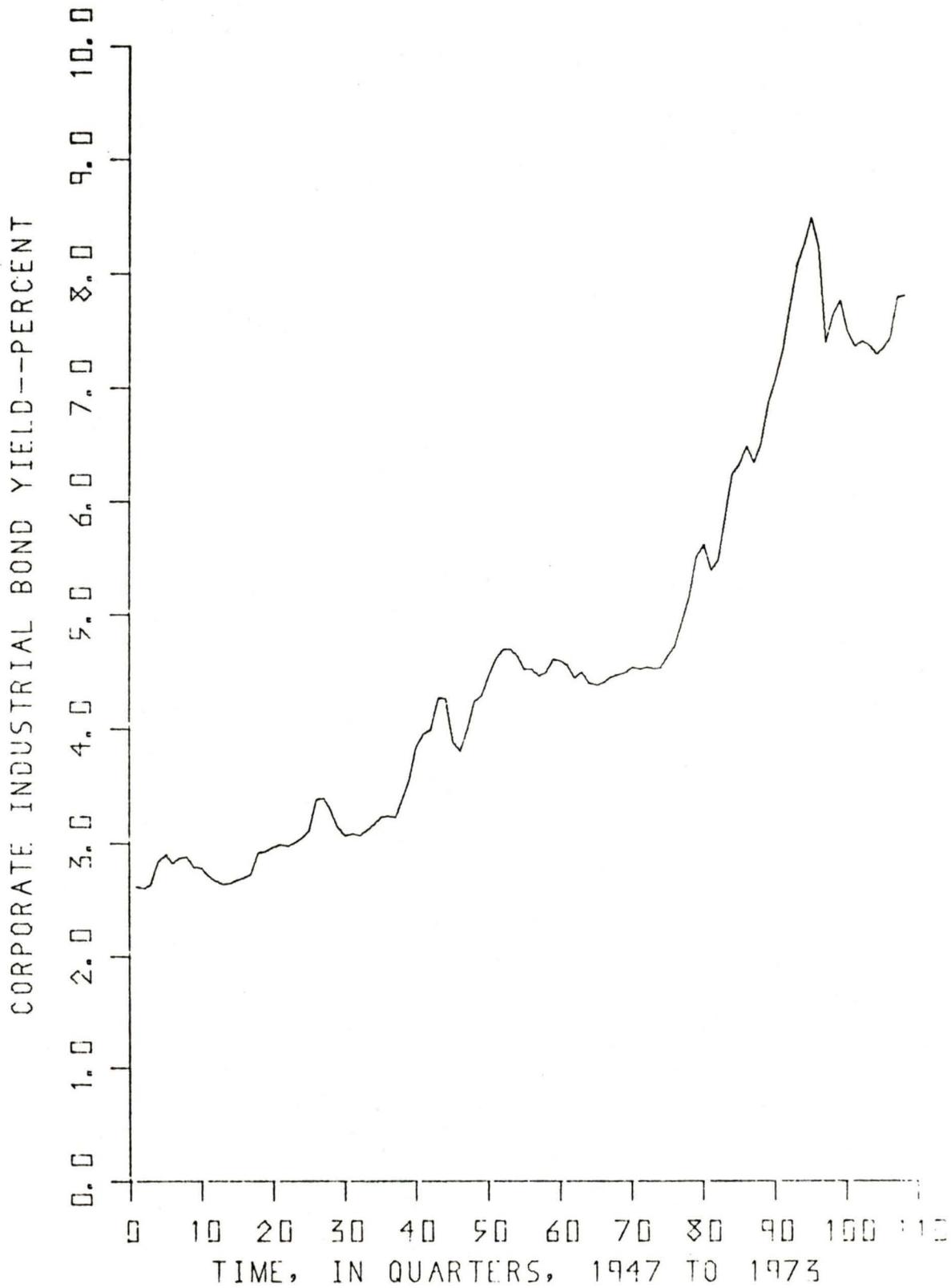
FIGURE 2.5 U.S. Corporate Industrial Bond Yield, 1947–1973, quarterly, in percent.
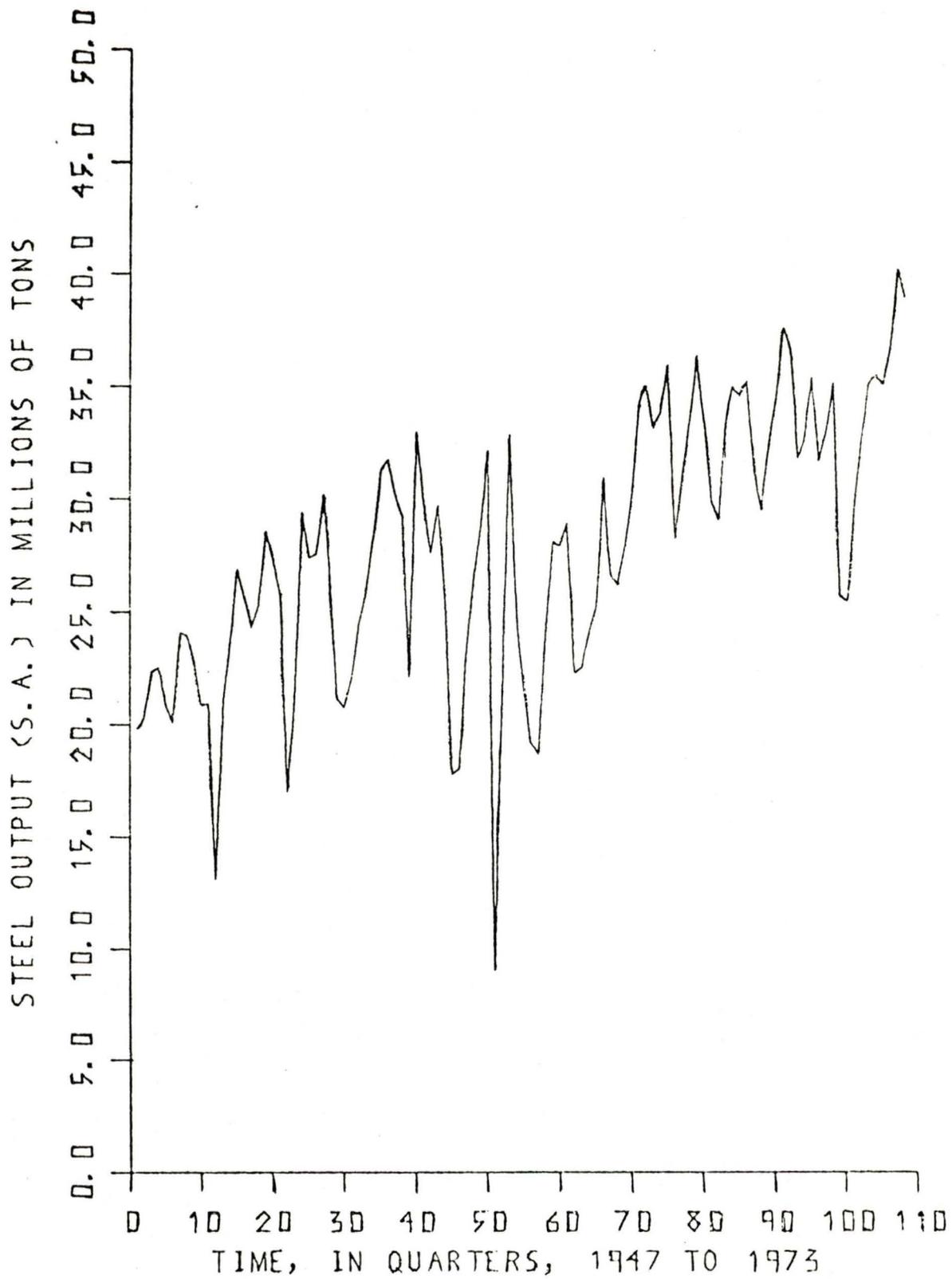
FIGURE 2.6   Raw Steel Production, 1947–1973, quarterly
(millions of tons).

of 2.5 percent per year.[7]   Projected values for raw steel production using this assumption are shown in Table 2.   The second output projection is based on the historical relationship between annual steel output and real GNP.   The future values of output are obtained by using revised projections of GNP from the Council of Economic Advisors for 1975 and 1976, and the assumed long-term growth rate for real GNP from 1976 to 1980.[8]   The projected values for raw steel production using this relationship and GNP projections are shown in Table 3.   To conserve space and to avoid unnecessary duplication, only the forecasts using the GNP relationship are presented in their entirety.   A summary of the forecasts using an output growth rate of 2.5 percent per annum will be given in the text (Table 2.11).

The rate of economic depreciation, which enters Equation 3 as δ, is taken as fixed at its present average quarterly rate of 0.0363. Although the rate of economic depreciation did increase somewhat in the 1960s, this change can be attributed to the changing market conditions (imports) and the adoption of the basic oxygen furnace.   It does not appear that any comparable development in the near future will affect the industry to such and extent,[9a] and thus, the assumption of a constant δ seems reasonable.

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[7]The 2.5 percent growth rate is a consensus figure used by several steel industry analysts, and is based on the assumption that imports will grow at a similar rate.   Imports therefore are assumed to remain constant at a level of about 14 percent of domestic consumption.   See American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy (Washington, D. C.: June 1975), pp. 22-3.

[8]The relationship estimated for the period 1950-1973 was

$$\hat{Q}_t = 56{,}145.5 + 105.282 \; GNP_t;$$
$$R^2 = 0.72, \; F(1,23) = 60.07$$

where Q_t is annual raw steel production in thousands of tons and GNP_t is annual real GNP in billions of 1958 dollars.

Revised projections of real GNP imply GNP growth of -3.3 percent for 1975, 4.8 percent for 1976, 5.6 percent in 1977, and 6.5 percent from 1978 through 1980.   See Wall Street Journal, June 2, 1975, p. 3.

[9a]See W. J. Vaughan, C. S. Russell, and H. C. Cochrane, Government Policies and the Adoption of Innovations in the Integrated Iron and Steel Industry (Washington, D.C.: Resources for the Future, Inc., May 1976), p. xiii.

TABLE 2.2

PROJECTED LEVELS OF RAW STEEL PRODUCTION
USING 2.5 PERCENT ANNUAL GROWTH RATE

Year	Projected Raw Steel Production[a] (1000 net tons)	Imported Steel Products[b] (1000 net tons)	Domestic Steel Product Consumption (1000 net tons)
1975-I	36,615.5		
II	36,857.6		
III	37,099.6		
IV	37,341.6		
1975[c]	147,914.3	15,882.0	113,442.9
1976-I	37,583.6		
II	37,825.7		
III	38,067.7		
IV	38,309.7		
1976	151,786.7	16,317.0	116,549.8
1977-I	38,551.8		
II	38,793.8		
III	39,035.8		
IV	39,277.9		
1977	155,659.3	16,752.0	119,656.0
1978-I	39,519.9		
II	39,761.9		
III	40,003.9		
IV	40,246.0		
1978	159,531.7	17,186.0	122,763.8
1979-I	40,488.0		
II	40,730.0		
III	40,972.1		
IV	41,214.1		
1979	163,404.2	17,621.9	125,870.8
1980-I	41,456.1		
II	41,698.2		
III	41,940.2		
IV	42,182.2		
1980	167,276.7	18,056.9	128,977.8

[a]Raw steel production is projected at an annual rate of growth of 2.5 percent per annum for 1975 through 1980, and then linearly interpolated between those two points in time. Raw steel production is converted to finished products by assuming an average yield factor of 69 percent. Annual finished product shipments (domestic plus exports), in thousands of net tons, are estimated at 102,060.9 tons in 1975, 104,732.8 tons in 1976, 107,404.9 tons in 1977, 110,076.9 tons in 1978, 112,748.9 tons in 1979, and 115,420.9 tons in 1980.

[b]Imported steel products consumption is assumed to remain constant at 14 percent of total domestic steel products consumption. Exports of iron and steel products are assumed to average 4,500 thousand net tons per year.

[c]These forecasts were prepared during 1975. The actual output of raw steel in 1975 was only 116.8 million net tons.

TABLE 2.3

PROJECTED LEVELS OF RAW STEEL PRODUCTION
USING REAL GNP ANNUAL GROWTH RATE
RELATIONSHIP

Year	Projected Raw Steel Production[a] (1000 net tons)	Imported Steel Products[b] (1000 net tons)	Domestic Steel Product Consumption (1000 net tons)
1975-I	35,997		
II	35,620		
III	35,243		
IV	34,867		
1975[c]	141,727	15,187.0	108,478.6
1976-I	35,195		
II	35,523		
III	35,851		
IV	36,180		
1976	142,749	15,301.8	109,298.6
1977-I	36,490		
II	36,800		
III	37,110		
IV	37,420		
1977	147,820	15,871.4	113,367.2
1978-I	37,747		
II	38,075		
III	38,403		
IV	38,730		
1978	152,955	16,448.2	117,487.2
1979-I	39,131		
II	39,532		
III	39,933		
IV	40,333		
1979	158,929	17,119.2	122,280.2
1980-I	40,761		
II	41,189		
III	41,616		
IV	42,044		
1980	165,610	17,869.7	127,640.6

[a]Raw steel production is projected using linear relationship between annual production and real GNP. Projections are linearly interpolated for each quarter for 1975 to 1980. Raw steel production is converted to finished product by assuming an average yield factor of 69 percent. Annual finished product shipments (domestic plus exports), in thousands of net tons, are estimated at 97,791.6 in 1975, 98,496.8 in 1976, 101,995.8 in 1977, 105,539.0 in 1978, 109,661.0 in 1979, and 114,220.9 in 1980.

[b]Imported steel products consumption is assumed to remain constant at 14 percent of total domestic steel products consumption. Exports of iron and steel products are assumed to average 4,500 thousand net tons per year.

[c]These forecasts were prepared during 1975. The actual output of raw steel during 1975 was only 116.8 million net tons.

The remaining terms in Equation 3--k, w, z--are the instrument variables. The values for these variables may be briefly explained as follows:[9]

1. <u>Investment tax credit (k)</u>--This parameter is currently set at 10 percent for 1975 and 1976, and 7 percent thereafter. Conditional forecasts are presented which fix k at 10 percent from 1975 and 1976, and 12 percent thereafter. Forecasts for a 10 percent rate through 1980 are also presented.

2. <u>Corporate income tax (w)</u>--This parameter is currently set at 48 percent. The conditional forecasts allow for a 48 percent rate for 1975 and 1976, and 42 percent thereafter.[10]

3. <u>Capital recovery period</u>--The capital recovery period, T, enters the calculation of z, the present value of depreciation per dollar gross investment.[11] The permitted average lifetime of assets in iron and steel is currently 14.5 years. The conditional forecasts allow for 14.5 years for 1975 and 1976, and either ten years or five years thereafter.

All possible combinations of the projections for the exogenous variables and the assumed changes in the instrument variables will not be presented. Rather, several alternative programs will be discussed which allow for increasing incentives for investment expenditures in iron and steel. The potential for increased incentives under alternative programs may be characterized as a steering problem, and permits the policy maker some leeway in choosing a constellation of values of the instrument variables. Conditional forecasts are presented for the following five programs:[12]

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[9]The economic policies examined represent a combination of various proposals of the Ford Administration and the American Iron and Steel Institute. In general, a liberal interpretation of these proposals has been adopted in order to explore the effect on investment expenditures under the most favorable circumstances conceivable.

[10]Current policy discussions indicate the possibility of a 2 percent reduction to a tax rate of 46 percent. However, past history suggests that the corporate income tax rate tends to be increased or decreased in steps. Again, the most favorable long-run interpretation of current policy discussions has been adopted for forecasting purposes.

[11]Neumann, <u>op. cit</u>., pp. 21-3.

[12]Unless indicated, policy parameters are fixed at 1974-76 values, e.g., for Program 1, the corporate tax rate is 48 percent and the capital recovery period is 14.5 years.

Program 1 - 10 Percent Investment Tax Credit

Program 2 - 12 Percent Investment Tax Credit

Program 3 - 12 Percent Investment Tax Credit and 42 Percent
Corporate Income Tax Rate

Program 4 - 12 Percent Investment Tax Credit, 42 Percent
Corporate Income Tax Rate, and 10-year Capital
Recovery Period

Program 5 - 12 Percent Investment Tax Credit, 42 Percent
Corporate Income Tax Rate, and 5-year Capital
Recovery Period.

Conditional Forecasts for Iron and Steel Investment Expenditures

For each program, a total of 18 conditional forecasts were pre-
pared. These 18 forecasts correspond to two alternative output pro-
jections and nine alternative assumptions about relative prices and
interest rates:

Assumption 1--The relative price ratio, P/q, remains constant
at its 1974-IV value. The market rate of interest is con-
stant and equal to its 1974-IV values (9.34 percent).

Assumption 2--The rate of inflation is assumed to decline,
affecting P and q equally, so that P/q is constant. The
market interest rate declines gradually from its 1974-IV
value to 6 percent by 1980-IV.

Assumption 3--The rate of inflation is assumed to decline,
affecting P and q equally. The high rate of interest
in 1974 is treated as transitory. Interest rates fall
sharply in 1975-1976 and then rise to 9 percent by 1980-IV.

Assumption 4--The price q grows 2 percent faster per year than
P during 1976-77. From 1978-80, the relative prices re-
main constant at their 1977 level. Interest rates behave
as in Assumption 1.

Assumption 5--Prices behave as in Assumption 4 and interest
rates behave as in Assumption 2.

Assumption 6--Prices behave as in Assumption 4 and interest
rates behave as in Assumption 3.

Assumption 7--The price P grows 2 percent faster per year
than q during 1976-77. From 1978-80, the relative prices
remain constant at their 1977 level. Interest rates be-
have as in Assumption 1.

Assumption 8--Prices behave as in Assumption 7 and interest
rates behave as in Assumption 2.

Assumption 9--Prices behave as in Assumption 7 and interest
rates behave as in Assumption 3.

In the context of the issue of a "capital crisis," major interest
will center on forecasts which assume high or rising interest rates.
These conditions correspond to Assumptions 1, 4, and 7 for permanently
high interest rates and Assumptions 3, 6, and 9 for rising interest
rates. The projected values under each of the three assumptions for
interest rate changes are summarized in Table 4 for 1975 to 1980.

Forecasts of investment expenditures for each of the five programs
are summarized by assumption in Tables 5 - 10, and in Figures 7 - 12
for Assumptions 1, 3, 4, 6, 7, and 9 for the GNP-based projections of
raw steel production. These tables and figures contain a total of 30
different forecasts. The remaining 60 forecasts under additional
assumptions and/or the 2.5 percent-based projects of raw steel pro-
duction are summarized in the text.

Under any set of conditions, future expenditures on plant and
equipment are forecasted to be substantial. For the five programs
and six assumptions, average annual expenditures range from $2.11 to
2.33 billion. However, the effect of tax policy on investment spending
is relatively minor when compared to the overall level of spending.
For example, under Assumption 1 (Table 5), increasing the investment
tax credit to 12 percent (Program 2) adds only $0.072 billion to cumu-
lative expenditures through 1980 when compared to a 10 percent tax
credit (Program 1), a differential of $72 million. Relative to Pro-
gram 1, tax policy changes under Program 5 add $0.64 billion to cumula-
tive expenditures, but this represents only a 5 percent increase in
spending through 1980.

Compared to some previous studies of the effect of tax policy
on investment spending,[13] these conditional estimates seem low. In
the present case, however, two effects work against increased expendi-
tures. First, the role of relative prices (P/c) is reduced in the present
model since the elasticity of substitution is considerably less than
unity. Second, due to the long lag structure in the present model,
the full effect of any policy changes will extent beyond 1980. In
sum, the conditional forecasts show only a moderate effect on in-
vestment expenditures in iron and steel through 1980, even under
the most favorable conditions conceivable:

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[13] See, for example, R. E. Hall and D. W. Jorgenson, "Tax Policy
and Investment Behavior," American Economic Review, 57 (June 1967),
pp. 391-414; "Application of the Theory of Optimal Capital Accumulation,"
in G. Fromm (ed.), Tax Incentives and Capital Spending (Washington, D.C.:
Brookings Institution, 1971), Chapter 2. See also "Investment Tax Credit
Rise Has Had Little Impact on Economy So Far," Wall Street Journal,
August 11, 1976, p. 1.

TABLE 2.4

COMPARISON OF ALTERNATIVE PROJECTIONS
FOR INTEREST RATES
(Annual Values per Quarter)

Series 2, 5, 8		Series 1, 4, 7	Series 3, 6, 9
1975-I	9.34%	9.34%	7.80%
II	9.34	9.34	7.80
III	9.34	9.34	7.80
IV	9.34	9.34	7.80
1976-I	9.16	9.34	7.84
II	9.00	9.34	7.92
III	8.84	9.34	7.96
IV	8.68	9.34	8.04
1977-I	8.52	9.34	8.08
II	8.32	9.34	8.16
III	8.16	9.34	8.20
IV	8.00	9.34	8.28
1978-I	7.84	9.34	8.32
II	7.68	9.34	8.40
III	7.52	9.34	8.44
IV	7.32	9.34	8.52
1979-I	7.16	9.34	8.56
II	7.00	9.34	8.64
III	6.84	9.34	8.68
IV	6.68	9.34	8.76
1980-I	6.52	9.34	8.80
II	6.32	9.34	8.88
III	6.16	9.34	8.92
IV	6.00	9.34	9.00

TABLE 2.5

CONDITIONAL FORECASTS OF INVESTMENT EXPENDITURES
IN THE IRON AND STEEL INDUSTRY, 1975-1980:
(Billions of 1973 dollars); ASSUMPTION 1

Year	Tax Program (1)	(2)	(3)	(4)	(5)
1975-I	.5058				
II	.5069				
III	.5143				
IV	.5257				
		SERIES ARE THE SAME AS FOR PROGRAM (1)			
1976-I	.5441				
II	.5564				
III	.5562				
IV	.5568				
1977-I	.5631	.5631	.5631	.5631	.5631
II	.5595	.5598	.5604	.5611	.5620
III	.5605	.5615	.5640	.5663	.5698
IV	.5661	.5679	.5721	.5761	.5820
1978-I	.5486	.5512	.5570	.5627	.5710
II	.5281	.5313	.5388	.5460	.5567
III	.5165	.5204	.5295	.5382	.5511
IV	.5108	.5154	.5259	.5361	.5512
1979-I	.5106	.5157	.5277	.5393	.5564
II	.5111	.5168	.5301	.5430	.5619
III	.5107	.5169	.5315	.5455	.5662
IV	.5137	.5204	.5360	.5511	.5734
1980-I	.5258	.5329	.5495	.5656	.5893
II	.5363	.5438	.5613	.5782	.6031
III	.5382	.5460	.5642	.5818	.6077
IV	.5437	.5517	.5705	.5886	.6153
Cumulative	12.8095	12.8810	13.0478	13.2089	13.4464
Ave. Annual	2.1349	2.1468	2.1746	2.2015	2.2411

TABLE 2.6

CONDITIONAL FORECASTS OF INVESTMENT EXPENDITURES
IN THE IRON AND STEEL INDUSTRY, 1975-1980:
(Billions of 1973 dollars); ASSUMPTION 3

Year	(1)	(2)	(3)	(4)	(5)
1975-I	.5121				
II	.5162				
III	.5266				
IV	.5408				
		SERIES ARE THE SAME AS FOR PROGRAM (1)			
1976-I	.5617				
II	.5763				
III	.5779				
IV	.5800				
1977-I	.5874	.5874	.5874	.5874	.5874
II	.5846	.5849	.5856	.5863	.5872
III	.5862	.5872	.5896	.5923	.5955
IV	.5919	.5938	.5978	.6024	.6080
1978-I	.5742	.5768	.5826	.5890	.5969
II	.5531	.5564	.5638	.5720	.5821
III	.5405	.5445	.5535	.5634	.5757
IV	.5335	.5382	.5486	.5602	.5745
1979-I	.5315	.5367	.5486	.5617	.5780
II	.5299	.5357	.5488	.5634	.5815
III	.5268	.5331	.5476	.5635	.5833
IV	.5268	.5336	.5491	.5663	.5876
1980-I	.5353	.5426	.5591	.5774	.6001
II	.5419	.5496	.5670	.5862	.6102
III	.5400	.5479	.5661	.5860	.6111
IV	.5426	.5507	.5695	.5901	.6159
Cumulative	13.2178	13.2907	13.4563	13.6392	13.8666
Ave. Annual	2.2030	2.2151	2.2427	2.2732	2.3111

TABLE 2.7

CONDITIONAL FORECASTS OF INVESTMENT EXPENDITURES
IN THE IRON AND STEEL INDUSTRY, 1975-1980:
(Billions of 1973 dollars); ASSUMPTION 4

Year	Tax Program				
	(1)	(2)	(3)	(4)	(5)
1975-I	.5058				
II	.5069				
III	.5143				
IV	.5257				
		SERIES ARE THE SAME AS FOR PROGRAM (1)			
1976-I	.5441				
II	.5563				
III	.5559				
IV	.5562				
1977-I	.5620	.5620	.5620	.5620	.5620
II	.5577	.5579	.5586	.5592	.5601
III	.5578	.5589	.5613	.5636	.5670
IV	.5625	.5643	.5684	.5724	.5782
1978-I	.5439	.5464	.5522	.5578	.5660
II	.5222	.5254	.5328	.5399	.5504
III	.5095	.5133	.5223	.5309	.5437
IV	.5028	.5073	.5177	.5277	.5426
1979-I	.5016	.5066	.5185	.5298	.5467
II	.5012	.5068	.5199	.5326	.5513
III	.4999	.5060	.5204	.5342	.5546
IV	.5022	.5088	.5242	.5391	.5610
1980-I	.5136	.5206	.5370	.5528	.5762
II	.5236	.5310	.5482	.5649	.5894
III	.5251	.5327	.5507	.5680	.5935
IV	.5302	.5381	.5566	.5744	.6007
Cumulative	12.6810	12.7513	12.9160	13.0745	13.3086
Ave. Annual	2.1135	2.1252	2.1527	2.1791	2.2181

TABLE 2.8

CONDITIONAL FORECASTS OF INVESTMENT EXPENDITURES
IN THE IRON AND STEEL INDUSTRY, 1975–1980:
(Billions of 1973 Dollars); ASSUMPTION 6

Year	Tax Program				
	(1)	(2)	(3)	(4)	(5)
1975-I	.5121				
II	.5162				
III	.5266				
IV	.5408				
1976-I	.5617	SERIES ARE THE SAME AS FOR PROGRAM (1)			
II	.5762				
III	.5776				
IV	.5793				
1977-I	.5862	.5862	.5862	.5862	.5862
II	.5827	.5830	.5837	.5844	.5852
III	.5834	.5845	.5868	.5894	.5927
IV	.5882	.5900	.5940	.5986	.6041
1978-I	.5694	.5719	.5776	.5840	.5918
II	.5471	.5503	.5576	.5657	.5757
III	.5334	.5373	.5461	.5559	.5680
IV	.5253	.5299	.5401	.5516	.5657
1979-I	.5223	.5274	.5391	.5521	.5681
II	.5197	.5254	.5384	.5528	.5707
III	.5158	.5221	.5363	.5520	.5715
IV	.5150	.5217	.5370	.5539	.5750
1980-I	.5229	.5301	.5464	.5643	.5868
II	.5290	.5365	.5537	.5726	.5962
III	.5266	.5344	.5523	.5720	.5966
IV	.5289	.5369	.5554	.5757	.6011
Cumulative	13.0864	13.1581	13.3212	13.5017	13.7259
Ave. Annual	2.1811	2.1930	2.2202	2.2503	2.2876

TABLE 2.9

CONDITIONAL FORECASTS OF INVESTMENT EXPENDITURES
IN THE IRON AND STEEL INDUSTRY, 1975-1980:
(Billions of 1973 Dollars); ASSUMPTION 7

			Tax Program		
Year	(1)	(2)	(3)	(4)	(5)
1975-I	.5058				
II	.5069				
III	.5143				
IV	.5257				
1976-I	.5441	SERIES ARE THE SAME AS FOR PROGRAM (1)			
II	.5565				
III	.5565				
IV	.5575				
1977-I	.5643	.5643	.5643	.5643	.5643
II	.5614	.5617	.5623	.5629	.5639
III	.5632	.5643	.5667	.5691	.5726
IV	.5698	.5716	.5758	.5799	.5859
1978-I	.5534	.5560	.5619	.5676	.5761
II	.5340	.5373	.5449	.5522	.5630
III	.5236	.5275	.5367	.5456	.5587
IV	.5190	.5236	.5343	.5446	.5599
1979-I	.5197	.5249	.5371	.5488	.5662
II	.5212	.5269	.5405	.5535	.5728
III	.5216	.5279	.5427	.5569	.5779
IV	.5254	.5321	.5481	.5634	.5860
1980-I	.5381	.5453	.5622	.5785	.6026
II	.5492	.5568	.5746	.5917	.6171
III	.5516	.5595	.5780	.5958	.6221
IV	.5574	.5655	.5846	.6029	.6301
Cumulative	12.9402	13.0125	13.1820	13.3450	13.5865
Ave. Annual	2.1567	2.1688	2.1970	2.2242	2.2644

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TABLE 2.10

CONDITIONAL FORECASTS OF INVESTMENT EXPENDITURES
IN THE IRON AND STEEL INDUSTRY, 1975-1980:
(Billions of 1973 Dollars); ASSUMPTION 9

| | | | Tax Program | | |
Year	(1)	(2)	(3)	(4)	(5)
1975-I	.5121				
II	.5162				
III	.5266				
IV	.5408				
1976-I	.5617		SERIES ARE THE SAME AS FOR PROGRAM (1)		
II	.5764				
III	.5782				
IV	.5806				
1977-I	.5887	.5887	.5887	.5887	.5887
II	.5886	.5869	.5875	.5882	.5891
III	.5889	.5900	.5924	.5951	.5984
IV	.5957	.5975	.6017	.6063	.6120
1978-I	.5791	.5817	.5876	.5941	.6021
II	.5592	.5625	.5700	.5783	.5886
III	.5478	.5518	.5609	.5709	.5834
IV	.5419	.5465	.5571	.5689	.5834
1979-I	.5408	.5462	.5582	.5715	.5880
II	.5401	.5460	.5594	.5742	.5926
III	.5379	.5444	.5590	.5752	.5953
IV	.5387	.5456	.5613	.5787	.6005
1980-I	.5479	.5552	.5720	.5905	.6137
II	.5551	.5628	.5805	.6000	.6243
III	.5536	.5616	.5800	.6003	.6257
IV	.5565	.5647	.5838	.6047	.6309
Cumulative	13.3511	13.4247	13.5927	13.7782	14.0093
Ave. Annual	2.2252	2.2374	2.2654	2.2964	2.3349
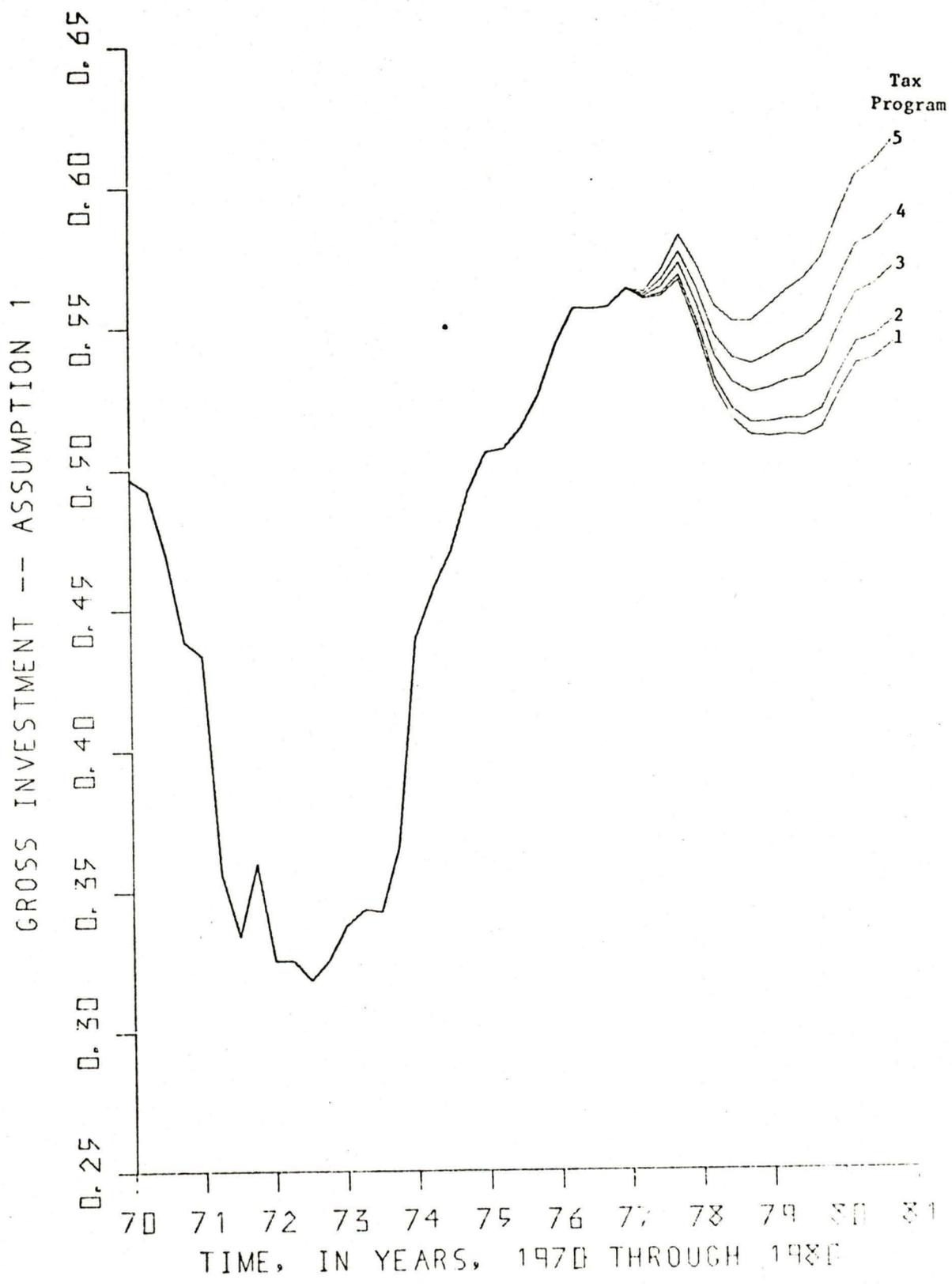
FIGURE 2.7   Conditional Forecasts of Investment Expenditures for
             1975-1980, Quarterly, Assumption 1 (Constant Interest
             Rates).
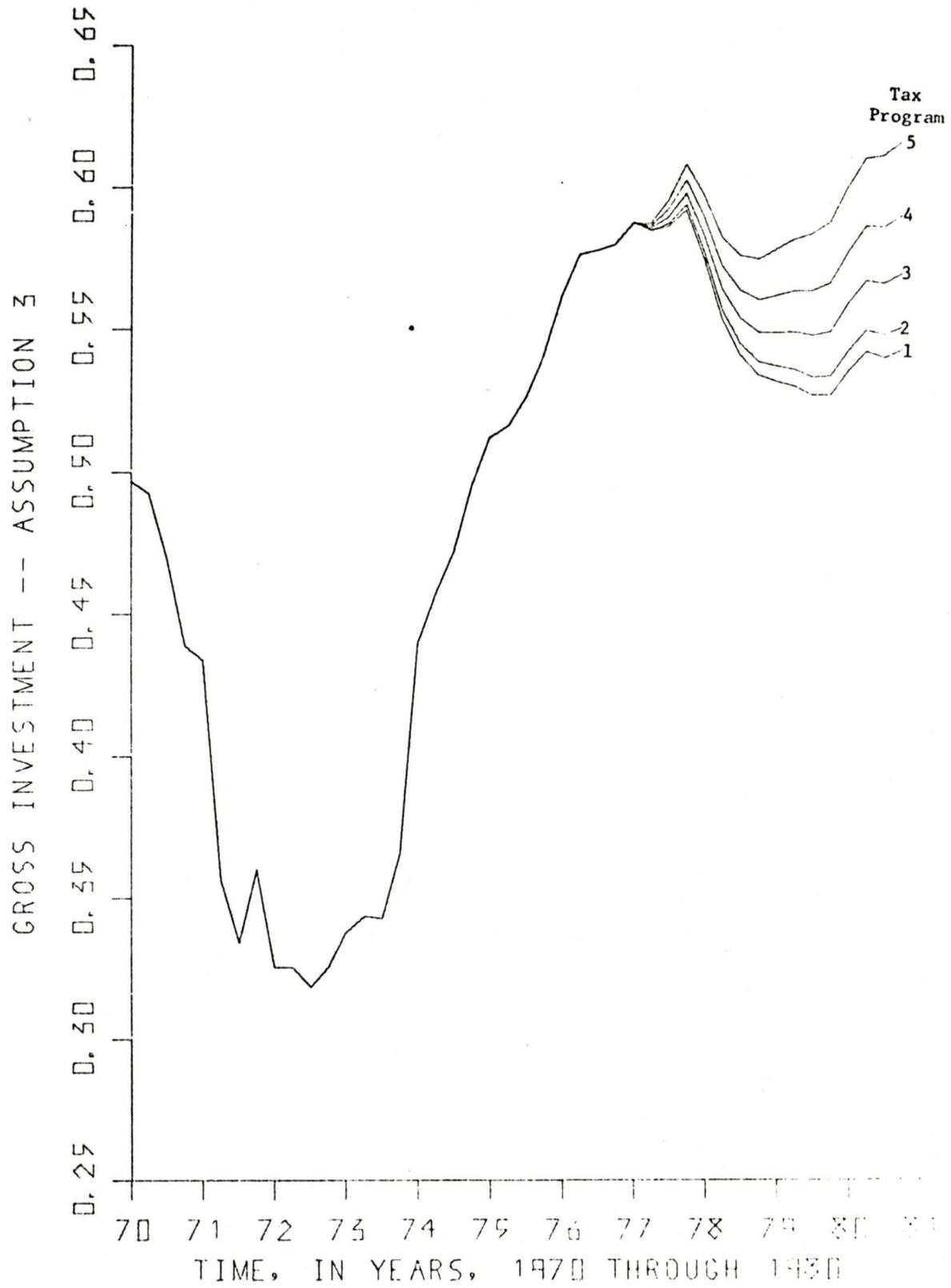
FIGURE 2.8   Conditional Forecasts of Investment Expenditures for
1975-1980, Quarterly, Assumption 3 (Rising Interest
Rates).
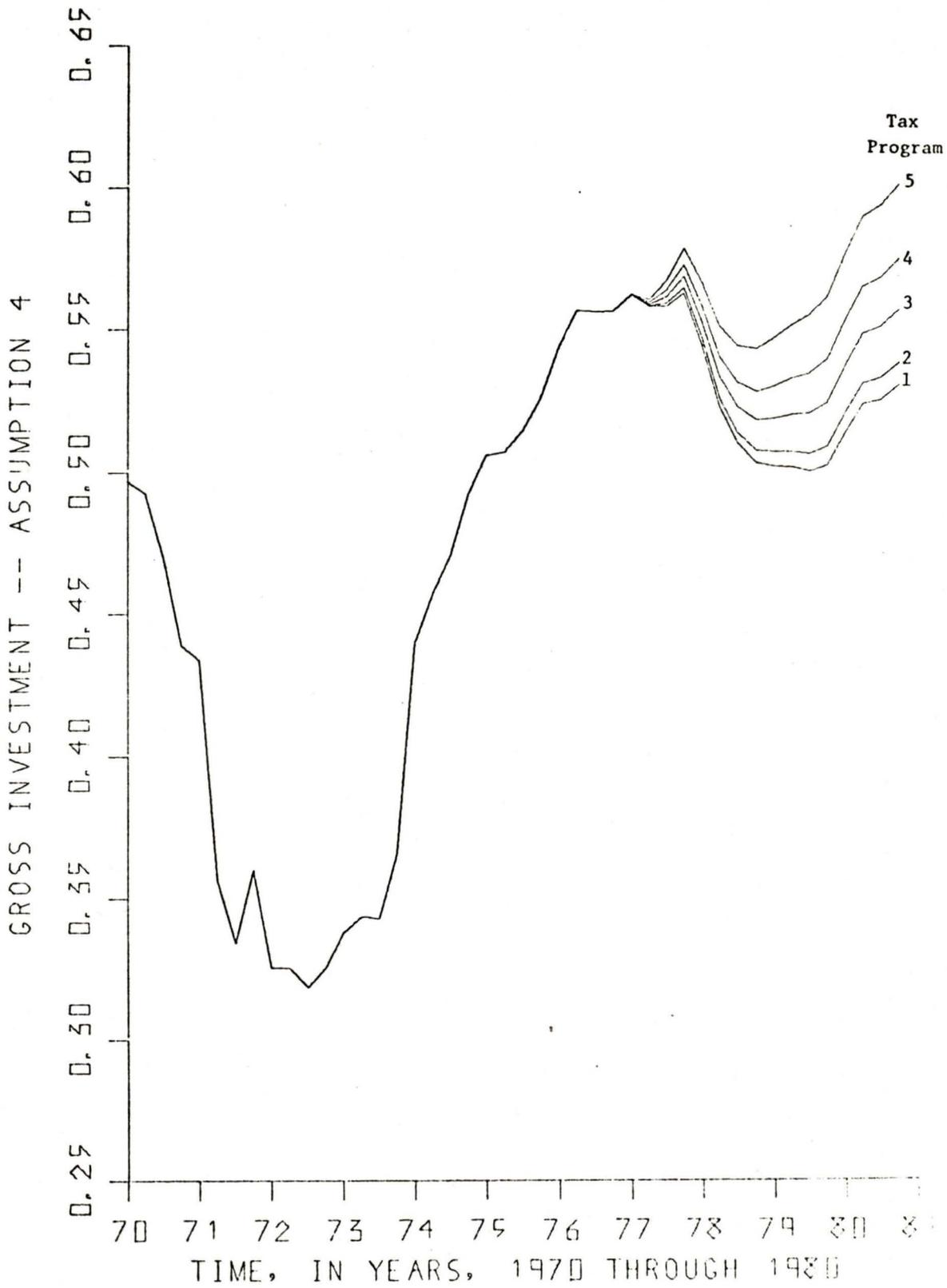
FIGURE 2.9 Conditional Forecasts of Investment Expenditures for 1975-1980, Quarterly, Assumption 4 (Constant Interest Rates).
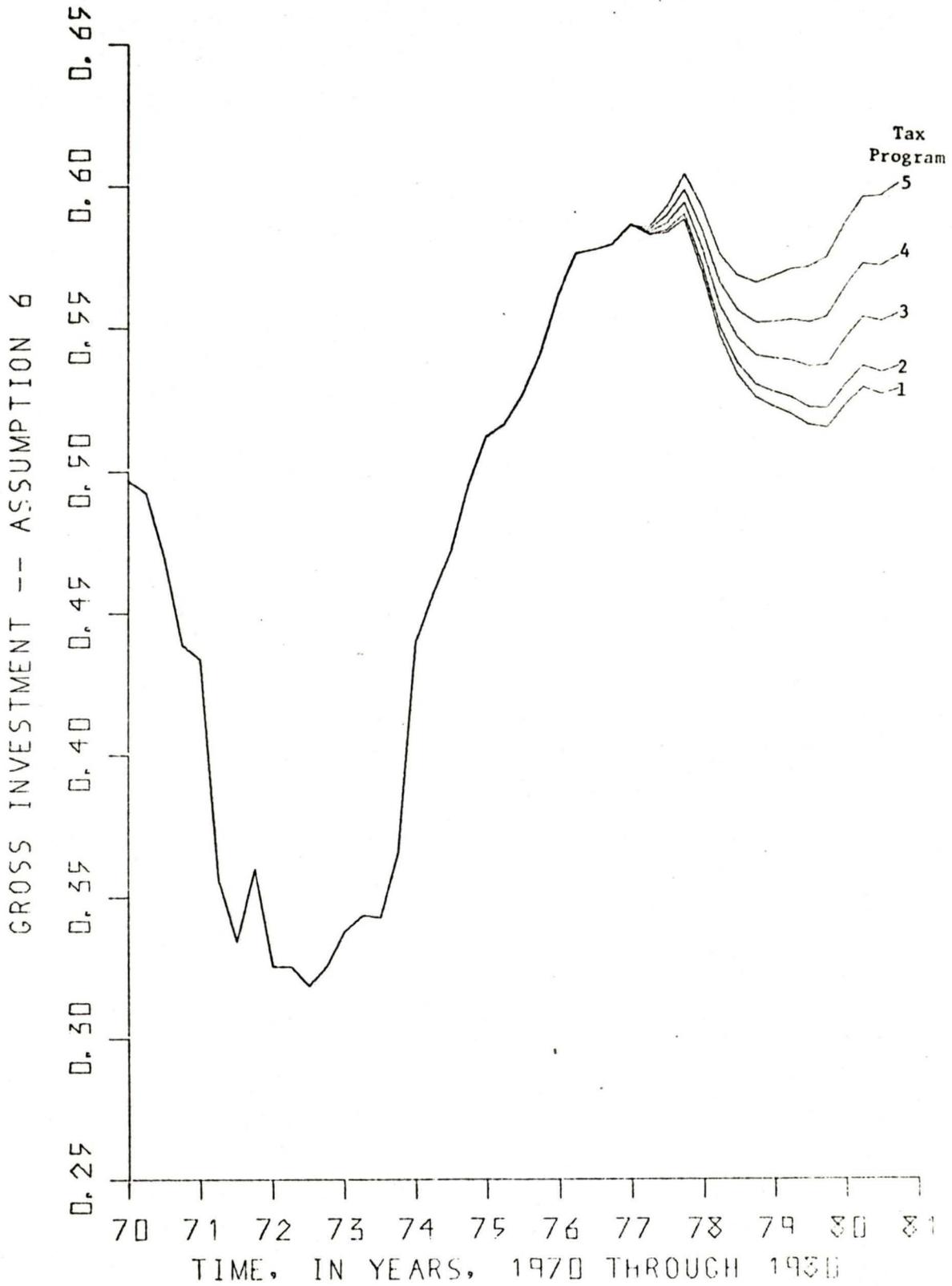
FIGURE 2.10 Conditional Forecasts of Investment Expenditures for 1975–1980, Quarterly, Assumption 6 (Rising Interest Rates).
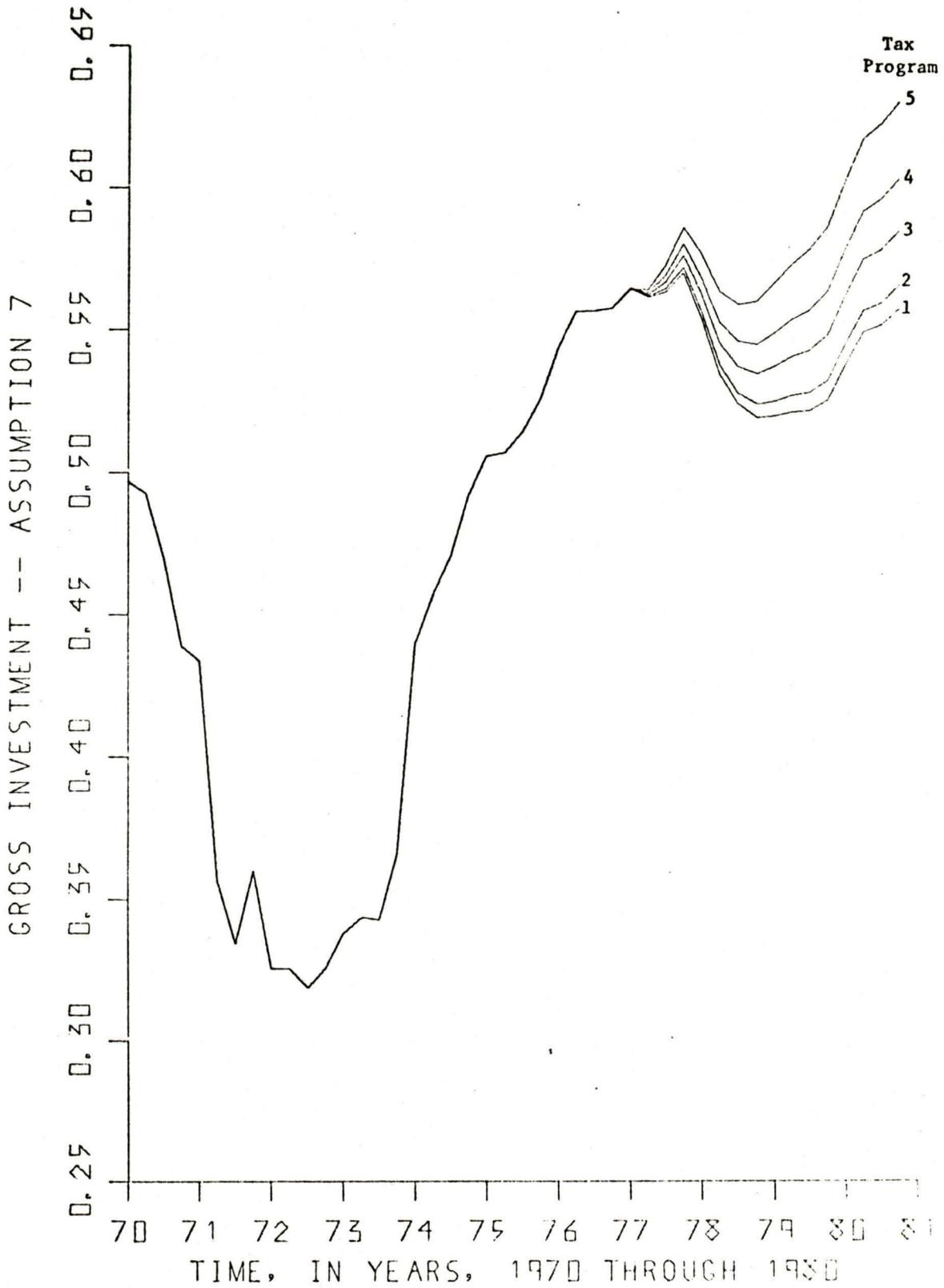
FIGURE 2.11 Conditional Forecasts of Investment Expenditures for 1975-1980, Quarterly, Assumption 7 (Constant Interest Rates).
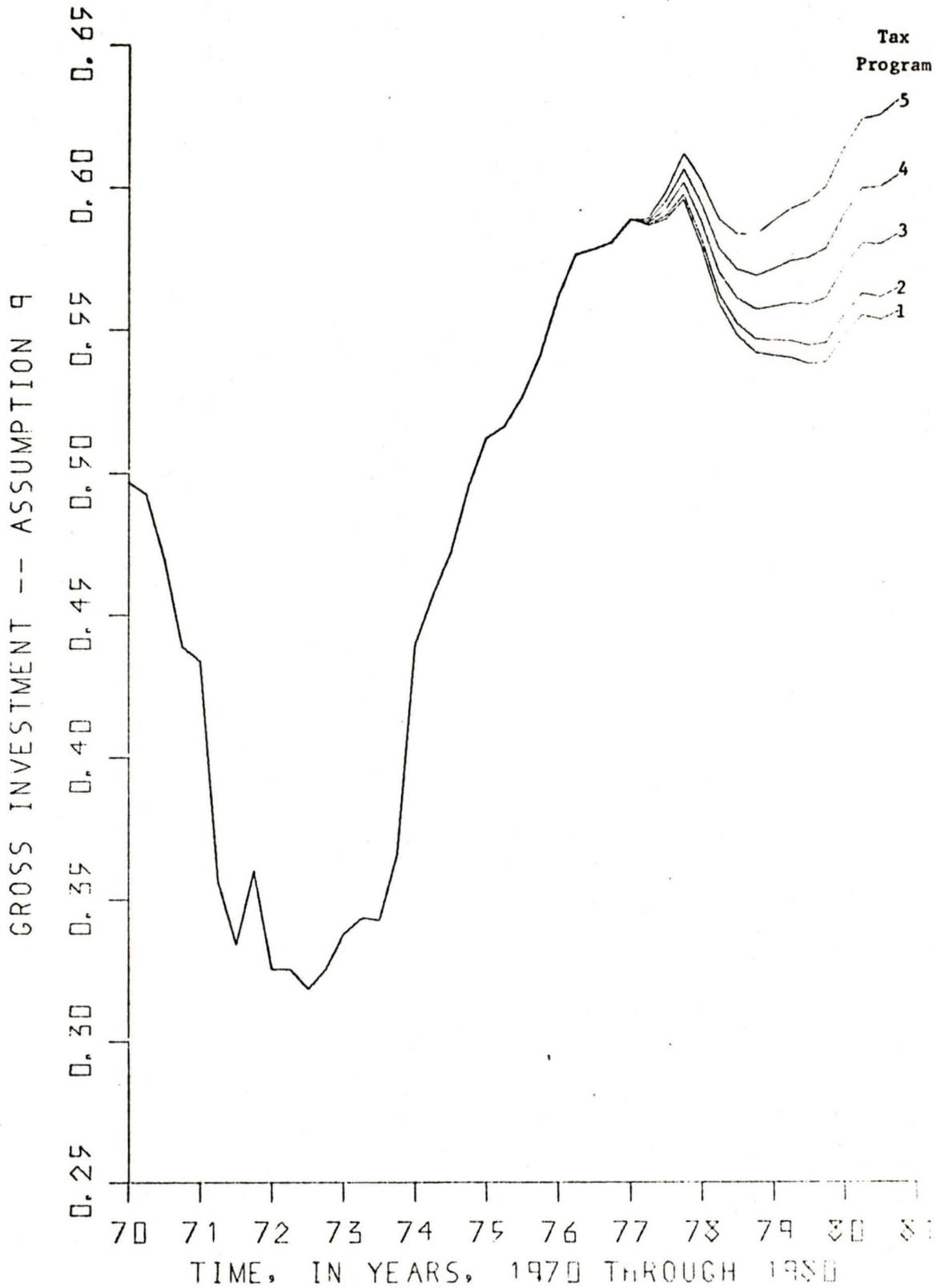
FIGURE 2.12   Conditional Forecasts of Investment Expenditures for 1975-1980, Quarterly, Assumption 9 (Rising Interest Rates).

Tax Program	Range of Expenditures
1	$2.11-2.23 billion per year
2	$2.13-2.24
3	$2.15-2.27
4	$2.18-2.30
5	$2.22-2.33

The pictorial view of the forecasts (Figures 7 - 12) show a pronounced increase in investment spending through 1977, a gradual tailing-off through 1979, and another build-up of expenditures beginning in 1980. This pattern reflects to a large extent (a) the increased demand for steel products in 1973 and 1974, (b) the recession of 1975, and (c) the actual and prospective changes in tax laws. Again, due to the model's lag structure, it takes almost five years for 90 percent of the effect of a change in the determinants of investment to be translated into actual spending. It is not surprising, therefore, that the "short-term" forecasts which cover only a six-year time period would be dominated by the recent past.

In order to compare the conditional forecasts to levels of investment expected due solely to market forces, two additional tables were prepared. Table 11 shows average annual expenditures under the nine assumptions and five programs plus the market-based forecasts from Phase I using the real GNP-steel output projections. Table 12 shows similar information but using the output projections based on a 2.5 percent annual growth in steel products. These two tables show the modest effect that tax law changes will have on investment expenditures in iron and steel through 1980.

Table 11 demonstrates that, under the most favorable circumstances (Program 5), tax law changes will add $0.101 to 0.128 billion to average annual expenditures depending on the economic conditions that prevail. This represents only a 4.6 to 5.8 percent increase relative to market-determined expenditure levels. Table 12 demonstrates that, under the most favorable circumstances (Program 5), tax law changes will add $0.105 to 0.133 billion to average annual expenditures, depending on economic conditions. This again represents a 4.6 to 5.8 percent increase relative to market-determined expenditure levels.

Capital Shortages and Conditional Forecasts

We turn now to the issue of a capital shortage in the iron and steel industry. The forecasts of expenditures for plant and equipment presented in the previous section imply that the period 1975-1980 will

TABLE 2.11

SUMMARY OF CONDITIONAL FORECASTS: AVERAGE ANNUAL
GROSS INVESTMENT EXPENDITURES IN IRON AND STEEL TO 1980
(Billions of 1973 Dollars); GNP PROJECTIONS

Tax Program	Assumption								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market	$2.118	$2.201	$2.186	$2.097	$2.179	$2.164	$2.139	$2.224	$2.207
1	2.135	2.220	2.203	2.114	2.197	2.181	2.157	2.242	2.225
2	2.147	2.232	2.215	2.125	2.209	2.193	2.169	2.255	2.237
3	2.175	2.255	2.243	2.153	2.232	2.220	2.197	2.278	2.265
4	2.202	2.267	2.273	2.179	2.244	2.250	2.224	2.291	2.296
5	2.241	2.303	2.311	2.218	2.280	2.288	2.264	2.327	2.335

Target Expenditures: $2.9 – 3.5 Billions of 1973 Dollars[a]

[a]Source: American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy (Washington, D. C.: February 1974), p. 27.

TABLE 2.12

SUMMARY OF CONDITIONAL FORECASTS: AVERAGE
ANNUAL GROSS INVESTMENT EXPENDITURES IN IRON AND STEEL TO 1980
(Billions of 1973 Dollars); 2.5 PERCENT PROJECTIONS

Tax Program	Assumption								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Market	$2.228	$2.315	$2.299	$2.206	$2.292	$2.276	$2.251	$2.339	$2.322
1	2.246	2.334	2.317	2.224	2.311	2.294	2.269	2.358	2.340
2	2.258	2.347	2.330	2.236	2.323	2.307	2.281	2.371	2.353
3	2.287	2.371	2.359	2.264	2.347	2.335	2.311	2.396	2.382
4	2.315	2.384	2.390	2.292	2.359	2.366	2.339	2.408	2.415
5	2.357	2.422	2.430	2.333	2.397	2.405	2.381	2.447	2.455

Target Expenditures: $2.9 - 3.5 Billions of 1973 Dollars[a]

[a]Source: American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax
Policy (Washington, D. C.: February 1974), p. 27.

be marked by a high level of investment spending. Depending on one's view of what economic (market) scenario will characterize the remainder of the 1970s, average annual expenditures will range between $2.10 and 2.34 billions of constant 1973 dollars.

During the period 1971-1974 investment expenditures in the iron and steel industry averaged $1.49 billion, and in 1972 were only $1.29 billion. Consequently, market-determined investment spending through 1980 is forecasted to be almost 50 percent greater in constant dollars than spending during the 1971-1974 period. With these new, higher levels of expenditures, it is possible that certain "boundary conditions" might be exceeded. For example, it is conceivable that a 50 percent increase in spending could only be financed externally with, say, a ratio of debt-to-equity in excess of 40 percent. Such a high level of borrowing might be impossible or only supportable at interest rates higher than those accounted for in the model (9 percent and 9.34 percent). However, an increase in interest rates will also increase the rental price of capital services, leading to a reduction in the desired level of capital and a resulting lower level of investment spending. This reduction in spending cannot be termed a shortage since it simply reflects a movement along the demand curve for capital services to a new equilibrium point. Market adjustments of this sort imply that a shortage can be no more than temporary. To have a continued shortage would imply that the demand schedule was continuously shifting and steadily increasing faster than supply.

As in the Phase I report,[14] a shortage will be understood here to mean the difference between some stated target and what is most likely to occur in a market setting. From an economic policy viewpoint, measurement of the shortage or shortfall is a part of the so-called planning stage.[15] That is, given the forecast or prospective state of affairs and some stated target, deviations between these two represent the changes that may have to be brought about in the target variable. Under this definition of a shortage, which is normative, changes in the target variable may be accomplished by a revision of the target, or changes in the instrument variables, or both. Estimating the effects of alternative policies due to changes in the instrument variables (e.g., tax policy) is accomplished through the use of conditional forecasts of the target variable. Estimating the effects of alternative policies due to revision in the target involves, to an important extent, knowledge of the preference function for the policy maker.[16]

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[14]Neumann, op. cit., Chapter 6.

[15]J. Tinbergen, Economic Policy: Principles and Design (Amsterdam: North-Holland, 1967), p. 10.

[16]Ibid., p. 56.

The present study adopts as a planning target the level of capital expenditures provided by the American Iron and Steel Institute's estimates of future capital needs.[17] Under the assumption that output will grow at a rate of 2.5 percent per year, the industry estimates that it will require a capacity of 180 million net tons of raw steel in 1980, and that this implies a net addition to capacity of 25 million net tons. In terms of average annual investment expenditures, the industry estimates may be expressed as follows:

	Annual Expenditures (Billions of 1973 Dollars)
Additions to Capacity	$1.15
Replacements of Capacity	1.75
Pollution Abatement	.40
Miscellaneous	.20
	$3.50

Even excluding the pollution abatement and miscellaneous portions of this estimate, an annual expenditure of $2.9-3.5 billion is 25 to 50 percent greater than the forecast of investment expenditures under the most favorable assumptions about the future ($2.34 billion). Consequently, the forecasts imply an average capital shortage or shortfall relative to the industry's target of at least $0.56 billion per year ($2.90 less $2.34 billion), and perhaps as great as $1.40 billion per year ($3.50 less $2.10 billion).

Given this conclusion, a question arises concerning the impact of tax policy changes on investment expenditures. This report concludes that tax policy changes will have a minor effect on the level of expenditures. As indicated in the previous section, the most favorable changes in tax policy (Program 5) would only increase spending by about $0.10 to 0.13 billion per year. Compared to potential shortages of $0.56 to 1.40 billion per year, these increases must be considered modest. It is possible, however, that tax policy changes could have a substantial impact on the form of financing (internal versus external funds) which is used to accomplish the forecasted expenditures. This possibility is not explicitly accounted for in the present model, and must await the development of a model which considers the sources of investment funding as well as the level of expenditures.

It should be recognized that the tax policy programs considered in this chapter represent, in and of themselves, substantial changes in the economic parameters faced by the steel industry, or any other

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[17] American Iron and Steel Institute, Steel Industry Economics and Federal Income T_x Policy (Washington, D.C.: February 1974), pp. 26-7. Subsequent revisions of the expenditure estimates are given on pages 20-24 in the June 1975 version of this report.

industry. This point can be illustrated by calculating a percentage change in the rental price of capital services implied by each of the five programs and the three assumptions about interest rates. These calculations are shown in Table 13 and indicate percentage changes in the rental price of capital services ranging from +2.7 percent to -22.3 percent. To be more specific, consider Program 5 under the conditions of constantly high interest rates (series 1, 4, 7). The rental price is reduced by 19.7 percent, a reduction which under the assumption of constant interest rates will be permanent for the period 1977 to 1980. However, as a result of the economic structure of the steel industry (low elasticity of substitution, long lag structure), the forecasted increase in spending through 1980 under Program 5 relative to the market-based forecast is only 5.8 percent.

Finally, there is a minor source of difficulty in relating the series on gross investment expenditures in iron and steel that we have used with the "targets" given by the American Iron and Steel Institute. The two series differ in coverage somewhat, but it is unlikely that this difference is of much importance. The major difference lies in the fact that certain items are not included as investment expenditures in the Commerce Department's series which we have used, but are included in the industry's estimates. Primary examples of the difference between the series are in the treatment of land and expenditures for capital equipment made outside the United States. Both of these are not included in the Commerce Department series, but are included in the industry series. Historically the government series on investment expenditures has been significantly less than the American Iron and Steel Institute series on capital expenditures, but the magnitude of the difference has been declining over time. Over the period 1950-1974, the Commerce Department series was 15 percent less on average than the industry series, although in recent years the difference has been narrowed substantially. Over the period 1965-1974, the difference averaged 7.9 percent per year, but for the period 1970-1974, the difference was less than 1 percent per year (Table 14). The convergence of the two series reflects the predominant forces in the market for steel products and particularly for the raw materials necessary to produce steel. Given the behavior of the two series, it seems reasonable to adjust our forecasts up by some amount to reflect the differences in measurement of investment. What is not clear, however, is by how much should our forecasts be adjusted to make them comparable with the industry figures. We have chosen two options: (a) assuming that investment in the U.S. rather than in foreign countries will continue, the adjustment factor is chosen as 0 percent, which is in accord with the results for 1970-1974; (b) assuming that the convergence trend in the two series reverses, an adjustment factor of 8 percent could be used to make our forecasts comparable. All of the series presented in this chapter assume that no adjustment is required; the reader may make the second adjustment simply by adding an additional 8 percent to our forecasts.

TABLE 2.13

AVERAGE PERCENTAGE CHANGE IN THE RENTAL PRICE OF CAPITAL SERVICES:
VARIOUS TAX PROGRAMS AND INTEREST RATE ASSUMPTIONS

Tax Program	Rental Price of Capital Services:[a]								
	Interest Rate Series[b] 2, 5, 8			Interest Rate Series[b] 1, 4, 7			Interest Rate Series[b] 3, 6, 9		
	1976	1977	% Change	1976	1977	% Change	1976	1977	% Change
1	.1125	.1042	−7.3%	.1156	.1156	−−	.1055	.1084	+2.7%
2	.1125	.1004	−10.8	.1156	.1116	−3.5%	.1055	.1046	−0.9
3	.1125	.0975	−13.3	.1156	.1072	−7.3	.1055	.1008	−4.5
4	.1125	.0948	−15.7	.1156	.1011	−12.5	.1055	.0944	−10.5
5	.1125	.0874	−22.3	.1156	.0928	−19.7	.1055	.0872	−17.3

[a]These estimates correspond to equation (2.2) with the parameter q set equal to its 1974 values (1958 = 100) for both 1976 and 1977; the absolute level of the rental price is not at issue here. Quarterly values for 1976 and 1977 are averaged. The year 1976 is the last full year prior to the prospective changes and the year 1977 is the first full year after such changes.

[b]See Table 2.4 for description of each series.

TABLE 2.14

ANNUAL IRON AND STEEL CAPITAL EXPENDITURES
(Current Dollars-Millions)

Year	AISI	COMMERCE (BEA)
1974	2,104	2,077
1973	1,399	1,377
1972	1,174	1,245
1971	1,425	1,385
1970	1,736	1,680
1969	2,046	1,847
1968	2,307	1,997
1967	2,145	1,915
1966	1,952	1,700
1965	1,822	1,552
Total	18,114	16,775
Average	1,811	1,678

Ratio of BEA to AISI = 1,678/1,811 = 0.926.

For the 10 years, AISI is 7.9 percent higher than BEA.

For 1970-74, AISI is $\frac{75}{7,764}$ = 0.97 percent higher than BEA.

Sources: American Iron and Steel Institute, Annual Statistical Report (Washington, D.C.: Annual Editions).

Bureau of Economic Analysis, Survey of Current Business (Department of Commerce, January 1970), p. 32. Recent data from various monthly issues of the Survey.

Summary

This chapter presented a series of conditional forecasts for alternative tax policies. To evaluate the effect of a specific tax policy, all determinants of investment spending except tax policy parameters are held equal to their actual or projected values. The impact of a specific tax policy is then measured by subsituting the parameters of the tax structure--tax rate, depreciation formulas, tax credits-- appropriate to alternative policies. The difference between investment forecasts resulting from no-change in current tax policy (do-nothing forecast) and investment forecasts conditional on alternative tax policies is a partial equilibrium measure of the impact of a policy alternative.

The results of this chapter indicate that even the most favorable changes in tax policy would only increase steel investment expenditures by about $0.10 to 0.13 billion per year. Compared to potential shortages of $0.56 to 1.40 billion per year, tax policy has a modest impact on expenditures levels. This conclusion reflects that economic structure of the iron and steel industry--low elasticity of substitution and long lag structure--which tends to reduce or retard the potential impact of policy-induced changed in the rental price of capital. However, this conclusion may also require some modification due to empirical evidence presented in Chapter 7. Additional forecasts are planned for Phase III of this project which will attempt to verify or modify the basic conclusions of this chapter.

CHAPTER 3

TWO MODELS OF INVESTMENT, DIVIDEND AND EXTERNAL FINANCE
BEHAVIOR OF THE BUSINESS FIRM

Introduction

This chapter describes alternative models of the inflow and out-
flow of funds for use in fixed investment in business plant and equip-
ment. The first model consists of three simultaneous equations and a
"cash flow" indentity--one equation each for the investment, dividend,
and external finance decisions. The second model is a recursive system
of equations describing the flow of funds into the firm in terms of pro-
fits; the division of cash flow into dividends and retained earnings;
the effect of retentions on the timing of investment expenditures; and
the impact of investment on external financing decisions. The recur-
sive model as formulated and tested in this report consists of five
behavioral equations and three identities.

These two models are described in general terms. Individual equa-
tions are formulated in considerably greater detail in subsequent
chapters. The equations to be estimated are derived from economic
theory and/or general propositions about economic behavior. The in-
dividual equations are explicitly formulated in mathematical terms
and can, therefore, be compared to other economic models derived or
derivable from economic theory. It should also be noted that most of
our empirical tests suggested that the recursive model was preferable
for explaining the economic magnitudes in question.

The Simultaneous Equations Model

The model consists of three simultaneous equations and a "cash
flow" identity--one equation each for the investment, dividend, and
external finance decisions. This system of equations is often alluded
to but seldom studied in a systematic fashion. For example, Van Horne
notes that

> Financial management involves the solutions of the three
> decisions of the firm (investment, financing, dividend)
> discussed above. Together, they determine the value of
> the firm to its shareholders. Assuming that our objec-
> tive is to maximize this value, the firm should strive
> for an optimal combination of the three decisions.[1]

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[1] J. C. Van Horne, Financial Management and Policy, Third edition,
(Englewood Cliffs: Prentice-Hall, 1974), p. 11.

Furthermore, the implication here is that these decisions are properly considered in a simultaneous framework.

> Because these decisions are interrelated, they should be solved jointly. The decision to invest in a new capital project, for example, necessitates the financing of the investment. The financing decision, in turn, influences and is influenced by the dividend decision, for retained earnings used in internal financing represent dividends foregone by stockholders. With a proper conceptual framework, joint decisions can be reached that tend to be optimal.[2]

Despite these arguments, the view adopted in much of the econometric literature is that investment decisions are taken only on real (nonfinancial) grounds, that dividends are a residual or at least characterized by a considerable degree of inertia, and that the financing of investment by internal or external funds is a mere detail. This view--the neoclassical model represented by Jorgenson[3] and Modigliani and Miller[4]--stands in strong juxtaposition to the traditional corporate finance model described in this section. Indeed, these objections provide part of the basis for the recursive model. In the empirical portions of this report, appropriate tests will be conducted to determine if the three decisions are in fact simultaneous within the context of quarterly data.

The simultaneous model can be rather simply outlined as follows. The firm faces an outflow of funds represented by its variable and fixed costs, tax and dividend payments, and by its investment activities. On the one hand, it can rely on an inflow of funds represented chiefly by its after-tax profits and depreciation allowances. On the other hand, the firm can use the proceeds obtained through various forms of external finance, i.e., by bond or stock flotation, to finance investment projects. Given the objective of maximizing stockholder wealth, these decisions could be competitive. Stockholders may have a preference for dividends as opposed to capital gains or they may value stable dividends; investment and dividend outlays are thus competitive. Management may exhibit a strong preference for the use of retained earnings for investment financing, or capital markets may be less than perfect. Consequently, the three decisions--to invest, to pay dividends, and to resort to external financing--are mutually determined. Hence, it is desirable to investigate this problem in the context of a simultaneous equations model.

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[2]Ibid., pp. 11-12.

[3]D. Jorgenson, "Capital Theory and Investment Behavior," American Economic Review, 53 (May 1963), pp. 247-59.

[4]F. Modigliani and M. H. Miller, "The Cost of Capital, Corporation Finance and the Theory of Investment," American Economic Review, 48 (June 1958), pp. 261-77.

Assuming that production, marketing and inventory decisions pre-
date the decision process in question (i.e., current output, profits,
inventory, and other short-term investments are exogenous), and ignoring
for the moment the question of a lag structure, the general model is:[5]

(3.1) $I = f_1(\text{Div, EF}_1, \text{EF}_2; X_1, \ldots, X_n)$

(3.2) $\text{Div} = f_2(I, \text{EF}_1, \text{EF}_2; X_1, \ldots, X_n)$

(3.3) $\text{EF}_1 = f_3(I, \text{Div, EF}_2; X_1, \ldots, X_n)$

(3.4) $\text{EF}_2 = f_4(I, \text{Div, EF}_1; X_1, \ldots, X_n)$

where X_i are predetermined variables, $i = 1, \ldots, n$, and where the en-
dogenous variables are:

I   = gross fixed investment expenditures,

Div = common stock dividends charged to surplus,

EF_1 = net external finance by borrowing (debt),

EF_2 = net external finance by new stock flotation (equity).

In addition, the firm faces a "budget constraint" given by the
following identity

(3.5) $I \equiv \text{EF}_1 + \text{EF}_2 + \pi - \text{Div} + \text{Dep}$

where π = after-tax profits,

Dep = depreciation allowances,

$\pi - \text{Div} + \text{Dep}$ = gross retained earnings.

Using the constraint in Equation 5, we can eliminate one of the endogenous
variables in the system. We have chosen to eliminate new stock flota-
tion on grounds that new equity is a minor source of external finance
for most iron and steel firms. Hence, the model to be estimated is of
the form:

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[5]P. J. Dhrymes and M. Kurz, "Investment, Dividend, and External
Finance Behavior of Firms," in R. Ferber (ed.), Determinants of Invest-
ment Behavior (New York: National Bureau of Economic Research, 1967),
p. 432.

$$(3.6) \qquad I = g_1(\text{Div}, \text{EF}_1; X_1, \ldots, X_n)$$

$$(3.7) \qquad \text{Div} = g_2(I, \text{EF}_1; X_1, \ldots, X_n)$$

$$(3.8) \qquad \text{EF}_1 = g_3(\text{Div}, I; X_1, \ldots, X_n)$$

Since there is no natural order to the equations in this model, we shall briefly discuss the dividend equation first, the investment equation second, and finally, the external finance equation.

1. The Dividend Equation. Following the work of Lintner,[6] dividends are hypothesized to be a function of after-tax profits and lagged dividends. In addition, it was suggested above that short-term investment is a predetermined variable. This variable should then be incorporated in the dividend equation since it represents an outflow of funds which are not available for dividend payments. To the extent that short-term investment is unintended, no specification error is committed. But to the extent that inventory accumulation is intended or short-term securities holdings are for other than liquidity-transaction purposes, then a specification error is committed. This could be corrected by including a separate equation in the system for short-term investments. However, this report does not consider this additional complication.

The basic form of the structural dividend equation to be subjected to empirical testing is

$$(3.9) \qquad D_t = G_2(I_t, \text{EF}_{1t}; \pi_t, D_{t-1}, N_t, u_t)$$

where D_t = dividends charged to surplus at time t,

I_t = gross fixed investment expenditures,

EF_{1t} = long-term borrowing (external finance),

π_t = after-tax profits,

N_t = net current position,[6a]

u_t = stochastic error term.

The Lintner model and other formulations of the dividend equation will be discussed in detail in Chapter 6 of this report.

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[6] J. Lintner, "Distribution of Incomes of Corporations Among Dividends, Retained Earnings and Taxes," American Economic Review, 46 (May 1956), pp. 97-113.

[6a] The net current position is defined as the excess of short-term assets (inventories, cash, short-term securities, accounts receivable) over accounts payable and other short-term liabilities.

2. <u>The Investment Equation</u>. The basic form of the investment equation was developed in Phase I of the project. Only a brief summary of the model of investment behavior will be given here. The interested reader should consult the Phase I report for additional details.[7] The investment function from Phase I can be summarized functionally by

$$(3.10) \qquad I_t = G_1 \left[\Delta \left[(\frac{p}{c})Q \right]'_{t-1}, \; K_{t-1}, U_t \right]$$

where I_t = gross investment, including replacement, in plant and equipment at time t,

  p = wholesale price index for iron and steel products,

  c = the user cost of capital,

  Q = production of raw steel,

  K_{t-1} = capital stock,

  U_t = stochastic error term, and the primes indicate long-run or permanent values.

Although this formulation is based on what Jorgenson has termed "the complete theory of investment," it is regarded as deficient in several respects by many economists. First, it ignores future expectations relevant to investment decisions under uncertainty. For example, it is common to assume that judgments of the relevant future magnitudes reflect current judgments of "permanent" or "true" output, price or cost levels, which are free of the random or transitory components in the unfiltered and unadjusted raw data on these magnitudes. However, it is not clear that a simple "learning" theory that reduces to exponential smoothing (or some similar weighted average) of current and past observed data is sufficient to reflect the process by which current estimates of permanent levels are formed. Changes in financial conditions--especially the level of profits--might be expected to have as much or more expectational significance as, for example, a smoothed output series.

A second major objection to the Jorgenson formulation is that it assumes that investment decisions are independent of the financial structure of the firm. In a simplified world without taxes, with perfect capital markets, and where corporate debt is a riskless asset to its owners, the firm's marginal cost of funds would be independent of its existing capital structure and of the mix of fund sources utilized to finance its current investments. Current profits, dividends, retained earnings, current assets or liabilities, funded debt and net worth would--in strict theory--all be completely irrelevant. However, with

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[7]G. R. Neumann, <u>Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975-1980</u> (University Park, Pa.: Institute for Research on Human Resources, The Pennsylvania State University, December 1975).

the introduction of corporate taxes into the model, then the cost of
capital depends upon tax rates. If corporate bonds as well as corporate
stocks are risky assets to their owners, then the cost of capital de-
pends on leverage as well.

In the investment model proposed here, financial variables are
incorporated in two equations. First, retained earnings (or gross
retained earnings) are used to determine the speed of adjustment in
the investment function. This specification of the investment function
follows Coen.[8] In addition, external financing will also be included
in the model as an endogenous variable. Second, financial variables
also enter the external finance function and would therefore affect
investment indirectly through the level of external finance. The basic
form of the investment function to be subject to empirical testing
in Chapter 7 is

$$(3.11) \qquad I_t = G_1[D_t, \; EF_{1t}; \; \Delta(\tfrac{c}{w})'_{t-i}, \; \Delta Q'_{t-i}, \; I_{t-i}, \; N_t, \; \Delta F'_{t-i}, \; U_t]$$

where I_t = gross fixed investment expenditures at time t,

D_t = dividends,

EF_{1t} = long-term borrowing (external finance),

c = the user cost of capital,

w = wage rate,

Q = production of raw steel,

N_t = net current position,

F_t = internal funds (retained earnings or gross retained earnings),

U_t = stochastic error term, and the primes indicate long-run
or permanent values.

3. The External Finance Equation. In the model proposed by
Dhrymes and Kurz, leverage, the interest rate, and depreciation have
an effect on investment only inasmuch as they influence the amount of
external borrowing that is possible. If the amount of internally generat-
ed funds is greater than the amount of planned investment, these funds
will not represent a constraint on investment. Essentially this result
implies an intersection of the demand schedule for investment (marginal
efficiency of investment) with the horizontal section of the supply of
funds schedule (marginal cost of funds). If, on the other hand, some
external borrowing is required, the amount of available internal funds
(i.e., after dividends and short-term investment) is of some importance.
Moreover, if the dividend and external finance decisions are

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[8]R. M. Coen, "The Effect of Cash Flow on the Speed of Adjustment,"
in G. Fromm (ed.), Tax Incentives and Capital Spending (Washington, D.C.:
Brookings Institution, 1971), Chapter 4.

made simultaneously, then the level of dividends and the level of external finance are mutually determined. The external finance decision is taken to be a function of the amount of investment undertaken. Other things being equal, the larger the amount of investment expenditures for a given level of dividends and other factors, the greater will be the required level of external finance.

In addition, the external finance equation is taken to be a function of current and lagged after-tax profits, current and lagged depreciation allowances, and dividends. These three variables are included to reflect the firm's cash flow and its ability "to service fixed charges." The greater and more stable the expected future cash flows of the firm, the greater the debt capacity. Finally, the interest rate and leverage variable are included to reflect the marginal cost of debt and the firm's ability to trade on equity. Other things being equal, the higher the interest rate, the less will external financing be used to finance investment outlays. Since actual interest charges currently paid are not observable, the leverage variable reflects higher "true" interest rates as the firm's debt capacity is exhausted. Other things being equal, the greater the leverage, the lower the coverage of fixed charges and the more risky the loan.

The basic form of the external finance equation to be subjected to empirical testing in Chapter 8 is

(3.12) $EF_{1t} = G_3(I_t, D_t; \pi_t, Dep_t, r_t, L_t, N_t, \varepsilon_t)$

where EF_{1t} = long-term borrowing (external finance) at time t,

I_t = gross fixed investment expenditures,

D_t = dividends,

π_t = after-tax profits,

Dep_t = depreciation allowances,

r_t = the interest rate,

L_t = a leverage variable,

N_t = net current position,

ε_t = stochastic error term.

The Recursive Model

The model outlined in the previous section was a system of three simultaneous equations and one identity. This formulation implies

feedbacks or interactions among the mutually determined variables D_t, I_t and EF_t, so that, in general, the error term in each equation is correlated with the included endogenous variables. These circumstances present special problems in econometric estimation which must be overcome through the use of special estimating procedures.[9]

An alternative view is that the economic system in question is really recursive. Wold, for example, has argued this point in many publications.[10] Recursive, or causal chain models, are dynamic, and propositions on equilibrium tendencies of the system are implications of the model, rather than key assumptions. Wold states that

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[9] In particular, if we wish to estimate one or more of a set of equations constituting a simultaneous system, then ordinary least-squares (OLS) procedures are inappropriate. If OLS is applied to an equation in a model, there will usually be more than one current endogenous variable in the relation. Whichever one selects as the dependent variable, the remaining endogenous variables will be correlated with the disturbance in the equation. The OLS estimates will be biased and inconsistent.

The simultaneous-equation bias is a consequence of the presence of correlation between the error term and some of the endogenous variables caused by the simultaneous satisfaction of all of the equations in the model. When the error term and the endogenous variables of a regression equation have no correlation, then there is no bias even though the equation may be part of simultaneous equation models. Therefore, estimating a single equation from a simultaneous equation model does not necessarily imply that the estimates are biased and inconsistent.

[10] See, for example, H. Wold, "Causality and Econometrics," Econometrica, 22 (April 1954), pp. 162-174; "A Case Study of Interdependent versus Causal Chain Systems," Review of the International Statistical Institute, 5 (1958), pp. 5-25; "Ends and Means in Econometric Model Building," in U. Grenander, (ed.), Probability and Statistics (New York: Wiley), pp. 355-434; "A Generalization of Causal Chain Models," Econometrica, 28 (April 1960), pp. 443-463; "Forecasting by the Chain Principle," in M. Rosenblatt (ed.), Time Series Analysis (New York: Wiley, 1963), pp. 471-497; and, Econometric Model Building: Essays on the Causal Chain Approach (Amsterdam: North-Holland, 1964).

See also R. H. Strotz and H. Wold, "Recursive vs. Nonrecursive Systems," Econometrica, 28 (April 1960), pp. 417-427; and E. J. Mosbaek and H. Wold, Interdependent Systems: Structure and Estimation (Amsterdam: North-Holland, 1970).

Every equilibrium assumption is an approximation that ignores
a potential driving force of the model. To assume instantan-
eous equilibrium between demand and supply is to ignore changes
in stocks; to equilibrate savings and investments is to ignore
the unplanned changes in money holdings and inventories and
so on. In reality, according to observed facts, such equili-
brium gaps are often quite considerable and to disregard them
in model construction is in conflict with basic arguments in
dynamic economic theory.[11]

Consequently, we digress somewhat from our main theme to draw out
these differences in econometric modeling.

A well-known example of a recursive system is the so-called cobweb
model of supply and demand. This causal system may be represented as
follows:

(3.13) $q_t = a_1 + a_2 p_{t-1} + u_{1,t}$ (supply)

(3.14) $p_t = b_1 + b_2 q_t + b_3 y_t + u_{2,t}$ (demand)

where q = equilibrium quantity, p = equilibrium price, y = income
(exogenous), and u_1, u_2 are stochastic disturbance terms. This model
is recursive since p_t and q_t are current endogenous variables and p_{t-1}
is predetermined with the causal sequence being

$$\cdots \to \underset{u_{1,t-1}}{\overset{q_{t-1}}{\nearrow}} \to \underset{u_{2,t-1}}{\overset{p_{t-1}}{\nearrow}} \to \underset{u_{1,t}}{\overset{q_t}{\nearrow}} \to \underset{u_{2,t}}{\overset{p_t}{\nearrow}} \to \cdots$$

which is a linear chain without any feedback, i.e., it is possible to
order the equations so that there is no (contemporaneous) interaction or
feedback from higher numbered (e.g., p_t) to lower-numbered (e.g., q_t)
endogenous variables.[12]

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[11]H. Wold, "A Generalization of Causal Chain Models," Econometrica,
28 (April 1960), pp. 461-462.

[12]Enforced aggregation over time due, for example, to the use of
yearly rather than quarterly or monthly data can turn a truly recursive
model into a fully simultaneous one. Indeed, it can be argued that
simultaneous equation models are only (misspecified) approximations of
the recursive structure. See R. H. Strotz, "Interdependence as a
Specification Error," Econometrica, 28 (April 1960), pp. 428-442.

If the error terms in the different equations are independent in all time periods, i.e., if $u_{1,t}$ and $u_{2,t}$ are uncorrelated, then endogenous variables in higher-numbered equations can be treated as predetermined with respect to that equation—in Equation 14, q_t is independent of $u_{2,t}$. Thus, this equation contains only one variable correlated with u_2, namely, p_t; the variable q_t depends on u_1, but u_1 and hence q_t is independent of u_2. In these rather special circumstances, ordinary least-squares (OLS) estimates of the individual equations will lead to consistent and asymptotically efficient coefficient estimates.[13] In the absence of lagged endogenous variables, the OLS estimates are also unbiased. Thus, the supply equation is estimated by a regression of q_t on p_{t-1} and the demand equation by a regression of p_t on q_t and y_t.

Klein[14] and other economists have argued that the assumption of independence among the error terms may not always be tenable. First, for there to be no correlation between $u_{2,t}$ and q_t, $u_{2,t}$ must not only be uncorrelated with $u_{1,t}$, but also with $u_{2,t-1}$, $u_{1,t-1}$, ..., etc. The errors $u_{2,t}$ must show no serial correlation, nor must they be correlated with previous or concomitant values of $u_{1,t}$. Where there is serial correlation, the errors will, in general, be correlated with the predetermined variables on which the regressions are calculated.

Second, other predetermined variables may have been omitted from both equations. If these omitted variables are correlated, then the disturbances which partially represent these neglected factors are also correlated. In sum, temporal aggregation, serial correlation, the use of lagged endogenous variables, and specification errors may all give rise to correlation of the error terms in an otherwise recursive model.

Where u_1 and u_2 are correlated, the technique of ordinary-least squares is not appropriate, and we must consider one of the several methods for estimating simultaneous equation systems. There are several possibilities. First, it might be possible to use an instrumental variable approach involving, for example, using p_{t-1} as an instrument for q_t. Second, in some circumstances, (i.e., exact identification) the reduced form of the system may be used and the structural parameter can then be recovered by indirect least squares. Third, two-stage least squares may be used. In the context of the cobweb model, this involves, first, estimating the supply function and obtaining the fitted values for q_t. These fitted values, denoted $\hat{q}_t$, are then substituted for the actual sample values, assuming no error term is present. Finally, the demand function is estimated by regressing p_t on $\hat{q}_t$ and y_t.

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[13] J. Kmenta, Elements of Econometrics (New York: MacMillan, 1971), p. 586.

[14] L. R. Klein, An Introduction to Econometrics (Englewood Cliffs: Prentice-Hall, 1962), pp. 75-81. See also A. W. Phillips, "Some Notes on the Estimation of Time-Forms of Reactions in Interdependent Systems," Economica, 23 (May 1956), pp. 99-113; E. Malinvaud, Statistical Methods of Econometrics (Chicago: Rand McNally, 1966), pp. 511-514, 540-543, 573-574.

To return to our main theme, the recursive model attempts to trace the flow of funds through the business firm in terms of: (1) the level of before-tax profits plus depreciation; (2) corporate tax payments; (3) the division of after-tax profits into dividend payments and retained earnings; (4) the impact of retained earnings on the timing of gross investment expenditures; and (5) the level of long-term debt required or permitted by the stock of capital resulting from the investment process.

The recursive system is summarized in equation form in Table 1 and illustrated in Figure 1. All financial flows are written here in cash flow terms, which includes depreciation allowances, although all equations are to be estimated in both profit and cash flow terms. The underlying economic and statistical rationale for each behavioral equation will be set out in considerable detail in subsequent chapters. At this stage of development of the model, it is instructive simply to trace the causal chain that the model implies, without, however, developing much of the economic reasoning for the particular specification of each equation.

In Equation 1 of Table 1, gross cash flow is hypothesized to be a function of sales revenue, lagged sales revenue, capacity utilization, and an import penetration index. The lagged sales term enters as a proxy for the wage demands of labor. In Equation 2, the amount of corporate taxes is determined,[15] and Equation 3 is an identity from which net cash flow is calculated. Equation 4 is the behavioral equation for the level of dividends. The structure of this equation is based on partial adjustment and/or adaptive expectation considerations. It assumes an i-period decision lag in the calculation of the permanent or expected level of net cash flow. In effect, information in the current period on financial flows is not available, has not yet fully been digested, or is otherwise irrelevant to the dividend payout decision. Equation 5 is an identity from which gross retained earnings (after-tax profits plus depreciation minus dividends) is calculated.

Equation 6 is the investment demand function and the most important relationship in the model. Gross investment expenditures are hypothesized to be a function of the permanent or expected level of raw steel production, relative factor prices, and the level of gross retained earnings relative to "the investment requirement," i.e., the investment requirement is the difference between the desired and actual capital stock. The first two variables are based on the neoclassical theory of factor demand and determine the optimal or desired level of capital. Gross retained earnings, however, enters

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[15]This equation is empirical and will be subsequently changed in Phase III of the project for conditional forecasting purposes.

TABLE 3.1

SUMMARY OF THE RECURSIVE MODEL

Dependent Variable		Explanatory Variables
(1) GCF'_t	=	$f_1(TR, TR_{-i}, CU, \Delta p, IMP, U_1)$
(2) TAX_t	=	$f_2(GCF, U_2)$
(3) NCF_t	$\equiv$	$(GCF - TAX)/PRICE\ DEFLATOR$
(4) DIV_t	=	$f_3(NCF_{-i}, DIV_{-i}, U_3)$
(5) GRE_t	$\equiv$	$NCF - DIV$
(6) I_t	=	$. f_4(\Delta Q'_{-i}, \Delta(c/w)'_{-i}, \Delta GRE_{-i}, I_{-1}, U_4)$
(7) K_t	$\equiv$	$(1-\delta) K_{-1} + I$
(8) LTD_t	=	$f_5(K, LTD_{-i}, U_5)$

Notation: GCF = gross cash flow; TR = sales revenue; CU = capacity utilization index; Δp = change in price index of steel mill products; IMP = import penetration index; TAX = taxes paid; NCF = net cash flow; DIV = dividends; GRE = gross retained earnings; I = gross investment; $\Delta Q'$ = change in permanent level of raw steel output; $\Delta(c/w)'$ = change in permanent relative factor prices where c = user cost of capital and w = wage rate; K = capital stock; δ = rate of economic depreciation; and LTD = long-term debt. The terms U_1, ..., U_5 are the stochastic error terms.

The subscripts -i refer to lagged values of variables or lagged values of changes in the level of variables. Unless otherwise indicated, the time period of explanatory variables is the current period t.

Equations (1) and (2) are in current dollars while Equations (3) - (8) are in constant 1973 dollars. The primes in Equation (6) indicate long-run or permanent values.

FIGURE 3.1

SCHEMATIC VIEW OF THE PHASE II RECURSIVE MODEL

(1)

Sales revenue, lagged
sales revenue, capacity
utilization, price
change, import pene-
tration
- - - - - - - - - - -
GROSS CASH FLOW

Error
Term
U_1

(2)

Gross cash flow
- - - - - - - - - - -
TAX PAYMENTS

Error
Term
U_2

(3)

Compute net
cash flow as
gross cash
flow less
tax payments

(4)

Lagged net
cash flow,
lagged divi-
dends
- - - - - - - -
DIVIDENDS

Error
Term
U_3

(5)

Compute gross
retained earnings
as net cash flow
less dividends

(6)

Change in permanent output,
change in permanent relative
factor prices, change in lagged
gross retained earnings, lagged
gross investment
- - - - - - - - - - - - - - - - - -
GROSS INVESTMENT

Error
Term
U_4

(7)

Compute capital stock
as beginning of period
capital stock minus
economic depreciation
plus gross investment

(8)

Capital stock,
lagged long-
term debt
- - - - - - - -
LONG-TERM DEBT

Error
Term
U_5

Legend:

Explanatory
Variables
- - - - - - -
Dependent
Variable

Behavioral
Equation

Computation
Instructions

Identity

77

the model as a determinant of the timing of investment expenditures. If the level of available internal funds is high, then the gap between desired and actual will be closed more rapidly than would otherwise be the case. Note that gross retained earnings enters the investment demand equation with a lag reflecting conditions of information and uncertainty.

Equation 7 is an identity from which the end-of-period capital stock can be calculated, and Equation 8 is a behavioral equation for the level of long-term debt or external finance that is permitted or required. This final equation also reflects partial adjustment or adaptive expectation considerations. The level of external financing is constrained by an optimal or desired debt-to-capital stock ratio. Consequently, this implies that the level of internal funds plus external funds may be insufficient, in any single period, to finance the predicted level of gross investment expenditures.

When investment is greater than new debt plus retentions, the resulting difference may be termed a "shortage" in this restricted sense of the term. Thus, while we could close the model with a fourth identity, namely, $I_t \equiv \Delta LTD + GRE$, this constraint has not been imposed on the model. If we are to talk meaningfully about "shortages," it must be possible for the model to produce disequilibrium situations. To paraphase Wold, the introduction of equilibrium assumptions is a key device, and models which include such assumptions are of limited scope for purposes of dynamic inference.[16]

Summary

This chapter outlined two models of investment, dividend and external finance behavior of the business firm. The first model consisted of three simultaneous equations and a cash flow identity. The second model consisted of five behavioral equations and three identities, which interact in a recursive manner. The equations in each model were discussed and estimation procedures were outlined. Finally, the implications of the recursive model for predicting financial shortages in the iron and steel industry were briefly noted.

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[16]Wold, op. cit., p. 461.

CHAPTER 4

A SURVEY OF STUDIES OF INVESTMENT BEHAVIOR
IN THE IRON AND STEEL INDUSTRY

Introduction

This chapter reviews several previous studies of investment be-
havior in the iron and steel industry.[1] The principal focus is on
(1) the determinants of desired capital stock which are incorporated
in each study, and (2) the time structure of the investment process
in each study. A total of six studies are reviewed here. All of
these studies use quarterly data on investment by two- and three-
digit SIC industry groups from the OBE - SEC Survey, "Expenditures
on New Plant and Equipment by U.S. Business," including the iron
and steel industry (SIC 331-2).

The chapter is divided into four sections. The first section is
a brief survey of the theories which underlie the studies in question.
The second section reviews the six studies, and the third summarizes
the determinants of iron and steel investment and the time structure
of investment. Suggestions for improved model specifications are
briefly noted in the fourth section.

General Theories of Investment

A starting point for most investment studies is the familiar
profit-maximizing prediction that firms should carry fixed invest-
ment to the point where the marginal efficiency of investment (meI)
is equal to the marginal cost of funds (mcf). This prediction may
be represented as follows:

$$(4.1) \qquad meI = f_1 (I, Z_1)$$

$$(4.2) \qquad mcf = f_2 (I, Z_2)$$

$$(4.3) \qquad meI = mcf$$

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[1]Readers whose main interest is the development and testing of
the models outlined in Chapter 3 might wish to skip this chapter.

where meI = marginal efficiency of investment,

    mcf = marginal cost funds,

      I = level of fixed investment,

    Z_1 = vector of determinants of meI,

    Z_2 = vector of determinants of mcf.

From Equations 1-3, one derives

$$(4.4) \qquad I = g(Z_1, Z_2)$$

which, ignoring lag structures, is the investment function in reduced form. Analyzing the investment decision in this manner is a little artificial, but it does enable one to concentrate on the main issues associated with determination of I. In general, the belief is that Z_1 is made up of real variables such as output, capacity utilization, or proxies for expected levels of real variables (e.g., changes in output, stock price indexes). The vector Z_2 represents determinants of the position of the mcf schedule. Following Duesenberry (1958),[2] many investigators believe that the mcf schedule is a rising function of investment and, hence, Z_2 will include financial variables such as retained earnings, depreciation allowances, long-term corporate bond rates, debt capacity, and so on.

An alternative approach to investment theory is provided by Jorgenson and his associates (1965, 1967a, 1967b, 1967c, 1969). Jorgenson assumes that a firm combines labor and capital to produce output so as to maximize its net worth, given the prices of factors and goods. Two constraints restrict the firm's behavior. The first constraint is the production function which is represented explicitly in either the Cobb-Douglas or constant elasticity of substitution form. The second constraint is an identity relating capital, investment, and depreciation. The first-order condition is that the rental price of capital services be equal to the value of the marginal product from these services. For the Cobb-Douglas case, this implies

$$\frac{\partial Q}{\partial K} = \alpha A K^{\alpha-1} L^{1-\alpha} = \frac{\alpha Q}{K} = \frac{c}{p}$$

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[2]References are given at the end of the chapter. This chapter follows Jorgenson (1971). See also Junankar (1973), Lund (1971), Bridge (1971), Rowley and Trivedi (1975), and Evans (1969).

or, rearranging,

(4.5) $K = \frac{\alpha pQ}{c}$

where Q = output,

   K = stock of capital,

   L = labor input,

   c = rental price of capital services,

   p = price of unit output,

   α = elasticity of output with respect to capital,

   A = a constant term.

The variable c, which is also referred to as the user cost of capital, may be calculated in the following manner

(4.6) $c = q \left[\frac{1-uv}{1-u} \delta + \frac{1-uw}{1-u} r \right]$

where q = price of investment goods,

   δ = rate of economic depreciation,

   r = cost of capital,

   u = the tax rate,

   v = the proportion of replacement deductible from income for tax purposes, and

   w = the proportion of the cost of capital deductible from income.

   To form the investment function, Jorgenson denotes

(4.7) $K_t^* = \alpha (\frac{pQ}{c})_t$

as the desired level of capital stock and substitutes Equation 7 in the following expression for investment

(4.8) $I_t = \mu(\theta) \left[K_t^* - K_{t-1}^* \right] + \delta K_{t-1}$

which is a form of the familiar flexible accelerator investment model, where $\mu(\theta)$ is a lag operator, and where replacement investment, δK_{t-1}, is proportional to the capital stock. A simple representation of the Jorgenson model of investment is

$$(4.9) \qquad I_t = \mu(\theta) \left[\alpha(\frac{pQ}{c})_t - \alpha(\frac{pQ}{c})_{t-1} \right] + \delta K_{t-1}$$

Jorgenson's model thus combines the effects of past changes in output levels with changes in the price of capital services.[3]

There is no fundamental disagreement about the theory of the firm underlying the various models of investment behavior to be reviewed here. Both approaches assume the objective of the firm is to maximize discounted profits subject to a technological constraint. This constrained optimization process results in a demand function for investment goods (the marginal efficiency of the capital schedule), or equivalently, a demand function for capital services (a factor demand schedule). The cost of capital is one of the determinants of the demand for investment goods or the demand for capital services.

Alternative specifications of econometric models of investment behavior differ mainly in the representation of the cost of capital and its effects on investment behavior. In the Jorgenson model, the cost of capital is represented explicitly and becomes a determinant of investment expenditures through the price of capital services. In the other models reviewed here, a more eclectic approach is followed. An attempt is made to represent a shifting, nonlinear cost of capital schedule, and this schedule is determined by a number of variables such as the flow of internal funds, the interest rate, stock market variables, debt capacity, and so on.

Review of the Literature

1. Anderson

The first econometric model of investment behavior to be considered was proposed by W. H. Locke Anderson in his monograph, Corporate Finance and Investment Behavior (1964). The determinants of investment expenditures in Anderson's model include: (1) pressure on capacity; (2) profits or gross retained earnings; (3) interest rates, both short-term and long-term; (4) short-term liquidity, such as stocks of government securities held at the beginning of the period; (5) accrued tax liability at the end of the period; and (6) long-term debt capacity. Pressure on capacity is measured by the difference between actual sales

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[3]For some criticisms of Jorgenson's model see, for example, Coen (1969) and Eisner (1968, 1969).

and previous maximum sales. Long-term debt capacity is defined as the difference between 18 percent of total assets and outstanding long-term debt at the beginning of the period. Debt capacity represents the availability of unused borrowing ability while stocks of government securities and tax liability determine available liquidity and the need for liquid assets. Anderson bases this specification on the work of Duesenberry (1958). The dependent variable is based on the OBE - SEC data on plant and equipment expenditures in current prices. Replacement investment is omitted from Anderson's model.

Anderson represents the underlying determinants of investment as four quarter moving averages of quarterly data so as to capture the lag between investment decisions to actual expenditures. The lag between a change in the expected values of determinants of investment behavior to the investment decision is based on equal weights to variables lagged one through four quarters. The best decision lag for iron and steel, as well as most other industries, is three quarters. Finally, the lag between changes in the determinants of investment behavior and changes in the anticipated values of these variables is represented by a time trend.

Anderson's results for the iron and steel industry are as follows (Anderson, 1964, p. 110)

$$(4.10) \qquad q_t I_t = b_o + 8t + \underset{(.0483)}{0.1531} (S - S_{max})_{t-3}$$

$$\underset{(.2970)}{-0.2702} \overline{RED}_{t-3} + \underset{(.0405)}{0.2728} \overline{G}_{t-3}$$

$$\underset{(.0438)}{-0.0959} \overline{Ta},_{t-3} + \underset{(.0718)}{0.0808} \overline{K}_{DL,t-3} - \underset{(27)}{153} \overline{i}_{t-3}$$

$$+ b_8 Q_1 + b_9 Q_2 + b_{10} Q_3 + e_t; \quad R^2 = 0.8143$$

In this model, $q_t I_t$ is investment in current prices, and a bar over a variable indicates a moving average for four quarters beginning with the quarter indicated (i.e., t-3) and extending backwards. The variable t is a time trend, $S - S_{max}$ corresponds to pressure on capacity, where S is sales, RED is gross retained profits equal to retained earnings plus depreciation, and i is the Treasury bill rate. The variable G is the stock of government securities, Ta is accrued tax liability, and K_{DL} is long-term debt capacity. The variables Q_1, Q_2, and Q_3 are seasonal dummies. None of the variables are deflated or seasonally adjusted. All of the independent variables are from the SEC - FTC, Quarterly Financial Report, except the Treasury bill rate which is from the Federal Reserve Bulletin. The sample period extends from the

first quarter of 1949 to the fourth quarter of 1958, a total of 40 quarters, excluding those lost in computing the moving averages.

The results for iron and steel indicate statistically significant results for t, $S - S_{max}$, i´, G, and Ta. The variables for gross retained earnings and debt capacity are not significant. Anderson also considered a number of other variables for short-term liquidity, nonfinancial assets, long-term interest rates, etc. Most of these variables performed poorly at the aggregate level and were omitted in the industry re-gressions. Furthermore, the coefficients on the short-term govern-ment securities and tax liabilities variables are almost equal and opposite in sign. Evans suggests that

> Anderson is measuring the well-known phenomenon that short-term
> government assets are specifically put aside for tax liabilities
> and do not have any effect on investment...the inclusion of short-
> term assets as a determinant of investment does not seem to be a
> very promising route to follow (Evans, 1969, pp. 124-25).

At least for the iron and steel industry, Anderson's model reduces to the flexible accelerator or capacity model in sales and capacity utiliza-tion.

2. Eisner

The second model of investment has been proposed by Robert Eisner in a series of articles (1960, 1962, 1965, 1967). The determinants of investment include changes in sales and changes in profits together with the level of capital stock. The underlying model is a version of the flexible accelerator model where net investment is equal to a weighted average of past changes in output. Changes in profits are introduced as a possible representation of changes in "the expected profitability of investment" (Eisner, 1965, p. 97). Eisner's model is, overall, an attempt to capture the effects of risk and uncertainty on investment behavior. Financial factors play a minor role in the model and enter only through changes in profit expectations. The dependent variable is gross investment expenditures from the OBE - SEC data, deflated by an implicit price deflator for producers' durable equipment and nonresi-dential construction. Capital stock is measured by the declining balance method while replacement investment is assumed to be propor-tional to net capital stock.

Eisner treats the time structure of investment behavior by means of a modified Koyck lag. The weights in this function are determined arbitrarily for the first lagged values of profits and sales and then decline geometrically. At the present time, Eisner's model has been applied to individual industry data by Jorgenson, Hunter, and Nadiri (1970a, 1970b). Their study is reviewed in the next section. A formalization of the Eisner model for individual industries is the following

$$(4.11) \quad I_t = b_0 + b_1 \Delta S_{t-1} + b_2 \Delta S_{t-2} + b_3 \Delta P_{t-1} + b_4 \Delta P_{t-2}$$

$$+ b_5 I_{t-1} + b_6 K_t + e_t.$$

In this model, ΔS is change in sales, ΔP is change in profits, and K is capital stock at the beginning of the period. The lagged value of investment expenditures is introduced in order to represent the effects of changes in sales and profits lagged more than two periods. The weights associated with these changes decline geometrically.

3. Evans

The determinants of investment in the model proposed by Michael Evans (1967) include capacity utilization, capital stock, sales, cash flow, and the interest rate. Capacity utilization is measured by the Wharton School capacity index which is calculated from the FRB index of industrial production. Cash flow is retained earnings plus depreciation. The interest rate is Moody's AAA bond rate.

The dependent variable is gross investment expenditures from the OBE – SEC data, deflated by an implicit deflator for producers' durable equipment and nonresidential construction. Capital stock is measured by deflating net fixed assets by a price index of investment goods. Evans assumes that replacement is proportional to the average of capital stock lagged five and six quarters.

The lag structure in Evans' model attempts to capture the effect of sales at the original time of planning and, in addition, sales immediately prior to the actual investment. The resulting structure is a double distributed lag based on the geometric distribution. Using Almon's (1965) study, Evans sets the appropriations lag at 13 to 15 months (5 to 6 quarters). Modifications in appropriation plans are assumed to be made in the quarter immediately prior to actual expenditures.

Evans' results for the steel industry are (Evans, 1967, p. 156)

$$(4.12) \quad I_t = b_0 + 0.0167 \, Cp_{t-1} + 0.0999 \, S_{t-5,6}$$
$$ (.0072) \phantom{Cp_{t-1} +} (.0205)$$

$$-0.2824 \, L_{t-5,6} - 0.1390 \, i_{t-5,6}$$
$$(.1990) \phantom{L_{t-5,6}} (.3150)$$

$$-0.0093 \, K_{t-5,6} + e_t$$
$$(.0163)$$

where I_t is gross investment and the notation t-5,6 indicates the average of a five-quarter and six-quarter lag. The variable Cp is capacity utilization, S is sales, L is cash flow, i is the interest rate, and K is capital stock. Replacement investment is assumed to be proportional to the average of capital stock lagged five and six quarters. In this model, only the capacity and sales variables are significant. Neither of the financial variables (profit, interest rate) is significant. The results with these latter variables dropped are (Evans, 1967, p. 157)

$$(4.13) \qquad I_t = -0.85 + \underset{(.0143)}{0.0738} \ Cp_{t-1}$$

$$+ \underset{(.0136)}{0.0553} \ S_{t-5,6} - \underset{(.0070)}{0.0270} \ K_{t-5,6} + e_t; \ \overline{R}^2 = 0.403$$

where Cp, S, and K are now significant.

Capacity utilization Cp is the Wharton School capacity index, sales S, and cash flow L are from the SEC - FTC, Quarterly Financial Report, and i is Moody's AAA corporate bond rate. All variables are deflated and seasonally adjusted. The time period covered is from 1949 through 1963 and consists of 60 quarterly observations.

Evans' model when estimated for the steel industry reduced to the flexible accelerator model in capacity and sales. Evans notes that it is particularly surprising that

> the regression results show that cash flow has no influence
> on investment in the steel industry.... However, there is
> a tendency for investment in this industry to remain high
> for about a year after (lagged) cash flow has been high.
> This does suggest that investment decisions are being back-
> logged (Evans, 1967, p. 158).

4. Jorgenson - Stephenson

The determinants of investment expenditures in the Dale Jorgenson and James Stephenson model include the value of output in current prices and the price of capital services together with capital stock, which is taken to determine investment for replacement. The price of capital services depends in turn on the price of investment goods, the cost of capital, and the tax structure (income tax, depreciation allowances, investment tax credits) for business income. The depen-dent variable is gross investment expenditures from the OBE - SEC data, deflated by an implicit deflator for producers' durable equip-ment and nonresidential structures. Capital stock at the beginning of the period is estimated from investment data, using a perpetual inventory method based on declining balance replacement. Replacement investment is assumed to be proportional to net capital stock.

Jorgenson-Stephenson characterize the time structure of the investment process by a rational distributed lag function of the general Pascal type. Empirically, their lag model is characterized by an inverted-V or peaked shape. For each industry, investment expenditure is unaffected by change in its underlying determinants for at least two quarters. Beginning at moderate levels, investment expenditures rise rapidly to a peak that occurs between four and eight quarters after the changes in the underlying determinants. After the peak is attained, the level of investment expenditures falls off gradually so that all influences of the change are felt after twenty-four quarters.

Jorgenson-Stephenson have described their model in several papers (1967a, 1967b, 1969). The basic result for iron and steel is (Jorgenson and Stephenson, 1967a, p. 187)

$$
\begin{aligned}
(4.14) \quad I_t = b_o &+ \underset{(.00119)}{0.00372} \; \Delta(\tfrac{pQ}{c})_{t-5} \\
&+ \underset{(.00179)}{0.00221} \; \Delta(\tfrac{pQ}{c})_{t-6} + \underset{(.00173)}{0.00265} \; \Delta(\tfrac{pQ}{c})_{t-7} \\
&- \underset{(.13929)}{1.14061} \; (I - \delta K)_{t-1} + \underset{(.13826)}{0.30577} \; (I - \delta K)_{t-2} \\
&+ \underset{(.00634)}{0.02170} \; K_t + e_t; \; R^2 = 0.855.
\end{aligned}
$$

In this model pQ is gross value-added in current prices and c is the rental price of capital services. The values of lagged <u>net</u> investment, $I-\delta K$, are introduced as part of the representation of the time structure of the investment process. The average lag between changes in desired capital and changes in net investment expenditure is 9.06 quarters for the iron and steel industry (1967b, p. 21). No investment expenditures are recorded until five quarters have elapsed; the peak impact occurs in the seventh quarter after the change, and then a gradual tailing-off occurs over the remainder of a twenty-four quarter period. However, it should be noted that Jorgenson-Stephenson's results do not show statistical significance for the $\Delta(pQ/c)_{t-6}$ and $\Delta(pQ/c)_{t-7}$ variables. At least for iron and steel, this suggests that the Jorgenson-Stephenson model may misrepresent the lag structure in question.

The value of output is taken to be gross value-added in the industry. The components of value added and the elements of the tax structure are taken from annual levels of profits, depreciation, etc., from the SEC – FTC, <u>Quarterly Financial Report</u>. All data are deflated and seasonally adjusted. The sample period is 1949 through 1960, a total of forty-eight quarters.

5. Meyer-Glauber

John R. Meyer and Robert R. Glauber proposed a model of investment in their monograph, Investment Decisions, Economic Forecasting, and Public Policy (1964). An eclectic model is examined; the determinants of investment expenditures include capacity utilization, profits, interest rates, and the percentage change in the price of common stocks. This model is sometimes referred to as the accelerator-residuals fund model (Rowley and Trivedi, 1975, p. 30). Pressure on capacity is measured by the ratio of the Federal Reserve Board index of industrial production to the McGraw-Hill capacity series. The profit variable is defined as retained earnings plus depreciation expense. The interest rate is Moody's AAA industrial bond rate while the stock price index is from Standard and Poor. The dependent variable is new investment from the OBE – SEC data, deflated by implicit deflator for producers' durable equipment and nonresidential construction. Replacement investment is omitted in the Meyer-Glauber model.

Meyer and Glauber employ a geometric lag to describe the time structure of investment expenditures. For each of the independent variables, a separate lag structure is determined; for example, the profit variable is lagged one quarter while the bond rate is lagged three quarters. The overall result is a double-peaked lag structure somewhat similar to that employed by Evans.

The Meyer-Glauber results for the iron and steel industry are (Meyer and Glauber, 1964, p. 155)

$$(4.15) \quad I_t = b_o + 0.122 \ (T-V)_{t-1} + 140.7 \ c^M_{t-1}$$

$$- 30.8 \ r_{t-3} + 75.5 \ \Delta SP_{t-1} + 0.876 \ I_{t-2}$$

$$+ b_6 Q_1 + b_7 Q_2 + b_8 Q_3 + e_t; \ R^2 = 0.750$$

where $T-V$ is gross retained profits, c^M is the capacity utilization variable, r is the corporate bond rate, and ΔSP is the percentage change in the Standard and Poor's index of stock prices of 425 industrials. The variables Q_1, Q_2, and Q_3 are seasonal dummy variables. In this model, only the lagged investment variable, I_{t-2}, is statistically significant. The Meyer-Glauber model reduces to a simple first-order autoregressive scheme. Any explanatory power that might be attributed to profits, capacity utilization, interest rates, or stock prices is largely captured in the lagged investment variable.

The profits variable is obtained from the SEC – FTC, Quarterly Financial Report. The capacity utilization variable is from Federal

Reserve Board and McGraw-Hill data; the interest rate is Moody's AAA industrial bond yield, and the stock price index is from Standard and Poor. All data are deflated. The sample period extends from 1950 through 1958, a total of thirty-six quarters.

6. Resek

A final model of investment expenditures is that proposed by Robert Resek (1966). In the Resek model, the determinants of expenditures include output, change in output, the rate of interest, a measure of debt capacity, and an index of stock prices. The dependent variable is gross investment, deflated by a price index for investment goods and divided by capital stock, but other independent variables enter the regression directly. Replacement investment is assumed to be proportional to capital stock. Capital stock is measured using the declining balance method.

Resek employs a fixed lag structure for all variables. The weights in this lag structure are taken directly from a regression of investment expenditures on capital appropriations by Almon (1965). Resek employs Almon's weights with all variables lagged one quarter, implying expectations and decision lags of only one quarter. Resek indicates "that since Almon's estimates are for the lag from appropriations to investment only, the actual lag is understated" (Resek, 1966, p. 327). For iron and steel, the appropriations lag is eight quarters with the peak impact in the sixth quarter. The average lag is between five and six quarters.

Resek presents his results in terms of elasticities evaluated at the mean of each variable. The output and change in output variables are highly correlated with each other. The best results for iron and steel (as well as most other industries) are obtained when the change in output variable is employed. The results in terms of elasticities for iron and steel are (Resek, 1966, p. 332):

Variable	Elasticity	t - Ratio
$\Delta Q_{L,t-1}/K_t$	0.24	0.83
$r_{L,t-1}$	-3.34	-6.21
$1/(M - \frac{D-F}{A})_{L,t-1}$	0.10	0.59
$SP_{L,t-1}$	1.18	6.44

$$\bar{R}^2 = 0.693$$

In this model the subscript L refers to a moving average of the corresponding variables with Almon weights, beginning in the t-1 quarter and extending backwards for eight quarters. The variable ΔQ is the change in output over four quarters, r is the interest rate, and SP is the stock price index. The variable $M - (D-F)/A$ is debt capacity, where D is debt, F is retained earnings, A is assets, and M is a constant. The interest rate and stock price variables are statistically significant but change in output and debt capacity are not significant. Thus, Resek's model does not reduce to a flexible accelerator model in output or sales. Some of these results may be occasioned by the peculiar form of the dependent variable, $(I/K)_t$. In addition, Resek experimented with relative prices variables for capital services and labor, and with an unfilled orders variable. Results for these variables were disappointing and they were dropped from the model. The output variable is measured as the FRB index of industrial production, the interest rate is Moody's AAA industrial bond rate, the debt capacity measure is from the SEC – FTC, Quarterly Financial Report, the stock price index is from the SEC. The variables are deflated and quarterly dummy variables are included as in the Anderson and Meyer-Glauber models. The time period is 1953 through 1962, a total of forty quarters.

The Determinants of Desired Capital Stock
and the Time Structure of Investment: An Evaluation

The determinants of the desired level of capital in the six studies may be divided into three groups: (1) capacity utilization; (2) internal finance; and (3) external finance.

Capacity utilization appears as a highly significant determinant of desired capital in most of the studies. Measures of capacity utilization that appear as significant determinants of investment include Anderson's measure of sales less previous peak sales and the Wharton School capacity index in Evans' study. However, Meyer-Glauber's measure of the ratio of the FRB index of industrial production to the McGraw-Hill capacity index was not significant. The level of real output (physical output or deflated sales) may be regarded as a measure of capacity in a relationship which also includes deflated capital stock. Measures of output employed in this way include the change in deflated sales employed by Eisner. The change in output in Resek's model is not significant for iron and steel, but his model does not include capital stock as a direct right-hand side variable. Jorgenson and Stephenson include real output along with the ratio of output price to the price of capital services and capital stock. In a limited way, their model also includes capacity utilization as a significant determinant of investment expenditures.

Variables associated with internal finance do not appear as significant determinants of desired capital in any model which also includes

output as a determinant of investment. Cash flow variables are not significant determinants in the models of Anderson, Evans, and Meyer-Glauber. Change in profits is included in Eisner's model but is generally subordinate to sales changes. Other measures of internal finance employed by Anderson--stocks of government securities and accrued tax liability--can be ignored for reasons noted above. Measures of debt capacity employed by Anderson and Resek are not significant as determinants of investment. Jorgenson and Stephenson do not include a measure of internal finance as such.

Among variables associated with external finance, the interest rate appears as a significant variable in the Anderson and Resek models. The interest rate is not significant in the Evans and Meyer-Glauber models. An index of stock prices is significant in Resek's model but not in Meyer-Glauber's. Eisner's model does not incorporate external finance variables except to the extent that the change in profits might measure the cost of external finance. Jorgenson and Stephenson include the cost of external finance as part of the rental price of capital services. The cost of external finance is measured as the weighted average of the rate of return on equity and the rate of interest on debt.

A review of these studies suggests that the most important variable to be accounted for is output or some form of capacity utilization. Internal finance variables--cash flow and debt capacity--do not appear as significant variables in the investment function. This is a somewhat surprising result for iron and steel. However, change in profits may be significant. External finance variables--interest rates and stock prices--appear to be of less significance in relation to output.

Part of the insignificance of some of these variables is undoubtedly due to the high intercorrelations and strong common trends that exist in time series data. However, Evans (1969, Chapter 5) makes a number of interesting and possibly significant observations about investment in the iron and steel industry. These comments are worth repeating here:

1.   There is some information besides that contained in sales, capital stock, interest rates, and various measures for cash flow that businessmen utilize when making investment decisions. The importance of expectations suggests that an index of stock prices is a proxy for expected future output. Stock price is, however, primarily a modifications variable; it is only significant with moderate-to-long lags.

2.   Another important variable, especially in the iron and steel industry, is unfilled orders. However, unfilled orders impart information about current requirements of demand and not future requirements; i.e., where sales fluctuate substantially, current sales will contain a substantial transitory component. Thus, unfilled orders are only significant with a short-to-moderate lag.

3.	Significant cash flow variables for the iron and
steel industry cannot be found even at the expense
of data mining. The steel companies are constantly
arguing that they need larger profits to have
enough money for investment in new plant and equip-
ment. According to Evans, it would appear that the
plea is really for higher profits alone, and that in-
vestment plans are determined largely by output re-
quirements.

The time structure of the investment process has been represented
by finite, geometric, and rational distributed lag structures. Finite
distributed lag structures are employed by Eisner and by Resek. Geo-
metric distributed lag functions are employed by Eisner and Meyer-
Glauber. Rational distributed lag functions are employed by Evans
and Jorgenson-Stephenson. The lag structure employed by Anderson
involves four quarter moving averages and a time trend.

The time structure of investment may be divided into three com-
ponents. One part of the lag is between changes in the determinants
of investment behavior and changes in the expectations about these
variables--the expectations lag. The second part of the time struc-
ture is a lag from a change in the expected values of determinants
of desired capital to the actual decision to invest--the decision
lag. The final lag is from the investment decision to actual ex-
penditures--the appropriations lag. The expectations lag has been
estimated at four quarters by Anderson (1964, p. 68) from National
Industrial Conference Board data. The average total lag from de-
cisions to the completion of the project has been estimated at seven
quarters by Mayer (1955, 1960). These results suggest an average
total lag from changes in the underlying determinants of investment
to completion of between seven and eleven quarters. These data
seem consistent with Jorgenson-Stephenson results. Most other studies
have probably employed too short an average lag structure; i.e., they
underestimate the average lag in the investment process.

To complete this summary, we have drawn on the survey results of
Jorgenson, Hunter, and Nadiri (1970a, 1970b). The authors attempt to
compare the explanatory and predictive power for the various models of
investment behavior due to Anderson, Eisner, Jorgenson-Stephenson, and
Meyer-Glauber. These results are also compared to a naive, fourth-order
autoregressive model and to a model based on anticipations data. The
authors fit the four models to deflated, seasonally adjusted data from
1949 through 1964.

Goodness of fit statistics for each investment function are given
in Table 1. Three measures of goodness of fit are presented. The
coefficient of determination, R^2, not adjusted for degrees of freedom,
is given in the first column. The second column gives the standard
error of the fitted regression residuals, s_y, corrected for degrees of
freedom. The final measure is the Durbin-Watson ratio, D-W, as a

TABLE 4.1

TEST STATISTICS FOR GOODNESS OF FIT

Model	R^2	s_y	D-W
Anderson	0.4631	0.0573	0.3630
Eisner	0.8047	0.0342	1.5758
Jorgenson-Stephenson	0.8451	0.0307	2.2556
Meyer-Glauber	0.6853	0.0431	0.6330
Autoregressive	0.8517	0.0286	1.9871
Anticipations	0.8999	0.0215	1.6326

Source: Jorgenson, Hunter, and Nadiri
        (1970a, p. 204-05).

TABLE 4.2

TEST STATISTICS FOR STRUCTURAL CHANGE

Variable	$F_{calc.}$	$F_{.05}$
Anderson	1.767	2.10
Eisner	1.055	2.21
Jorgenson-Stephenson	0.422	2.15
Meyer-Glauber	2.126	2.29

Source: Jorgenson, Hunter, and Nadiri
        (1970b, p. 222)

measure of autocorrelation of the residuals. The best (highest) R^2 is provided by the Jorgenson-Stephenson model and this model also has the smallest regression standard error. The R^2 and s_y of the Jorgenson-Stephenson model are slightly inferior to the fourth-order autoregressive model. The Jorgenson-Stephenson model performs best with respect to the autocorrelation of residuals.

A predictive test is also provided by the authors. First, the models are fitted for 1949 through 1960 and for 1961 through 1964. To test for predictive accuracy, i.e., absence of structural change, the models are then fitted for 1960 through 1964 and the appropriate F-statistic (Chow test) is calculated. These statistics are presented in Table 2. Although the null hypothesis of no structural change is not rejected for any of the four models for the steel industry, the Jorgenson-Stephenson model does have the best (i.e., lowest) calculated F-statistic.

Summary

It is disappointing not to be able to come to more definitive conclusions after a survey of six studies of investment in iron and steel. None of these studies were concerned, however, with the iron and steel industry alone, and all are concerned with fitting a general model to a number of two- and three-digit industries. This perhaps explains the lack of definite empirical conclusions.

A few general conclusions can nevertheless be drawn from this survey. First, output and relative prices seem to be the key variables in explaining iron and steel investment. (However, Junankar (1972, p. 68) suggests that there is a shorter lag for output changes than for relative prices.[4]) Second, a liquidity variable (e.g., change in profits) is possibly significant. Following Eisner (1965), current opinion suggests that internal funds available to the firm may affect the timing of investment but not the long-run rate of investment. Third, the investment process is a long drawn-out affair. A change in an exogenous variable leads to changes in investment over a long period of time. The average lag is between seven to eleven quarters. In iron and steel, the average lag may be even greater, depending on the plant and equipment in question.

Each of these points can be incorporated in a model of investment demand. However, they are perhaps best considered in a model which does not use an explicit production function. For this reason, the investment model presented in Chapter 7 will be based on a general model suggested by Coen (1968, 1969, 1971). Output changes and relative price changes will be entered as separate variables, with possibly different

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[4] See also Bischoff (1971).

lag structures.   Internal funds are included as a determinant of the speed at which firms eliminate the gap between their desired and actual stocks of capital.   At least in terms of goodness of fit, the model is an improvement over the Phase I investment model (Neumann, 1975).   Other real and financial factors are represented by the recursive relationships discussed in Chapter 3.

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CHAPTER 5

PROFITS, CAPACITY UTILIZATION, AND IMPORTS

Introduction

This chapter examines the determinants of profits in the iron
and steel industry for the period 1960 to 1973. To many observers,
the magnitude of profits (or the broader aggregate, cash flow), is
a critical variable in determining the level of investment expendi-
tures. For example, Hogan states that:

> As steel makers organize their investment planning,
> the 1970s should logically be a period of expansion.
> Substantial expenditures will be needed to meet the
> demand for steel by 1980, but it is difficult to
> justify the required capital outlay for added capa-
> city on the basis of the low profits recorded in
> 1970 and 1971. As a consequence, the next few years
> are critical for steel, for if the profit picture
> does not improve materially, there could be a
> question about future steel investment and about
> the future growth of the industry.[1]

To determine what factors have influenced the level of steel
industry profits in the recent past, this chapter develops several
models of the profits function. The models proposed are based on
the theoretical and empirical work of Michael K. Evans and parallel
the profits functions which are incorporated in the Wharton Econometric
and Forecasting Unit Model of the macroeconomy.[2] Among the variables
examined in this chapter are the level of steel mill product prices,
labor costs, capacity utilization, import steel tonnage, and long-term
debt capacity. It is argued that these factors influence the level
of fixed investment in the steel industry through their impact on
profits. These factors by no means exhaust the list of variables which
determine profits, but they are among the more important variables that
must be considered.

Before presenting the profits function model and the empirical
results, we briefly review some of the salient data on this subject.
First, as noted in Chapter 2, raw steel output could grow to 167

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[1]W. T. Hogan, S. J., The 1970s: Critical Years for Steel (Lexington,
Mass.: Lexington Books, 1972), p. 1.

[2]See M. K. Evans, Macroeconomic Activity: Theory, Forecasting,
and Control (New York: Harper and Row, 1969), pp. 274-280; and M. K.
Evans, "An Industry Study of Corporate Profits," Econometrica, 36
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million net tons by 1980 and would probably average 170 to 175 million net tons in the 1980s. Current raw steel capacity is about 160 to 165 million net tons. Allowing for peak periods of production (85 to 90 percent capacity utilization), total capacity would have to increase to between 190 and 200 million net tons to meet these requirements. Depending on the assumptions made, the required investment outlay for, say, 30 million tons of capacity by 1980 would be around $8.25 billion dollars in 1973 dollars, or more, plus $12.25 billion for replacement and modernization of existing facilities.[2a]

To see how these investment magnitudes might affect the financial structure of the steel industry, Table 1 presents annual steel industry sales revenue, after tax profits, and various rates of return for the period 1953 to 1975. Sales revenues, in current dollars, have steadily grown during this period but profits have not kept pace. For example, profits averaged $737 million per annum during the 1958-62 period and only $748 million per annum during 1968-72. The most important indicator of profitability--percent return on stockholders' equity--fell from an average yield of 7.1 percent in 1958-62 to 5.7 percent in 1968-72, and reached a low of 4.1 percent in 1970. Although low profits or profitability in one year is largely irrelevant for the magnitude of fixed investment over the long run, continued low profits would raise considerable questions about the ability of the steel industry to attract financial capital. On the other hand, historical, average rates of return do not adequately reflect the profitability of fixed investments at the margin. It can be argued that the necessary financial sums could be acquired by either (1) increasing the amount of leverage (debt relative to equity) in the industry's financial structure or (2) reducing dividend payments to existing stockholders and thereby retaining a greater percentage of profits or cash flow.

Data on past levels of profits, depreciation, dividends and capital expenditures are presented in Table 2. In general, these data show the relative importance of retained earnings and depreciation (gross retentions) in financing capital expenditures. Gross retained earnings were 89 percent of capital expenditures during 1958-62, 96 percent during 1963-67, and 86 percent during 1968-72. Since the steel industry has issued very little new equity capital, these differences between capital expenditures and retentions have been met by increases in the amount of long-term debt held. Of course, there are presumably limits to which leverage can be used without endangering the financial security of all investors, especially in a cyclical industry such as iron and steel. In part, given the low level of profits during much of the post-1960 period, capital expenditure requirements have been met through a combination of increases in the percent of profits or cash flow retained (reduced dividend payouts) and increases in the proportion of debt-to-equity.

[2a]See American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy, (Washington, D.C.: February 1975), pp. 26-7.

TABLE 5.1

IRON AND STEEL INDUSTRY REVENUES, PROFITS AND RATES OF RETURN
(Millions of Current Dollars)

	Revenue[a]	After-Tax Profits	Percent of Revenues	Percent of Stockholders' Equity	Percent of Total Invested Capital
1953	$13,156	$ 735	5.6%	11.5%	9.1%
1954	10,593	637	6.0	9.4	7.4
1955	14,049	1,099	7.8	15.4	11.6
1956	15,272	1,113	7.3	14.1	10.9
1957	15,592	1,132	7.3	13.1	10.0
1953-57 Ave.	$13,732	$ 943	6.9%	11.8%	9.9%
1958	12,551	788	6.3	8.3	6.5
1959	14,233	831	5.8	8.4	6.6
1960	14,221	811	5.7	7.9	6.2
1961	13,295	690	5.2	6.5	5.1
1962	13,981	566	4.1	5.3	4.2
1958-62 Ave.	$13,656	$ 737	5.4%	7.1%	5.7%
1963	14,613	782	5.4	7.3	5.7
1964	16,357	992	6.1	9.0	7.0
1965	17,972	1,069	5.9	9.4	7.1
1966	18,288	1,075	5.9	8.9	7.2
1967	16,880	830	4.9	6.9	5.1
1963-67 Ave.	$16,822	$ 950	5.6%	8.1%	6.4%
1968	18,679	992	5.3	8.1	5.8
1969	19,231	879	4.6	7.0	5.0
1970	19,270	532	2.8	4.1	2.9
1971	20,358	563	2.8	4.3	3.1
1972	22,556	775	3.4	5.8	4.1
1968-72 Ave.	$20,019	$ 748	3.7%	5.7%	4.2%
1973	28,863	1,272	4.4	9.3	6.5
1974	38,244	2,475	6.5	17.1	11.8
1975	33,746	1,588	4.7	9.8	6.9

[a]Net billing of products shipped plus interest, dividends and other income.

Source: American Iron and Steel Institute, Annual Statistical Report.

TABLE 5.2

IRON AND STEEL INDUSTRY SELECTED FINANCIAL DATA
(Millions of Current Dollars)

	Profits After Taxes	Depreciation Depletion, etc.[a]	Net Cash Flow	Cash Dividends	Gross Retained Earnings	Capital Expenditures
1953	$ 735	$ 598	$1,333	$ 324	$1,009	$ 988
1954	637	703	1,340	343	997	609
1955	1,099	783	1,882	437	1,445	714
1956	1,113	794	1,907	508	1,399	1,311
1957	1,132	816	1,948	566	1,382	1,723
1953-57 Ave.	$ 943	$ 739	$1,682	$ 436	$1,246	$1,069
1958	788	713	1,501	540	961	1,136
1959	831	653	1,484	553	931	934
1960	811	840	1,651	564	1,087	1,521
1961	690	749	1,439	557	882	960
1962	566	958	1,524	508	1,016	911
1958-62 Ave.	$ 737	$ 783	$1,520	$ 544	$ 976	$1,092
1963	782	1,034	1,816	443	1,373	1,040
1964	992	1,046	2,038	462	1,576	1,600
1965	1,069	1,117	2,186	468	1,718	1,823
1966	1,075	1,199	2,274	483	1,791	1,953
1967	830	1,444	2,274	481	1,793	2,146
1963-67 Ave.	$ 950	$1,167	$2,118	$ 467	$1,651	$1,712
1963	992	1,316	2,308	452	1,856	2,307
1969	879	1,173	2,052	489	1,563	2,047
1970	532	1,128	1,660	488	1,172	1,736
1971	563	1,123	1,686	390	1,296	1,425
1972	775	1,196	1,971	402	1,569	1,174
1968-72 Ave.	$ 748	$1,187	$1,935	$ 444	$1,491	$1,738
1973	1,272	1,329	2,601	443	2,158	1,400
1974	2,475	1,553	4,028	674	3,354	2,115
1975	1,588	1,593	3,181	658	2,523	3,215

[a] Includes changes in reserves.

Source: American Iron and Steel Institute, Annual Statistical Report.

Table 3 shows changes in the debt-equity ratio while Table 4 illustrates the changes in dividend payouts. Debt as a percentage of equity rose from about 25 percent in 1958-62 to 38 percent in 1968-72, an increase of 13 percentage points. Dividend payouts averaged 74 percent of after tax profits during the former period and 59 percent of profits during the latter period. However, an average dividend payout of 59 percent is about 10-13 percentage points greater than the payouts experienced during the capital expansion and modernization periods of 1953-57 and 1963-67. This experience suggests that the short-run upper limit on the debt-equity ratio might be about 35-40 percent while the short-run lower limit on dividend-to-profits payout is around 40-45 percent.

What implications can be drawn from these broad comparisons? First, given a forecast of the expected level of profits, we can predict the amount of profits which are retained for capital expenditures conditional on either a structural model of the dividend decision or an _a priori_ estimate of the lowest possible dividend payout consistent with financial stability and integrity. Second, given an estimate of retained earnings and forecast of the level of investment expenditures, we can then determine the level of required debt financing from either a structural model of the external financing decision or from an _a priori_ estimate of the debt-equity ratio consistent with financial stability and integrity. To the extent that these decisions are made simultaneously, they must be considered in the context of a simultaneous equation system. To the extent that the decisions are made recursively (at least within the context of quarterly data), then single-equation, ordinary least-squares may suffice. This report focuses on the first of these alternatives-- the structural equation approach--and considers both simultaneous and recursive equation systems.

Profits--The Conceptual Model

We first consider the effects of labor cost increases on the level of profits. Corporate profits before income taxes are defined as an economic residual:

(5.1) $\pi \equiv TR - TC$

$$= pQ - I - W' - T_B - D - R$$

where π = corporate profits before corporate income taxes,
  TR = total sales revenue,
  pQ = revenue expressed as price times quantity,
  TC = total cost of production,
  I = total cost of all intermediate goods,
  W' = compensation of employees,
  T_B = indirect business taxes,
  D = depreciation, and
  R = rent and net interest.

TABLE 5.3
IRON AND STEEL INDUSTRY LONG-TERM DEBT AND STOCKHOLDERS' EQUITY
(Millions of Current Dollars)

December 31	Long-Term Debt	Stockholders' Equity[a]	Percent Debt to Equity	Percent Debt to Total Invested Capital
1953	$1,327	$ 6,781	19.6%	16.4%
1954	1,486	7,140	20.8	17.2
1955	1,547	7,920	19.5	16.3
1956	1,568	8,665	18.1	15.3
1957	1,802	9,466	19.0	16.0
1953-57 Ave.	$1,546	$ 7,994	19.3%	16.2%
1958	2,145	9,898	21.7	17.8
1959	2,303	10,248	22.5	18.3
1960	2,488	10,545	23.6	19.1
1961	2,969	10,648	27.9	21.8
1962	2,854	10,676	26.7	21.1
1958-62 Ave.	$2,552	$10,403	24.5%	19.7%
1963	2,695	11,008	24.5	19.7
1964	2,874	11,399	25.2	20.1
1965	3,120	12,032	25.9	20.6
1966	2,782	12,045	31.4	23.9
1967	4,205	12,169	34.6	25.7
1963-67 Ave.	$3,135	$11,731	26.7%	21.1%
1968	4,601	12,618	36.5	26.7
1969	4,608	12,836	35.9	26.4
1970	5,134	12,967	39.6	28.4
1971	5,144	13,281	38.7	27.9
1972	5,230	13,675	38.3	27.7
1968-72 Ave.	$4,943	$13,075	37.8%	27.4%
1973	4,963	14,513	34.2	25.5
1974	4,651	16,243	28.6	22.3
1975	5,699	17,192	33.1	24.9

[a]Net worth.
Source: American Iron and Steel Institute, Annual Statistical Report.

TABLE 5.4

IRON AND STEEL INDUSTRY DIVIDEND PAY-OUTS

	Dividends (million dollars)	Percent of Net Profits	Percent of Net Cash Flow
1953	$324	44.1%	24.3%
1954	343	53.8	25.6
1955	437	39.8	23.2
1956	508	45.6	26.6
1957	566	50.0	29.1
1953-57 Ave.	$436	46.2%	25.9%
1958	540	68.5	36.0
1959	553	66.5	37.3
1960	564	69.5	34.2
1961	556	80.7	38.7
1962	508	89.8	33.3
1958-62 Ave.	$544	73.8%	35.8%
1963	443	56.6	24.4
1964	462	46.6	22.7
1965	468	43.8	21.4
1966	483	44.9	21.2
1967	481	58.0	21.2
1963-67 Ave.	$467	49.2%	22.1%
1968	452	45.6	19.6
1969	489	55.6	23.8
1970	488	91.7	29.4
1971	390	69.3	23.1
1972	402	51.9	20.4
1968-72 Ave.	$443	59.4%	23.0%
1973	443	34.8	17.0
1974	674	27.2	16.7
1975	658	41.4	20.7

Source: American Iron and Steel Institute, Annual Statistical Report.

This identity must hold for either current dollars or for appropriately defined constant dollars. However, it may be more relevant to write the identity in money terms. If product prices fluctuate while some factor prices remain constant, profits will be substantially effected. We treat this as an empirical question so that the relationships to be estimated are expressed in either current or constant dollars.

Equation 1 may be simplified somewhat by treating I and W' as variable costs and D and R as fixed costs, which do not fluctuate cyclically. That is, I and W' are generally output dependent while D and R are generally proportional to the capital stock (K) over the short run. Indirect business taxes are treated as a variable cost component. Thus, profits may be divided into variable and fixed components by using the following expression:

$$(5.2) \quad \pi \equiv TR - TVC - TFC - T_B$$

$$= pQ - (I + W') - (D + R) - T_B$$

$$= pQ - W - rK - T_B$$

where TVC = total variable costs or $I + W' = W$, and

TFC = total fixed costs or $D + R = rK$.

Turning to the effects of wage changes on profits, assume some simplified functions of the form $W = wL$, $L = bQ$, so that $W = wbQ$, where w = wage rate and L = labor input in appropriately defined units.[3] Assume also that $T_B = t(pQ)$, where t is the indirect tax rate on sales revenue. Making these substitutions, we have

$$(5.3) \quad \pi = (1 - t)pQ - (wb)Q - rK$$

For perfect competition, the following expression for price is assumed to hold

$$(5.4) \quad p = \frac{1}{\alpha}MC = \frac{w}{\alpha MPP_L}$$

where $1/\alpha$ = a full cost markup factor which incorporates capital costs, where α is the share of output received by labor,
   MC = marginal cost,
   MPP_L = marginal product of labor.

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[3]The relationship $W = wL$ assumes that either: (1) the total cost of intermediate goods is functionally related to the level of labor; or (2) there is little short-run substitutability between intermediate goods and the other factors of production. If (2) is the case, then the ratio of intermediate goods to final output (I/Q) remains constant over the business cycle and does not cause cyclical flucuations in profits.

Assume that firms are producing on the horizontal part of their MC curve, so that MC = Average Variable Cost (AVC), then

$$(5.5) \qquad p = \frac{w}{\alpha APP_L} = \frac{wL}{\alpha Q} = \frac{wb}{\alpha}$$

Substituting for p from Equation 4 in Equation 3 yields

$$(5.6) \qquad \pi = b \left[\frac{(1-t)}{\alpha} - 1 \right] (wQ) - rK$$

To examine the effects of a wage change on profits (under the assumptions made), differentiate Equation 6 with respect to wages

$$(5.7) \qquad \frac{\partial \pi}{\partial w} = b \left[\frac{(1-t)}{\alpha} - 1 \right] \left[Q + w\frac{dQ}{dw} \right]$$

Since $w = (\alpha/b)p$, then $dw = (\alpha/b)dp$, and Equation 7 can be rewritten in the following form:

$$(5.8) \qquad \frac{\partial \pi}{\partial w} = b \left[\frac{(1-t)}{\alpha} - 1 \right] Q \left[1 + \frac{pdQ}{Qdp} \right]$$

$$= b \left[\frac{1-t}{\alpha} - 1 \right] Q (1+e)$$

where e is the price elasticity of demand for the product. The sign of $\partial \pi / \partial w$ will thus depend on the relative magnitudes of the parameters t, α and e. For example, if the product demand is inelastic and the markup factor is greater than unity, then any changes in wages will change profits in the same direction. More generally, the following relationships hold:

	Case (1):	Case (2):
$\frac{\partial \pi}{\partial w} > 0$	e > -1 $\frac{1-t}{\alpha} > 1$	e < -1 $\frac{1-t}{\alpha} < 1$
$\frac{\partial \pi}{\partial w} < 0$	Case (3): e > -1 $\frac{1-t}{\alpha} < 1$	Case (4): e < -1 $\frac{1-t}{\alpha} > 1$

where Case (1) corresponds to the inelastic demand and markup greater than unity example.

The criterion of inelastic demand is likely to be quite stringent in the long-run or in the presence of competition from imports. In addition a markup much greater than unity implies a redistribution of income away from labor which is inconsistent with the long-run evidence on factor shares. Consequently, Case (4) would prevail if continued industry-wide price increases imply an increase in the factor share occurring to capital and demand is elastic. Wage increases are also likely to be granted quite liberally as long as it is possible to pass all or most of the wage increase on to consumers, and not reduce profits. However, when new sources of supply and substitutes are found, there is likely to be a great deal of switching away from the relatively higher-priced product (to imports or substitute products such as plastics), revealing a much higher long-run elasticity of demand. If money wage demands in excess of productivity gains continue to take place, then real profits will fall in the long run, all other things being equal. In the steel industry, the sharp drops in profits after 1958 and increased steel imports are the bellwether of an increasing elasticity of demand. Consequently, a negative effect of wages or unit labor costs on real profits should be expected. However, we cannot rule out a positive relationship since Case (2) could also hold during certain phases of the business cycle. These predictions must also be qualified in light of the generally oligopolistic structure of the steel industry. Market structure considerations are discussed in the next section.

Profits--The Empirical Model

Having examined some aspects of costs and profits, we now proceed to derive a profits function. The starting point is the identity for profits in which are substituted various linear equations for the factor shares of labor and capital. The result is an explicit profits function which may incorporate alternative hypotheses about the determinants of factor shares. To illustrate the underlying methodology, suppose that wage demands of labor are a function of lagged sales revenue and, in the short run, fixed costs are proportional to the capital stock. These hypotheses are consistent with the following expressions for wages

$$(5.9) \quad w = h(pQ)_{-i}$$

and for fixed costs

$$(5.10) \quad rK = f'(K)$$

The necessary substitutions are quite tedious and are thus presented in Appendix A. The general relationship is of the form

$$(5.11) \quad \pi = a(pQ) + (b'Q - f'K) + dp - h'(pQ)_{-i} + c'$$

where a, b´, f´, d, h´, and C´ are parameters. If we define the
capacity utilization rate CU ≡ actual Q/maximum Q, and maximum Q =
m(K), then CU = (1/m) (Q/K). Equation 11 can then be rewritten
in the form

(5.12) $\pi = a(pQ) + m(CU) + dp - h´(pQ)_{-i} + C$

which is the basic equation form considered for empirical implementa-
tion. Several alternatives were also considered for Equation 12;
for example, the substitution of Δp for p could be considered (see
Appendix A). This and other specifications are discussed in the next
section.

Before turning to the empirical results, some comments on
market structure and profits are in order. The iron and steel industry
is widely regarded as an oligopolistic industry, although the degree of
recognized interdependence has probably declined somewhat over time.
In an imperfectly competitive case, profit maximizing firms should always
attempt to be in a price-profit situation where Case (4) is applicable.
Indeed, this was our dynamic explanation for the pricing behavior of
the steel industry prior to 1958. The markup factor if firms are
not perfectly competitive (or if there is some adjustment lag in competitive
markets) is given by the following expression:

(5.13) $p = \dfrac{1}{\alpha} \left(\dfrac{e}{e-1}\right) MC$

$\qquad = \dfrac{1}{\alpha} \left(\dfrac{e-1}{e-1} + \dfrac{1}{e-1}\right) MC$

$\qquad = \dfrac{1}{\alpha} (1 + k) MC$

where e is again the price elasticity of demand and MC is assumed to be
constant in the relevant range of output. Price p is now determined
on the basis of the full cost markup $(1/\alpha)$ and an additional markup
factor k = 1/e-1. The k-factor is in a sense a measure of the degree
of monopoly power. For $1 \leq |e| < \infty$, the k-factor will approach zero
as elasticity becomes more elastic and infinity as elasticity approaches
unity. Thus, industries characterized by oligopoly should almost
certainly find themselves in Case (4), where demand is elastic (e < -1)
and the markup factor is greater than unity, i.e., $(1 + k - t/\alpha) > 1$.
In these circumstances, increases in wage rates, or more generally,
increases in unit labor costs, should reduce profits, all other things
being equal.

There are, however, a number of other circumstances that must be
accounted for in interpreting Equation 12. First, the lagged sales
term in the profit function is supposed to reflect the negative effect
of lagged wage responses on profits. An increase in wages might not
lead to much change in profits if demand is inelastic and markups are small.

Futhermore, if the lagged sales term is only supposed to represent unit labor costs, then the inclusion of a unit labor cost (ULC) term should reduce the importance of lagged sales, where $ULC = wL/Q$. The lagged sales term would not, however, be entirely negated if increased sales in one period lead to higher capital expenditures by existing firms and by new entrants in subsequent periods. In this case, the optimum lag structure for the sales term might be around five to six periods or more.

In an oligopolistic industry such as steel, prices are likely to increase before the increase in labor costs in some periods. This will probably occur most often during the recovery phase of the business cycle when demand is inelastic. In the next year, labor will bargain for a share of the increased profits which will tend to increase unit labor costs. If demand is still inelastic or if firms take a less than full markup, then profits need not fall or may fall only slightly. However, if demand is now elastic or if firms continue to take a full markup, then profits will fall. Finally, if entry into the industry is blocked, lagged sales and unit labor costs might represent much the same thing. But when entry is occurring, then the lagged sales term will also represent the influence of new entrants on the industry's demand elasticity and its profits. Consequently, it would be possible for both a unit labor cost term and a lagged sales term to be statistically significant and negative, if entry is ineffectively impeded. To the extent that lagged sales reflect entry considerations, the inclusion of an additional variable representing import penetration should reduce considerably the importance of lagged sales as an explanatory variable.

The differences between oligopoly with blocked entry and oligopoly with actual or potential entry can be pursued in another direction. The profits function incorporates both unlagged sales and capacity utilization. Without entry, these two variables may represent the same measure of business activity. When sales are high, average fixed costs are low and capacity utilization is high. Of the two variables, sales is probably a better predictor of profits. One would not expect capacity utilization to make a significant net addition to the explanation of profits if oligopolists can earn close to their average rate of profit, even with low capacity utilization. When sales and profits are high, excess profits, over and above the amount necessary to meet target rates of return, may simply be absorbed into fixed investment, research and development, advertising, etc. However, if entry occurs or oligopolists experience difficulty maintaining price interdependence at less than full capacity utilization due to increases in fixed costs, then these predictions are less certain. Even if capacity utilization is high, new or enhanced competition could restrain increased sales revenue. Both sales and capacity utilization impart additional information about the profit position of the industry.

For the steel industry, current sales and capacity utilization are highly correlated; the simple correlation is $r = 0.861$. However, capacity utilization is more highly correlated with current profits ($r = 0.570$) than is current sales ($r = 0.423$). It seems likely, given

a priori arguments and this empirical evidence, that both sales
and capacity utilization have some independent role to play in deter-
mining the level of iron and steel profits.

In summary, the following market structure factors should be
kept in mind in interpreting the empirical results:

(a) Sales and capacity utilization are both important
determinants of profits, although sales should be more
important when entry is blocked or fixed costs do
not complicate pricing decisions of oligopolists.

(b) The lagged sales term should be less significant
when unit labor costs are included.

(c) Unit labor costs will be negatively related to
profits if they are not fully passed on.

(d) Inclusion of a term representing import competition
should add significantly to the explanatory power
of the profits function.

Initial Empirical Results

All regressions were estimated from 1960 through 1973 by
ordinary least squares and consist of 55 quarterly observations.
Data sources, descriptions of the variables, and simple correlations
are given in Appendix C. Before tax profits or gross cash flow
(before tax profits plus depreciation), in millions of dollars, were
used as the dependent variables.[4] The use of cash flow concepts in
this chapter and the next chapter is based on the following considera-
tions. First, the figures given are accounting profits which include
an arbitrary distinction between profits and depreciation allowances.
Such distinctions are particularly important when depreciation guide-
lines change (e.g., 1962) or when firms make major changes in accounting
conventions. For example, in 1968 almost all of the major steel firms
which had not already done so changed from accelerated to straight line
depreciation. Second, regressions using gross cash flow as the
dependent variable sometimes provided a better fit, i.e., higher R^2.
This distinction among dependent variables is somewhat arbitrary since
the regressions in question explain different measures of business
financial activity.

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[4]Some regressions were also run with net profits or net cash
flow as dependent variables. No significant improvement in the results
followed from these regressions and they have been omitted here.
Regressions using Δp in place of p were superior.

The basic model chosen for empirical investigation is as follows

$$(5.14) \quad Y = f(TR, TR_{-i}, CU, \Delta p, IMP, X)$$

where Y = a measure of profits or cash flow, in millions of dollars,
   TR = sales, in millions of dollars,
   TR_{-i} = sales lagged i periods where period zero is the current period,
   CU = capacity utilization, in percentage points,
   Δp = change in the price index for steel mill products, where $\Delta p = p_t - p_{t-1}$,
   IMP = an import penetration index, in percentage points, defined as the ratio of imported steel mill products, in tons, to total domestic steel mill products shipments, in tons,
   X = other explanatory variables to be discussed below.

All data are seasonally adjusted. The explanatory variable IMP is included to represent the changing competitive position of the iron and steel industry during the 1960 to 1973 period. The variable Δp is obtained by rearranging current and constant dollar sales terms where profits are expressed in current dollars (see Appendix A). Since the price term would properly disappear when profits are in constant dollars, including a price term also measures changes in the iron and steel industry's competitiveness. In addition, the profit series are unadjusted for inventory valuation changes, so that capital gains or losses are also included in the profit figures. Inventory valuation adjustment is usually closely correlated with changes in the price level. However, the Δp variable appears with a negative coefficient whether the regressions were run in current or in constant dollars. This suggests that the major effect being captured is the industry's price competitiveness.

The initial regressions for the profits function are shown in Tables 5 and 6, where the profits, cash flow, and sales variables are all in constant 1973 dollars. The regressions in Table 5 show gross cash flow as a function of sales, lagged sales, capacity utilization, steel product price change, and the import penetration index. Sales were lagged one through eight periods although only the values for three through five periods are reported in Tables 5 and 6. The best lag structure was selected using the following criteria:[5] (a) the coefficient appears with a negative sign as predicted by the theoretical model; (b) R^2 is maximized; and (c) the lagged coefficient has the highest t-value. The simple correlations between the three lagged sales terms and current period sales were 0.694, 0.545, and 0.541, respectively.

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[5] P. Rao and R. L. Miller, Applied Econometrics (Belmont, Ca.: Wadsworth, 1971), p. 19.

TABLE 5.5

REGRESSIONS TO DETERMINE SALES (TR)
LAG STRUCTURE

(Dependent Variable in Gross Cash Flow
in Millions of Constant 1973 Dollars)

	Regression Coefficient (Student t)		
Variable	(1)	(2)	(3)
CONSTANT	-36.191 (0.188)	0.814 (0.004)	-10.477 (0.050)
TR	0.065 (1.403)	0.062 (1.491)	0.059 (1.466)
TR_{-3}	-0.014 (0.484)	--	--
TR_{-4}	--	-0.018 (0.651)	--
TR_{-5}	--	--	-0.001 (0.043)
CU	11.204 (2.693)*	11.303 (2.711)*	10.402 (2.309)*
Δp	-59.246 (2.455)*	-59.597 (2.450)*	-60.707 (2.475)*
IMP	-19.635 (4.296)*	-19.137 (3.916)*	-20.761 (3.908)*
R^2	0.676	0.671	0.658
$\overline{R}^2$	0.654	0.635	0.620
F	19.601	18.744	17.296
D-W	0.488	0.484	0.517

*Significant at the 95 percent confidence level. Sample size n = 55. Standard errors of estimate are \$143.690, \$144.868, and \$145.723 million, respectively.

TABLE 5.6

REGRESSIONS TO DETERMINE SALES (TR)
LAG STRUCTURE

(Dependent Variable is Gross Profits
in Millions of Constant 1973 Dollars)

	Regression Coefficient (Student t)		
Variable	(1)	(2)	(3)
CONSTANT	−188.982 (1.198)	−177.906 (1.056)	−221.960 (1.291)
TR	0.079 (2.079)*	0.068 (2.003)*	0.060 (1.776)**
TR_{-3}	−0.026 (1.066)	--	--
TR_{-4}	--	−0.028 (1.203)	--
TR_{-5}	--	--	−0.013 (0.498)
CU	7.871 (2.311)*	8.757 (2.569)*	8.934 (2.394)*
Δp	−51.829 (2.624)*	−52.507 (2.641)*	−53.595 (2.638)*
IMP	−19.755 (5.280)*	−18.746 (4.692)*	−19.720 (4.481)*
R^2	0.715	0.715	0.701
$\overline{R}^2$	0.685	0.684	0.668
F	23.566	23.085	21.127
D-W	0.580	0.588	0.594

*Significant at the 95 percent confidence level. Sample size n = 55. Standard errors of estimate are $117.627, $118.422, and $120.730 million, respectively.

Taking all these factors into account, the best lag structure was de-
termined to be a four-period lag for sales, or the previous year's sales
value for the same quarter. For example, if the current period is
1973-I, then the lagged sales term is for 1972-I.

The regressions in Table 6, which employ gross profit as the
dependent variable, yield slightly better results in terms of goodness
of fit. Regression (2), which employs a four-period sales lag, represents
the best results for the profits function. All explanatory variables
appear with their expected signs and are statistically significant at
conventional levels, with the exception of TR_{-4}. It should be recalled
that the coefficients must be interpreted in the context of the theore-
tical model and, in particular, that the coefficients do not necessarily
have a straightforward dollar-to-dollar interpretation. For example,
the coefficient on sales, TR, is approximately equal to 1-t-b, where
t is the indirect tax rate (t $\simeq$ 0.1) and b can be shown to be greater
than or equal to labor's share of full employment output (b $\geq$ 0.6).[6]
Consequently, the coefficient for sales should be equal to or less
than 0.3.

Tables 5 and 6 provide the basis for a more detailed study of
iron and steel profits. In particular, we wish to examine these initial
results for: (a) specification errors due to omission of other relevant
economic variables, including unit labor costs and debt capacity; (b)
specification errors due to the use of constant rather than current
dollars; and (c) inefficient estimation due to serial correlation in
the error term. The remainder of this section reviews the attempts
to improve on the model's specification while the econometric adjustments
for serial correlation are covered in the next section of this chapter.

Specification errors are a common econometric problem. Regression
models which omit relevant variables are subject to a possible bias due
to specification errors. A major problem in applied econometrics is
determining which variables should and should not be included in the
set of independent, explanatory variables. Typically, economic theory
and the investigator specifies a particular set of independent variables
which influence the dependent variable. If the correct set of variables
is not used, due to exclusions of relevant variables or inclusions
of irrelevant variables ("kitchen-sink models"), then the researcher
has made a specification error. If a variable that should be included
in the set of independent variables is omitted, the ordinary least
squares estimators are biased, unless by luck the observations on the
omitted variable(s) are uncorrelated in the sample with the observations
on the other included independent variables. In addition, the classical
estimator of the variance-covariance matrix is biased upward, causing
inferences concerning these parameters to be inaccurate.

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[6]Evans, op. cit., p. 345.

To test for specification error in the present model, two additional variables were examined for inclusion in the set of independent variable. The first variable, unit labor costs, was also used in Evans' study of corporate profits. For his set of eight "primarily oligopolistic" industries, unit labor costs was a significant explanatory variable in three industries, while lagged sales was significant in four industries.[7] The second new variable examined in this study was a measure of debt capacity which is explained in detail below.

Including unit labor costs (ULC) per ton of raw steel did not improve the regression results. Table 7 shows that ULC appears with a positive and significant coefficient. As suggested by the theoretical model, it is not clear whether this variable will enter with a negative or positive sign, and in some cases it may be close to zero. Two factors suggest that a positive coefficient should be rejected in this case and probably represents a statistical artifact. First, there is overwhelming evidence that the steel industry was operating during the 1960s with a generally elastic demand curve. Second, the coefficient for sales, TR, in regressions (1) and (2) is not significantly different from zero, which seems inconceivable given the nature of the theoretical model. We conclude that our ability to capture the separate effects of unit labor costs and sales revenue is limited, despite a reasonably low simple correlation between these two variables ($r = -0.557$). Unit labor costs was, therefore, dropped from further consideration as an explanatory variable.

The second new variable was a measure of debt capacity. Over some range, an increasing ratio of debt-to-equity (or debt-to-total assets) should have the effect of decreasing the firm's cost of capital and, therefore, increasing its profits, other things being equal. However, there is no reason to believe the relationship in question is linear, nor can we assert with confidence the lag structure for debt capacity. A priori, it is likely that there is some optimal level of debt beyond which the cost of capital will increase. Also, it seems inconceivable that the current level of debt-to-equity should influence profits since debt will be used for investment to obtain future profits.

With these thought in mind, we defined a measure of debt capacity, DECAP, where[8]

$$(5.15) \quad DECAP \equiv (M - D/E)^2$$

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[7]Ibid., pp. 352-55.

[8]Let the underlying nonlinear relationship be a quadratic where, say, $Y = a + bX + cX^2$. The coefficient on the transformed variable, DECAP, can be shown to be equal to c. The parameter M can be shown to be equal to $-b/2c$, which is the maximum or minimum point on the parabolic relationship between X and Y, where $Y = $ profits and $X = D/E$.

TABLE 5.7

REGRESSION RESULTS FOR UNIT LABOR COSTS
AND DEBT CAPACITY

(Dependent Variable is Gross Profits
in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)		
	(1)	(2)	(3)
CONSTANT	-1262.45 (2.040)*	-1372.70 (2.632)*	-129.43 (0.788)
TR	0.031 (0.801)	0.023 (0.689)	0.132 (2.941)*
TR_{-4}	-0.147 (0.618)	--	-0.042 (1.796)**
CU	15.249 (3.125)*	15.809 (3.654)*	4.030 (1.009)
Δp	-44.391 (2.230)*	-43.420 (2.264)*	-49.306 (2.561)*
IMP	-14.033 (2.997)*	-14.451 (3.266)*	-20.117 (5.142)*
ULC	0.018 (1.818)**	0.018 (2.080)*	--
$(30-D/E)^2_{-4}$	--		-0.795 (2.088)*
R^2	0.734	0.732	0.740
$\bar{R}^2$	0.699	0.705	0.706
F	20.752	26.754	21.369
D-W	0.656	0.695	0.727

*Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level. Sample size n = 55. Standard errors of estimate are $115.562, $112.020, and $114.320 million, respectively.

where M = an _a priori_ estimate of the optimal ratio of debt-to-equity,
   D/E = the debt-equity (or debt-asset) ratio.

Given an estimate for M, this relationship allows us to capture the effect of a change in the debt-equity ratio on profits, while allowing for an optimal debt-equity (or debt-asset) ratio, M, and a non-linear relationship with profits. The sign on the DECAP variable should be negative, since we expect an increasing amount of debt to increase profits up to M, and decrease profits thereafter.

We experimented with several alternative values for M, ranging from a low value of 25 to a high of 35 for the debt-equity ratio, and values of 20 or 25 for the debt-asset ratio. Several lag structure were also examined, where DECAP was lagged four through eight periods. One example of these experiments is presented as regression (3) in Table 7, where DECAP = $(30-D/E)^2$. The sign on this variable is negative and significant, which is in accord with general expectations. However, employing debt capacity as an explanatory variable is obtained only at the expense of an insignificant coefficient on the capacity utilization term, CU, and a significant change in the magnitude of the coefficient on current sales, TR. Both of these results might be due to specification error, but most likely multicollinearity is again affecting the coefficient magnitudes or their significance. In the absence of a firmer theoretical foundation for debt capacity, this variable was omitted from the remaining regressions for the profits function.

The second way in which specification error might occur is through the use of constant rather than current dollars for gross profits, gross cash flow, and sales. In particular, if product prices increase while some factor prices remain constant, there may be a substantial effect on profits. This effect is in general ignored when constant dollars are used which may create a specification error. In addition, it is not clear what is the appropriate deflator to use in calculating constant dollars, i.e., product prices, factor prices, or some combination. Table 8 presents the results for gross profits and gross cash flow in millions of current dollars, regressed on sales in millions of current dollars, lagged sales in millions of current dollars, capacity utilization, steel product price change, and the import penetration index. The fits (R^2s) of the equations are much improved by using current dollar values rather than constant dollars. Movements in both prices and real output are important in these functions. In contrast to our earlier results, the best fit is now obtained using gross cash flow as the dependent variable.

Serial Correlation Adjustments

A common problem in econometric investigations with time series data is serial correlation or autocorrelation in the error term. If the value of the error term is correlated with its own preceding value (or values), the three main consequences ensue: (a) the estimators obtained by ordinary least squares are unbiased, but the sampling variances of the estimators may be unduly large compared with those achievable by some different method of estimation; (b) the ordinary least squares sampling variances for the estimators are likely to be seriously underestimated; and (c) the predictions resulting from a

TABLE 5.8

REGRESSIONS EMPLOYING CURRENT DOLLARS
FOR DEPENDENT VARIABLES AND SALES

(Dependent Variables in Millions of Current Dollars)

Variable	Regression Coefficient (Student t)	
	Gross Profits	Gross Cash Flow
CONSTANT	-257.208 (2.092)*	-205.586 (1.531)
TR	0.050 (2.557)*	0.054 (2.529)*
TR_{-4}	-0.041 (1.837)**	-0.032 (1.347)
CU	10.030 (5.347)*	12.119 (5.916)*
Δp	-36.549 (2.517)*	-35.543 (2.241)*
IMP	-10.622 (3.425)*	-8.259 (2.438)*
R^2	0.767	0.783
$\bar{R}^2$	0.742	0.760
F	30.278	33.212
D-W	0.702	0.658

*Significant at the 95 percent confidence level. Sample size n = 55. Standard errors of estimate are $84.763 and $92.570 million, respectively.

serially correlated model will have unnecessarily large sampling
variances. Consequently, it is desirable to test if serial correlation
is present in the regression model and if so, to correct the regressions
for this problem.

Two tests suggest that positive serial correlation is present
in the model. First, the Durbin-Watson (D-W) statistic is less than
its critical lower value (about 1.18). Second, the plot of the
regression residuals against time produced significant runs, or
clustering, with several positive residuals followed by several
negative residuals.

To correct for serial correlation, the Cochrane-Orcutt iterative
procedure was employed. These results are presented in Table 9 for
both current and constant dollars, where ρ (rho) is the estimate of
the first-order serial correlation coefficient obtained through k
iterations. The R^2s in Table 9 are not directly comparable since the
dependent variables are different in each case and depend on the
value of ρ used. All the coefficients have their expected sign and
are significant at either the 90 or 95 percent confidence level.
Using these regressions we turn now to the problem of short run
forecasting.

Short-Run Profits Forecasts

The short-run forecasting ability of the profits function was
tested against the available quarterly data for 1974 and 1975. However,
it should be recognized that 1974 was an exceptional year for iron
and steel industry profits. For example, quarterly profits in
current dollars averaged $410.1 million in 1972, $703.4 million in
1973, $1,352.4 million in 1974, and $769.5 million in 1975. Also,
quarterly gross cash flow in current dollars averaged $772.6 million
in 1972, $1,084.5 million in 1973, $1,739.7 million in 1974, and
$1,157 million in 1975.

Since the 1974 levels of profits and gross cash flow are far
outside the range of past experience, we should not expect too much
from the model given this exceptional year of economic activity.
The forecasts for 1974 are summarized in Table 10, where the fore-
casting equations (in current dollars) are taken from Table 9. The
forecast errors produced are clearly large and exceed by a substantial
amount the residuals from the estimating equations. For example,
the largest residual for profits was $140 million for 1966-III while
the standard error of estimate was $61.1 million for the period 1960-
1973. The forecast errors are considerably greater--the largest
error is $1,386.12 million in 1974-III while the root-mean-squared
error is $778.9 million. The annual forecast for 1974 gross profits
is $2,954.3 million compared to actual profits of $5,409.6 million.
The annual forecast for 1974 gross cash flow is $4,593.6 million
compared to actual cash flow of $6,958.7 million.

To attempt to improve on the 1974 forecasts, two experiments
were conducted. First, the price change variable was dropped from the
regressions and the entire estimation-forecast procedure was repeated.

TABLE 5.9

REGRESSION RESULTS ADJUSTED FOR SERIAL CORRELATION USING THE COCHRANE-ORCUTT PROCEDURE

Variable	Regression Coefficient (Student t)			
	Gross Profit (Current Dollars)	Gross Cash Flow	Gross Profit (Constant Dollars)	Gross Cash Flow
CONSTANT	-419.671 (2.147)*	-195.862 (1.006)	-1055.14 (2.844)*	-1064.91 (2.233)*
TR	0.087 (3.518)*	0.097 (3.871)*	0.131 (3.392)*	0.162 (3.821)*
TR_{-4}	-0.037 (1.983)**	-0.039 (1.995)**	-0.017 (0.883)	-0.015 (0.710)
CU	7.911 (4.144)*	8.793 (4.363)*	8.374 (3.264)*	8.663 (3.149)*
Δp	-16.468 (1.757)**	-14.790 (1.483)	-12.781 (1.201)	-9.873 (0.872)
IMP	-7.573 (2.151)*	-8.800 (2.391)*	-4.675 (1.093)	-5.279 (1.152)
R^2	0.877	0.890	0.893	0.902
$\bar{R}^2$	0.863	0.877	0.881	0.891
F	63.936	72.443	74.822	82.820
D-W	2.376	2.287	2.470	2.436
ρ	0.835	0.811	0.931	0.960
k	10	5	6	5

*Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level. Sample size n = 55. Standard errors of estimate are $61.076, $64.317, $72.380, and $77.983 million, respectively.

Because of the exceptional demand for steel during 1974, it is quite likely that demand was almost perfectly inelastic at quoted prices, and there was a substantial "gray market" in steel during this year. Dropping the price variable resulted in a mean absolute error of $330.1 million for 1974 and a root-mean-squared error of $470.5 million for current profits. The mean absolute error for gross cash flow was $410.1 million while the root-mean-squared error was $556.5 million. Thus, some improvement in the forecasts resulted. The second experiment dropped the price change variable from the regressions and recalculated the entire estimation-forecast procedure in constant 1973 dollars. The mean absolute error for gross profits was $300.6 million while the root-mean squared error was $420.3 million. The mean absolute error for gross cash flow was $260.6 million while the root-mean-squared error was $382.3 million. These errors are still substantially greater than the standard errors of estimate of $72.7 and $77.8 million, respectively.

At this point, we can only conclude that our ability to forecast the level of profits in 1974 is very limited indeed. This should not bother us too greatly if 1974 is an exceptional year and represents the more or less unique outcome of a combination of special events. On the other hand, it could well be that the steel industry is entering yet another discrete stage in its history due to a sequence of events begun in the 1960s, (e.g., basic oxygen furnace investment, devaluation of the dollar, increases in energy prices). In this case, we should be reluctant to use the regressions estimated in this chapter as a guide to the future of the iron and steel industry.[9]

Table 11 presents the forecasts for 1975 for gross profits and gross cash flow in millions of current dollars. Although these forecasts represent an improvement over the 1974 forecasts, the forecast errors remain quite large, especially in the first and fourth quarters of the year. The 1975 annual gross profits forecast is $1,953.2 million compared to actual profits of $3,078.0 million, a difference of $1,124.8 million. The 1975 annual gross cash flow forecast is $3,384.5 million compared to actual cash flow of $4,628.0, a difference of $1,243.5 million. Thus, the cash flow forecasts seem to perform slightly better for 1975 given the larger magnitude to be predicted.

Summary

This chapter formulated and estimated models for the level of before-tax profits and before-tax gross cash flow in current dollars for the iron and steel industry for 1960-1973. The basic independent or explanatory variables used were sales revenue, lagged sales revenue, capacity utilization index, change in the price index for steel mill

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[9]As a consequence of the problems encountered here, additional development of the profit model is planned for Phase III of this project.

TABLE 5.10

SHORT-RUN PROFITS FORECASTS FOR 1974
(Using Table 5.9 Regressions)

| | Millions of Current Dollars | | | | | |
| | Gross Profits | | | Gross Cash Flow | | |
Time	Actual	Forecast	Error	Actual	Forecast	Error
1974-I	$ 799.28	$ 716.72	$ 82.56	$1,193.89	$1,104.28	·$ 89.61
1974-II	1,065.69	607.85	·457.84	1,456.98	1,019.27	·437.71
1974-III	2,127.76	741.64	-1,386.12	2,515.13	1,185.33	·1,329.80
1974-IV	1,416.85	879.24	537.61	1,792.74	1,284.73	·508.01
Mean Absolute Error			$616.0			$591.3
RMS-Error*			$778.9			$746.0

*Root-mean-squared error of forecast.

TABLE 5.11

SHORT-RUN PROFITS FORECASTS FOR 1975
(Using Table 5.9 Regressions)

| | Millions of Current Dollars | | | | | |
| | Gross Profits | | | Gross Cash Flow | | |
Time	Actual	Forecast	Error	Actual	Forecast	Error
1975-I	$1,137.0	$573.9	$563.0	$1,531.0	$952.3	$579.0
1975-II	544.0	502.9	41.1	918.0	841.2	76.8
1975-III	628.0	501.9	126.0	1,028.0	857.0	171.0
1975-IV	769.0	374.5	394.0	1,151.0	734.0	417.0
Mean Absolute Error			$281.2			$310.8
RMS-Error*			$350.1			$368.6

*Root-mean-squared error of forecast.

products, and an import penetration index. The models fitted the data well with R^2s of about 0.88-0.89 and standard errors of estimate of $61-64 million. The short-run forecasting ability of the model was tested aginst available quarterly data for 1974 and 1975. These are rather exceptional years and the forecasting errors are large. For example, for 1975 gross cash flow, the forecast root-mean-squared error was $369 million. This error is roughly 30 percent of the average quarterly gross cash flow for the year.

In Chapter 9 of this report, the recursive model will be estimated using simultaneous equation estimation procedures. By comparison, this chapter used ordinary least squares procedures, adjusted for serial correlation. The equation employed in the recursive model uses as a dependent variable gross cash flow in millions of current dollars. The comparable equation in this chapter is regression (2) in Table 9. To complete the econometric analysis of this equation, cash flow forecasts for 1974 and 1975 were rerun with proper adjustment for lagged residual feedback.[10] These revised forecasts are presented in Table 12; although the forecast errors for gross cash flow are still rather large, the results do demonstrate the improvement that is obtained by accounting for residual feedback.[11] We suggest that it may be necessary in long-run forecasting to treat 1974 and perhaps 1975 as years with a substantial transitory component in profits or cash flow. Long-run forecasts are more appropriately based on the permanent values of economic variables, which eliminate or reduce the extent of transitory fluctuations present. Additional development of the profit equation will be considered in Phase III of this project.

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[10] See, for example, R. S. Pindyck and D. L. Rubinfeld, Econometric Models and Economic Forecasts (New York: McGraw-Hill, 1976), pp. 170-73. In addition, the estimate of the first-order serial correlation coefficient was checked using the Hildreth-Lu scanning procedure. No significant improvement resulted from use of this method.

[11] Naive forecasts using a fourth-order autoregressive model were, however, somewhat poorer. The autoregressive model was

$$G\hat{C}F_t = 0.7701GCF_{t-1} + 0.0161GCF_{t-2} + 0.1952GCF_{t-3}$$
$$\phantom{G\hat{C}F_t =} (5.376) \qquad\quad (0.087) \qquad\quad (1.069)$$

$$+ 0.0334GCF_{t-4}; \quad R^2 = 0.434, \text{ SEE} = 146.340.$$
$$(0.246)$$

while the forecasts for 1974-75 had a mean absolute error of $366.7 million and a root-mean squared error of $521.5 million.

TABLE 5.12

GROSS CASH FLOW FORECASTS FOR
1974 and 1975[a]
(Using Table 5.9 Regressions)

| Time | Millions of Current Dollars | | |
	Actual	Forecast	Error
1974-I	$1,194	$1,104	$ 90
1974-II	1,457	1,092	365
1974-III	2,515	1,540	975
1974-IV	1,793	2,363	-570
1975-I	1,531	1,364	167
1975-II	918	1,310	-392
1975-III	1,028	919	109
1975-IV	1,151	873	278
Mean Absolute Error			$368.2
RMS-Error*			$459.3

[a]Forecasts adjusted for lagged residual feedback.

*Root-mean-squared error of forecast.

CHAPTER 6

DIVIDENDS AND PROFITS

Introduction

The fact that corporate profits may either be retained by the firm or paid out to stockholders as dividend payments is expressed by the identity

$$(6.1) \qquad \pi \equiv R + D$$

where π = corporate profits after taxes and depreciation allowances, R = retained earnings, D = dividend payments, and where D/π = dividend payout ratio. Retained earnings represent corporate savings which may be used for purposes of long-term investment in fixed plant and equipment or for other uses such as repurchase of common stock or short-term investments. For many firms, a large portion of their financing of investment projects is based on retained earnings. These funds are not free, however, for there is a definite opportunity cost involved. In the absence of taxation, the minimum cost of retentions is the cost of equity capital, based upon the current market price of common stock.

In studying the division of corporate profits between dividends and retentions, the traditional approach has been to derive behavioral relationships for D and to treat R as a residual. This approach is based partly on the stated preferences of firms for maintaining a certain dividend payout and partly on the empirical observation that changes in dividend payments occur very gradually over time, while retained earnings and net profits exhibit rather volatile movements.

These general relationships are also true for the iron and steel industry. Figures 1-4 show the seasonally adjusted, deflated values for quarterly dividends, after tax profits, net cash flow, and retained earnings, respectively. These figures suggest that dividend payments is the most stable of the four series, a conclusion which is confirmed by calculation of the coefficient of variation for each series:
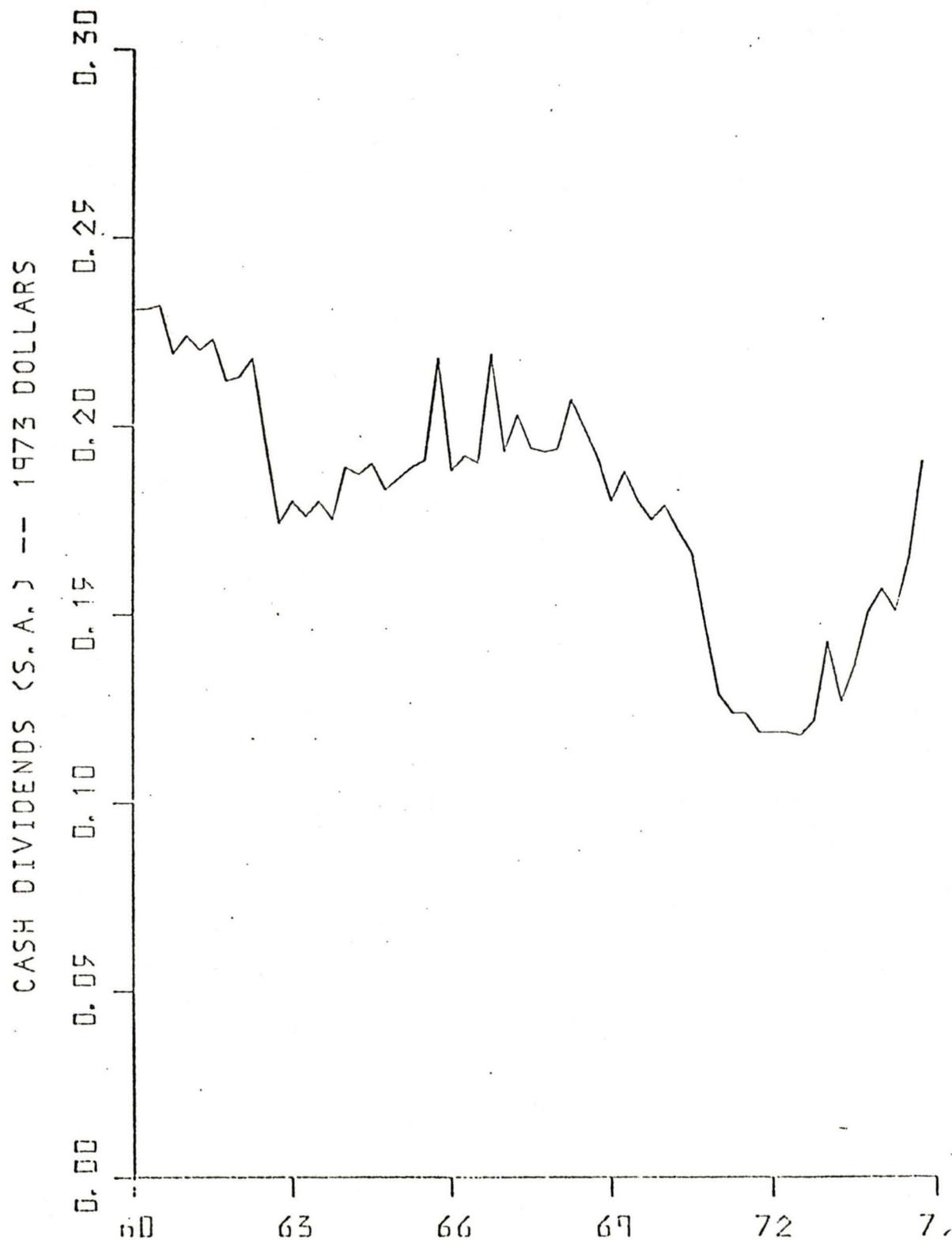
FIGURE 6.1 Cash Dividends in the U.S. Iron and Steel Industry, 1960-1974; quarterly, seasonally adjusted (in billions of 1973 dollars).
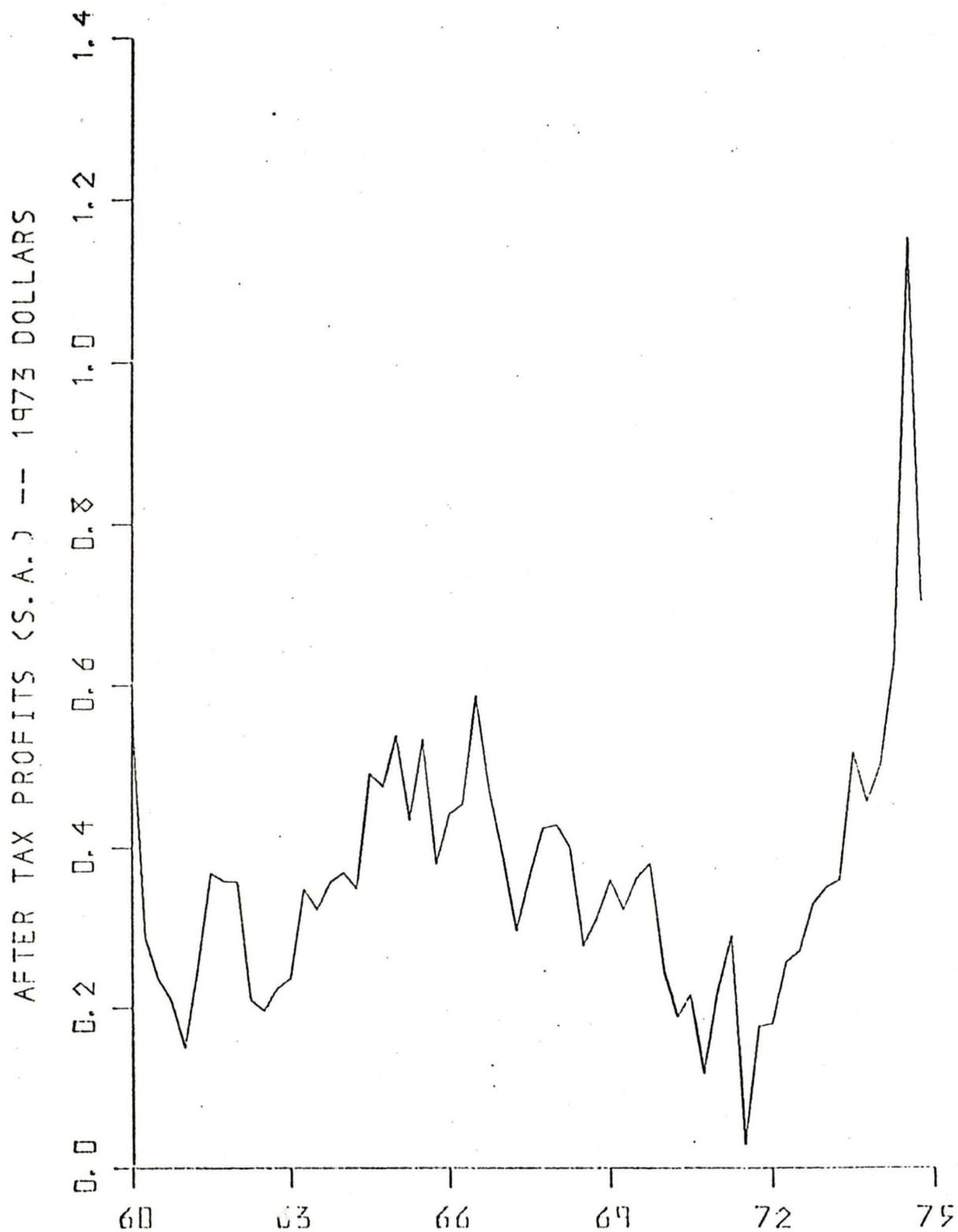
FIGURE 6.2 After-Tax Profits in the U.S. Iron and Steel Industry, 1960-1974; quarterly, seasonally adjusted (in billions of 1973 dollars).

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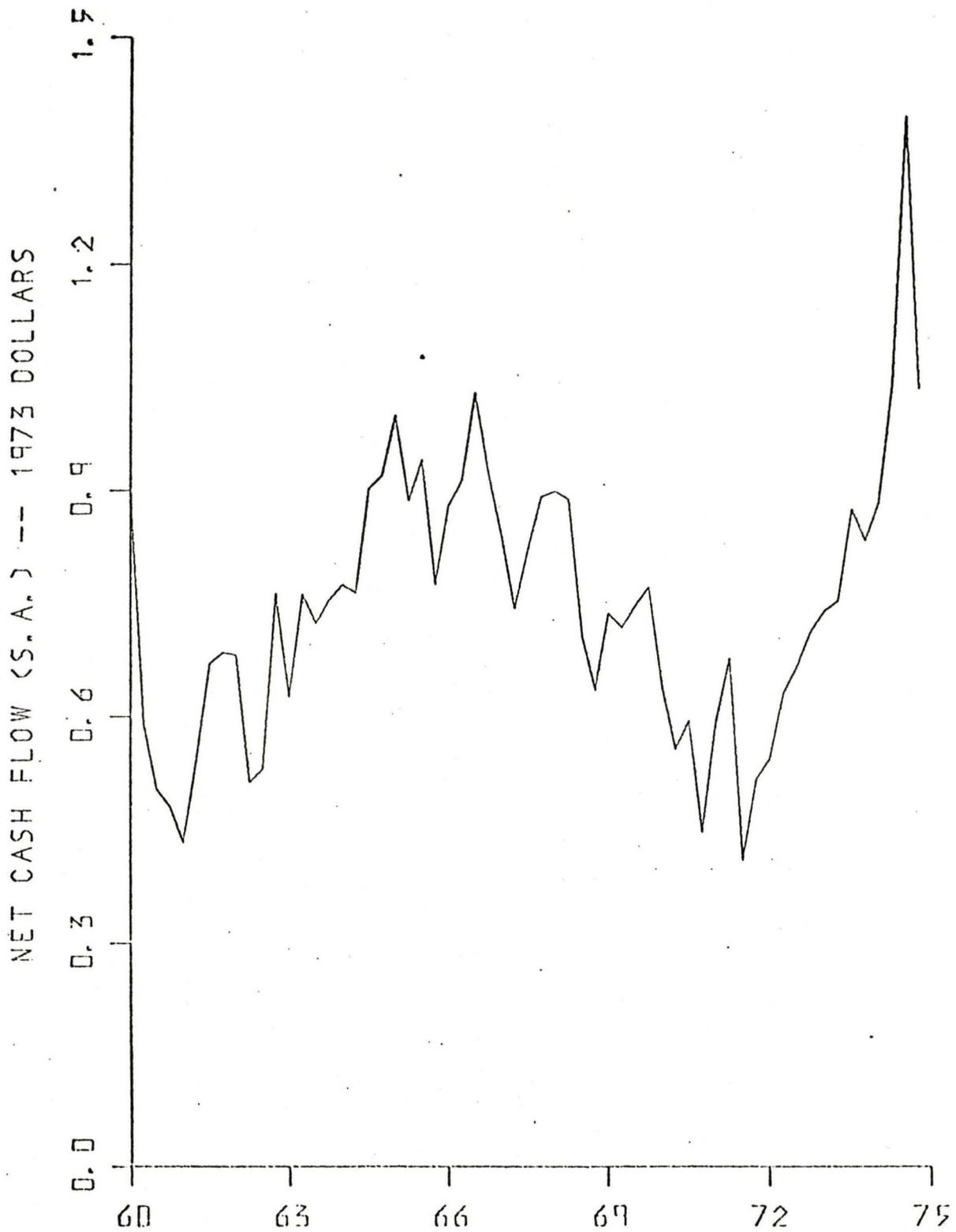
FIGURE 6.3 Net Cash Flow (After-Tax Profits plus Depreciation) in the U.S. Iron and Steel Industry, 1960-1974; quarterly, seasonally adjusted (in billions of 1973 dollars).
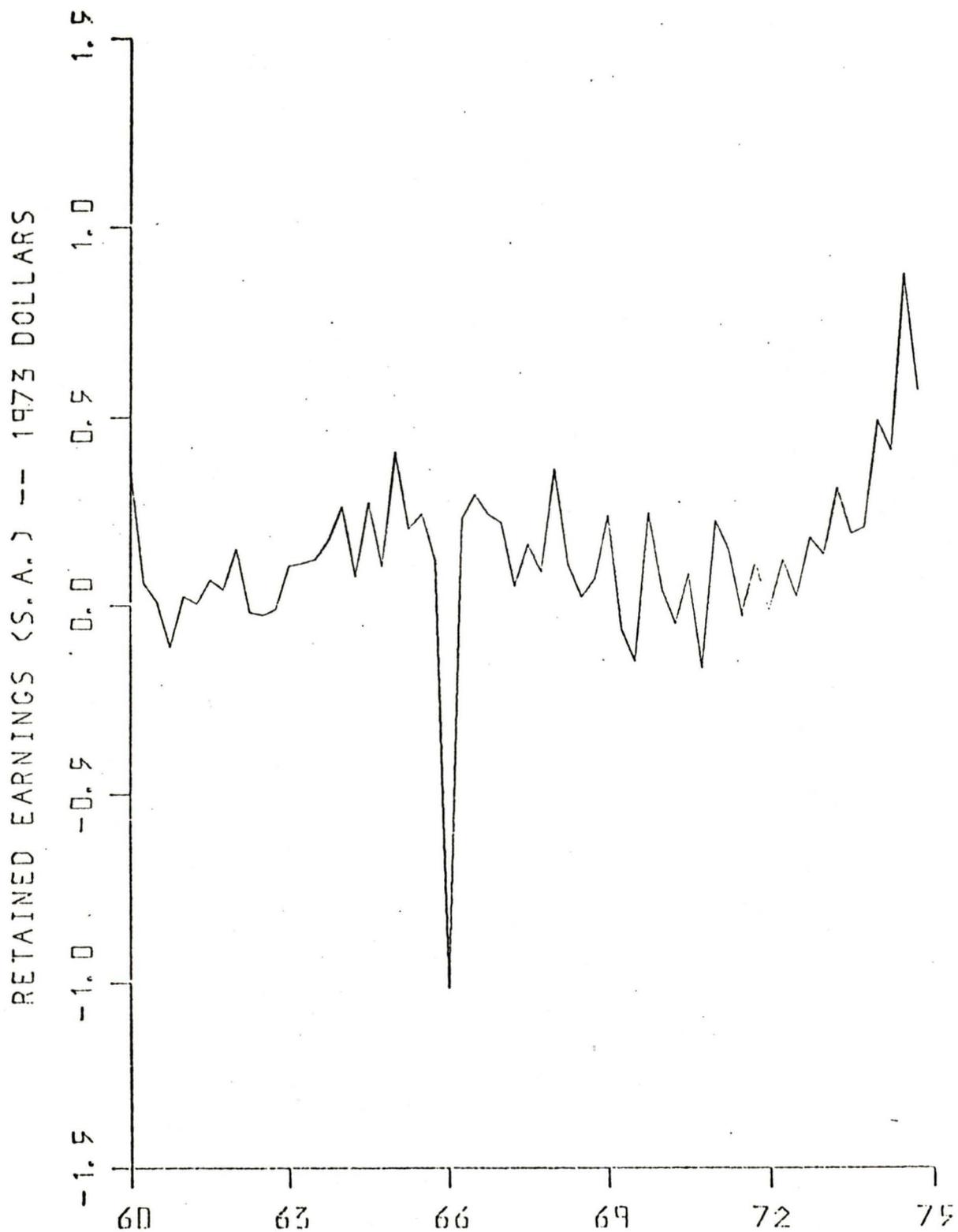
FIGURE 6.4 Retained Earnings in the U.S. Iron and Steel Industry, 1960-1974; quarterly, seasonally adjusted (in billions of 1973 dollars).

	Mean	Standard Deviation	Coefficient of Variation
	(Millions of 1973 Dollars)		(Percent)
Dividends	$179.7	$ 32.4	18.1%
Profits	362.8	167.4	46.1
Cash Flow	747.2	180.8	24.2
Ret. Earnings	129.0	232.2	180.0

The least variable of the four series is dividend payments, followed by net cash flow, net profits, and retained earnings.

The relative stability of dividend payments suggests that the payout decision is guided to a considerable degree by previous dividend payments which reflect strategic decisions about the appropriate payout ratio, leaving the amount retained by the firm to be the remainder after these payments have been made. Lintner, for example, states that:

> The question that comes up first--and usually continues to be the dominant issue--is "Is there any sufficient reason to change it, and if so, by how much?" not "How much should we pay this quarter (or this year)?" considered de novo...Current dividend distributions are primarily determined by last year's dividends and current profits. The net effect of other factors, insofar as not systematically reflected by current profits and lagged dividends, is small and random.[1]

The general Lintner hypothesis has been questioned by Dhrymes and Kurz in the study discussed in Chapter 3. Their argument is essentially that the firm's objective is profit maximization through optimal hiring of factor inputs (labor and capital). In particular, Dhrymes and Kurz postulate that dividend decisions should also depend on the firm's demand for investment funds. We treat this as an alternative to the Lintner hypothesis and select the "best model" on the basis of statistical tests.

With these general thoughts as a background, this chapter formulates and tests several alternative models of the dividend function for the iron and steel industry. The Lintner partial adjustment model is laid out in considerable detail, while alternative model specifications are dealt with more tersely.

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[1]J. Lintner, "Determinants of Corporate Savings," in W. W. Heller, (ed.), Savings in the Modern Economy (Minneapolis: University of Minnesota Press, 1953), pp. 251-52.

The Lintner Partial Adjustment Model

A starting point for empirical investigation is the familiar
model of dividend behavior based on the work of Lintner.[2] Lintner's
model is an application of the so-called partial adjustment model of
economic behavior. For any given time period t, target dividends (D_t^*)
are assumed to be related to profits (π_t) according to

$$(6.2) \quad D_t^* = \gamma\pi_t, \quad \gamma > 0$$

where γ is the firm's target payout ratio. The decision as to how
close actual dividends should approximate target dividends is assumed
to be subject to uncertainty, inertia, and the time and money costs of
change. In any time period, the firm will only partially adjust to
the target dividend level, so that changes in dividend payments from
period t-1 to period t are assumed to be given by a reaction of adjust-
ment function

$$(6.3) \quad \Delta D_t = D_t - D_{t-1}$$
$$= b_0 + \delta(D_t^* - D_{t-1}) + U_t$$

where $0 < \delta \leq 1$ and $b_0 \geq 0$, and where b_0 is a constant, δ is the frac-
tional, speed-of-adjustment coefficient, and U_t is a stochastic error
term. The closer δ is to unity, the greater the adjustment made in
the current period. The constant term will be positive if: (a) firms
have a greater reluctance to reduce dividends than to raise them; or
(b) slow-growing or declining firms tend chronically to pay more than
is called for by their historic target ratios.

Substituting Equation 2 into Equation 3 yields

$$(6.4) \quad \Delta D_t = b_0 + \delta\gamma\pi_t - \delta D_{t-1} + U_t$$

or rewriting Equation 4 in terms of the level of dividends

$$(6.5) \quad D_t = b_0 + b_1\pi_t + b_2 D_{t-1} + U_t$$

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[2]Ibid., pp. 230-55; and J. Lintner, "Distribution of Incomes of
Corporations Among Dividends, Retained Earnings and Taxes," American
Economic Review, 46 (May 1956), pp. 97-113.

where $b_1 = \delta\gamma$ and $b_2 = 1-\delta$. Equation 5 is the final or reduced equation for the partial adjustment model of dividend behavior.[3] This equation, or an alternative specification of this equation, is the subject of our empirical investigation in the next section and the remainder of this chapter. It should be noted at the outset, however, that the presence of D_{t-1} as an explanatory variable creates rather considerable problems in the econometric estimation of this model and in its use as a forecasting equation. In particular, as a forecasting device, the partial adjustment model tends to accumulate errors incurred in forecasting any one period. This problem is in part compensated by the high degree of fit (R^2) obtained with models incorporating lagged dependent variables.

Initial Empirical Results

All regressions were estimated from 1960 through 1973 by ordinary least squares and consist of 55 quarterly observations. Data sources, descriptions of the variables, and zero-order correlations are given in Appendix C. Quarterly cash dividends charged to surplus, in millions of dollars, was used as the dependent variable. The basic explanatory variables were quarterly net profits (or net cash flow), and lagged dividends. All data are seasonally adjusted and deflated (1973 = 100).[4]

The initial results for the Lintner model are presented in Table 1. For example, regression (1) shows dividends as a function of net profits and dividends lagged one period. Since the constant term is not significantly different from zero, regressions are also presented with this term suppressed. Suppressing the constant yields a slightly lower $\bar{R}^2$, but the estimate of the target payout ratio is now more reasonable.[5] Using seasonally-adjusted, quarterly data, the average payout ratio for the period 1960-1973 was 49.5 compared to 47.8 percent estimated in regression (2). Note also that the partial adjustment is relatively slow since δ is substantially less than unity.

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[3] A neoclassical basis for partial adjustment models of economic behavior is given in Z. Griliches, "Distributed Lags: A Survey," _Econometrica_, 35 (January 1967), pp. 16-49.

[4] Some regressions were also run in current dollars. However, these regressions performed considerably worse, and have been omitted here.

[5] Let R^2 be the coefficient of multiple determination for the regression. Then R^2, adjusted for degrees of freedom, is

$$\bar{R}^2 = 1 - \left[(1-R^2)\frac{T-\theta}{T-K-\theta}\right]$$

where T is the sample size, K is the number of explanatory variables, and θ is 1 if the model includes a constant, and 0 otherwise.

TABLE 6.1

REGRESSION RESULTS FOR THE LINTNER MODEL
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	4.919 (0.545)	--	0.654 (0.060)	--
PROFIT	0.029 (2.201)*	0.032 (2.607)*	--	--
CASH FLOW	--	--	0.017 (1.690)**	0.017 (2.242)*
$DIVIDEND_{-1}$	0.912 (19.894)*	0.933 (40.321)*	0.921 (19.863)*	0.923 (29.718)*
R^2	0.889	0.889	0.885	0.885
$\bar{R}^2$	0.885	0.884	0.881	0.881
F	208.777	422.865	200.557	408.797
D-W	2.764	2.820	2.663	2.670
h	3.003	3.083	2.610	2.556
$\hat{\delta}$	0.088	0.067	0.079	0.077
$\hat{\gamma}$	0.330	0.478	0.215	0.221

*Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level. Sample size n = 55. Standard errors of estimate are $11.089, 11.015, 11.288, and 11.182, respectively.

The Durbin-Watson (D-W) statistics in Table 1 are in the range 2.7 - 2.8, which is greater than the critical value of 2.55 for a two-tailed test at the 5 percent level of significance. The D-W test thus indicates the possibility of serial correlation in the residuals. However, when lagged dependent variables are included as explanatory variables, the D-W test is generally not valid. An alternative test has been suggested by Durbin using a test statistic defined as[6]

$$h = [(1 - \frac{D-W}{2})] \sqrt{\frac{T}{1 - T \cdot \hat{\sigma}_b^2}}$$

where D-W is the Durbin-Watson statistic, T is the sample size, and $\hat{\sigma}_b^2$ is the estimate of the variance for the coefficient on the lagged dependent variable. The h statistic for a first-order Markov process is distributed as standard normal with mean zero and variance unity. The critical value of h is approximately 2.00 for a 5 percent test of significance. The calculated values in Table 1 all exceed this level so that we reject the null hypothesis that the error term in the regressions are serially independent. The regression results, in terms of the precision of the coefficient estimates and the goodness of fit, should be interpreted with caution at this point. Both the reported t-ratios and R^2s are quite likely to be biased upward.[7] Adjustments for serial correlation using the Cochrane-Orcutt procedure are reported below.

A number of extensions of the Lintner model have been suggested in the literature. Some investigators replace net profits with net cash flow in the dividend equation.[8] This formulation is consistent with the profits functions reported in the previous chapter which employ gross cash flow as the dependent variable. Regressions (3) and (4) in Table 1 show the empirical results for a modified Lintner model

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[6]J. Durbin, "Testing for Serial Correlation in Least-Squares Regression When Some of the Regressors are Lagged Dependent Variables," *Econometrica*, 38 (May 1970), pp. 410-21.

[7]The R^2s in Table 1 are also inflated due to the regression of D_t on D_{t-1}. Although we could use ΔD_t as the dependent variable, this would not change the magnitude of the coefficient estimates.

[8]See J. A. Brittain, "The Tax Structure and Corporate Dividend Policy," *American Economic Review*, 54 (May 1964), pp. 272-87; J. A. Brittain, *Corporate Dividend Policy* (Washington, D.C.: Brookings Institution, 1966); P. Darling, "The Influence of Expectations and Liquidity on Dividend Policy," *Journal of Political Economy*, 65 (June 1957), pp. 209-24; and E. Kuh, *Capital Stock Growth* (Amsterdam: North-Holland, 1963).

using net cash flow as the basis for the target payout, i.e., Equation 2. Comparing the net cash flow regressions with those employing net profits suggests that there is relatively little to choose between. The goodness of fit (R^2) and the t-ratios are slightly better for the regressions employing profits, but the differences are not substantial. Serial correlation is slightly reduced in the cash flow regressions. The estimate of the payout ratio in regression (4) is 22.1 percent, which is fairly close to the average quarterly value of 26.1 percent for 1960-1973. Since there are no strong statistical reasons for choosing net cash flow over net profits, we have used net profits for further testing. Final regressions are, however, presented for both net profits and net cash flow.

Among the other alternative versions of the Lintner model are the following:[9]

1. Adding depreciation along with net profits as explanatory variables--this model did not result in the correct, positive sign on the depreciation variable.

2. Using profits and lagged profits as independent variables, excluding lagged dividends--this model resulted in a very poor R^2 and insignificant co-efficients on the profit variables due to the high degree of intercorrelation (r = 0.719) between profits and lagged profits.

3. Using a payout ratio which varies with the level of pretax profits and including taxes as a separate explanatory variable. The general expectation is that pretax profits and aggregate taxes will produce positive and negative coefficients, respectively, of about the same magnitude. The maintained hypothesis is that the corporate tax rate reduces the level of dividends but not the after-tax payout ratio. This model performed very poorly. Pretax profits and aggregate taxes are so highly correlated (r = 0.960) that many incorrect signs and insignificant coefficients resulted. Apparently it is adequate to allow for taxes by simply using after-tax profits as an explanatory variable.

4. Using a payout ratio which varies with other variables, such as the level of sales or change in sales--models of this type performed poorly despite attempts at several alternative model specifications.

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[9]See the references listed in the previous footnote and also E. F. Fama and H. Babiak, "Dividend Policy: An Empirical Analysis," Journal of the American Statistical Association, 63 (December 1968), pp. 1132-61.

Some success with the above models has been reported in the literature on dividend behavior. However, these formulations did not produce noticeably improved results for the iron and steel industry. Undoubtedly this is in part due to the powerful role played by lagged dividends, the use of quarterly rather than annual data, and the fact that the dependent variable is D_t rather than ΔD_t.

Griliches has suggested that in cases where Equation 5 may seem appropriate on the basis of a priori behavior considerations, the underlying lag structure should be tested against a wider range of alternatives.[10] An appropriate test in this case is the simple addition of lagged values involving one or both of the earnings and dividend variables.

Results for a more extensive lag structure for the Lintner model are presented in Table 2, where we again show the effect of suppressing the constant term. Adding twice-lagged dividends results in some improvement in $\bar{R}^2$, which should be expected given the low speed-of-adjustment coefficient. This model does not seem very satisfactory on a priori grounds and the improvement in the goodness of fit is relatively slight. Moreover, including both lagged profits and twice lagged dividends resulted in an insignificant coefficient on current profits. The lagged variables are highly correlated with their current values which complicates the testing of more extensive lag structures due to multicollinearity. The simple correlation between π_t and π_{t-1} is $r = 0.719$, while for D_t and D_{t-1}, $r = 0.938$.

To summarize the results to this point, a number of extensions of the basic Lintner model were investigated using suggestions found in the empirical literature on dividend behavior. Since no significant improvements seemed to follow from these suggestions, we turn to alternative behavioral hypotheses for iron and steel dividends.

Adaptive Expectations and Dividends

An obvious difficulty with the partial adjustment model is that it may be implausible to assume that the optimal value of dividends depends on the current and only the current value of profits. Indeed, if profits are subject to important changes from period to period (as they are--see Figure 2), then it would not be sensible to base dividend decisions solely on current profits. This point of view is expressed in the adaptive expectations model which postulates that dividends are set equal to the permanent level of profits. That is

$$(6.6) \quad D_t = a_o + \beta \pi_t^* + V_t, \quad a_o \geq 0, \quad 0 < \beta \leq 1$$

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[10]Griliches, op. cit., p. 46.

TABLE 6.2

REGRESSION RESULTS FOR DIVIDEND
LAG STRUCTURE
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coeffient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	0.751 (0.083)	--	-0.802 (0.101)	--
PROFIT	0.034 (2.659)*	0.035 (2.933)*	-0.001 (0.609)	-0.010 (0.656)
PROFIT$_{-1}$	--	--	0.065 (3.882)*	0.065 (3.920)*
DIVIDEND$_{-1}$	0.610 (4.641)*	0.611 (4.706)*	0.516 (4.355)*	0.516 (4.401)*
DIVIDEND$_{-2}$	0.312 (2.397)*	0.314 (2.505)*	0.376 (3.238)*	0.372 (3.338)*
R^2	0.896	0.897	0.921	0.921
$\overline{R}^2$	0.890	0.891	0.915	0.915
F	144.539	221.111	142.668	194.063
D-W	2.239	2.243	1.881	1.880
h	3.291	3.020	0.893	0.893
$\hat{\delta}$	0.078	0.075	0.108	0.112
$\hat{\gamma}$	0.436	0.467	0.509	0.491

*Significant at the 95 percent confidence level. Sample size n = 55.
Standard errors of estimate are $10.675, 10.571, 9.431, and 9.337,
respectively.

where $\pi_t{}^*$ denotes the expected value of permanent profits formed in the current time period and V_t is a disturbance term. The disturbance term is included to indicate that the firm or decision maker does not have complete control over dividends due to uncertainty in the decision-making process. Equation 6 must be supplemented with some assumption about how expectations are formed. One expression for adaptive expectations is given by

(6.7) $\quad \pi_t{}^* - \pi_{t-1}{}^* = \delta(\pi_{t-1} - \pi_{t-1}{}^*), \quad o < \delta \leq 1$

so that expectations in the current period are updated by a fraction of the discrepancy between the observed value of profits in the previous period and the previous expected value. This model attributes adjustment lags to uncertainty and the discounting of current information rather than to the costs of change.

Avoiding some tedious substitutions, the final equation formed by Equations 6 and 7 is given by

(6.8) $\quad D_t = a_o(1 - \lambda) + \beta\delta \, \pi_{t-1} + \lambda D_{t-1} + (V_t - \lambda V_{t-1})$

where $\delta = 1-\lambda$. However, if successive earnings changes are independent, then the optimal value of δ is one, and the coefficient estimate for D_{t-1} would not be significantly different from zero. The empirical results reported below suggest that this is not the case for quarterly data.

The adaptive expectations model can be criticized in turn for assuming somewhat implausibly that the dividend level is adjusted immediately to the expected profit level, subject only to the discrepancy caused by a stochastic disturbance term. A more general model is obtained by combining the assumptions of partial adjustment and adaptive expectations. Dividend changes follow the partial adjustment model

(6.9) $\quad \Delta D_t = b_o + \gamma(D_t{}^* - D_{t-1}) + u_t, \quad b_o \geq 0, \quad 0 < \gamma \leq 1$

and target dividends are proportional to long-run expected earnings

(6.10) $\quad D_t{}^* = a_o + \beta\pi_t{}^*, \quad a_o \geq o, \quad o < \beta \leq 1$

No error term is required in Equation 10 since this relationship now applies to target dividends rather than current dividends. Finally, long-run expected earnings are given by the adaptive expectations relationship.

$$(6.11) \quad \pi_t^* - \pi_{t-1}^* = \delta(\pi_{t-1} - \pi_{t-1}^*), \; o < \delta \leq 1$$

The final equation for this three-equation model is

$$(6.12) \quad D_t = (b_o\delta + a_o\delta\gamma) + \beta\delta\gamma \; \pi_{t-1} + [(1 - \delta) + (1 - \gamma)] \; D_{t-1}$$

$$-[(1 - \delta)(1 - \gamma)] \; D_{t-2} + (u_t - \lambda u_{t-1})$$

where again $\lambda = 1-\delta$. It is not possible in this model to obtain the individual estimates for the parameters δ and γ. However, it is possible to obtain estimates of $\gamma + \delta$, $\gamma\delta$, and hence β, where β is the target payout ratio from Equation 10.

Table 3 presents the regression results for the final equations models given by Equations 8 and 12. Regressions (1) and (2) present the results for the adaptive expectations model; R^2 is slightly improved relative to the Lintner partial adjustment model. Also, the estimated payout ratio ($\hat{\beta}$) for regression (2) is almost identical to the average value for 1960-1973. Regressions (3) and (4) present the results for the combined partial adjustment-adaptive expectations model. Goodness of fit is improved over either the partial adjustment or adaptive expectations model. The estimated coefficient for twice-lagged dividends is statistically significant and the estimate for the target payout ratio is of the correct magnitude. Given the added complexity of forecasting with twice-lagged dividends, these differences seem small enough to ignore. The adaptive expectations model was, therefore, chosen for further investigation. Note also that the use of lagged profits in this model implies a lack of simultaneity between dividends and profits in the current period.

The dividend equation was then adjusted for serial correlation using the Cochrane-Orcutt iterative procedure. These estimates are presented in Table 4 for both lagged profits and lagged net cash flow as explanatory variables. The first-order autocorrelation coefficient is given by ρ (rho) while k is the number of iterations in the Cochrane-Orcutt procedure. The results in Table 4 support a conclusion that the dividend model using lagged profits is slightly superior to the same model employing net cash flow even after adjustment for serial correlation. Using these results and procedures, the next step is to introduce other explanatory variables into the dividend equation as a check on the model's specification.

TABLE 6.3

REGRESSION RESULTS FOR ADAPTIVE EXPECTATIONS
AND COMBINED ADJUSTMENT-EXPECTATIONS MODEL
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	5.046 (0.640)	--	-1.924 (0.250)	--
$PROFIT_{-1}$	0.048 (3.987)*	0.050 (4.274)*	0.058 (4.905)*	0.057 (5.125)*
$DIVIDEND_{-1}$	0.875 (20.175)*	0.899 (39.951)*	0.517 (4.391)*	0.516 (4.425)*
$DIVIDEND_{-2}$	--	--	0.376 (3.261)*	0.369 (3.327)*
R^2	0.907	0.907	0.920	0.920
$\bar{R}^2$	0.904	0.903	0.916	0.916
F	254.436	514.185	192.522	294.161
D-W	2.652	2.693	1.897	1.894
h	2.555	2.605	0.758	0.756
$\hat{\delta}$	0.125	0.101	--	--
$\hat{\beta}$	0.388	0.496	0.542	0.494
$(\hat{\gamma}+\delta)$	--	--	1.483	1.484
$(\hat{\gamma}\delta)$	--	--	0.107	0.115

*Significant at the 95 percent confidence level. Sample size n = 55.
 Standard error of estimate are $10.146, 10.090, 9.371, and 9.285,
 respectively.

TABLE 6.4

REGRESSION RESULTS FOR ADAPTIVE EXPECTATIONS
MODEL ADJUSTED FOR SERIAL CORRELATION
BY COCHRANE-ORCUTT PROCEDURE
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	0.254 (0.046)	--	-9.028 (1.284)	--
PROFIT$_{-1}$	0.043 (4.626)*	0.043 (4.839)*	--	--
CASH FLOW$_{-1}$	--	--	0.028 (3.905)*	0.023 (3.837)*
DIVIDEND$_{-1}$	0.912 (29.624)*	0.913 (54.576)*	0.932 (29.420)*	0.902 (38.315)*
R^2	0.916	0.916	0.909	0.906
$\bar{R}^2$	0.913	0.913	0.905	0.902
F	278.136	576.160	253.558	499.677
D-W	1.979	1.979	1.940	1.930
h	0.081	0.076	0.225	0.263
ρ	-0.378	-0.378	-0.353	-0.322
k	2	2	2	2
$\hat{\delta}$	0.088	0.087	0.068	0.098
$\hat{\beta}$	0.489	0.494	0.412	0.235

* Significant at the 95 percent confidence level. Sample size n = 55.
Standard errors of estimate are $9.527, 9.435, 9.937, and 9.995, respectively.

The Dividend Equation, Including Investment,
External Finance and Liquidity

This section presents the ordinary least-squares estimates
(adjusted for serial correlation) for the structural dividend equa-
tion described in Chapter 3. This equation has the following form

(6.13) $D_t = G_2(I_t, EF_t; \pi_{t-1}, D_{t-1}, N_t, U_t)$

where D_t = dividends charged to surplus at time t,

I_t = gross fixed investment expenditures,

EF_t = long-term borrowing (external finance),

π_{t-1} = net profits (or net cash flow),

N_t = net current position (short-term liquidity),

U_t = the stochastic error term.

The expected signs on each of the above variables are as follows:
investment (-), external finance (+), profits (+), lagged dividends (+),
and short-term liquidity (-). The investment and external finance
variables are regarded as endogenous to the system so that the Lintner
model can be thought of as a reduced-form of the appropriate structural
equation. The objective here is to present some tentative ordinary
least-squares estimates of the structural equation, recognizing that
these estimates might contain simultaneous-equation bias. That is,
if the true model is the simultaneous-equation model presented in
Chapter 3, then ordinary least-squares estimates of the structural
dividend equation will be inconsistent, i.e., they are asymptotically
biased so that even if the sample size were increased, the expected
value of an estimator's sampling error would not approach zero.

Before presenting the regression estimates, it is instructive
to look at the matrix of simple correlations among the hypothesized
jointly dependent variables. These correlations are given in Table 5.
We note first that the correlation between dividends and investment
is positive and statistically significant. This is somewhat surprising
since these two quantitites are not expected to vary in the same
direction. Second, the simple correlation between dividends and
external finance is not significantly different from zero, suggesting
that the iron and steel industry has not found it necessary in the past
to reduce dividends as a direct consequence of capital attraction
problems. Third, the correlation between investment and external
finance is positive as would be expected in general. These conclusions
apply, of course, on average to the industry's past experience, and it

TABLE 6.5

SIMPLE CORRELATION MATRIX,
ENDOGENOUS VARIABLES, 1960–1973

Variable	DIVIDEND	INVESTMENT	EXTERNAL FINANCE
DIVIDEND	1.0000	0.3424*	0.0073
INVESTMENT		1.0000	0.2642*
EXTERNAL FINANCE			1.0000

*Critical values of $|r|$ for rejecting the hypothesis of zero correlation at
 the 5 and 1 percent levels, respectively, are approximately 0.262 and 0.340.

is possible that at certain points in time actual experience might deviate substantially from the norm. For example, if during peak years profits and investment spending are high and dividend payouts are maintained, then a positive correlation might exist between dividends and external finance. Of course, one would not want to base forecasts of the future on exceptional time periods unless there were some high probability that the exceptional experience of these periods would be the norm in the future.

The ordinary least-squares estimates for Equation 13 are presented in Table 6, where the adaptive expectations model of dividend behavior is used as the underlying behavioral hypothesis. The results are in general disappointing. Among the endogenous variables, only the investment variable has the correct sign and this variable is only "weakly significant" in regression (1). Neither the external finance (debt) nor the liquidity (net working capital) variables have the expected signs, and neither variable is statistically significant. It is difficult to rationalize these results with either general expectations or the simple correlations reported in Table 5. As an experiment, the regressions were re-run with net cash flow substituted for profits. These results are presented in Table 7 and reflect much the same outcome as the results in Table 6. Neither investment nor external finance is statistically significant at conventional confidence levels and external finance has an incorrect sign.[10a] At this point, however, it is best to reserve judgment on the results due to the potential pitfalls of the single equation approach and ordinary tests of significance.

Short-Run Dividend Forecasts

The short-run forecasting ability of the adaptive expectations model is tested against actual data for 1974 and 1975. In 1974, after-tax profits increased substantially and the dividend payout ratio was reduced. For the four quarters of 1974, dividend payouts were 31.5, 26.7, 15.8 and 19.2 percent, respectively, compared to an average payout of 49.5 percent for 1960-1973. Given the lags in behavior incorporated in the dividend model, decreases in the payout ratio should be initially expected.

A summary of the 1974 forecasts using regression (2) in Table 4 is presented below in Table 8. It should be noted that there are short-run forecasts and in particular the actual values for both lagged profits and lagged dividends are employed. The model consistently over-predicts the level of dividends, especially in the second and fourth quarters of 1974. However, the root-mean-squared error is actually smaller than the standard error of the regression ($8.039 compared to $9.937). Thus, the forecasts are within the margin of

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[10a]See also E. F. Fama, "The Empirical Relationships Between the Dividend and Investment Decisions of Firms," American Economic Review, 64 (June 1974), pp. 304-18; S. J. Turnovsky, "The Allocation of Corporate Profits between Dividends and Retained Earnings," Review of Economics and Statistics, 49 (November 1967), pp. 583-89.

TABLE 6.6

REGRESSION RESULTS FOR EQUATION 6.13
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
$PROFIT_{-1}$	0.051 (4.933)*	0.042 (4.655)*	0.049 (4.376)*	0.047 (3.717)*
$DIVIDEND_{-1}$	0.931 (46.858)*	0.919 (51.312)*	0.930 (45.770)*	0.917 (24.824)*
INVESTMENT	-0.013 (1.480)	--	-0.016 (1.041)	-0.011 (1.070)
EXTERNAL FINANCE	--	-0.007 (1.222)	-0.004 (0.587)	-0.004 (0.575)
LIQUIDITY	--	--	--	0.0004 (0.419)
R^2	0.919	0.918	0.920	0.920
$\overline{R}^2$	0.915	0.914	0.914	0.912
F	290.927	286.539	191.429	141.247
D-W	2.008	1.990	2.004	1.998
h	0.030	0.036	0.015	0.009
ρ	-0.405	-0.345	-0.382	-0.380
k	2	2	3	3
$\hat{\delta}$	0.069	0.081	0.070	0.083
$\hat{\beta}$	0.739	0.519	0.700	0.566

*Significant at the 95 percent confidence level. Sample size n = 55. Standard errors of estimate are $9.332, 9.397, 9.396, and 9.474, respectively.

TABLE 6.7

REGRESSION RESULTS FOR EQUATION 6.13,
INCLUDING NET CASH FLOW
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CASH FLOW$_{-1}$	0.030 (3.975)*	0.023 (3.745)*	0.028 (3.349)*	0.039 (2.839)*
DIVIDEND$_{-1}$	0.915 (38.246)*	0.909 (36.745)*	0.915 (36.873)*	0.956 (20.859)*
INVESTMENT	-0.017 (1.573)	--	-0.012 (0.969)	-0.018 (1.328)
EXTERNAL FINANCE	--	-0.010 (1.556)	-0.006 (0.906)	-0.004 (0.619)
LIQUIDITY	--	--	--	-0.002 (1.015)
R^2	0.910	0.910	0.911	0.913
$\overline{R}^2$	0.905	0.904	0.904	0.904
F	258.040	257.040	171.302	128.695
D-W	1.931	1.947	1.938	1.941
h	0.258	0.198	0.530	0.229
ρ	-0.345	-0.270	-0.303	-0.337
k	2	3	3	3
$\hat{\delta}$	0.085	0.091	0.085	0.044
$\hat{\beta}$	0.353	0.253	0.329	0.886

*Significant at the 95 percent confidence level. Sample size n = 55. Standard errors of estimate are $9.858, 9.876, 9.886, and 9.887, respectively.

TABLE 6.8

DIVIDENDS FORECAST FOR 1974, USING
REGRESSION (2) IN TABLE 6.4

	Dividends in Millions of Constant 1973 Dollars		
Time	Actual	Forecast	Error
1974-I	$156.787	$157.144	-$ 0.357
1974-II	151.266	164.812	- 13.546
1974-III	164.619	165.139	- 0.520
1974-IV	191.370	200.007	- 8.637
Mean Absolute Error			$ 5.765
RMS - Error*			$ 8.039

*Root-mean-squared error of forecast.

TABLE 6.9

DIVIDENDS FORECAST FOR 1974, USING
REGRESSION (4) IN TABLE 6.4

	Dividends in Millions of Constant 1973 Dollars		
Time	Actual	Forecast	Error
1974-I	$156.787	$146.272	$10.515
1974-II	151.266	152.904	- 1.638
1974-III	164.619	150.751	13.868
1974-IV	191.370	174.755	16.615
Mean Absolute Error			$10.91
RMS - Error*			$12.55

*Root-mean-squared error of forecast.

error that might be expected given the estimated empirical relationship. The annual forecast for 1974 using this equation is $687.0 million compared to actual dividends of $664.1 million, a difference of $22.9 million. The 1974 forecasts using regression (4) in Table 4 are summarized in Table 9. These forecasts are somewhat poorer; the annual forecast for 1974 is $627.7 million.

Separate forecasts for 1975 were also prepared using these two regressions and the results are presented in Tables 10 and 11. Forecasts based on after-tax profits consistently exceed the actual level of dividends for 1975 and the annual forecast for 1975 overstates the level of dividends by $97.2 million. Using after-tax cash flow as the independent variable also results in an overstatement of the level of dividends for 1975, although the annual forecast is now off by $78.0 million. Much of the error in these forecasts occurs in the first and second quarters of 1975, which reflects the high (transitory) level of profits in 1974.

Summary

This chapter formulated and estimated several models for the level of dividends in constant dollars for the iron and steel industry for 1960-1973. The basic explanatory variables used were after-tax profits lagged one period, after tax cash flow lagged one period, and dividends lagged one period. The regression model fitted the data well; R^2s were 0.91-0.92 and the standard error of estimate was about $9.5-10 million. The short-run forecasting ability of the models was tested against the available quarterly data for 1974 and 1975. The model forecasted the 1974 data quite well and the forecast errors were within the range that one would expect on the basis of the regressions. The forecast errors for 1975 were somewhat larger and the model consistently overestimated the level of dividends. The mean absolute error for 1975 was about $20-24 million, which was about 14-17 percent of the average level of quarterly dividends. Short-run forecasting errors for dividends appear to be small to moderate depending on the circumstances present.

In Chapter 9 of this report, the recursive model will be estimated using simultaneous equation estimation procedures. By comparison, this chapter used ordinary least squares procedures, adjusted for serial correlation. The dividend equation employed in the recursive model uses as an independent variable net cash flow in millions of constant 1973 dollars. The comparable equation in this chapter is regression (4) in Table 4, which excludes the constant term. To complete the

TABLE 6.10

DIVIDEND FORECAST FOR 1975, USING REGRESSION
(2) IN TABLE 6.4

| Time | Dividends in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1975-I	$167.2	$205.0	-$37.8
1975-II	134.6	178.0	- 43.4
1975-III	135.4	136.0	- 0.6
1975-IV	126.0	141.4	- 15.4
Mean Absolute Error			$24.3
RMS-Error*			$29.8

*
Root-mean-squared error of forecast.

TABLE 6.11

DIVIDEND FORECAST FOR 1975, USING
REGRESSION (4) IN TABLE 6.4

| Time | Dividends in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1975-I	$167.2	$196.2	-$28.9
1975-II	134.6	171.5	- 36.8
1975-III	135.4	135.3	0.1
1975-IV	126.0	138.2	- 12.2
Mean Absolute Error			$19.5
RMS-Error*			$24.2

*
Root-mean-squared error of forecast.

econometric analysis of this equation, dividend forecasts for 1974 and 1975 were re-run with proper adjustment for lagged residual feedback.[11],[12] The revised forecasts are presented in Table 12; the results demonstrate the improvement to be obtained by accounting for residual feedback.[13] The dividend model seems well-suited for both short-run and long-run forecasting.

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[11]See, for example, R. S. Pindyck and D. L. Rubinfeld, Econometric Models and Economic Forecasts (New York: McGraw-Hill, 1976), pp. 170-73. In addition, the estimates of the first-order serial correlation coefficient was checked using the Hildreth-Lu scanning procedure. No significant improvement resulted from use of this method.

[12]Regression (4) in Table 5 was also re-estimated with an adjustment for the bias in standard errors and t-statistics due to the presence of a lagged dependent variable. Changes in the estimates were minor-- the estimated t-statistics were 3.808 and 38.005 compared to 3.837 and 38.315 for net cash flow and lagged dividends, respectively.

[13]Comparison of the forecasts with a naive fourth-order autoregressive model indicated that the dividend model produced superior forecasts. The autoregressive model was

$$\hat{D}_t = \underset{(4.926)}{0.7247} D_{t-1} + \underset{(1.577)}{0.2818} D_{t-2} - \underset{(0.615)}{0.1124} D_{t-3} + \underset{(0.630)}{0.0936} D_{t-4};$$

$$R^2 = 0.871, \; SEE = 11.629$$

while the forecasts for 1974-75 had a mean absolute error of $43.2 million and a root-mean-squared error of $46.5 million.

TABLE 6.12

DIVIDEND FORECASTS FOR 1974 AND
1975, USING REGRESSION (4)
IN TABLE 6.4[a]

| Time | Dividends in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1974-I	$156.8	$154.8	$2.0
1974-II	151.3	160.9	-9.6
1974-III	164.6	163.4	1.2
1974-IV	191.4	178.8	12.6
1975-I	167.2	192.6	-25.4
1975-II	134.6	180.8	-46.2
1975-III	135.4	147.2	-11.8
1975-IV	126.0	138.2	-12.2
Mean Absolute Error			$15.12
RMS-Error*			$20.37

[a]Forecasts are adjusted for lagged residual feedback.

*Root-mean-squared error of forecast.

CHAPTER 7

INVESTMENT AND RETAINED EARNINGS

Introduction

Firms may finance investment in one of three ways.[1] They may
finance internally, either from retained earnings or depreciation
allowances; they may borrow from banks or through the bond market;
or they may borrow through equity financing. There are, of course,
different costs and risks inherent in each method of financing. There
is little or no risk attached to spending internal funds, but these
funds are not costless. Internal funds may also be loaned to other
borrowers at the going interest rate or paid to stockholders in the
form of dividends.

In general, it can be argued that firms should pay out excess
funds in the form of dividends only if the rate of return that the
excess can earn on possible future projects is less than the average
rate of return on equity capital. However, this argument does not
take into account the differential tax treatment of dividends and
capital gains; dividends are taxed at rates that are at least twice
as high as capital gains. Thus, in order for stockholders' after-
tax equity to be maximized, they would have to receive a dividend yield
twice as great as the yield on internal investment projects or business
loans. For this reason, the imputed cost of financing investment with
internal funds is more closely related to the yield on bonds than to the
yield on equities. If this cost is generally low relative to the
average yield on investment projects, then internal funds will not
appear as a major determinant of the level of investment. However, as
discussed below, it could be that the availability of internal funds
plays a significant role in the timing of investment projects, especially
when projects can be deferred without totally disrupting production.

If a large firm wishes to borrow to invest, it will probably be
able to borrow at about the same rate as it could lend out excess funds.
Although the actual cost of the loan may be no greater than the imputed
loss of not lending, the true interest cost will generally be higher.
The true interest cost will include a risk premium required to service
additional debt relative to the earnings available, but this risk factor
need not be reflected in the actual market interest rate. If a firm is
committed to a certain size payment for debt service and its profits

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[1]The general discussion in this section follows M. K. Evans,
Macroeconomic Activity: Theory, Forecasting, and Control (New York:
Harper and Row, 1969), Chapter 4-5.

decrease below the necessary amount to meet payments, then it must consider reducing retained earnings, reducing dividends, or borrowing new funds to pay old debts. None of these solutions is costless in terms of the reactions of potential and actual investors. This extra risk factor must be included as part of the true interest cost of borrowing additional funds.

A general picture of the marginal cost of funds schedule is given in Figure 1.
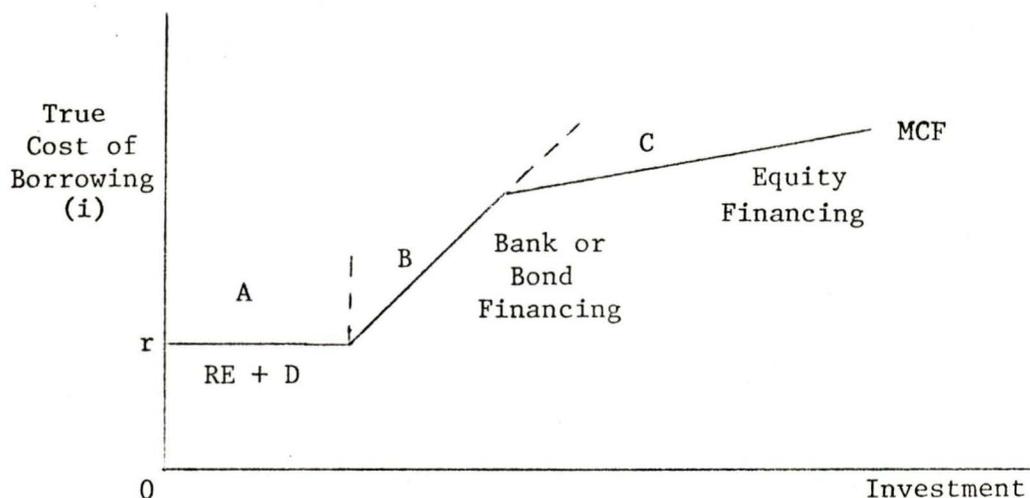
FIGURE 7.1
MARGINAL COST OF FUNDS (MCF)

Region A represents financing done with available retained earnings (RE) or depreciation allowances (D), where r is the market interest rate. In Region B, the sharp rise in the true cost of borrowing is not primarily due to a rise in the market interest rate at which firms borrow. Rather it is due to the imputed risk factor which occurs with increased debt servicing. Region C represents financing done through equity capital. Here the increase in the true cost of borrowing is partly due to the fact that as the firm offers more and more of its stock on the market, this will invariably depress the price and raise the yield that is paid. There are, however, several other factors which make it generally desirable to use debt rather than equity financing.

Most of the external financing of iron and steel investment is done through long-term debt rather than the sale of equities.[2] This

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[2] "Since World War II, none of the big eight steel companies have done any equity financing, and this type of financing has been more on the part of the smaller companies." H.R. Wood, "The Financial Challenge for the American Steel Industry in the 70s," in American Iron and Steel Institute, Third National Seminar: Steel Industry Economics (Washington, D.C.: 1972), p. 19. Most recently, Inland Steel has used equity financing; see Business Week, April 19, 1976, p. 145. Also U.S. Steel has announced plans to sell convertible debentures; see Wall Street Journal, May 26, 1976 and June 3, 1976.

occurs because equity capital is generally more costly than borrowing
from banks or through the bond market; there are several reasons for
this. First, interest payments are deductible before corporate income
taxes, while dividends are not deductible. Thus, a firm must earn twice
as much pretax profit to service equity financing as bond financing.
Second, some additional charges may arise from the cost of flotation for
a large issue of stock. Third, if the firm expects to maintain the same
dividend-earnings ratio on the new stock issue, then this will increase
the amount that must be earned to service equity capital. Taking tax
and payout considerations into account means that investment generally
costs about four times as much to finance through equity if no signifi-
cant risk was involved in bond financing. As the risk factor in debt
financing causes an increase in the true cost of borrowing, equity
financing may be possible. The main advantages of equity financing are
that dividend payments are not mandatory, implying the absence of a risk
factor.

The parameters of the mcf schedule are retained earnings, depre-
ciation, the market interest rate, and possibly the debt-to-equity ratio
or some other measure of indebtedness. In Figure 2, the investment
demand or meI schedule is shown along with the supply of funds or mcf
schedule. The parameters of the meI schedule are output, capital stock,
and the relative price of capital. The intersection of the meI and mcf
schedules will, at any point in time, determine the desired level of
investment. The possibility exists that the intersection of the meI and
mcf schedules will shift over the business cycle. Since the meI sche-
dule depends primarily on output, it will shift out when output in-
creases and shift back when output decreases. This effect is shown in
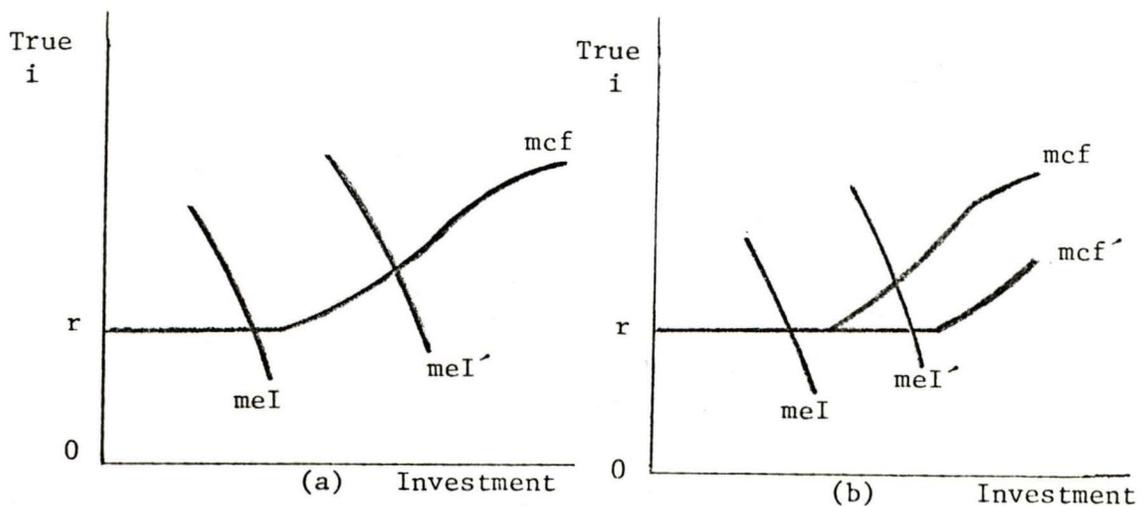
FIGURE 7.2
INVESTMENT DETERMINATION

panel (a) and indicates that bond interest rates might be an important financial determinant of investment during booms while internal funds would be important only during recessions.

However, cash flow also increases in booms. If output and cash flow increase proportionately, then it could be that output and internal funds are approximately synchronized and the intersection of the two schedules occurs in about the same relative position over the entire business cycle. This effect is shown in panel (b).

Duesenberry suggests that the more profits fluctuate cyclically, the more sharply the slope of the mcf schedule for a firm rises.[3] This in turn would be primarily due to fluctuations in output caused by cyclical fluctuations of industry sales due to the nature of the product (e.g., durable goods) and pricing policies of the producers. The iron and steel industry is noted for its cyclical output behavior and, consequently, we would expect iron and steel firms to be especially reluctant to finance new investment via long-term debt. Thus, retained earnings or some related measure of internal funds may act as a determinant of the timing of investment since firms will generally want to be operating in the elastic portion (Region A) of the mcf schedule. The apparent willingness of iron and steel firms to delay investment in periods of financial uncertainty suggests that this timing mechanism may be an important factor in explaining iron and steel investment.[4]

The maintained hypothesis--that internal funds are a determinant of the timing of investment--must be qualified in light of three additional facts. First, the appropriate lag structure on the internal funds variable is at this point uncertain. More likely than not, the lag from appropriations to expenditures is complex and extends over several time periods. Also, if a weighted lag model is used, a high correlation may exist between the expected output variable and internal funds, making it very difficult to distinguish their separate influences.

Second, it is evident that iron and steel firms were able to finance a considerable portion of their fixed investment in the late 1960s with debt. Table 1 shows the extent to which gross retained earnings exceeded or fell short of capital expenditures during the

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[3] J. S. Duesenberry, Business Cycles and Economic Growth (New York: McGraw-Hill, 1958), p. 98.

[4] See, for example, "Bethlehem Steel Slows Construction at Two Facilities," Wall Street Journal, December 12, 1975; "U.S. Steel Corporation is Considering Major New Mill," Wall Street Journal, March 29, 1976; "Lykes-Youngstown Stretches Timetable on Two Big Projects," Wall Street Journal, March 30, 1976.

TABLE 7.1

GROSS RETAINED EARNINGS AND CAPITAL
EXPENDITURES IN IRON AND STEEL INDUSTRY
(Millions of Current Dollars)

	Gross Retained Earnings[a]	Capital Expenditures	Excess (+) or Deficit (−) of Internal Funds over Capital Expenditures	Capital Expenditures as a Percent of Gross Retained Earnings	
				Steel Industry	Total Nonfarm Nonfinancial Corporate Business
1953	$1,009	$ 988	+$ 21	97.9%	112.8%
1954	997	609	+ 388	61.1	101.3
1955	1,445	714	+ 731	49.4	91.1
1956	1,399	1,311	+ 88	93.7	107.6
1957	1,382	1,723	− 341	124.7	111.4
1953-57 Ave.	$1,246	$1,069	+$ 177	85.8%	104.6%
1958	961	1,136	− 175	118.2	101.0
1959	931	934	− 3	100.3	92.9
1960	1,087	1,521	− 434	139.9	104.7
1961	882	960	− 78	108.8	98.6
1962	1,016	911	+ 105	89.7	94.0
1958-62 Ave.	$ 976	$1,092	−$ 116	111.9%	98.0%
1963	1,373	1,040	+ 333	75.7	93.8
1964	1,576	1,600	− 24	101.5	91.5
1965	1,718	1,823	− 105	106.1	96.1
1966	1,791	1,953	− 162	109.0	101.5
1967	1,793	2,146	− 353	119.7	104.2
1963-67 Ave.	$1,651	$1,712	−$ 61	103.7%	97.9%
1968	1,856	2,307	− 451	124.3	111.2
1969	1,563	2,047	− 484	131.0	126.7
1970	1,172	1,736	− 564	148.1	132.0
1971	1,296	1,425	− 129	110.0	120.7
1972	1,569	1,174	+ 395	74.8	117.9
1968-72 Ave.	$1,491	$1,738	−$ 247	116.6%	121.4%
1973	2,158	1,400	+ 758	64.9	128.4
1974	3,354	2,115	+ 1,239	63.1	NA
1975	2,523	3,215	− 692	127.4	NA

[a]After-tax profits plus depreciation minus dividends.

Source: American Iron and Steel Institute, Annual Statistical Report.

period 1953 to 1975. From 1960 through 1973, gross retained earnings exceeded capital expenditures in only four years while for the entire period capital expenditures exceeded gross retained earnings by $1,193 million dollars. Capital expenditures might have been greater if greater amounts of internal funds were available. However, the availability of internal funds clearly did not place an absolute limit on the level of capital expenditures. It is, of course, difficult to tell from annual data the extent to which the timing of capital expenditures was influenced by internal funds availability. Indeed, given the importance of long-term debt as a source of finances, it is possible that the timing mechanism during the 1960s had little or nothing to do with internal sources of funds.

Table 2 shows the stock and changes in the stock of long-term debt, the average interest rate on debt, and various measures of interest coverage. Long-term debt increased by $2,475 million during the period 1960 to 1973. The increase in the industry's debt burden was matched by increase in interest charges and a rise in the average interest rate on long-term debt. Interest coverage measured, for example, by the percentage of interest charges to net cash flow (after tax profits plus depreciation before dividends) increased to 15 percent in the 1968 – 1972 period compared to an average of 7 percent during 1958 – 1967.

A third factor which might increase the importance of internal funds is the nature of investment in iron and steel over the past decade. Table 3 shows that from 1953 to 1960, raw steel capacity expanded by 31 million tons while during the period 1960 to 1970, capacity increased by about 15 million tons. Since 1970, capacity has been roughly constant at about 163 million tons of raw steel per year. These comparisons serve to emphasize that much of the capital expenditures in iron and steel have been for replacement and modernization of facilities, rather than for expansion of capacity. It is not clear what role internal funds will play when the major portion of investment is replacement and not net additions to capital stock. Conceivably, internal funds could be more important in these circumstances due to the heavy reliance on depreciation as the return of investment (capital recovery) for future expenditures. Moreover, given the rate of inflation in recent years, serious deficiencies in depreciation allowances can develop which may further delay capital appropriations.[5]

With the above comments as general background we now turn to the task of incorporating internal funds in a neoclassical model of investment demand. From our discussion, the role of internal funds in the level or timing of investment expenditures cannot be considered a foregone fact. Some aspects of economic activity suggest that these funds should be very important in the investment process; other aspects, e.g., the importance of long-term debt in the 1960s, suggest quite the opposite conclusion.

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[5]See American Iron and Steel Institute, Steel Industry Economics and Federal Income Tax Policy (Washington, D.C.: June 1975), pp. 36-37.

TABLE 7.2

IRON AND STEEL INDUSTRY LONG-TERM DEBT AND INTEREST CHARGES ON LONG-TERM DEBT
(Millions of Current Dollars)

December 31	Long-Term Debt	Change in Long-Term Debt	Interest Charges on Long-Term Debt	Average Interest Rate on Debt	Interest Charges as[a]		
					Percent of Revenue	Percent of Net Cash Flow	Percent of Net Profits
1953	$1,327	−$120	$ 55	4.1%	0.4%	4.1%	7.5%
1954	1,486	+159	53	3.6	0.5	4.0	8.3
1955	1,547	+ 61	54	3.5	0.4	2.9	4.9
1956	1,568	+ 21	55	3.5	0.4	2.9	4.9
1957	1,802	+234	65	3.6	0.4	3.3	5.7
1953–57 Ave.	$1,546	+$ 71	$ 56	3.6%	0.4%	3.3%	5.9%
1958	2,145	+343	80	3.7	0.6	5.3	10.2
1959	2,303	+153	94	4.1	0.6	6.3	11.3
1960	2,488	+158	101	4.1	0.7	6.1	12.5
1961	2,969	+480	123	4.1	0.9	8.5	17.8
1962	2,854	−115	132	4.6	0.9	8.7	23.3
1958–62 Ave.	$2,552	+$210	$106	4.2%	0.8%	7.0%	14.4%
1963	2,695	−159	128	4.7	0.9	7.0	16.3
1964	2,874	+179	129	4.5	0.8	6.3	13.0
1965	3,120	+245	137	4.4	0.8	6.3	12.3
1966	2,782	+659	178	4.7	1.0	7.8	16.5
1967	4,205	+423	185	4.4	1.1	8.1	22.3
1963–67 Ave.	$3,135	+$270	$151	4.8%	0.9%	7.1%	15.9%
1968	4,601	+396	224	4.9	1.2	9.7	22.6
1969	4,608	+ 7	246	5.3	1.3	12.0	27.9
1970	5,134	+526	288	5.6	1.5	17.3	56.2
1971	5,144	+ 10	332	6.5	1.6	19.7	59.0
1972	5,230	+ 85	346	6.6	1.5	17.6	44.6
1968–72 Ave.	$4,943	+$204	$287	5.8%	1.4%	14.8%	38.4%
1973	4,963	−265	357	7.2	1.2	13.7	28.1
1974	4,651	−312	354	7.6	0.9	8.8	14.3
1975	5,699	+ 1,448	384	6.7	1.1	12.1	24.2

[a]PBIT is Profits Before Interest and Taxes.

Source: American Iron and Steel Institute, Annual Statistical Report.

TABLE 7.3

IRON AND STEEL INDUSTRY INGOT PRODUCTION,
CAPACITY AND UTILIZATION RATE

| January 1 | Production | Capacity[a] | Utilization |
	(thousands of tons)		Rate
1953	111,610	117,547	94.9%
1954	88,312	124,330	71.0
1955	117,036	125,828	93.0
1956	115,216	128,363	89.8
1957	112,715	133,459	84.5
1953–57 Ave.	108,978	125,905	86.6%
1958	85,255	140,743	60.6
1959	93,446	147,634	63.3
1960	99,282	148,571	66.8
1961	98,014	148,800	65.9
1962	98,328	149,300	65.9
1958–62 Ave.	94,865	147,010	64.5%
1963	109,261	150,900	72.4
1964	127,076	154,900	82.0
1965	131,462	156,100	84.2
1966	134,101	160,200	83.7
1967	127,213	161,800	78.6
1963–67 Ave.	125,823	156,780	80.3%
1968	131,462	162,300	81.0
1969	141,262	162,800	86.8
1970	131,514	163,400	80.5
1971	120,443	163,400	73.7
1972	133,241	163,400	81.5
1968–72 Ave.	131,584	163,060	80.7%
1973	150,799	163,400	92.3
1974	145,720	163,400	89.2
1975	116,642	163,400	71.4

[a]Capacity as of January 1. Until January 1, 1960, The American Iron and Steel Institute published capacity data based on average performance under normal operating conditions, including allowance for periods when furnaces were idle because of regular maintenance shutdowns. After 1960, actual capacity measurement is distorted by such factors as obsolete equipment which had been abandoned in place but not dismantled, production which was due to repair and regular rehabilitation activities, and the temporary unavailability of labor, power or materials. As a consequence, post-1960 capacities are probably somewhat inflated.

Sources: Production data--American Iron and Steel Institute. Capacity data for 1953-1960--American Iron and Steel Institute, Annual Statistical Report; 1961-1967--Jon r. Nelson, "An Interregional Recursive Programming Model of the U.S. Iron and Steel Industry: 1947-1967," unpublished Ph.D. dissertation, University of Wisconsin, 1970, pp. 69-75; 1968-1975--Joint Economic Committee report, November 29, 1974.

The Investment-Retained
Earnings Model

Investment spending on fixed plant and equipment represents a dynamic process by which firms adjust to their desired or optimum stocks of capital. Econometric models of investment spending typically characterize this process by two stages of analysis. In the first stage, the determinants of the optimum capital stock are postulated or derived. In the second stage, the nature of the adjustment process is investigated, with various arguments presented for technological and economic constraints on the rate at which discrepancies between the optimum and actual stocks can or will be eliminated. It is generally assumed that the factors that delay adjustment are relatively stable over time, so that the adjustment process can be characterized by a fixed lag distribution of either a simple or complex form. The assumption of a fixed lag structure does not account for essentially short-run factors which affect the timing of investment expenditures.

The ideal approach would be to develop a model of investment demand in a single stage and to justify the form of the lag distribution adopted by deriving it from the profit-maximizing behavior of firms. The danger is that an investigator, using a two-stage analysis, will select that lag structure which most closely vindicates his model of the first stage. It is quite likely that some lag structure can be found that will lead to significant results for practically any economic variable and, as a consequence, futile controversies may arise over the relative importance of different "determinants" of capital expenditures.

Although a single-stage approach[6] is beyond the scope of the present report, we do narrow the set of possible lag distributions somewhat by using prior estimates of the lag weights from studies of investment behavior by Neumann and Almon. This method allows us to concentrate on specific explanatory variables and not become too heavily involved in the statistical and theoretical problems concerning the lag structure.

The model proposed in this chapter does, however, allow for a flexible capital stock adjustment process in contrast to the fixed adjustment model commonly found in the literature. This model, which is due primarily to Coen,[7] allows the speed of adjustment to vary with

[6]A single-stage approach is found in R. Eisner and R. H. Strotz, "Determinants of Business Investment," in Commission on Money and Credit, Impacts of Monetary Policy, Research Study Number Two (Englewood Cliffs: Prentice - Hall, 1963), pp. 60-337. See also M. Nerlove, "Lags in Economic Behavior," Econometrica, 40 (March 1973), pp. 221-251.

[7]R. M. Coen, "The Effect of Cash Flow on the Speed of Adjustment," in G. Fromm (ed.), Tax Incentives and Capital Spending (Washington, D.C.: Brookings Institution, 1971), Chapter 4.
This section is based on Coen's work and closely follows his model development and analysis.

retained earnings or some other measure of liquidity. It is argued that the availability of internal funds is a determinant of the speed at which gaps between the desired and optimal capital stock are eliminated rather than a determinant of the long-run optimum capital stock itself. For this reason, retained earnings are introduced into the model only after the demand for capital has been explored.

The Demand for Capital

The model of capital demand presented here is written in discrete time and in the absence of taxation.[8] At the beginning of period one, a firm must choose an investment program for the future, I_t, $t = 1$, $2,\ldots,n$, and decide on labor inputs as well as each future date, L_t, $t = 1, 2,\ldots,n$.

The firm maximizes its net worth W, which may be written as

$$(7.1) \qquad W = \sum_{t=1}^{n} (pQ_t - wL_t - qI_t)(1+r)^{-t}$$

where Q_t = output at time t,

p = price of the output,

w = wage rate,

q = price of the capital good,

r = rate of interest.

Equation 1 is maximized subject to two constraints. The first is a general production function relating Q_t to L_t and K_{t-1}, the capital stock on hand at the end of the preceding period. Thus,

$$(7.2) \qquad Q_t = Q(L_t, K_{t-1})$$

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[8]For a treatment in continuous time see G. R. Neumann, Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975 - 1980 (University Park, Pennsylvania: Institute for Research on Human Resources, December 1975), Chapter 2.

The implications of corporate taxation are taken up in Coen, op. cit., and R. M. Coen, "Effects of Tax Policy on Investment in Manufacturing," American Economic Review, 58 (May 1968), pp. 200-11.

The second constraint is an identity relating current and past investments to the current capital stock. Assuming a constant percentage depreciation rate δ on past investments, this relationship is:

$$(7.3) \qquad K_t \equiv I_t + (1-\delta)I_{t-1} + (1-\delta)^2 I_{t-2} + \ldots + (1-\delta)^i I_{t-i}$$

$$\equiv I_t + (1-\delta) K_{t-1}$$

Maximization of Equation 1 subject to Equations 2 and 3 yields the familiar marginal productivity conditions:

$$(7.4) \qquad \frac{\partial Q_t}{\partial L_t} = \frac{w}{p}$$

$$(7.5) \qquad \frac{\partial Q_t}{\partial K_t} = \frac{q(r+\delta)}{p} = \frac{c}{p}$$

for $t = 1, 2, \ldots, n$, where $c = r + \delta$ is the implicit rental price of a unit of capital per period, in the absence of taxation.

The derived demand functions for the optimum capital and labor inputs, K* and L*, are obtained by solving the first-order conditions for the unknowns in terms of the knowns. These solutions are the long-run demand functions of the firm for capital and labor, respectively, and can be written as:

$$(7.6) \qquad K* = K(w/p, \ c/p)$$

$$(7.7) \qquad L* = L(w/p, \ c/p)$$

A notable feature of these relationships is the exclusion of output or any other variable closely related to output, e.g., sales or new orders. In order to introduce output into the firm's capital demand function, additional features of the production and pricing process must be considered.

A crucial and unrealistic assumption made in deriving the demand functions is that output produced and sales are identical. If this were always the case, there would be no reason for firms to hold inventories of semi-finished and finished goods. In general, firms can be expected to hold inventories for two reasons. First, inventories and order backlogs act as a buffer against unexpected fluctuations in sales. If, for example, actual sales exceed planned sales, then inventories will be drawn down in the current period. If realized sales exceed output or planned sales for a number of periods, firms would at some point adjust

their expectations about permanent sales upward and would then adjust their labor and capital inputs so as to produce at minimum cost. In this way, realized sales--given exogenously--would enter the demand function for capital along with user cost. Empirically, there is a question here whether expectations about the future level of sales are best reflected in an average of realized output or sales in several previous periods. We have chosen to use output.

A second reason for holding inventories is to reduce or prevent sharp changes in product prices. In an oligopolistic industry, this strategy has the advantage of promoting "orderly" pricing.[9] Implicit in this argument is a presumption that product prices are relatively sticky, so that short-run adjustments in markets take place via un-intended changes in inventories. This is not to say that prices will necessarily be inflexible in the long run; rather sellers will revise prices only in response to clear-cut changes in long-run demand, cost, or other supply conditions. Under these circumstances, short-run prices and outputs are given and the firm is faced with a problem of short-run cost minimization.

First-order conditions for cost minimization imply that the marginal rate of substitution of the two inputs should be equated to the ratios of their prices. The demand function for capital can be written as

$$(7.8) \qquad K^* = K(Q, c/w)$$

where Q is realized output in real terms or an average of realized outputs in several previous periods.

Investment and Retained Earnings

A theory of investment must specify how the demand for capital (a stock) is translated into investment demand (a flow). Investment demand is made up of two components--net investment and replacement. Net investment results from changes in the desired stock of capital while replacement can be assumed to be a constant fraction δ of the capital stock on hand at the beginning of the period. However, due to recognition, financing, and order lags, a change in the desired capital stock may generate net expenditures over a number of periods. After accounting for this adjustment process, net investment during period t is

$$(7.9) \qquad I^N_t = \sum_{i=0}^{n} \beta_i (K^*_{t-i} - K^*_{t-1-i})$$

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[9]See F. M. Scherer, Industrial Market Structure and Economic Performance (Chicago: Rand McNally, 1970), pp. 149-57.

where n+1 is the number of periods over which a change in the desired
stock generates net expenditures with a distributed lag pattern given by
β_i, i = 0, ..., n, and where $\Sigma_i \beta_i$ = 1. Gross investment during period t
is then given by

$$(7.10) \qquad I_t = \sum_{i=0}^{n} \beta_i (K^*_{t-i} - K^*_{t-1-i}) + \delta K_{t-1}$$

Following Coen,[10] net investment is always a fraction b (the speed
of adjustment) of the gap between desired capital stock and the actual
capital stock. Using a Koyck transformation it is possible to reduce
the number of parameters of the lag distribution to one. Equation 10
may be re-written as

$$(7.11) \qquad I_t = b(K^*_t - K_{t-1}) + \delta K_{t-1}$$

where $0 < b \leq 1$, is the fractional, speed of adjustment parameter.

Retained earnings, or some other measure of internal funds avail-
able for investment, can be viewed as a constraint on the timing of
investment expenditures rather than a determinant of the optimum capital
stock. It is argued by some that firms prefer to finance investment
expenditures from internal sources (retained earnings, depreciation
allowances) and use external sources (debt, equity issues) only when
absolutely necessary. Implicit in this argument is the assumption that
capital markets are imperfect--to a degree--and firms can borrow only at a
rate higher than they can lend, or that the true interest rate increases
with the ratio of debt-to-equity or some other measure of indebtedness
such as interest coverage.

An alternative explanation of the preference for internal financing
rests on the divergence between ordinary income tax rates and tax rates
on capital gains. The importance of internal funds as a source of
financing may reflect not so much the preference of management for
internal financing as the preference of stockholders for capital gains
income.

To incorporate retained earnings as an influence on the speed of
adjustment, we write the basic investment demand model as

$$(7.12) \qquad I_t = \left[b_0 + b_1 \frac{F_{t-i}}{K^*_t - (1-\delta)K_{t-1}} \right] \left[K^*_t - (1-\delta)K_{t-1} \right]$$

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[10]Coen, op. cit., pp. 147-49. The transformation from Equation 10
to Equation 11 is based on the assumption that β's form an infinite
decaying geometric series or Koyck lag distribution.

where I = real gross investment expenditures,

K = actual real capital stock, measured end of period,

K* = desired real capital stock, end of period,

b_i = an adjustment coefficient, i = 0, 1, 0 < b_i ≤ 1,

δ = the depreciation rate,

$K*_t$ - $(1-δ)K_{t-1}$ = the investment requirement,

F = real retained earnings (after tax profits minus dividends) or real gross retained earnings (retained earnings plus depreciation).

The amount of internal funds available for investment relative to the investment requirement determines the speed of adjustment. The firm is assumed to adjust more rapidly the higher the ratio of internal funds to desired expansion plus replacement. As a partial consequence, the adjustment speed in a flexible adjustment model may temporarily equal zero or exceed unity without implying long-run instability in the investment process. Also, if investment and dividend decisions are made simultaneously, then the firm has the option of decreasing dividend payments so as to force the adjustment speed to exceed unity. Thus, while it might be argued that restrictions should be placed on the adjustment coefficients, this procedure seems unwarranted, at least in the problem considered here.

The actual capital stock variable can be eliminated from Equation 12 by using the identity between the capital stock and all past investments

$$(7.13) \qquad K_t \equiv \sum_{i=0}^{\infty} (1-δ)^i I_{t-i}$$

Cross multiplication of Equation 12 yields

$$(7.14) \qquad I_t = b_o \left[K*_t - (1-δ)K_{t-1} \right] + b_1 F_{t-i}$$

where the total speed of adjustment is composed of a fixed value (b_o) and a portion (b_1) that depends on the level of retained earnings relative to the investment requirement. Substituting for K_{t-1}, and avoiding some tedious substitutions (see Appendix B), we have the following transformation

$$(7.15) \quad I_t = b_o \left[K^*_t - (1-\delta)K^*_{t-1} \right] + (1-b_o)(1-\delta)I_{t-1}$$

$$+ \; b_1 [F_{t-i} - (1-\delta)F_{t-1-i}]$$

This transformation is based partly on the observation that an investment equation assuming one capital stock series could yield coefficients different from those obtained with some alternative series. If, however, Equation 12 contains a nonautocorrelated disturbance, then Equation 15 will contain an autocorrelated disturbance. All regressions estimated in this chapter were adjusted for autocorrelations using the Cochrane-Orcutt iterative procedure.

Expectation Lags

Estimation of Equation 15 requires specification of the determinants of the desired capital stock, K_t^*. In this section we employ a general specification of the desired capital stock which does not depend on a specific form of the production function. However, the model is still capable of generating values for the capital-output elasticity and the capital-relative price elasticity (evaluated at the means for the sample period). These estimates may be used as a check on the general procedures employed. The desired capital stock is determined by two variables--output and the user cost of capital divided by the wage rate. The current values of these variables are likely to contain both transitory and permanent components. It is assumed that firms base their decisions on the permanent components only, and that the permanent component of each variable can be approximated by some weighted average of current and past values of the variable (a lag structure).

Among the alternative lag structures are the following:

1. The rectangular, or uniform distribution. Each quarter receives equal weight of $1/n$.

2. The arithmetic distribution. The weights are proportional to n, n-1, n-2, ..., 1. The proportionality factor that makes the weights sum to unity is $2/n(1+n)$.

3. The inverted-V distribution. The weights are proportional to $1,2,3,...,n/2, n/2, n/2$ minus $1,..., 3,2,1$. The proportionality factor that makes the weights sum to unity is $4/(n^2 + 2n)$.

4. The general polynomial approximation to the lag structure due to Almon.[11] The weights will generally approximate an inverted-V distribution. See Appendix C for the Almon weights used in this study.

The K* function is assumed to be linear

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[11] S. Almon, "The Distributed Lag Between Capital Appropriations and Expenditures," _Econometrica_, 33 (January 1965), pp. 178-196.

(7.16) $\quad K^*_t = d_o + \sum\limits_{i=0}^{n-1} \gamma_{t-i}\left[d_1\, Q_{t-i} + d_2(c/w)_{t-i}\right]$

where the γ's are the weights given by the expectations lag distribution.
Thus,

(7.17) $\quad K^* - (1-\delta)K^*_{t-1} = \delta d_o + \sum\limits_{i=0}^{n-1} \gamma_{t-i}\left[d_1\left[Q_{t-i} - (1-\delta)\,Q_{t-1-i}\right]\right.$

$$+\, d_2\left[(c/w)_{t-i} - (1-\delta)\,(c/w)_{t-1-i}\right]\Big]$$

Let the general lag operator be $\mu(\theta)$, then for any variable X

(7.18) $\quad \mu(\theta)X_t = \sum\limits_{i=0}^{n-1} \gamma_{t-i}\left[X_{t-i} - (1-\delta)X_{t-1-i}\right]$

but for simplicity in notation let $\mu(\theta)X_t = \Delta X'_t$, where the prime in-
dicates the expected or permanent value of the change in X. Then, for
the investment requirements we can write

(7.19) $\quad K^* - (1-\delta)K^*_{t-1} = \delta d_o + d_1(\Delta Q)'_t + d_2(\Delta c/w)'_t$

Substituting Equation 19 into Equation 15, the basic investment relation
is[12]

(7.20) $\quad I_t = b_o\delta d_o + b_o d_1(\Delta Q)'_t + b_o d_2(\Delta c/w)'_t$

$$+\, (1-b_o)\,(1-\delta)I_{t-1} + b_1\left[F_{t-i} - (1-\delta)F_{t-1-i}\right]$$

Given a value for the depreciation rate δ, all of the parameters in
Equation 20 can be identified.

Initial Empirical Results

Using the model presented in the previous section, the basic
empirical relationship proposed for estimation is of the form

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[12]In most empirical tests, the $(\Delta Q)'_t$ and $(\Delta c/w)'_t$ terms were lagged
one period to reduce in any possible simultaneity between these variables
and I_t.

$$(7.21) \quad I_t = a_0 + a_1(\Delta Q)\acute{}_{t-1} + a_2(\Delta c/w)\acute{}_{t-1} + a_3 I_{t-1}$$

$$+ a_4[F_{t-i} - (1-\delta)F_{t-1-i}] + \varepsilon_t$$

where I_t = gross investment expenditures in period t, t = 0, ..., n,

$\Delta Q\acute{}_{t-1}$ = weighted average of past changes in output, beginning in period t-1,

$\Delta(c/w)\acute{}_{t-1}$ = weighted average of past changes in the ratio of the user cost of capital, c, to the wage, w, beginning in period t-1,

F_{t-i} = retained earnings (or gross retained earnings) in period t-i,

δ = the depreciation rate set equal to 0.036,[13]

ε_t = the stochastic error term, possibly autocorrelated due to transformation.

The structural equations which underlie the model of investment demand are given by:

$$(7.22) \quad I_t = \left[b_o + b_1 \frac{F_{t-i}}{K_t^* - (1-\delta)K_{t-1}} \right] \left[K_t^* - (1-\delta)K_{t-1} \right]$$

and

$$(7.23) \quad K_t^* = d_0 + d_1 Q\acute{}_{t-1} + d_2(c/w)\acute{}_{t-1}$$

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[13]Neumann, op. cit., p. 21.

Given an estimate of the depreciation rate δ, all of the structural parameters can be estimated from the coefficients of the final investment relationship:

(7.24) $b_0 = 1 - (a_3/(1-\delta))$,

   $b_1 = a_4$,

   $d_0 = a_0/\delta b_0$,

   $d_1 = a_1/b_0$,

   $d_2 = a_2/b_0$.

A complete description of the sources of data, variable definitions, and construction methods is given in Appendix C. Where appropriate, all data were seasonally adjusted, deflated and expressed at quarterly rates. Investment and retained earnings are expressed in millions of 1973 dollars and output is expressed in millions of tons of raw steel. All relations were fitted by ordinary least squares, with adjustment for serial correlation using the Cochrane-Orcutt procedure. The sample period is 1960 to 1973, consisting of 55 quarterly observations.

The following formula was applied to calculate the rental price of capital (see Appendix D)[14]

(7.25) $c_t = q_t(\delta_t + r_t)\left[(1 - k_t - u_t z_t)/(1 - u_t)\right]$

where q_t = fixed investment deflator (1973 = 100) in period t,

   δ_t = the quarterly rate of economic depreciation,

   r_t = cost of capital at its quarterly rate,

   k_t = rate of investment credit against income tax,

   u_t = corporate income tax rate, and

   z_t = present value of allowable future depreciation deductions on a dollar's worth of gross investment.

The initial empirical estimates for Equation 22 were obtained using the distributed lag weights for output and the user cost of capital from

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[14]Ibid., pp. 19-25. One shortcoming of this model is that it is not possible to identify coefficients associated with individual variables which make up c, i.e., r, k, u, and z. Individually these variables do not change much from one period to another, although collectively the variable c does. The data used to generate c are presented in Appendix D.

the Phase I report.[15] The total lag is 24 quarters with a mean lag of
12.01 quarters. The lag weights closely approximate an inverted-V
distribution although a slight skewness to the distribution is notice-
able; it takes almost five years before 90 percent of the original
stimulus to capital expansion is actually realized in the form of
investment spending.

The initial empirical results are presented in Tables 4 and 5,
along with the estimated values of the structural parameters for Equations
23 and 24. Although the model fits the data extremely well--R^2 is
always above 0.94--the coefficient on the internal funds variable is
negative, although not statistically significant at conventional con-
fidence levels. This result, which is not explicable in terms of the
theory, occurs when either retained earnings (RE) or gross retained
earnings (GRE) is used as the measure of internal funds availability.
The adjustment coefficient b_o is in the range 0.21 to 0.23, implying
that about 20 percent of the gap between desired and actual stocks of
capital will be closed during the quarter. This value seems to be
somewhat on the high side compared to Coen's results, and may reflect
the aggregate nature of Coen's data.

Given the uncertainty of the lag on F_{t-i}, a number of alternative
formulations of the model were tried. The objective was to find a lag
structure for the model which would yield a positive coefficient for the
internal funds variable. Several alternative lag specifications were
used; however, only slight changes in the model specification were in
fact necessary to obtain the desired positive coefficient. Tables 6 and
7 present the results for the new lag structure on gross retained
earnings and retained earnings, respectively.

Regression (3) in Table 6 seems to yield the best results, both in
terms of a priori theory and by the standard error of estimate criterion.
The model fits the data well; R^2 is 0.957. All coefficients have the
correct signs and are statistically significant at the 95 percent con-
fidence level. The adjustment coefficients are 0.197 and 0.061, respec-
tively. This implies that if cash flow available for expansion is quite
small relative to the gap between desired and actual stocks of capital,
then about 20 percent of the gap will be closed during the quarter; but
if cash flow available for expansion is roughly equal to the gap, then
about 26 percent of the gap will be closed.

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[15]Ibid., p. 55. The weights were normalized so that they sum to
unity. These weights are presented in Appendix C along with the weights
obtained from a 24-quarter inverted-V distribution.

TABLE 7.4

REGRESSION RESULTS FOR EQUATION 22
WITH COCHRANE-ORCUTT PROCEDURE
(Dependent Variable is Gross Investment in Millions of 1973 Dollars)

Variable	Regression Coefficient (Student t)		
	(1)	(2)	(3)
CONSTANT	123.376 (4.091)*	125.367 (4.829)*	126.838 (4.923)*
$\Delta Q'_{-1}$	56.216 (2.996)*	67.365 (4.008)*	67.036 (4.026)*
$\Delta(c/w)'_{-1}$	-177,294 (4.918)*	-184,231 (5.922)*	-185,209 (6.004)*
I_{-1}	0.774 (16.172)*	0.746 (17.328)*	0.746 (17.451)*
ΔRE_{-1}	--	-0.020 (1.495)	--
ΔGRE_{-1}	--	--	-0.021 (1.620)
R^2	0.952	0.961	0.961
$\bar{R}^2$	0.950	0.957	0.958
F	334.465	293.540	296.014
D-W	2.156	1.943	1.939
h	-0.612	0.220	0.233
SEE	27.457	25.394	25.292
ρ	-0.049	-0.131	-0.137
k	2	2	2
$\hat{b}_0$	0.197	0.226	0.226
$\hat{b}_1$	--	-0.020	-0.021
$\hat{d}_0$	17,377	15,671	15,855
$\hat{d}_1$	285.216	298.075	296.619
$\hat{d}_2$	-899,513	-815,181	-819,509

*Significant at the 95 percent confidence level. Sample size n = 55.

TABLE 7.5

REGRESSION RESULTS FOR EQUATION 22,
WITHOUT SERIAL CORRELATION ADJUSTMENT
(Dependent Variable is Gross Investment in Millions of 1973 Dollars)

Variable	Regression Coefficient (Student t)		
	(1)	(2)	(3)
CONSTANT	125.432 (3.721)*	125.213 (4.050)*	127.174 (4.130)*
$\Delta Q'_{-1}$	48.415 (2.356)*	61.570 (3.198)*	61.574 (3.215)*
$\Delta(c/w)'_{-1}$	-174,144 (4.324)*	-179,570 (4.857)*	-181,020 (4.918)*
I_{-1}	0.789 (15.013)*	0.758 (15.470)*	0.756 (15.488)*
ΔRE_{-1}	--	-0.025 (1.883)**	--
ΔGRE_{-1}	--	--	-0.026 (2.015)*
R^2	0.945	0.956	0.956
$\bar{R}^2$	0.942	0.952	0.952
F	293.990	263.895	266.606
D-W	1.998	2.175	2.189
h	0.006	-0.688	-0.745
SEE	29.239	26.813	26.682
$\hat{b}_0$	0.211	0.214	0.217
$\hat{b}_1$	--	-0.025	-0.026
$\hat{d}_0$	15,679	15,652	15,897
$\hat{d}_1$	266.427	287.710	283.751
$\hat{d}_2$	-840,256	-839,112	-834,194

*Significant at the 95 percent confidence level. Sample size n = 55.

TABLE 7.6

TESTS FOR INTERNAL FUNDS LAG
STRUCTURE ON GROSS RETAINED EARNINGS (GRE)
(Dependent Variable is Gross Investment in Millions of 1973 Dollars

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	112.781 (4.039)*	113.089 (3.436)*	116.192 (4.026)*	125.680 (3.685)*
$\Delta Q'_{-1}$	50.476 (2.955)*	49.383 (2.496)*	58.202 (3.254)*	48.608 (2.335)*
$\Delta(c/w)'_{-1}$	−167,550 (5.070)*	−164,830 (4.227)*	−171,583 (4.989)*	−174,477 (4.279)*
I_{-1}	0.799 (18.012)*	0.799 (15.732)*	0.774 (16.989)*	0.788 (14.788)*
ΔGRE_{-2}	0.047 (1.568)	0.061 (2.242)*	--	--
ΔGRE_{-3}	--	--	0.061 (2.344)*	−0.002 (0.116)
R^2	0.954	0.950	0.957	0.945
$\bar{R}^2$	0.951	0.946	0.954	0.941
F	255.971	239.158	274.745	216.230
D−W	2.076	2.278	2.290	2.006
h	−0.297	−1.113	−1.133	−0.026
SEE	27.206	28.149	26.302	29.526
ρ	−0.147	--	−0.057	--
k	2	--	2	--
$\hat{b}_0$	0.171	0.171	0.197	0.183
$\hat{b}_1$	0.047	0.061	0.061	--
$\hat{d}_0$	18,797	18,848	16,599	17,954
$\hat{d}_1$	295.181	288.789	295.442	265.617
$\hat{d}_2$	−979,825	−963,918	−870,980	−953,426

*Significant at the 95 percent confidence level. Sample size n = 55.

The lag structure in regression (3) of Table 6 is $\Delta GRE_{-3} = (GRE_{t-3} - (1-\delta) GRE_{t-4})$, where the current period is $t = 0$. This implies that F_{t-3} should be used in Equation 23 rather than F_{t-1}. When the regressions were run without adjustment for serial correlation, the best results were obtained using F_{t-2}. When the regressions were run using retained earnings rather than gross retained earnings, about the same results were obtained. Table 7 shows that regression (3) using F_{t-3} has the lowest standard error of the four regressions and that F_{t-2} performs better when serial correlation is ignored. The estimates for the structural coefficients in Table 7 are very similar to those obtained in Table 6. We conclude that the investment demand model with flexible adjustment performs best with either F_{t-2} (no serial correlation adjustment) or F_{t-3} (serial correlation adjustment) and either gross retained earnings or net retained earnings.[16] Further empirical tests will be necessary to choose among these alternatives. The significant lags in information and behavior suggested by these findings again indicate that the overall model is recursive rather than simultaneous.

Lag Structure

To test the robustness of the flexible adjustment model, the lag structure on output and the relative price term was altered. In the first experiment, the lag structure on both variables was shortened to 20, 16, and 12 quarters using the inverted-V lag weights. In the second experiment, the lag structure on output was set at 24 or 20 quarters, and the lag on relative prices was shortened to 20, 16, 12, and finally, 8 quarters using the inverted-V lag weights.[17]

The results from the first experiment are summarized in Table 8, where we report the standard error of estimate (SEE), R^2, and ρ(rho), the coefficient of first-order autocorrelation for each regression. Also reported in Table 8 are the coefficient estimates from Equation 22 for lagged investment ($\hat{a}_3$) and gross retained earnings ($\hat{a}_4$). Examination of the summary statistics in Table 8 suggest that there is no

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[16]These findings tend to support Evans' observation that "...there is a tendency for investment in this industry [iron and steel] to remain high for about a year after (lagged) cash flow has been high. This does suggest that investment decisions are being backlogged." M. K. Evans, "A Study of Investment Decisions," Review of Economics and Statistics, 49 (May 1967), p. 158.

[17]In addition, we experimented with shorter lags on output, holding the lag on relative prices fixed at 24 and 20 quarters. These regressions performed poorly. Also, we tried excluding some of the more recent quarters (see Evans, ibid.) on output. No significant improvement followed from this more complicated lag structure.

TABLE 7.7

TESTS FOR INTERNAL FUNDS LAG STRUCTURE
ON RETAINED EARNINGS (RE)
(Dependent Variable is Gross Investment in Millions of 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	114.053 (4.141)*	114.746 (3.529)*	118.534 (4.134)*	125.873 (3.700)*
$\Delta Q'_{-1}$	50.126 (2.952)*	49.634 (2.526)*	58.342 (3.269)*	49.030 (2.358)*
$\Delta (c/w)'_{-1}$	-168,104 (5.133)*	-165,835 (4.291)*	-173,153 (5.059)*	-174,989 (4.301)*
I_{-1}	0.799 (18.171)*	0.797 (15.838)*	0.772 (16.986)*	0.787 (14.806)*
ΔRE_{-2}	0.063 (1.668)**	0.081 (2.416)*	--	--
ΔRE_{-3}	--	--	0.074 (2.270)*	-0.009 (0.372)
R^2	0.955	0.951	0.957	0.946
$\bar{R}^2$	0.951	0.947	0.952	0.941
F	257.432	242.870	272.886	216.800
D-W	2.071	2.290	2.303	2.021
h	-0.276	-1.160	-0.900	-0.086
SEE	27.133	27.943	26.387	29.489
ρ	-0.152	--	-0.069	--
k	2	--	1	--
$\hat{b}_0$	0.171	0.173	0.199	0.184
$\hat{b}_1$	0.063	0.081	0.074	--
$\hat{d}_0$	19,009	19,124	16,933	17,982
$\hat{d}_1$	293.134	286.902	293.176	266.467
$\hat{d}_2$	-983,064	-958,584	-870,116	-951,027

*Significant at the 95 percent confidence level. Sample size n = 55.

TABLE 7.8

EXPERIMENTS WITH LAG STRUCTURE ON BOTH OUTPUT AND RELATIVE PRICES

Lag Periods	Summary Statistics			Coefficients (t-ratio)	
	SEE	R^2	ρ [a]	$\hat{a}_3$	$\hat{a}_4$
24	26.3015	0.9573	-0.0566	0.7743 (16.989)	0.0609 (2.344)
20	27.9233	0.9519	-0.0057	0.8689 (21.017)	0.0787 (2.832)
16	30.4746	0.9427	-0.0180	0.9310 (21.497)	0.0600 (2.034)
12	32.5762	0.9345	0.0182	0.9646 (20.634)	0.0563 (1.814)

[a]Durbin-Watson statistics after adjustment for serial correlation were 2.0064, 2.3366, 2.1678, and 2.0149, respectively.

significant improvement from shortening the lag structure on both
the output and relative price variables. The standard error of estimate
(SEE) and R^2 both fall as the lag is shortened. The major change in
the regressions occurs in the value of the speed of response coeffi-
cient, $\hat{a}_3$. For example, the 24 period lag has a response rate of 19.7
percent while the 20 period lag has a response rate of 9.9 percent. The
latter value is closer to that obtained in Coen's study of aggregate
investment demand. The speed of response due to retained earnings ($\hat{a}_4$)
increases slightly from about 6 percent to 8 percent when the 20 period
lag is employed.

Tables 9 and 10 show the same information for the lag structure
on relative prices with the output lag fixed at 24 and 20 quarters,
respectively. The results are very similar to those found in Table
8; R^2 and SEE fall as the lag structure is shortened. The speed
of response decreases while the coefficient $\hat{a}_4$ on gross retained
earnings varies between 0.05 and 0.08. It is difficult to reach a
definitive conclusion on the basis of these results. In terms of
goodness of fit, the best lag structure is 24 quarters for both
variables. The basis for using a shorter lag (20 quarters) seems to
lie in changes in the values of individual coefficients. The re-
gressions in the remainder of this chapter employ a 24 quarter lag on
both output and relative prices.

Investment, Dividends and External Finance

This section presents the ordinary least-squares estimates (ad-
justed for serial correlation) for the structural investment equation
described in Chapter 3. This equation has the following form:

$$(7.26) \qquad I_t = G_1[D_t, EF_{1t}; \Delta\left(\tfrac{c}{w}\right)'_{t-1}, \Delta Q'_{t-1}, I_{t-1}, N_t, \Delta F_{t-i}, U_t]$$

where I_t = gross fixed investment expenditures at time t,

D_t = dividends,

EF_{1t} = long-term borrowing (external finance),

$\Delta(c/w)'_{t-1}$ = permanent change in the price of capital
services relative to the wage rate,

$\Delta Q'_{t-1}$ = permanent change in raw steel output,

I_{t-1} = lagged gross investment,

N_t = net current position,

ΔF_{t-i} = change in internal funds available between period t-i and
period t-i-1,

U_t = stochastic error term, and the primes indicate long-run
or permanent values.

TABLE 7.9

EXPERIMENTS WITH LAG STRUCTURE ON
RELATIVE PRICES ONLY
(Output Lag is 24 Quarters)

Lag Periods	Summary Statistics			Coefficients (t-ratio)	
	SEE	R^2	ρ [a]	$\hat{a}_3$	$\hat{a}_4$
24	26.3015	0.9573	-0.0566	0.7743 (16.989)	0.0609 (2.344)
20	27.3908	0.9537	-0.0461	0.8328 (17.724)	0.0656 (2.443)
16	28.6727	0.9493	-0.0039	0.8487 (16.260)	0.0623 (2.259)
12	30.0969	0.9441	0.0686	0.8413 (13.910)	0.0579 (2.064)
8	30.9198	0.9410	0.1429	0.8119 (11.531)	0.0537 (1.942)

[a]Durbin-Watson statistics after adjustment for serial correlation were 2.0064, 2.2919, 2.2056, 2.1227, and 2.1051, respectively.

TABLE 7.10

EXPERIMENTS WITH LAG STRUCTURE ON
RELATIVE PRICES ONLY
(Output Lag is 20 Quarters)

Lag Periods	Summary Statistics			Coefficients (t-ratio)	
	SEE	R^2	ρ^a	$\hat{a}_3$	$\hat{a}_4$
20	27.9233	0.9519	-0.0057	0.8689 (21.017)	0.0774 (2.832)
16	28.3328	0.9505	0.0245	0.8743 (19.561)	0.0797 (2.871)
12	28.6554	0.9493	0.0538	0.8704 (18.315)	0.0799 (2.889)
8	29.0466	0.9479	0.0761	0.8655 (17.010)	0.0789 (2.843)

[a]Durbin-Watson statistics after adjustment for serial correlation were 2.3366, 2.3299, 2.3142, and 2.2820, respectively.

The investment, dividend, and external finance variables are re-
garded as endogenous to the system. The expected signs on the coeffi-
cients are negative for dividends and positive for external finance.
Preliminary least-squares estimates for Equation 26 are presented in
Table 11. We note that the dividend variable (D) is significant but
appears with the wrong sign. The external finance variable (EF) is
never significantly different from zero. The net current position
variable (N) also was not significantly different from zero.

It is difficult to rationalize the positive sign of the dividend
coefficient with prior expectations, which could suggest potential pit-
falls in the single-equation approach. Indeed, if one is determined to
use single-equation methods, it is preferable to formulate the problem
recursively or to use as explanatory variables those which are truly
exogenous, even though some explanatory power is thereby lost. The
results in Table 11 suggest that a recursive model may be sufficient to
reflect the impact on investment spending of firms' dividend decisions.
The impact of dividend decisions in the recursive model will be captured
through the inclusion of (lagged) retained earnings in the investment
demand function.

Final Investment Equations

In this section, three additional procedures are employed to
formulate the final investment model. First, the output and relative
price variables were scaled in order to make the coefficients more
manageable; output was scaled by a factor of 10^3, so that output is now
in thousands of tons of raw steel, while the relative price term was
scaled by a factor of 10^6. Second, we compare the 24-period Almon lag
weights for both output and relative prices against the 24-period lag
weights based on the inverted-V expectations distribution. Third, we
compute the estimated elasticities of the demand for capital with
respect to output and with respect to relative factor prices for several
of the lag structures.

The regression results for steps one and two are presented in Table
12. These two regressions show that the improvement resulting from the
more complex Almon procedure is in fact very slight. As previously
indicated, the Almon weights calculated from the Phase I report are very
close to an inverted-V. Nonetheless, the Almon weights do produce a
slightly higher R^2 and a slightly lower standard error of estimate.

In addition, we converted the slope-coefficients of the demand for
capital function into elasticities. The means of the relative price and
output variables are sample means of "permanent" user cost divided by the

TABLE 7.11

REGRESSION RESULTS FOR STRUCTURAL INVESTMENT EQUATION
(Dependent Variable is Gross Investment in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)		
	(1)	(2)	(3)
CONSTANT	0.404 (0.007)	116.327 (3.934)*	-0.441 (0.007)
$\Delta Q'_{-1}$	114.491 (3.737)*	58.157 (3.220)*	116.316 (3.725)*
$\Delta(c/w)'_{-1}$	-117,343 (2.776)*	-171,692 (4.907)*	·117,707 (2.728)*
I_{-1}	0.647 (9.016)*	0.774 (16.306)*	0.639 (8.548)*
ΔGRE_{-3}	0.049 (1.950)**	0.061 (2.320)*	0.049 (1.929)**
D	0.447 (2.190)*	--	0.457 (2.195)*
EF	--	0.0006 (0.032)	0.005 (0.303)
R^2	0.961	0.957	0.961
$\overline{R}^2$	0.957	0.953	0.957
F	237.614	215.316	194.223
SEE	25.347	26.574	25.594
D-W	2.243	2.290	2.238
h	1.069	1.138	1.048
ρ	-0.035	-0.056	-0.023
k	2	2	2

*Significant at the 95 percent confidence level.
**Significant at the 90 percent confidence level. Sample size n = 55.

TABLE 7.12

FINAL REGRESSIONS FOR INVESTMENT DEMAND FUNCTION
(Dependent Variable is Gross Investment in Millions of Constant 1973 Dollars)

| Variable | Regression Coefficient (Student t) | |
	24-Period Almon Lags (1)	24-Period Inverted-V Lags (2)
CONSTANT	116.1920 (4.026)*	98.6005 (3.5192)*
$\Delta Q'_{-1} \times 10^3$	0.0582 (3.254)*	0.0494 (3.005)*
$\Delta(c/w)'_{-1} \times 10^6$	-0.1716 (4.989)*	-0.1487 (4.571)*
I_{-1}	0.7743 (16.989)*	0.8111 (19.735)*
ΔGRE_{-3}	0.0609 (2.344)*	0.0691 (2.605)*
R^2	0.9573	0.9564
$\bar{R}^2$	0.9538	0.9528
F	274.7450	269.0270
SEE	26.3015	26.5675
D-W	2.2904	2.3374
h	-1.1333	-1.3007
ρ	-0.0566	-0.0683
k	2	1
$\hat{b}_0$	0.1968	0.1586
$\hat{b}_1$	0.0609	0.0691
$\hat{d}_0$	16,599	17,298
$\hat{d}_1$	0.2957	0.3115
$\hat{d}_2$	-0.8720	-0.9376

*Significant at the 95 percent confidence level. Sample size n = 55.

wage rate and "permanent" output, respectively. That is, they are means of weighted averages of the variables, the weights being given by the appropriate expectations lag distribution. With these means, the average level of the desired stock over the period can be estimated. The elasticities of optimum stock are then evaluated at the mean values of the variables.

The elasticity estimates are presented in Table 13. The mean value of the optimal, permanent capital stock is about $14-14,500 millions of 1973 dollars compared to the 1973 capital stock of $12,260 million, an increase of about $2 billion. Estimates of the capital-output elasticity range from 0.57 to 0.96, with higher estimates produced by the model employing a 20-period lag structure. Estimates of the capital-relative price elasticity range from -0.77 to -0.82, with the higher elasticity (in absolute value) again being produced by the 20-period model. In the Phase I report, the same elasticity is used for both output and relative prices. The "best" estimate in Phase I was 0.4 when the model was adjusted for serial correlation and 0.8 when it was not.[18] In the investment model developed in this report, the amount of serial correlation is not terribly great, due apparently to the presence of lagged gross investment as an explanatory variable. The factor price elasticity estimates lie close to 0.8 in absolute value and are, therefore, consistent with the estimates produced in Phase I. The output elasticity, however, is about halfway between 0.4 and 0.8, since the estimates in Table 13 cluster around 0.6 except when the shorter lag structure is used. The 20-period lag structure produces elasticity estimates which are close to those implied by, say, a Cobb-Douglas production function with constant returns to scale. Since the elasticity estimates produced in this report are greater for relative factor prices compared to the estimate used in Chapter 2, this does suggest that the forecasted impact of taxation policy on capital spending may be somewhat understated. However, tests of this proposition must await the forecasting analysis planned for Phase III of the project.

Short-Run Investment Forecasts

Short-run forecasts for gross investment were prepared for 1974 and 1975, using the final regressions in Table 12. The forecasts are

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[18] Neumann, op. cit., p. 41.

TABLE 7.13

STRUCTURAL PARAMETERS OF INVESTMENT
MODEL BY LAG DISTRIBUTION

$$K_t^* = d_0 + d_1 Q_{t-1}' + d_2 (c/w)_{t-1}'$$

Parameter	24-period Almon Lags[a]	24-period Inverted-V[b]	20-period Inverted-V[c]	24-period Almon Lags[d]
$\hat{d}_0$	16,599	17,298	12,452	17,377
$\hat{d}_1$	0.2957	0.3115	0.4802	0.2852
$\hat{d}_2$	-0.8720	-0.9376	-0.9362	-0.8995
Mean Q' x 10^3	28,769.11	28,816.88	28,997.21	28,769.11
Mean $(c/w)'$ x 10^6	12,518.46	12,562.83	12,710.08	12,518.46
Mean K*	$14,190	$14,495	$14,477	$14,322
Elasticity K*: Q'	0.60	0.62	0.96	0.57
Elasticity K*: $(c/w)'$	-0.77	-0.81	-0.82	-0.79

[a] Regression (1) in Table 7.12.

[b] Regression (2) in Table 7.12.

[c] Regression with 20 Lag Periods in Table 7.8.

[d] Regression (1) in Table 7.4. Note that including the internal funds variable does not alter significantly the estimated elasticities. This suggests that internal funds will affect the timing of investment, rather than the level of investment.

presented in Tables 14 and 15. In general, the results are quite good. The mean absolute errors of forecasts are $23.4 and $26.2 million, respectively. The root-mean-squared errors are $30.4 and $33.0 million compared to the standard errors of $26.3 and $26.6 million, respectively. Both forecasts are able to capture the turning point in the third quarter of 1975, although both forecasts incorrectly predict a turning point in the fourth quarter of 1975. It can be noted that these forecasts do represent an improvement over the short-run forecasts based on the investment model estimated in Phase I, but only if account is taken of both 1974 and 1975.

Revised forecasts using the Phase I model are presented in Table 16. The annual forecast for 1974 is off by only $24.9 million using the Phase I model, compared to an error of $82.5 million for the Phase II model developed in this chapter. However, the Phase I model fails to capture the substantial increase in gross investment expenditures during 1975. The annual forecast is off by $283.6 million compared to an error of $64.8 million for the Phase II model. For short-run forecasting at least, there seems to be considerable advantage in incorporating both long-run, permanent determinants of investment (output, relative prices, lagged investment) and short-run, transitory changes in the availability of internal funds (gross retained earnings).

<div align="center">Summary</div>

This chapter formulated and estimated a model of gross investment expenditures in constant dollars for the iron and steel industry for 1960-1973. The basic independent or explanatory variables used were the change in the permanent level of output, the change in the permanent level of relative factor prices, lagged gross investment, and the change in the lagged value of gross retained earnings. The model fits the data extremely well with an R^2 of 0.96 and a standard error of estimate of about $26 million. The short-run forecasting ability of the model was tested with the available quarterly data for 1974 and 1975, and then compared with the forecasts from the Phase I model of investment demand. The forecast errors are within the range that would be expected based on the regression results--the mean absolute error was $23 million and the root-mean-squared error was $30 million. The model estimated in this report was superior for short-run forecasting relative to the Phase I model when account was taken of both 1974 and 1975 realizations in gross investment expenditures.

In Chapter 9 of this report, the recursive model will be estimated using simultaneous equation estimation procedures. By comparison, this chapter used ordinary least-squares procedures, adjusted for serial correlation. The equation to be employed in the recursive model uses gross retained earnings as an explanatory variable and the 24-period Almon lag structure. The comparable regression in this chapter is regression (1) in Table 12. To complete the econometric analysis of this equation, investment forecasts for 1974 and 1975 were re-run with

TABLE 7.14

SHORT-RUN FORECASTS FOR GROSS INVESTMENT,
USING REGRESSION (1) IN TABLE 7.12

| Period | Gross Investment in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1974-I	$408.6	$389.5	$19.2
1974-II	456.0	447.4	8.6
1974-III	465.2	473.8	-8.6
1974-IV	555.3	492.0	63.3
1975-I	556.7	582.4	-25.7
1975-II	596.5	601.6	-5.1
1975-III	587.1	575.8	11.4
1975-IV	538.9	584.3	-45.5
Mean Absolute Error			$23.4
RMS-Error*			$30.4

*
Root-mean-squared error of forecast.

TABLE 7.15

SHORT-RUN REGRESSIONS FOR GROSS INVESTMENT,
USING REGRESSION (2) IN TABLE 7.12

| Period | Gross Investment in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1974-I	$408.6	$387.7	$20.9
1974-II	456.0	449.5	6.5
1974-III	465.2	475.5	-10.2
1974-IV	555.3	494.8	60.5
1975-I	556.7	592.3	-35.6
1975-II	596.5	615.4	-18.9
1975-III	587.1	583.3	3.8
1975-IV	538.9	591.9	-53.0
Mean Absolute Error			$26.2
RMS-Error*			$33.0

*
Root-mean-squared error of forecast.

TABLE 7.16

SHORT-RUN FORECASTS FOR GROSS INVESTMENT,
USING PHASE I MODEL

Time	Gross Investment in Millions of Constant 1973 Dollars		
	Actual	Forecast	Error
1974-I	$409	$439.7	-$30.7
1974-II	456	457.4	- 1.4
1974-III	465	471.0	- 6.0
1974-IV	555	492.0	63.0
1975-I	557	505.8	51.2
1975-II	597	503.3	93.7
1975-III	587	497.2	89.8
1975-IV	539	490.1	48.9
Mean Absolute Error			$48.1
RMS-Error*			$57.9

*Root-mean-squared error of forecast.

proper adjustment for lagged residual feedback.[19,20] The revised forecasts are presented in Table 17; the results obtained demonstrate that improvement is obtained by accounting for residual feedback, although the amount of improvement is relatively minor. Based on the forecasts presented here, the gross investment model seems ideally suited for both short-run and long-run forecasting. This is, of course, an accurate statement only if the econometric model of investment demand is superior to a naive forecasting model. As a final step in examination of the model, forecasts were prepared for 1974 - 1975 using a fourth-order autoregressive scheme.[21] These results are summarized in Table 18 and indicate that the forecasting errors are more than twice as large as those achieved by the econometric model, with or without lagged residual feedback adjustment.

Finally, forecasts incorporating lagged residual feedback were also prepared for the Phase I model and for the investment model which omits the retained earnings variable, regression (1) in Table 4. Summarizing, an ordering of the forecasts using the root-mean-squared error is as follows:

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[19] See, for example, R. S. Pindyck and D. L. Rubinfeld, Econometric Models and Economic Forecasts (New York: McGraw-Hill, 1976), pp. 170-73. In addition, the estimate of the first-order serial correlation coefficient was checked using the Hildreth-Lu scanning procedure. No significant improvement resulted from use of this method.

[20] Regression (1) in Table 12 was also reestimated with an adjustment for the bias in standard errors and t-statistics due to the presence of a lagged dependent variable. Changes in the estimates were minor--the estimated t-statistics were 4.003, 3.163, 4.977, 16.094, and 2.344 compared to 4.026, 3.254, 4.989, 16.989, and 2.344 for the constant, output, relative prices, lagged investment, and gross retained earnings, respectively.

[21] The autoregressive model using quarterly seasonally-adjusted data for 1960-1973 is

$$\hat{I}_t = \underset{(8.605)}{1.1280}\ I_{t-1} + \underset{(0.085)}{0.0168}\ I_{t-2} + \underset{(0.398)}{0.0784}\ I_{t-3}$$

$$\underset{(1.787)}{-0.2285}\ I_{t-4};\ R^2 = 0.934,\ SEE = 32.797$$

Model	Root-Mean Squared Error	
	Without Feedback	With Feedback
1. Regression (1), Table 7.12	$30.4 million	$29.8 million
2. Regression (2), Table 7.12	33.0	32.4
3. Regression (1), Table 7.4	33.9	33.6
4. Phase I Model	57.9	34.0
5. Naive Model	69.2	--

This comparison suggests that incorporating a retained earnings variable will almost always lead to an improvement in forecasting accuracy, at least in the short-run. Both the Phase I and Phase II models are an improvement over the autoregressive niave model.

TABLE 7.17

GROSS-INVESTMENT FORECASTS
FOR 1974 AND 1975,
USING REGRESSION (1) IN TABLE 7.12[a]

	Millions of Constant 1973 Dollars		
Time	Actual	Forecast	Error
1974-I	$408.6	$389.5	$19.1
1974-II	456.0	446.3	9.7
1974-III	465.2	473.4	− 8.2
1974-IV	555.3	492.5	62.8
1975-I	556.7	578.8	− 22.1
1975-II	596.5	603.0	− 6.5
1975-III	587.1	576.0	11.1
1975-IV	538.9	583.6	− 44.7
Mean Absolute Error			$23.03
RMS-Error*			$29.85

[a]Forecasts are adjusted for lagged residual feedback.

*Root-mean-squared error of forecast.

TABLE 7.18

GROSS INVESTMENT FORECASTS FOR 1974
AND 1975 USING A NAIVE, FOURTH-
ORDER AUTOREGRESSIVE MODEL

| | Millions of Constant 1973 Dollars | | |
Time	Actual	Forecast	Error
1974-I	**$408.6**	**$403.6**	$ 5.0
1974-II	456.0	466.9	− 10.9
1974-III	465.2	521.3	− 56.1
1974-IV	555.3	532.4	22.9
1975-I	556.7	634.2	− 77.5
1975-II	596.5	637.3	− 40.8
1975-III	587.1	682.2	− 95.1
1975-IV	538.9	672.3	−133.4
Mean Absolute Error			$ 55.21
RMS-Error*			$ 69.22

*
Root-mean-squared error of forecast.

CHAPTER 8

EXTERNAL FINANCE AND CAPITAL STOCK;
TAXES AND PROFITS

Introduction

This chapter completes the model by presenting empirical rela-
tionships for: (1) the level of long-term debt in the iron and steel
industry; and (2) the amount of gross profit (or gross cash flow) paid
out in the form of taxes. The first relationship provides a link be-
tween the level of gross investment, the stock of capital, and the in-
dustry's financial structure. The importance of long-term debt in the
financing of fixed investment was discussed in Chapter 7, and only a
brief recounting will be given here. The second relationship for taxes
paid is a simple accounting equation which provides a link between
before-tax profits and the level of net profits (or net cash flow) in
the dividend equation.

Long-Term Debt and Capital Stock

The initial relationship for long-term debt formulated in Chapter 3
was[1]

$$(8.1) \quad EF_{1t} = G_3(I_t, D_t; \pi_t, Dep_t, r_t, L_t, N_t, \varepsilon_t)$$

where EF_{1t} = long-term borrowing (external finance) at time t,

I_t = gross fixed investment expenditures,

D_t = dividends,

π_t = after-tax profits,

Dep_t = depreciation allowances,

r_t = the interest rate,

---

[1]See P. J. Dhrymes and M. Kurz, "Investment, Dividend, and External
Finance Behavior of Firms," in R. Ferber (ed.), Determinants of Invest-
ment Behavior (New York: National Bureau of Economic Research, 1967),
pp. 427-67.

L_t = a leverage ratio such as the ratio of long-term debt-to-stockholder's equity,

N_t = net current position,

ε_t = stochastic error term.

Attempts to apply this equation to the iron and steel industry for the period 1960–1973 proved to be unsuccessful; few of the variables were significant or had the correct sign. Moreover, the model fit the data poorly with an R^2 of about 0.50 or less. Many of the empirical problems posed by Equation 1 are probably due to the form of the dependent variable. In order to obtain the necessary data on the level of external financing, the dependent variable was defined as the first-difference of the book value of long-term debt outstanding. The measure of external finance was thus <u>net</u> current long-term borrowing and not <u>new</u> current long-term borrowing. The former measure is frequently negative due to contractual retirements of outstanding debt and is also biased by the transfer of maturing long-term debt to the short-term category.

An alternative model of the long-run debt decision might be based on the stock adjustment model of economic behavior. This model was described in detail in Chapter 6 so that only a sketch of the stock adjustment model of debt financing will be given here. For any time period t, let the target level of long-term debt (DEBT*) be related to the current level of real capital stock (K_t) according to

(8.2) $DEBT_t^* = \gamma K_t + U_t', \quad \gamma > 0$

where γ is the firm's optimal ratio of debt-to-capital stock. In any time period, the firm only partially adjusts to the optimal ratio and the adjustment function is given by

(8.3) $\Delta DEBT_t = DEBT_t - DEBT_{t-1}$

$= b_o + \delta(DEBT_t^* - DEBT_{t-1})$

where $0 < \delta \le 1$ and $b_o > 0$, b_o is a constant, and where δ is the fractional, speed of adjustment coefficient. The stochastic error term, U_t', appears in Equation 2 in this formulation of the model.

Substituting Equation 2 into Equation 3, and rearranging terms, we have

(8.4) $\text{DEBT}_t = b_o + b_1 K_t + b_2 \text{DEBT}_{t-1} + U_t$

where $b_1 = \delta\gamma$, $b_2 = 1 - \delta$, and $U_t = \delta U_t'$.

A basic problem with the above formulation is that the cost of external financing is ignored. Alternative formulations for Equation 2 might be (the error term is suppressed):

(8.2a) $\text{DEBT}_t^* = \gamma K_t + \alpha r_t, \quad \gamma > 0, \, \alpha < 0$

or

(8.2b) $\text{DEBT}_t^* = \gamma K_t$

$$= (a + b\, r_t)\, K_t$$

$$= aK_t + b(rK)_t, \quad a > 0, \, b < 0$$

where r_t is the interest rate on long-term debt and rK_t is a measure of the total cost of capital used in production. Substituting Equation 2a or 2b is Equation 3 leads to:

(8.4a) $\text{DEBT}_t = b_o + c_1 K_t + c_2 r_t + c_3 \text{DEBT}_{t-1} + U_t$

and

(8.4b) $\text{DEBT}_t = b_o + d_1 K_t + d_2 (rK)_t + d_3 \text{DEBT}_{t-1} + U_t$

where $c_1 = \delta\gamma$, $c_2 = \delta\alpha$, $c_3 = 1-\delta$, $d_1 = \delta a$, $d_2 = \delta b$, and $d_3 = 1-\delta$.

The variables were defined as: (1) <u>DEBT</u>--quarterly long-term debt due in more than one year to banks or other lenders, in millions of constant 1973 dollars; (2) <u>CAPITAL</u> (K)--the quarterly stock of capital equipment and structures estimated in the Phase I report,[2] in millions of constant 1973 dollars; (3) r_t--the interest rate measured by the U.S. corporate industrial bond yield (Moody's), quarterly rate; and (4) rK_t--the total cost of capital measured by the product of r_t and K_t. All data were seasonally adjusted and deflated.[3] More complete descriptions of the variables and data sources are given in Appendix C.

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[2] G. R. Neumann, <u>Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975-1980</u> (University Park, Pa.: Institute for Research on Human Resources, December 1975), p. 21.

[3] The capital stock series was not available in current dollars so that it was not possible to carry out the estimation in current dollar terms.

Table 1 presents the data for seasonally-adjusted, long-term debt and capital stock for the period 1960-1973. It is evident from these data that there has been a continual increase over time in the ratio of long-term debt-to-capital stock. For example, from 1960-1966, the ratio averaged 0.386, while for 1967-1973, the average ratio was 0.528. The increase in this ratio is, of course, consistent with the evidence presented in Chapter 5 on the financial structure of the iron and steel industry. It should be noted that the data in Table 1 are in constant dollars so that the level of long-term debt will appear inflated when compared to current dollar values for earlier years. Also, after 1971, the level of long-term debt as reported by the FTC, Quarterly Financial Report and the AISI, Annual Statistical Report are less comparable due to the inclusion of nonsteel producing activities in the former series.

Table 2 shows the regression results for the long-term debt equation. The variables r_t and rK_t did not have the expected negative signs. Consequently, the results for Equations 4a and 4b have been omitted and Table 1 shows only the regressions for Equation 4. The model with the constant term included fits the data well; R^2 is 0.980 in regressions (1) and (2). The speed of response coefficient $\hat{\delta}$ is about 0.07, indicating that only 7 percent of the gap between the desired and actual stock of long-term debt would be closed in the current period. However, the estimated optimal debt-to-capital ratio is greater than unity, which is unreasonable a priori and inconsistent with the available data on this ratio. This result apparently reflects the strong upward trend in debt financing during the latter part of the 1960s.

When the constant term is suppressed, the model fits the data equally well although the standard error of estimate increases slightly from about $204 million to $210 million. The optimal debt-to-capital ratio is now in the range 0.64-0.66 which is consistent with the long-run evidence for this ratio. The speed-of-adjustment coefficient is now about 0.035. Regressions (3) and (4) seem to perform about equally well since there is, in fact, little evidence of serial correlation in regression (4); the Durbin h statistic is 0.683 which is less than the critical value of 2.00. Apparently much of the serial correlation is removed through the use of lagged debt as an explanatory variable. The autocorrelation coefficient ρ was very close to one (0.98) in regressions which omitted the lagged debt variable.[4]

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[4]These regressions are not presented; although they fitted the data equally well, they seemed to perform poorly from a forecasting standpoint.

TABLE 8.1

LONG–TERM DEBT–TO–CAPITAL STOCK RATIO
(All Data Seasonally Adjusted and Expressed in
Millions of Constant 1973 Dollars)

Period	Long–Term Debt	Capital Stock	Ratio	Period	Long–Term Debt	Capital Stock	Ratio
1960–I	--	$11695	--	1967–I	$5561	$12499	.445
-II	$3578	11800	.303	-II	5582	12683	.440
-III	3719	11920	.312	-III	5759	12838	.449
-IV	3834	11953	.321	-IV	5853	12978	.451
1961–I	3786	11923	.318	1968–I	6145	13128	.468
-II	4459	11834	.377	-II	6255	13240	.472
-III	4397	11697	.376	-III	6480	13412	.483
-IV	4505	11570	.389	-IV	6353	13564	.468
1962–I	4474	11441	.391	1969–I	6512	13676	.476
-II	4416	11323	.390	-II	6525	13755	.474
-III	4425	11217	.394	-III	6797	13791	.493
-IV	4366	11096	.939	-IV	6812	13789	.494
1963–I	4297	10979	.391	1970–I	6812	13786	.494
-II	4218	10898	.387	-II	7107	13779	.516
-III	4133	10850	.381	-III	7366	13749	.536
-IV	4116	10813	.381	-IV	7301	13689	.533
1964–I	4079	10906	.374	1971–I	7269	13627	.533
-II	4118	10988	.375	-II	7211	13490	.535
-III	4138	11096	.373	-III	7056	13335	.529
-IV	4403	11248	.391	-IV	7735	13212	.585
1965–I	4405	11350	.388	1972–I	7664	13059	.587
-II	4357	11474	.380	-II	7690	12911	.596
-III	4492	11630	.386	-III	7837	12762	.614
-IV	4710	11800	.399	-IV	7832	12625	.620
1966–I	5686	11920	.477	1973–I	7870	12506	.629
-II	5636	12068	.467	-II	7717	12396	.622
-III	5615	12199	.460	-III	7832	12314	.636
-IV	5442	12329	.441	-IV	7594	12260	.619

TABLE 8.2

REGRESSION RESULTS FOR PARTIAL
ADJUSTMENT MODEL OF LONG-TERM DEBT
(Dependent Variable is Long-Term Debt in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)			
	(1)	(2)	(3)	(4)
CONSTANT	−813.638 (2.136)*	−857.675 (1.970)**	--	--
CAPITAL(K)	0.103 (2.618)*	0.108 (2.406)*	0.023 (2.024)*	0.023 (1.878)**
$DEBT_{-1}$	0.932 (34.036)*	0.929 (30.477)*	0.965 (40.788)*	0.964 (37.766)*
R^2	0.980	0.980	0.978	0.978
$\bar{R}^2$	0.979	0.979	0.977	0.977
F	1,240.280	1,275.900	2,319.480	2,416.480
SEE	203.678	205.233	210.440	210.741
D-W	1.995	2.258	1.967	2.181
h	0.020	0.982	0.122	0.683
ρ	−0.145	--	−0.110	--
k	1	--	1	--
$\hat{\delta}$	0.068	0.071	0.035	0.036
$\hat{\gamma}$	1.515	1.521	0.657	0.639

* Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level.
  Sample size n = 55.

Short-Run Forecasts for
Long-Term Debt

Short-run forecasts were prepared for 1974 and 1975 using re-
gressions (3) and (4) in Table 2. A summary of the 1974 forecasts
is presented in Tables 3 and 4. For 1974, the equations consistently
overestimate the level of long-term debt for the iron and steel in-
dustry. However, the equations do capture the downward trend in
long-term debt, and much of the forecast error occurs in the first
quarter of 1974. The second and third quarter forecast errors are,
for example, close to the standard errors of estimate for the regres-
sion in question. Since the values in these tables refer to stocks
rather than flows, it is appropriate to speak of the end of year fore-
cast rather than the annual forecast. For 1974-IV, the actual value
of long-term debt is constant 1973 dollars was $6,160.7 million.
The forecasts for this quarter are about $6,572 million, a difference
of about $412 million.

Tables 5 and 6 present the forecasts for long-term debt for
1975. The 1975 forecasts are slightly improved over 1974 in terms
of the mean absolute error of forecast. The regressions do signi-
ficantly overpredict the debt level for the first quarter of 1975.
For 1975-IV, the actual value of long-term debt in constant 1973
dollars is $5,885.0 million. The forecasts for this quarter are
about $5,976 million, a difference of $91 million. Relative to the
magnitudes in question, this error does not appear to be very signi-
ficant.

Summary of the Long-Term Debt Model

The first part of this chapter formulated and estimated a model
for long-term debt in constant dollars for the iron and steel industry
for 1960-1973. The independent or explanatory variables used were
the level of the capital stock and long-term debt lagged one period.
The model fitted the data well; R^2 was 0.98 and the standard error
of estimate was about $210 million. The short-run forecasting ability
of the model was tested against available quarterly data for 1974 and
1975. The model generally overestimated the level of long-term debt
for 1974-1975. However, the magnitude of the errors appear to be
about what would be expected on the basis of the regression equations.
For example, for 1975, the mean absolute error of forecast was about
$334 million, or roughly 6 percent of the end of year capital stock.

In Chapter 9 of this report, the recursive model will be esti-
mated using simultaneous equation estimation procedures. By com-
parison, this chapter used ordinary least-squares procedures, adjusted
for serial correlation. The equation to be employed in the recursive

TABLE 8.3

LONG–TERM DEBT FORECAST FOR 1974, USING
REGRESSION (3) IN TABLE 8.2

| Time | Long-Term Debt in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1974-I	$6,987.83	$7,601.40	-$ 614
1974-II	6,750.72	7,016.57	-266
1974-III	6,525.71	6,788.30	-263
1974-IV	6,160.73	6,573.73	-413
Mean Absolute Error			$388.8
RMS-Error*			$414.4

*Root-mean-squared error of forecast.

TABLE 8.4

LONG–TERM DEBT FORECAST FOR 1974, USING
REGRESSION (4) IN TABLE 8.2

| Time | Long-Term Debt in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1974-I	$6,987.83	$7,597.84	-$ 610
1974-II	6,750.75	7,013.25	-263
1974-III	6,525.71	6,785.08	-259
1974-IV	6,160.73	6,570.60	-410
Mean Absolute Error			$385.4
RMS-Error*			$411.2

*Root-mean-squared error of forecast.

TABLE 8.5

LONG-TERM DEBT FORECAST FOR 1975, USING
REGRESSION (3) IN TABLE 8.2

| Time | Long-Term Debt in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1975-I	$5,424.0	$6,224.0	-$800.0
1975-II	5,436.0	5,517.0	- 81.1
1975-III	5,897.0	5,531.0	366.0
1975-IV	5,885.0	5,977.0	- 92.0
Mean Absolute Error			$334.7
RMS-Error*			$443.9

*
Root-mean-squared error of forecast.

TABLE 8.6

LONG-TERM DEBT FORECAST FOR 1975, USING
REGRESSION (4) IN TABLE 8.2

| Time | Long-Term Debt in Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1975-I	$5,424.0	$6,221.0	-$797.0
1975-II	5,436.0	5,514.0	- 78.4
1975-III	5,897.0	5,528.0	368.0
1975-IV	5,885.0	5,975.0	- 89.4
Mean Absolute Error			$333.2
RMS-Error*			$442.9

*
Root-mean-squared error of forecast.

model omits the constant term from the regression. The comparable regression in this chapter is regression (3) in Table 2. To complete the econometric analysis of this equation, long-term debt forecasts for 1974 and 1975 were re-run with proper adjustment for lagged residual feedback.[5,6] In contrast to forecasting results presented in Chapters 5-7, the use of residual feedback did improve the forecasts for long-term debt in terms of the end-of-period stock. This suggests that it may be necessary to correct this model for serial correlation when performing either short-run or long-run forecasting. Also, because the equation seems to consistently underpredict during 1974-75, additional "fine-tuning" of this equation will be considered in the Phase III forecasts, e.g., by addition of a constant term.

Taxes and Profits

The final equation in the model is a simple accounting equation which explains the level of taxes conditional upon the level of gross profits or gross cash flow.[7] Thus:

(8.5) $TAX_t = a + b\ GP_t + u_1$

or

(8.6) $TAX_t = c + d\ GCF_t + u_2$

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[5]See, for example, R. S. Pindyck and D. L. Rubinfeld, Econometric Models and Economic Forecasts (New York: McGraw-Hill, 1975), pp. 170-73. In addition, the estimate of the first-order serial correlation coefficient was checked using the Hildreth-Lu scanning procedure. No significant improvement resulted from use of this method.

[6]Regression (3) in Table 2 was also re-estimated with an adjustment for the bias in standard errors and t-statistics due to the presence of a lagged dependent variable. Changes in the estimates were minor--the estimated t-statistics were 2.000 and 40.288, compared to 2.024 and 40.788 for capital stock and lagged debt, respectively.
   In addition, we estimated a naive fourth-order autoregressive model for long-term debt. The model was

$$\hat{LTD}_t = 0.9233\ LTD_{t-1} + 0.1510\ LTD_{t-2} - 0.1942\ LTD_{t-3} + 0.1333\ LTD_{t-4};$$
$$(6.327) \qquad (0.762) \qquad (0.976) \qquad (0.890)$$
$$R^2 = 0.975,\ SEE = 224.323$$

while the forecasts for 1974-75 had a mean absolute error of \$651.2 million and a root-mean squared error of \$716.9 million.

[7]A model for the level of depreciation was also estimated, where $DEPRECIATION_t = b_o + b_1\ CAPITAL_{t-1} + b_2\ GCF_t$. This equation performed poorly and is omitted here. Additional work on an equation to explain and forecast depreciation is planned for Phase III.

TABLE 8.7

LONG-TERM DEBT FORECASTS FOR
1974 and 1975, USING REGRESSION (3)
IN TABLE 8.2[a]

| Time | Millions of Constant 1973 Dollars | | |
	Actual	Forecast	Error
1974-I	$6,988	$7,601	-$614
1974-II	6,751	7,084	- 334
1974-III	6,526	6,818	- 292
1974-IV	6,161	6,603	- 442
1975-I	5,424	6,270	- 845
1975-II	5,436	5,605	- 169
1975-III	5,897	5,540	357
1975-IV	5,885	5,937	- 52
Mean Absolute Error			$388.0
RMS-Error*			$452.9

[a]Forecasts are adjusted for lagged residual feedback.

*Root-mean-squared error of forecast.

where TAX = taxes paid in millions of dollars, GP = gross profits, GCF = gross cash flow, and u_1 and u_2 are stochastic error terms. These relationships were fitted in both current and constant dollars for ther period 1960-1973. However, the current dollar regressions performed somewhat better so that only these results are reported. All data were seasonally adjusted. More complete descriptions of the variables and data sources are given in Appendix C.

It should be noted that the tax equation employed in this report is an empirical construct and will be replaced by appropriate accounting identities in Phase III. The reasons for this procedure are several. First, there is evidence that all firms did not immediately adjust to various changes in the tax laws, e.g., accelerated depreciation.[8] Second, in the 1950s, final settlement of tax bills was not required for three years. After a succession of long-range adjustments and short-term fiscal actions, tax payments become equal to liabilities by 1968. Third, as a purely practical matter, using an empirical relationship for taxes greatly facilitates testing of the overall model without, at this point, greatly complicating the matter with a possibly long list of accounting identities and associated calculations.

In order to forecast physical and final capital expenditures in Phase III it will be necessary to replace, or at least supplement, the empirical tax equation with the appropriate accounting identities. These tax equations will show the impact of tax incentives on cash flow and will be kept consistent with the tax incentives which enter the formula for the rental price of capital.[9]

Table 8 shows the regression results for Equations 5 and 6, Regressions (2) and (4) in this table indicate that there is extreme serial correlation in the tax equation. Consequently, the preferred regressions are those indicated by regressions (1) and (3) which adjust for seial correlation using the Cochrane-Orcutt procedure. The marginal tax rate in regression (1) is about 46 percent, which is very reasonable, while the marginal tax rate from gross cash flow is

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[8]See N. B. Ture, Accelerated Depreciation in the United States, 1954-60 (New York: National Bureau of Economic Research, 1967), pp. 27-37.

[9]Most of the necessary calculations are outlined in R. M. Coen, "The Effect of Cash Flow on the Speed of Adjustment," in G. Fromm (ed.), Tax Incentives and Capital Spending (Washington, D.C.: The Brookings Institution, 1971), especially pp. 153-63.

TABLE 8.8

REGRESSION RESULTS FOR TAXES PAID
(Dependent Variable is Taxes Paid in Millions of Current Dollars)

	Regression Coefficient (Student t)			
Variable	(1)	(2)	(3)	(4)
CONSTANT	-26.008 (2.497)*	-18.398 (1.992)**	-140.117 (6.394)*	-84.710 (3.637)*
GROSS PROFIT	0.462 (27.433)*	0.452 (23.842)*	--	--
GROSS CASH FLOW	--	--	0.412 (21.270)*	0.354 (12.080)*
R^2	0.956	0.913	0.925	0.730
$\bar{R}^2$	0.955	0.912	0.924	0.725
F	1,154.480	568.415	653.170	145.933
SEE	16.016	23.866	20.943	42.110
D-W	2.523	0.546	2.610	0.338
ρ	0.697	--	0.823	--
k	2	--	3	--

*Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level.
  Sample size n = 55.

about 41 percent. Both regressions fit the data well; R^2s are 0.956 and 0.925, respectively. Thus, there does not seem to be any substantial disadvantage at this point in using gross cash flow as an explanatory variable rather than the more appropriate gross profit variable.

Short-Run Tax Forecasts

Short-run tax forecasts were prepared for 1974 and 1975 using regressions (1) and (3) in Table 8. A summary of the 1974 forecasts is presented in Tables 9 and 10. For 1974, the equations consistently overestimate the level of taxes paid by the iron and steel industry. However, the equation using gross cash flow has a smaller mean absolute error and root-mean-squared error for 1974. Using gross profits, the annual forecast for 1974 is $2,396.4 compared to actual taxes paid of $2,112.4, a difference of $284 million. Using gross cash flow, the annual forecast for 1974 is $2,307.3, a difference of $194.9 million.

Tables 11 and 12 present the tax forecasts for 1975. The level of taxes paid in 1975 are very low compared to previous years--in 1973 and 1974, the average tax rate was about 40 percent compared to only 32 percent for 1975. It is not clear to the author why federal taxes should be so low in 1975. The forecasted level of taxes imply an average tax rate of about 44 percent, which is quite reasonable given past experience.

Summary of the Tax Model

The second part of this chapter formulated and estimated an empirical model of tax payments in current dollars for the iron and steel industry for 1960-1973. The independent or explanatory variables used were before-tax profit or before-tax cash flow. The model fitted the data well; R^2s were 0.956 and 0.925 while the standard errors of estimate were $16.0 and $21 million, respectively. The short-run forecasting ability of the model was tested against available data for 1974 and 1975. In both years, the model tended to overpredict the level of taxes. The tendency to overpredict in these years is due to sharp declines in the average tax rate for the iron and steel industry to 40 percent in 1974 and 32 percent in 1975. The decreases in average tax rates may be due to changes in accounting practices such as the switch from FIFO to LIFO for valuation of inventories.[10]

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[10]See, for example, "More Companies Alter Accounting Methods to Neutralize Inflation," Wall Street Journal, October 7, 1974, p. 1; "Earnings Head Lower as Economy Slows Up, Firms Switch to LIFO," Wall Street Journal, January 3, 1975, p. 1.

TABLE 8.9

TAXES PAID FORECAST FOR 1974, USING
REGRESSION (1) IN TABLE 8.8

| | Taxes Paid in Millions of Current Dollars | | |
Time	Actual	Forecast	Error
1974-I	$275.174	$343.441	-$68.3
1974-II	394.257	466.582	-72.3
1974-III	850.107	957.501	-107.0
1974-IV	592.800	628.898	-36.1
Mean Absolute Error			$71.02
RMS-Error*			$75.38

*Root-mean-squared error of forecast.

TABLE 8.10

TAXES PAID FORECAST FOR 1974,
USING REGRESSION (3) IN TABLE 8.8

| | Taxes Paid in Millions of Current Dollars | | |
Time	Actual	Forecast	Error
1974-I	$275.174	$351.875	-$76.7
1974-II	394.257	460.293	-66.0
1974-III	850.107	896.350	-46.2
1974-IV	592.800	598.658	-5.9
Mean Absolute Error			$48.71
RMS-Error*			$55.71

*Root-mean-squared error of forecast.

TABLE 8.11

TAXES PAID FORECAST FOR 1975,
USING REGRESSION (1) IN TABLE 8.8

Time	Taxes Paid in Millions of Current Dollars		
	Actual	Forecast	Error
1975-I	$401.0	$499.5	-$ 98.5
1975-II	158.0	225.4	- 67.4
1975-III	100.0	264.3	- 164.0
1975-IV	276.0	329.4	- 53.4
Mean Absolute Error			$ 95.9
RMS-Error*			$105.0

*Root-mean-squared error of forecast.

TABLE 8.12

TAXES PAID FORECAST FOR 1975,
USING REGRESSION (3) IN TABLE 8.8

Time	Taxes Paid in Millions of Current Dollars		
	Actual	Forecast	Error
1975-I	$401.0	$490.8	-$ 89.8
1975-II	158.0	238.2	- 80.2
1975-III	100.0	283.5	- 184.0
1975-IV	276.0	334.2	- 58.2
Mean Absolute Error			$102.9
RMS-Error*			$113.5

*Root-mean-squared error of forecast.

In Chapter 9 of this report, the recursive model will be estimated using simultaneous equation estimation procedures. By comparison, this chapter used ordinary least-squares procedures, adjusted for serial correlation. The equation to be employed in the recursive model uses gross cash flow as an explanatory variable. The comparable regression in this chapter is regression (3) in Table 8. To complete the econometric analysis of this equation, tax forecasts for 1974 and 1975 were re-run with proper adjustment for lagged residual feedback.[11] The revised forecasts are presented in Table 13; the results demonstrate the improvement to be obtained from using residual feedback. The empirical tax model seems well suited for forecasting purposes, although some amount of fine tuning may be required. Also, as indicated above, in order to simulate alternative tax policies it will be necessary to replace or supplement this equation with various accounting identities.

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[11]See Pindyck and Rubinfeld, op. cit., pp. 170-73. The estimate of the first-order serial correlation coefficient was checked using the Hildreth-Lu scanning procedure. No significant improvement resulted from use of this method.

In addition, the tax model was estimated using a naive fourth-order autoregressive model

$$\hat{TAX}_t = \underset{(6.135)}{0.8774} \ TAX_{t-1} - \underset{(1.188)}{0.2191} \ TAX_{t-2} + \underset{(2.343)}{0.4221} \ TAX_{t-3} - \underset{(0.639)}{0.0846} \ TAX_{t-4};$$

$$R^2 = 0.404, \ SEE = 61.894.$$

The forecasts for 1974-75 had a mean absolute error of $228.9 million and a root-mean-squared error of $275.4 million.

TABLE 8.13

TAX FORECASTS FOR 1974 AND
1975, USING REGRESSION (3)
IN TABLE 8.8[a]

| Time | Taxes Paid in Millions of Current Dollars | | |
	Actual	Forecast	Error
1974-I	$275.2	$351.9	-$76.7
1974-II	394.3	397.2	- 2.9
1974-III	850.1	842.0	8.1
1974-IV	592.8	560.6	32.2
1975-I	401.0	486.0	- 85.0
1975-II	158.0	164.3	- 6.3
1975-III	100.0	217.5	-117.5
1975-IV	276.0	183.2	92.8
Mean Absolute Error			$52.69
RMS-Error*			$67.71

[a]Forecasts are adjusted for lagged residual feedback.

*Root-mean-squared error of forecast.

CHAPTER 9

THE RECURSIVE MODEL: SIMULTANEOUS ESTIMATION

Introduction

In Chapter 3, it was pointed out that unbiased and consistent estimates of relationships in a recursive model can be obtained using ordinary least squares estimation procedures. This technique, with corrections for serial correlation (generalized least squares), was applied in Chapters 5-8 to estimate the five economic relationships which make up the recursive model and the three simultaneous equations which make up the Dhrymes-Kurz model. Each relationship was derived from economic theory, estimated using data for 1960-1973, and applied to short-run forecasting for 1974 and 1975. The application or ordinary least squares to the recursive model depends critically on the assumption that the error terms are not contemporaneously correlated across equations. If they are so related, then we must consider one or more of the several methods available for simultaneously estimating systems of equations.

The purpose of this chapter is to determine empirically whether any improvement results when the recursive model is estimated as a system. Major attention is focused on the coefficient estimate and the standard error of estimate for the several equations. Two methods of estimation for systems of equations are considered. The first is a modified form of two-stage least squares. Instruments for the lagged endogenous variables are constructed using the fitted values from prior equations in the model.[1] The second proposed estimation method is Zellner's seemingly unrelated regression model, adjusted for autoregressive disturbances.[2] We begin the estimation by summarizing the model and examining the correlations among the estimated residuals from application of ordinary least squares.

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[1]This method is employed by L. R. Klein and H. Barger, "A Quarterly Model for the United States Economy," Journal of American Statistical Association, 49 (September 1954), pp. 413-437; and M. Desai, "An Econometric Model of the World Tin Economy," Econometrica, 34 (January 1966), pp. 105-134.

See also F. M. Fisher, "The Choice of Instrumental Variables in The Estimation of Economy-Wide Econometric Models," International Economic Review, 6 (September 1965), pp. 245-274.

[2]J. Kmenta, Elements of Econometrics (New York: MacMillian, 1971), pp. 528-29.

Residual Correlations

The recursive model consists of five behavioral equations and three identities (see Table 3.1, Chapter 3). Equation 1 determines the level of gross, before-tax cash flow (gross profits plus depreciation). Equation 2 determines the level of taxes paid out of gross cash flow. Equation 3 is an identity which computes net cash flow by subtracting taxes paid from gross cash flow. Equation 4 determines the level of dividends conditional on the level of net cash flow and lagged dividends. Equation 5 is an identity which computes gross retained earnings by subtracting dividends from net cash flow. Gross retained earnings are net retained earnings plus depreciation. Equation 6 determines the level of gross investment expenditures on fixed plant and equipment. Equation 7 is an identity which computes the end-of-period capital stock by adding gross investment in the current period to the depreciated beginning of period capital stock. Equation 8 determines the level of long-term debt conditional on the level of capital stock and lagged long-term debt.

Table 1 shows the contemporaneous correlations among the residuals from the five equations when estimated by ordinary least squares (OLS). The proper tests of significance for this type of correlation coefficient are not adequately dealt with in the econometric literature.[3] If the OLS estimates are consistent, then it is permissable to treat the residuals as estimates of the unobservable disturbances. This assumes that there are no specification errors in the model, a rather strong assumption to make in any econometric model. Given the assumptions of consistent estimation and no specification errors, then a proper test of significance can be based on the simple correlation coefficient. With 52 degrees of freedom, the critical value for rejecting the hypothesis of no correlation is $|r| = 0.273$, employing a two-tail test at the 5 percent level of significance. Table 2 repeats the same experiment with the transformed variables, adjusted for first-order serial correlation using the estimated autocorrelation coefficients. With allowance for rounding errors, these results are identical with Table 1, and require no further discussion.

Table 1 shows that the hypothesis is accepted in all cases except for the tax and dividend residuals. The correlation between the tax and long-term debt residuals is also relatively high, although not significant at the stated level. These results suggest that it may indeed be sufficient to estimate the model and prepare forecasts based on simpler, OLS procedures. The test proposed in Table 1, however, is relatively informal and based on strong assumptions. It might be instructive, therefore, to proceed with systems estimation keeping these results in mind. An additional reason for using two-stage least squares procedures

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[3]The procedure used here follows Desai, op. cit., p. 116; and P. J. Dhrymes and M. Kurz, "Investment, Dividend, and External Finance Behavior of Firms," in R. Ferber (ed.), Determinants of Investment Behavior (New York: National Bureau of Economic Research, 1967), pp. 448-450.

TABLE 9.1

RESIDUAL CORRELATION MATRIX FROM
ORDINARY LEAST SQUARES ESTIMATION,
ADJUSTED FOR SERIAL CORRELATION

	Taxes	Dividends	Investment	Debt
Cash Flow	−0.1487	−0.1221	−0.1600	−0.0465
Taxes		0.3822*	−0.0347	−0.2245
Dividends			−0.0236	−0.1422
Investment				−0.0076

*Critical value of $|r| = 0.273$ for a 5 percent level of significance, two-tailed test. The residuals cover the period 1961-I through 1973-IV.

TABLE 9.2

RESIDUAL CORRELATION MATRIX FROM
ORDINARY LEAST SQUARES ESTIMATION,
TRANSFORMED VARIABLES[a]

	Taxes	Dividends	Investment	Debt
Cash Flow	−0.1486	−0.1218	−0.1585	−0.0464
Taxes		0.3822*	−0.0346	−0.2246
Dividends			−0.0236	−0.1423
Investment				−0.0074

[a]Transformed variables adjusted with estimated values for the first-order serial correlation coefficient.

*Critical value of $|r|$ = 0.273 for a 5 percent level of significance, two-tailed test. The residuals cover the period 1961-I through 1973-IV.

is that the presence of lagged endogenous variables leads to biased, though consistent, estimators when OLS is applied. However, in models with both lagged endogenous variables and serial correlation, OLS estimators are both biased and inconsistent.[4] One method of attempting to deal with these problems is to use Cochrane-Orcutt iterative procedures to remove serial correlation.[4a] This procedure, however, is bound to be somewhat imprecise since the correlation among the estimated residuals depends on both the true value of the disturbances and the true value of the regression coefficients, which are what we are trying to estimate. A second method of dealing with the serially correlated-autoregressive model is to use instrumental variables estimation or two-stage least squares.

Finally, if the OLS estimates are unbiased and consistent, the efficiency of estimation can be improved by use of Zellner's seemingly unrelated regression model. This method depends, however, on mutual correlation among the regression disturbances across equations for the resulting gain in estimation efficiency. Tables 1 and 2 suggest that the amount of residual correlation in the recursive model is indeed quite small. The gains from using Zellner estimation procedures would likewise be relatively small. High degrees of correlation among the explanatory variables in the equations are also known to limit the efficiency gain when using Zellner estimation procedures.[5]

The remainder of this chapter compares the results obtained by ordinary least squares (OLS) with those obtained using the two methods of simultaneous equation estimation--two-stage least squares (TSLS) and Zellner's seemingly unrelated regressions (ZLS). We first examine the changes in the coefficient estimates and the standard error of estimate for each of the five equations. Then a comparison is made of the forecast errors for 1974 and 1975 based on the three estimation methods.

Simultaneous Estimation

The two-stage least squares procedure used in this report combines both Cochrane-Orcutt adjustments for serial correlation and instrumental

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[4]J. Johnston, Econometric Methods, Second Edition (New York: McGraw-Hill, 1972), pp. 305-07.

[4a]See Ibid., pp. 316-20; and E. Malinvaud, Statistical Methods of Econometrics (Chicago: Rand McNally, 1966), pp. 458-72.

[5]Kmenta, op. cit., p. 524; Johnston, op. cit., p. 239.

variables adjustment for the presence of lagged endogenous variables. In the first stage, instruments are obtained for the lagged endogenous variables. The instruments are constructed by estimating a prior equation in the model, adjusting for serial correlation in the residuals. For example, the instrumental (fitted) values for gross cash flow in the tax equation are obtained by regressing gross cash flow on the set of instruments obtained in the profit equation. In the second stage, the fitted values are used in place of the actual values of the lagged endogenous variables, again adjusting for serial correlation in the residuals.[6] Thus, for the tax equation, taxes are regressed on a constant and the fitted values of gross cash flow.

Tables 3-7 present the results for the five equations estimated by OLS, TSLS, and ZLS. An examination of the TSLS results in these tables suggests the following important conclusions:

1. In only one or two cases are the coefficient estimates (excluding constants) significantly altered by the use of TSLS. The coefficient on ΔGRE_{-3} in Table 5 increases from about 0.60 to 0.10, an increase of 67 percent. The coefficient on gross cash flow in Table 4 increases from 0.023 to 0.026, an increase of 13 percent. In all other cases, the coefficients change by only 10 percent or less.

2. In all cases the use of TSLS increases the regression standard error of estimate (SEE) by slight to moderate amounts.

3. An examination of the estimated standard errors of the coefficients indicated that (excluding constants) in all cases the individual standard errors were higher using TSLS. In several cases, the percentage increases in the standard errors were quite large.

In sum, a comparison of the OLS and TSLS results suggest that the co-efficient magnitudes, with one exception, are unaltered by the use of TSLS, but that TSLS tends to increase the standard error of the coeffi-cients. No significant improvement would thus seem to follow from the use of TSLS rather than OLS estimation procedures.

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[6]See R. C. Fair, "The Estimation of Simultaneous Equation Models with Lagged Endogenous Variables and First-Order Serially Correlated Errors," Econometrica, 38 (May 1970), pp. 507-516.

The procedures employed in this report depart somewhat from Fair's suggestions in the construction of the first-stage instruments. Also actual values were used for a few early periods to prevent loss of degrees of freedom in the second-stage.

TABLE 9.3

COMPARISON OF OLS AND SYSTEMS
ESTIMATION FOR PROFIT EQUATION
(Dependent Variable is Gross Cash Flow in Millions of Current Dollars)

| | Regression Coefficient (Student t) | |
Variable	OLS	ZLS
CONSTANT	-195.862 (1.006)	-143.326 (0.746)
TR	0.097 (3.871)*	0.095 (3.846)*
TR_{-4}	-0.039 (1.995)**	-0.045 (2.371)*
CU	8.793 (4.363)*	8.741 (4.460)*
Δp	-14.790 (1.483)	-17.154 (1.781)**
IMP	-8.800 (2.391)*	-8.248 (2.309)*
R^2	0.890	0.889
$\bar{R}^2$	0.877	0.877
F	72.443	72.072
SEE	64.317	64.525
D-W	2.287	2.309
ρ	0.811	0.811
k	5	--

*Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level. Degrees of freedom are 45 and 45, respectively.

TABLE 9.4

COMPARISON OF OLS AND SYSTEMS
ESTIMATION FOR TAX EQUATION
(Dependent Variable is Taxes in Millions of Current Dollars)

Variable	Regression Coefficient (Student t)		
	OLS	TSLS	ZLS
CONSTANT	−140.117 (6.394)*	−103.769 (3.588)*	−156.644 (6.630)*
GROSS CASH FLOW	0.412 (21.270)*	0.371 (11.156)*	0.427 (21.967)*
R^2	0.925	0.803	0.928
$\overline{R}^2$	0.924	0.800	0.927
F	653.170	216.513	630.732
SEE	20.943	33.900	21.245
D−W	2.610	2.318	2.755
ρ	0.823	0.656	0.823
k	3	2	--

*Significant at the 95 percent confidence level. Degrees of freedom
are 53, 53, and 49, respectively.

TABLE 9.5

COMPARISON OF OLS AND SYSTEMS
ESTIMATION FOR DIVIDEND EQUATION
(Dependent Variable is Dividends in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)		
	OLS[a]	TSLS[a]	ZLS
NET CASH FLOW$_{-1}$	0.023 (3.808)*	0.026 (3.868)*	0.028 (4.564)**
DIVIDEND$_{-1}$	0.902 (38.005)*	0.890 (33.756)*	0.879 (35.318)*
R^2	0.906	0.902	0.892
$\bar{R}^2$	0.902	0.898	0.888
F	499.677	469.354	403.695
SEE	9.995	10.021	9.877
D-W	1.930	1.941	1.955
h	0.263	0.217	0.163
ρ	-0.322	-0.327	-0.322
k	2	2	--
$\hat{\delta}$	0.098	0.110	0.121
$\hat{\beta}$	0.235	0.236	0.231

*Significant at the 95 percent confidence level. Degrees of freedom are 52, 51, and 49, respectively.

[a]Standard errors are adjusted for presence of a lagged dependent variable.

TABLE 9.6

COMPARISON OF OLS AND SYSTEMS
ESTIMATION FOR INVESTMENT EQUATION
(Dependent Variable is Gross Investment in Millions of Constant 1973 Dollars)

Variable	Regression Coefficient (Student t)		
	OLS[a]	TSLS[a]	ZLS
CONSTANT	116.1920	125.2240	126.0138
	(4.003)*	(4.300)*	(4.452)*
$\Delta Q'_{-1} \times 10^3$	0.0582	0.0623	0.0571
	(3.163)*	(3.300)*	(2.648)*
$\Delta(c/w)'_{-1} \times 10^6$	-0.1716	-0.1806	-0.1845
	(4.977)*	(5.203)*	(5.369)*
I_{-1}	0.7743	0.7522	0.7707
	(16.094)*	(14.974)*	(14.083)*
ΔGRE_{-3}	0.0609	0.0992	0.0401
	(2.344)*	(2.032)*	(1.304)
R^2	0.9573	0.9562	0.9608
$\bar{R}^2$	0.9538	0.9526	0.9574
F	274.7450	267.6950	281.7628
SEE	26.3015	26.6306	25.9092
D-W	2.2905	2.2633	2.2520
h	1.1384	1.0340	1.0061
ρ	-0.0566	-0.0599	-0.0566
k	2	2	--
$\hat{b}_0$	0.1968	0.2197	0.2005
$\hat{b}_1$	0.0609	0.0992	0.0401
$\hat{d}_0$	16,599	15,851	17,502
$\hat{d}_1$	0.2957	0.2836	0.2748
$\hat{d}_2$	-0.8720	-0.8220	-0.9202
$E_{K*:Q'}$	0.60	0.59	0.57
$E_{K*:(c/w)'}$	-0.77	-0.75	-0.83

*Significant at the 95 percent confidence level. Degrees of freedom are 49, 49, and 46, respectively.

[a]Standard errors are adjusted for presence of a lagged dependent variable.

TABLE 9.7

COMPARISON OF OLS AND SYSTEMS ESTIMATION
FOR LONG-TERM DEBT EQUATION
(Dependent Variable is Long-Term Debt in Millions of Constant 1973 Dollars)

	Regression Coefficient (Student t)		
Variable	OLS[a]	TSLS[a]	ZLS
CAPITAL (K)	0.023 (2.000)*	0.022 (1.892)**	0.031 (2.512)*
DEBT$_{-1}$	0.965 (40.288)*	0.966 (39.297)*	0.947 (36.923)*
R^2	0.978	0.977	0.974
$\bar{R}^2$	0.977	0.976	0.973
F	2,319.480	2,174.980	1,863.598
SEE	210.440	212.796	215.273
D-W	1.967	1.964	1.730
h	0.122	0.132	0.982
ρ	-0.110	-0.111	-0.110
k	1	2	--
$\hat{\delta}$	0.035	0.034	0.053
$\hat{\gamma}$	0.657	0.647	0.585

*Significant at the 95 percent confidence level.

**Significant at the 90 percent confidence level. Degrees of freedom are 52, 51, and 49, respectively.

[a]Standard errors are adjusted for the presence of a lagged dependent variable.

Turning to the estimates using Zellner least squares (ZLS), these results are also summarized in Tables 3-7. The basic purpose of the ZLS procedure is to improve the efficiency of estimation. Direct comparison of the OLS and ZLS results is, however, complicated by two factors. First, due to the presence of lagged variables, the number of observations for all the ZLS regressions was reduced to 51; this resulted in some changes in the OLS coefficient estimates and their standard errors. Second, the ZLS standard errors are unadjusted for the presence of a lagged dependent variable so that there is a downward bias in these estimates. The ZLS coefficient estimates were obtained using the procedures outlined in Kmenta;[7] all variables were transformed using the estimates of the first-order autocorrelation coefficient from the OLS regressions. The ZLS regressions were then estimated from the transformed variables using the computational algorithm available in the Econometric Software Package (ESP). An examination of the ZLS results suggest the following important conclusions:[8]

1. The magnitudes of the estimated coefficients are significantly altered in four or five cases. In Table 3, the lagged sales and the price change coefficients are both decreased about 15 percent. In Table 6, the gross retained earnings coefficient is reduced by about 20 percent while in Table 7 the capital coefficient is increased by 20 percent. In all other cases the coefficients values change by 10 percent or less.

2. The estimated standard errors are always reduced by using ZLS. In Table 3, the standard errors are reduced by about 3 percent; in Table 4, 10 percent; in Table 5, 7.7 percent; in Table 6, 1.3 percent; and in Table 7, 2.5 percent.

3. The regression standard error of estimate (SEE) is improved in only two cases using ZLS. In both the dividend and investment equations, SEE falls by about 1.5 percent. In all other cases, SEE increased by about 2 percent or less when ZLS is used.

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[7]Kmenta, op. cit., pp. 528-29.

[8]The coefficients and standard errors are changed due to differences in estimation procedures and differences in the time period used for estimation. The comparisons are for OLS and ZLS regressions which covered the same time period. For example, the OLS coefficient for net cash flow in Table 6 was 0.028, which is identical to the ZLS estimate.

In sum, a comparison of the OLS and ZLS results suggests that the efficiency gains from use of ZLS are relatively modest. A check of the correlations among the _transformed_ variables used to obtain the ZLS coefficients revealed only seven cases of "high" correlation among the independent variables, i.e., simple correlations of 0.7 or greater. This suggests that the modest efficiency gains are due to the low residual correlations across equations (see Tables 1 and 2) rather than high correlations among the explanatory variables.

Short-Run Forecasts

An additional check on the results obtained using the three methods of estimation is provided by the short-run forecasts for 1974-1975. Table 8 provides a summary of the short-run forecasts for the five equations. All the forecasts incorporate lagged residual feedback. The TSLS forecasts were prepared using both the fitted values for the instrumental variables and the actual values in 1974 and 1975. The ZLS forecasts were prepared using both the fitted values of the dependent variable and the actual value in adjusting for lagged residual feedback.[9] A comparison of the forecasts suggests the following important conclusions:

1. In only one case is a summary statistic improved by the use of TSLS. The root-mean-squared error for the tax equation is reduced for $67.7 million to $66.0 million.

2. The use of ZLS improves the summary statistics in about one-half of the cases. For example, using the actual value for Y_t, the mean absolute error in the investment equation is reduced by about 4 percent. In all cases, the gain in forecasting accuracy by using ZLS is relatively modest.

Table 9 compares the forecasts for gross investment using OLS, TSLS (actual values for the instrumental variables) and ZLS (using Y_t for lagged residual feedback). All three methods are able to forecast the _level_ of gross investment quite accurately, although the TSLS forecasts tend to produce rather large errors in 1975. The errors using OLS and ZLS occur mainly in the fourth quarters of 1974 and 1975. The

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[9]The basic relationship for forecasting with serially correlated errors is

$$\hat{Y}_{t+1} = \hat{\rho}Y_t + \hat{\alpha}(1-\hat{\rho}) + \hat{\beta}(X_{t+1} - \hat{\rho}X_t), \ \hat{\rho} = \text{autocorrelation coefficient}$$

where Y is the dependent variable and X is the independent variable(s). The ZLS forecasts were prepared using both Y_t (the preferred procedure) and $\hat{Y}_t$.

TABLE 9.8

COMPARISON OF FORECAST ERRORS
FOR OLS AND SYSTEMS ESTIMATION
(Millions of Dollars)

Equation/ Estimation Method	Mean Absolute Error	Root Mean Square Error
Profits:		
OLS	$368.2	$459.3
ZLS[c]	521.3	652.2
ZLS[d]	395.9	480.4
Taxes:		
OLS	52.7	67.7
TSLS[a]	169.1	219.1
TSLS[b]	54.9	66.0
ZLS[c]	81.2	92.4
ZLS[d]	53.6	68.0
Dividends:		
OLS	15.1	20.4
TSLS[a]	17.9	22.3
TSLS[b]	15.3	20.8
ZLS[c]	13.2	18.3
ZLS[d]	15.3	20.8
Investment:		
OLS	23.0	29.8
TSLS[a]	27.1	32.6
TSLS[b]	25.2	31.1
ZLS[c]	22.6	30.7
ZLS[d]	22.0	30.2
Debt:		
OLS	388.0	452.9
TSLS[a]	392.4	458.5
TSLS[b]	395.6	461.4
ZLS[c]	355.5	423.1
ZLS[d]	381.1	445.8

[a]Using fitted values of the instrumental variable for 1974-75.

[b]Using actual values of the instrumental variable for 1974-75.

[c]Using fitted values of the dependent variable for lagged residual feedback.

[d]Using actual values of the dependent variable for lagged residual feedback.

TABLE 9.9

COMPARISON OF INVESTMENT FORECASTS FOR OLS
AND SYSTEMS ESTIMATION
(Gross Investment in Millions of Constant 1973 Dollars)

Time	Actual	OLS[a]		TSLS[a]		ZLS[a]	
		Forecast	Error	Forecast	Error	Forecast	Error
1974-I	$408.6	$389.5	$19.1	$396.4	$12.2	$389.7	$18.9
1974-II	456.0	446.3	9.7	456.2	-0.2	443.3	12.7
1974-III	465.2	473.4	-8.2	472.1	-6.9	476.2	-11.0
1974-IV	555.3	492.5	62.8	492.7	62.6	495.0	60.3
1975-I	556.7	578.8	-22.1	586.7	-30.0	576.0	-19.3
1975-II	596.5	603.0	-6.5	622.5	-26.0	594.4	2.1
1975-III	587.1	576.0	11.0	559.4	27.7	586.5	0.6
1975-IV	538.9	583.6	-44.7	574.5	-35.6	590.3	-51.4
Mean Absolute Error			$23.0		$25.2		$22.0
RMS-Error*			$29.8		$31.1		$30.2

[a]Forecasts are adjusted for lagged residual feedback.

*Root-mean-squared error of forecast.

direction of investment was increasing throughout 1974 and reached a
peak (in 1973 dollars) in the second quarter of 1975. Each of the
three forecasts correctly predict the peak and the subsequent downturn
in 1975-III. Each of the forecasts incorrectly predict a turning point
in 1975-IV. Thus, in each case, the forecasts tend to miss some major
changes in the direction of investment expenditures. Finally, the aggre-
gate level of investment expenditures in 1974-1975 was $4,164.3 million.
The OLS underpredicts this aggregate by $21.2 million, the TSLS under-
predicts by only $3.8 million, and the ZLS underpredicts by $12.9 mil-
lion. The gain in accuracy using TSLS appears to depend on offsetting
errors since this method performs relatively poorly during 1975.

In sum, while there appears to be some gain in some equations in
forecasting accuracy from using simultaneous equation estimation, the
magnitude of the gain is relatively modest. The OLS forecasts are
quite satisfactory overall in forecasting the level and direction of
investment expenditures.

<center>Summary</center>

This chapter examined two econometric methods for estimating systems
of equations and applied these methods to the recursive model of in-
vestment demand and financial flows. Each equation in the model was
estimated using ordinary least squares (OLS), a form of modified two-
stage least squares (TSLS), and Zellner's seemingly unrelated regression
model (ZLS). A comparison of the estimated coefficients and standard
errors, summary statistics, and short-run forecasts suggests that the
gains from using these more sophisticated estimation methods are rela-
tively modest. The flexibility of the OLS method appears to offset
any possible gains in estimation efficiency or forecasting accuracy
obtained by simultaneous estimation methods.

APPENDIX A

DERIVATION OF EQUATION (5.12)

APPENDIX A
DERIVATION OF EQUATION (5.12)

This appendix presents the derivation of the profit function

given by Equation 12 in Chapter 5. We begin with the relationship[1]

(A.1) $\pi = (1-t)pQ - W - F_1$, $t > 0$, $F_1 > 0$

where π is before-tax corporate profits; pQ is sales; W is the wage bill; F_1

is fixed costs; and t is the indirect business tax rate. The basic

behavioral expression for the wage rate (assuming a one period lag)

is given by

(A.2) $w = h\,(pQ)_{-1}$, $h > 0$

It is further assumed that a certain amount of labor is fixed input F_2

so that manhours, N, is a <u>linear</u> function of output

(A.3) $N = gQ + F_2$, $g > 0$, $F_2 > 0$

Substituting Equations 2 and 3 in Equation 1 yields

(A.4) $\pi = (1-t)pQ - gh(Q(pQ)_{-1}) - F$

where $F = F_1 + wF_2$, $F > 0$. The expression $Q(pQ)_{-1}$ can be approximated by[2]

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[1] See M. K. Evans, "An Industry Study of Corporate Profits," <u>Econometrica</u>, 36 (April 1968), pp. 343-64.

[2] See L. R. Klein, <u>A Textbook of Econometrica</u> (Evanston: Row, Peterson and Co., 1953), pp. 120-21.

(A.5) $Q(pQ)_{-1} \cong Q(\overline{pQ})_{-1} + (pQ)_{-1} \overline{Q} + C_1$

where $C_1 = -\overline{Q} \, (\overline{pQ})_{-1}$, and the bars indicate arithmetic mean values of the terms in question. Substituting Equation 5 in 4, we can write

(A.6) $\pi = (1-t)\, pQ - gh[Q(\overline{pQ})_{-1} + (pQ)_{-1} \overline{Q} + C_1] - F$

$\quad\quad = (1-t)pQ - g'Q - h' \, (pQ)_{-1} - F + C'_1$

where $g' = gh(\overline{pQ})_{-1}$, $\quad\quad g' > 0$,

$\quad\quad h' = gh\overline{Q}$, $\quad\quad\quad\quad h' > 0$,

$\quad\quad C'_1 = ghC_1 = -gh\overline{Q}(\overline{pQ})_{-1}$, $C'_1 < 0$.

Let $(1-t)pQ = apQ + bpQ$, where $a+b = 1-t$. If $b(pQ) \cong b[p\overline{Q} + Q\overline{p} + C_2]$, where $C_2 = - \overline{p}.\overline{Q}$, then [3]

(A.7) $\pi = a(pQ) + b'Q + dp - h'(\overline{pQ})_{-1} - F + C'$

where $b' = b\overline{p} - g' = b\overline{p} - gh(\overline{pQ})_{-1}$, $b' \gtrless 0$,

$\quad\quad d = b\overline{Q}$, $d \gtrless 0$,

$\quad\quad C' = C'_1 + bC_2 = -[gh\overline{Q}(\overline{pQ}))_{-1} + b\overline{p}.\overline{Q}]$, $C' < 0$.

To complete the model, assume that F is proportional to capital stock K, so that $F = f'(K)$, then $f' > 0$, and

(A.8) $\pi = a(pQ) + (b'Q - f'K) + dp - h'(pQ)_{-1} + C'$

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[3]Evans argues that both a and b can be expected to be positive, op. cit. p. 345.

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Define the capacity utilization rate as CU ≡ Actual Q/ Maximum Q, and let Maximum Q = m(K), m > 0. Then CU = (1/m) (Q/K), where[4]

(A.9) $\dfrac{Q}{K} \cong \left[\dfrac{1}{\bar{K}} Q\right] - \left[\dfrac{\bar{Q}}{\bar{K}^2} \cdot K\right] + C_3$

and $C_3 = \bar{Q}/\bar{K}$. If $b' \cong 1/\bar{K}$ and if $f' \cong \bar{Q}/\bar{K}^2$, then we can write

(A.10) $b'Q - f'K \cong Q/K - C_3$

This implies that

(A.11) $\dfrac{b'}{f'} \cong \dfrac{1/\bar{K}}{\bar{Q}/\bar{K}^2} = \dfrac{\bar{K}}{\bar{Q}}$

Using Equation 10, capacity utilization is now

(A.12) $b'Q - f'K \cong mCU - C_3$

Substituting Equation 12 into 8, the profit function can be written as

(A.13) $\pi = a(pQ) + mCU + dp - h'(pQ)_{-1} + C$

where $a = 1-t-b$, $a > 0$,

$d = b\bar{Q}$, $d \gtrless 0$,

$h' = gh\bar{Q}$, $h' > 0$,

$C = C' - C_3 = -[gh\bar{Q}(\overline{pQ})_{-1} + b\bar{p}.\bar{Q}] - [\bar{Q}/\bar{K}]$, $C < 0$.

[4]Klein, op.cit. p. 121.

An alternative formulation of the model can be obtained by rearranging current and constant dollar sales terms. We have

$$(A.14) \quad b(pQ) \cong b[p\bar{Q} + Q\bar{p} - \bar{p}\cdot\bar{Q}]$$

$$= b\bar{p}Q + b\bar{Q}(p - \bar{p})$$

$$= b\bar{p}Q + b\bar{Q}(\Delta p)$$

The profit function using Equation 14 is

$$(A.15) \quad \pi = a(pQ) + b'Q + d'\Delta p - h'(pQ)_{-1} - F + C_1'$$

where $d' = b\bar{Q}$. Substituting Equation 12 yields

$$(A.16) \quad \pi = a(pQ) + mCU + d'\Delta p - h'(pQ)_{-1} + C''$$

where $C'' = C_1' - C_3$. Thus, the coefficient on the price change variable is

$$(A.17) \quad d' = b\bar{Q}$$

$$= (1-t-a)\bar{Q}$$

The coefficients and expected signs in Equation 16 are:

$a = 1-t-b$, $a > 0$,

$m > 0$,

$d' = b\bar{Q} = (1-t-a)\bar{Q}$, $d' \gtrless 0$,

$h' = gh\bar{Q}$, $h' > 0$,

$C'' = C_1' - C_3 = -[gh\bar{Q}(\overline{pQ})_{-1} + (\bar{Q}/\bar{K})]$, $C'' < 0$.

The coefficient on the price change term is $(1-t-a)\overline{Q}$, which might be expected to be positive in general since $(1-t-a) > 0$ and of course, $\overline{Q} > 0$. This term could be negative if a is sufficiently large $(a > 0.9)$ or if, in a time series, $\overline{Q}$ is falling over time as a consequence of price policy. Consequently, we expect $d' \gtrless 0$ depending on the effect of pricing policy on expected output and the position of the demand schedule, i.e., inward shifts of the demand schedule due to competition from substitute products and entry.

Evidence broadly consistent with a negative price coefficient is presented in Table A-1. Based on a three-year moving average, real output of steel products increased from 1960 to 1965 as the economy recovered and steel prices were quite stable in nominal terms. However, after 1965 average output remained constant at about 87 million tons until 1972. During the period 1965-1973, steel prices increased at a rate of about 3.5 percent per annum.

TABLE A-1

AVERAGE NET DOMESTIC SHIPMENTS OF
STEEL MILL PRODUCTS
(Million Net Tons)

Year	Net Domestic Shipments[a]	3-Year Moving Total	3-Year Moving Average
1960	68.1	199.9	66.63
1961	64.1	200.8	66.93
1962	68.6	206.6	68.87
1963	73.4	223.3	74.43
1964	81.5	245.1	81.70
1965	90.2	260.0	86.67
1966	88.3	260.7	86.90
1967	82.2	260.2	86.73
1968	89.7	260.6	86.87
1969	88.7	262.1	87.37
1970	83.7	256.6	85.53
1971	84.2	256.6	85.53
1972	88.9	280.4	93.47
1973	107.3	299.9	99.97
1974	103.7	288.0	96.00
1975	77.0	--	

[a]Total net shipments less exports of steel mill products.

Source: American Iron and Steel Institute, Annual Statistical Report (Various issues).

APPENDIX B

DERIVATION OF EQUATION (7.15)

APPENDIX B

DERIVATION OF EQUATION (7.15)

This appendix presents the derivation of the investment function

given by Equation 15 in Chapter 7. We begin with the relationship[1]

(B.1) $I_t = b_o[K^*_t - (1-\delta)K_{t-1}] + b_1F_{t-i}$

which can be expanded to

(B.2) $I_t = b_o K^*_t + b_o(\delta-1)K_{t-1} + b_1F_{t-i}$

If $(1-\delta)I_{t-1}$ is subtracted from both sides of the equation, then

(B.3) $I_t - (1 - \delta)I_{t-1} = b_o K_t^* + b_o(\delta - 1) K_{t-1} + b_1F_{t-i} - (1-\delta)I_{t-1}$

and substituting for I_{t-1}, we have

(B.4) $I_t - (1-\delta)I_{t-1} = b_o K_t^* + b_o(\delta-1)K_{t-1} + b_1F_{t-i} - b_o(1-\delta)K^*_{t-1}$

$$- b_o(\delta-1)(1-\delta)K_{t-2} - b_1(1-\delta)F_{t-i-1}$$

By definition, it is true that

---

[1] See R. M. Coen, "The Effect of Cash Flow on the Speed of Adjustment," in G. Fromm (ed.), Tax Incentives and Capital Spending (Washington, D.C.: The Brookings Institution, 1971), p. 164.

$$K_{t-1} - (1-\delta)K_{t-2} = I_{t-1}$$

so that

$$(B.5) \quad b_o(\delta-1)K_{t-1} - b_o(\delta-1)(1-\delta)K_{t-2} = b_o(\delta-1)I_{t-1}$$

Substituting Equation 5 in 4 and collecting terms

$$(B.6) \quad I_t - (1-\delta)I_{t-1} = b_o[K_t{}^* - (1-\delta)K_t{}^*{}_{-1}] + b_1[F_{t-i} - (1-\delta)F_{t-i-1}]$$
$$+ bo(\delta-1)I_{t-1}$$

Therefore, it follows that

$$(B.7) \quad I_t = b_o[K_t{}^* - (1-\delta)K_t{}^*{}_{-1}] + b_1[F_{t-i} - (1-\delta)F_{t-i-1}]$$
$$+ (1-b_o)(1-\delta)I_{t-1}$$

which is the desired result.

APPENDIX C

DESCRIPTION OF VARIABLES, SUMMARY
STATISTICS, ZERO-ORDER CORRELATIONS,
AND ALMON LAG WEIGHTS

DESCRIPTION OF VARIABLES

All variables were constructed for 1960 through 1975 in quarterly form. Unless otherwise noted, all are seasonally adjusted in millions of dollars. Variables in Equations III, IV, and V were converted to constant 1973 dollars using the GNP implicit price deflator for fixed investment (1973 = 100).[1]

I. PROFITS EQUATION -- CURRENT DOLLARS

Variable Name	Description, Source, and Method of Construction
1. GROSS PROFIT (GP_t)	Profit Before Federal Income Taxes. Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: Sum of seasonally adjusted after-tax profits (seasonal factors = 0.9750, 1.2779, 0.7874, and 1.0194) and seasonally adjusted federal income tax payments (factors = 1.0580, 1.3952, 0.7964, and 0.8506).
2. GROSS CASH FLOW (GCF_t)	Gross Cash Flow. Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: Sum of GP_t and seasonally adjusted depreciation (factors = 0.9909, 1.0453, 0.9836, and 0.9817).
3. TR_t	Sales (Net of Returns, Allowances, and Discounts). Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: Seasonal adjustment with geometric normalization, factors = 0.9954, 1.0830, 0.9671, and 0.9592.
4. CU_t	Rate of Capacity Utilization, in percent. Source: Output measure from American Iron and Steel Institute, Annual Statistical Report, various editions. Capacity measures for 1960 to 1967 from J. P. Nelson, "An Interregional Recursive Programming Model of the U. S. Iron and Steel Industry: 1947-1967," unpublished Ph.D. dissertation, University of Wisconsin, 1970; For 1968 and 1969, interpolated; For 1970-74, from the U.S. Joint Economic Committee as reported in Business Week, December 14, 1974. The value for 1975 was assumed to be constant at the 1974 level. Construction: 100 x Raw Steel Output ÷ Raw Steel Capacity. Seasonal adjustment with geometric normalization, factors = 1.0352, 1.0676, 0.9358, and 0.9669.

[1] A downward revision in the fixed investment deflator for 1971 through 1974 has been incorporated into the data for this report. This has resulted in an upward revision in the deflated variables, particularly investment, in comparison to the Phase I study.

Variable Name	Description, Source, and Method of Construction
5. Δp_t	Change in Wholesale Price Index of Steel Mill Products (BLS 1013), 1973=100. Source: 1960 to 1966 in American Iron and Steel Institute, Annual Statistical Report, various editions. 1967 to 1975 in U. S. Department of Labor, Bureau of Labor Statistics, Monthly Labor Review, various issues. Construction: Converted to 1973 = 100. Seasonal adjustment with geometric normalization, factors = 0.9986, 1.0000, 1.0020, and 0.9993.
6. IMP_t	Import Penetration Index, in percent. Source: Imports of Steel Mill Products from U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, various monthly issues. Net Shipments of Steel Products also from Survey of Current Business. Construction: 100 x Imports ÷ Shipments. Seasonal adjustment with geometric normalization, factors = 0.7983, 0.9806, 1.1366, and 1.1239.
7. TR_{-4}	TR_t (described above), lagged four quarters.

II. TAX EQUATION -- CURRENT DOLLARS

Variable Name	Description, Source, and Method of Construction
1. TAX_t	Provision for Federal Income Tax. Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: Seasonal adjustment with geometric normalization, factors = 1.0580, 1.3952, 0.7964, and 0.8506.
2. GP_t	Profit Before Federal Income Taxes (described above).
3. GCF_t	Gross Cash Flow (described above)

III. DIVIDENDS EQUATION -- CONSTANT DOLLARS

Variable Name	Description, Source, and Method of Construction
1. DIVIDEND (D_t)	Cash Dividends Charged to Surplus. Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: Deflated, seasonal adjustment with geometric normalization, factors = 1.0057, 0.9771, 0.9658, and 1.0536.
2. PROFIT$_{-1}$ (π_{-1})	Profit After Federal Income Taxes, once lagged. Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: Deflated, seasonal adjustment with geometric normalization, factors = 0.9762, 1.2777, 0.7865, and 1.0193.
3. CASH FLOW$_{-1}$ (NCF_{-1})	Net Cash Flow, once lagged. Source: Federal Trade Commission, Quarterly Financial Report For Manufacturing Corporations, various issues. Construction: Sum of deflated after-tax profits and deflated depreciation. Seasonal adjustment with geometric normalization, factors = 0.9797, 1.1396, 0.8970, and 0.9985.
4. DIVIDEND$_{-1}$ (D_{-1})	D_t (described above), lagged once.

IV. INVESTMENT EQUATION -- CONSTANT DOLLARS

Variable Name	Description, Source, and Method of Construction
1. I_t	Expenditures for New Blast Furnace and Steel Works, seasonally adjusted (Commerce Department weights). Source: U. S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, January 1970, p. 32, and various monthly issues Construction: Deflated. Note: The value for 1975-IV is a preliminary value based on expected capital expenditures reported by business in October and November 1975. The deflated value for 1974-IV has been revised sharply upward to $553.3 million from the preliminary value of $486.3 million reported in the Phase I study. A downward revision in the GNP fixed investment deflator has also been incorporated into this series (see preceding footnote).

Variable Name	Description, Source, and Method of Construction
2. $\Delta Q'_{-1}$	Moving Average of Changes in Raw Steel Production (millions of tons). Source: Raw Steel Production series from American Iron and Steel Institute, Annual Statistical Report, various editions. Moving average weights are from the distributed lag coefficients estimated in the Phase I study, p. 55. Construction: Seasonal adjustment of Raw Steel Production, factors = 1.0584, 1.0519, 0.9125, and 0.9843. Formation of output change variable: $\Delta OUTPUT = OUTPUT - 0.064 \, (LAGGED \; OUTPUT)$. $\Delta Q'_{-1}$ was then formed as: $$\Delta Q'_{-1} = \sum_{i=1}^{24} b_i \, \Delta OUTPUT_{t-i},$$ where the b's are the Phase I distributed lag coefficients, whose sum has been normalized to unity. Alternative series were constructed using b's from the inverted-V lag distribution.
3. $\Delta(c/w)'_{-1}$	Moving Average of Changes in the Ratio of the Net User Cost of Capital to Average Hourly Earnings of Production Workers. Source: The net user cost of capital was calculated as described in Phase I study, pp. 19-25. Average hourly earnings of production workers was taken from U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, Bulletin 1312-9 and various monthly issues. Construction: Seasonal adjustment of average hourly earnings, factors = 0.9998, 0.9944, 1.0064, 0.9995. Formation of relative price change variable: $$\Delta(c/w)_t = (c/w)_t - 0.964 \, (c/w)_{t-1}$$ $\Delta(c/w)'_{-1}$ was then formed as: $$\Delta(c/w)'_{-1} = \sum_{i=1}^{24} b_i \, \Delta(c/w)_{t-i},$$ where the b's are the Phase I distributed lag coefficients, whose sum has been normalized to unity. Alternative series were constructed using b's from the inverted-V lag distribution.
4. I_{-1}	I_t (described above), lagged once.
5. ΔRE_{-2}	Change in the Flow of Retained Earnings, lagged twice. Source: Federal Trade Commission, Quarterly Financial Report for Manufacturing Corporations, various issues. Construction: $$\Delta RE_{-2} = \pi_{t-2} - D_{t-2} - 0.946(\pi_{t-3} - D_{t-3})$$
6. ΔRE_{-3}	ΔRE_{-2} lagged once.

Variable Name	Description, Source, and Method of Construction
7. ΔGRE_{-2}	Change in the Flow of Gross Retained Earnings, lagged twice. <u>Source</u>: Federal Trade Commission, <u>Quarterly Financial Report for Manufacturing Corporations</u>, various issues. <u>Construction</u>: Let DEP_{t-i} be seasonally adjusted, deflated depreciation lagged i quarters (factors = 1.0297, 1.0713, 0.9505, and 0.9538). ΔGRE_{-2} was constructed according to:

$$\Delta GRE_{-2} = \pi_{t-2} - D_{t-2} + DEP_{t-2} - 0.964(\pi_{t-3} - D_{t-3} + DEP_{t-3})$$

8. ΔGRE_{-3}	ΔGRE_{-2} lagged once.

V.   LONG-TERM DEBT EQUATION -- CONSTANT DOLLARS

Variable Name	Description, Source, and Method of Construction
1. $DEBT_t$	Long-term Debt Due in More Than One Year. <u>Source</u>: Federal Trade Commission, <u>Quarterly Financial Report for Manufacturing Corporations</u>, various issues. <u>Construction</u>: Deflated, seasonal adjustment with geometric normalization, factors = 1.0017, 1.0032, 0.9963, and 0.9988.
2. $CAPITAL(K_t)$	Stock of Capital Equipment and Structures in the Iron and Steel Industry. <u>Source</u>: Estimated in G. R. Neumann, <u>Investment Behavior in the Iron and Steel Industry of the United States. Phase I: Forecasts for 1975-1980</u>, Institute for Research on Human Resources, December 1975, p. 21. <u>Construction</u>: See Phase I report, p. 21.
3. $DEBT_{-1}$	$DEBT_t$ (described above), lagged once.

MEANS, STANDARD DEVIATIONS, AND COEFFICIENTS OF VARIATION

Equation No. and Variable	Mean	Standard Deviation	Coefficient of Variation
I. 1. GP_t	457.49	169.83	0.3712
2. GCF_t	770.41	193.57	0.2513

Equation No. and Variable	Mean	Standard Deviation	Coefficient of Variation
3. TR_t	7453.04	1580.11	0.2449
4. CU_t	78.68	10.04	0.1276
5. Δp_t	0.56	0.95	1.7018
6. IMP_t	12.67	5.50	0.4339
7. TR_{-4}	6023.93	1207.33	0.2004
II. 1. TAX_t	188.28	80.29	0.4264
2. GP_t	457.49	169.83	0.3712
3. GCF_t	770.41	193.57	0.2513
III. 1. D_t	179.80	32.70	0.1819
2. π_{-1}	333.14	118.69	0.3563
3. NCF_{-1}	720.80	153.56	0.2130
4. D_{-1}	181.27	33.18	0.1830
IV. 1. I_t	441.59	121.53	0.2752
2. $\Delta Q´_{-1}$ (24 Almon Lags)[a]	1145.87	307.33	0.2682
$\Delta Q´_{-1}$ (24 Inverted-V Lags)[a]	1144.02	316.48	0.2766
$\Delta Q´_{-1}$ (20 Inverted-V Lags)[a]	1151.49	337.66	0.2932
3. $\Delta (c/w)´_{-1}$ (24 Almon Lags)[b]	511.71	113.94	0.2227
$\Delta (c/w)´_{-1}$ (24 Inverted-V Lags)[b]	515.53	120.00	0.2328
$\Delta (c/w)´_{-1}$ (20 Inverted-V Lags)[b]	512.75	136.82	0.2668
4. I_{-1}	443.38	120.92	0.2727
5. ΔRE_{-2}	16.37	114.28	6.9809
6. ΔRE_{-3}	0.25	159.21	644.7400
7. ΔGRE_{-2}	32.64	141.98	4.3495
8. ΔGRE_{-3}	14.93	187.89	12.5885
V. 1. $DEBT_t$	5715.13	425.13	0.2494
2. CAPITAL (K_t)	12348.60	974.77	0.0789
3. $DEBT_{-1}$	5742.36	429.58	0.2534

[a] Multiplied times 10^3 as in Table 7.12.

[b] Multiplied times 10^6 as in Table 7.12.

ZERO-ORDER CORRELATION MATRICES

I. <u>Profits Equation</u>

	GP_t	GCF_t	TR_t	CU_t	Δp_t	IMP_t	TR_{-4}
GP_t	1.0000	0.9677	0.3881	0.7312	-0.3373	-0.2417	0.0503
GCF_t	0.9677	1.0000	0.5385	0.8186	-0.2304	-0.0628	0.2218
TR_t	0.3881	0.5385	1.0000	0.6992	0.3109	0.5655	0.8454
CU_t	0.7312	0.8186	0.6992	1.0000	-0.0004	0.2258	0.4332
Δp_t	-0.3373	-0.2304	0.3109	-0.0004	1.0000	0.4631	0.3898
IMP_t	-0.2417	-0.0628	0.5655	0.2258	0.4631	1.0000	0.6845
TR_{-4}	0.0503	0.2218	0.8454	0.4332	0.3898	0.6845	1.0000

II. <u>Tax Equation</u>

	TAX_t	GP_t	GCF_t
TAX_t	1.0000	0.9556	0.8544
GP_t	0.9556	1.0000	0.9592
GCF_t	0.8544	0.9592	1.0000

III. <u>Dividends Equation</u>

	D_t	π_{-1}	NCF_{-1}	D_{-1}
D_t	1.0000	0.4261	0.3037	0.9375
π_{-1}	0.4261	1.0000	0.9391	0.2822
NCF_{-1}	0.3037	0.9391	1.0000	0.1645
D_{-1}	0.9375	0.2822	0.1645	1.0000

IV. Investment Equation*

	I_t	$\Delta Q´^{**}_{-1}$	$\Delta Q´^{***}_{-1}$	$\Delta(c/w)´_{-1}{}^{**}$	$\Delta(c/w)´_{-1}{}^{***}$	I_{-1}	ΔGRE_{-3}
I_t	1.0000	0.8012	-0.7554	-0.5916	-0.5436	0.9563	0.0001
$\Delta Q´^{**}_{-1}$	0.8012	1.0000	0.9731	-0.4633	-0.4349	0.7683	0.0471
$\Delta Q´^{***}_{-1}$	-0.7554	0.9731	1.0000	-0.4963	-0.4806	0.7132	0.0306
$\Delta(c/w)´_{-1}{}^{**}$	-0.5916	-0.4633	-0.4963	1.0000	0.9890	-0.4734	-0.0677
$\Delta(c/w)´_{-1}{}^{***}$	-0.5436	-0.4349	-0.4806	0.9890	1.0000	-0.4200	-0.0722
I_{-1}	0.9563	0.7683	0.7132	-0.4734	-0.4200	1.0000	-0.0165
ΔGRE_{-3}	0.0001	0.0471	0.0306	-0.0677	-0.0722	-0.0165	1.0000

*Only those variables in the final investment demand function (i.e., Table 7.12) are included in the correlation matrix.

**Constructed from 24-period Almon Lags.

***Constructed from 24-period Inverted-V lags.

V. Long-Term Debt Equation

	DEBT	K_t	$DEBT_{-1}$
$DEBT_t$	1.0000	0.7895	0.9888
K_t	0.7895	1.0000	0.7679
$DEBT_{-1}$	0.9888	0.7679	1.0000

ALMON LAG WEIGHTS

Quarter	24-Quarter Almon Weights	24-Quarter Inverted-V Weights
1	.00327	.00641
2	.01200	.01282
3	.02008	.01923
4	.02751	.02564
5	.03425	.03205
6	.04030	.03846
7	.04564	.04487
8	.05024	.05128
9	.05409	.05769
10	.05718	.06410
11	.05949	.07051
12	.06100	.07692
13	.06168	.07692
14	.06155	.07051
15	.06055	.06410
16	.05869	.05769
17	.05594	.05128
18	.05229	.04487
19	.04772	.03846
20	.04221	.03205
21	.03574	.02564
22	.02830	.01923
23	.01989	.01282
24	.01045	.00641

APPENDIX D

CONSTRUCTION AND DATA FOR THE RENTAL PRICE VARIABLE (c)

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An important determinant of investment demand discussed in Chapter 7 was the rental price of capital services or user cost (denoted c). This variable was constructed initially for the Phase I report for the period 1947 to 1973 (see Chapter 3, pp. 19-25). This appendix will summarize the construction and provide a listing of the component data for 1960 to 1975.

The following definition was used for the rental price variable:

$$c = q\ (\delta + r)\left[(1-k-uz)/(1-u)\right]$$

where q = GNP fixed investment deflator (1973 = 1.00),
    δ = quarterly rate of economic depreciation,
    r = corporate bond yield at quarterly rate,
    k = rate of investment credit against income tax,
    u = corporate income tax rate, and
    z = present value of allowable future depreciation deductions on a dollar's worth of gross investment.

The variable q is a seasonally adjusted composite price index of both nonresidential structures and producers' durable equipment. The corporate bond yield is an arithmetic average of forty individual industrial bond yields as reported by Moody's Investors Service. The bonds used for this calculation consist of ten of each rating classification (Aaa, Aa, A, Baa). Annual figures were converted to quarterly rates by dividing by a factor of four. The rate of economic depreciation (δ) was calculated using the relation

$$(D.1)\quad K_T = K_o\ (1-\delta)^T + \sum_{j=1}^{T} I_j (1-\delta)^{T-j}$$

where K_o = initial real net capital stock estimate,
    K_T^o = terminal real net capital stock estimate,
    T^T = total number of quarters, and
    I_j = seasonally adjusted real gross investment in quarter j.

This relation assumes a geometric mortality distribution, i.e.,

$$K_{j+1} = I_j + (1-\delta)K_j$$

where K_j is the value of real net capital stock in quarter j. Equation 1 was then solved for δ. Separate estimations for δ were conducted for the periods 1960 to 1965 and 1966 to 1973. Initial and terminal capital stock values were $11.695 billion and $11.800 billion, respectively, for the first period and $11.800 billion and $12.260 billion, respectively, for the second.[1] The quarterly depreciation rates calculated from these estimates were 0.03466 and 0.03633, respectively, or 0.132 and 0.138 on an annual basis.

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[1] See the Phase I Report, pp. 20-1, for the calculation of these values. The capital stock estimates are in constant 1973 dollars.

The values for the other parameters in the rental price variable, u and k, were taken from federal tax law. The value for u has changed relatively little since 1960, in contrast to 1950s.[2] The prevailing rate of 52 percent of net income was reduced in two stages under the Revenue Act of 1964. The rate was set at 50 percent for the calendar year of 1964 with the full reduction to 48 percent effective January 1, 1965. It has remained at that level since that date. The investment tax credit (k) has been changed somewhat more frequently, having been instituted or raised four times within the study period. It was instituted at 7 percent in the fourth quarter of 1962, suspended in the fourth quarter of 1966, but reinstated in the second quarter of 1967. In April 1969, the tax credit was repealed but was reinstated in the third quarter of 1971 by the Nixon Administration. The rate was raised from 7 to 10 percent in the second quarter of 1975 under the Tax Reduction Act of 1975 and is scheduled to stay at that level through 1976.

The present value of depreciation (z) measures the desirability of various accounting formulas of capital recovery. It differs markedly in interpretation from δ, the rate of economic depreciation. Whereas δ attempts to measure the physical loss of productive services (deterioration and obsolescence) of a capital good, z only measures depreciation for tax purposes. Thus, z and δ measure conceptually different aspects of the total rental price of capital services and are not necessarily closely related. The present value of depreciation per dollar of gross investment is a measure of how rapidly funds which have been sunk into a capital good are recovered. It is thus an important consideration to a businessman weighing the desirability of capital investment against other possible uses of the given funds (hiring additional labor, buying bonds, increasing dividends, etc.). The present value of depreciation in a given period can range in value from zero to one, and is determined by three considerations: the appropriate rate of discount, the average service life of the asset, and the particular accounting formula used for depreciation. Three depreciation formulas are allowable under federal tax law: the straight-line method, the declining balance method, and the sum-of-the-year's-digits method. The last two are called accelerated depreciation formulas since they provide for a more rapid write-off of an asset than does the straight-line method. This is a desirable property since it involves a smaller time discount and thus higher present value of future depreciation allowances. While there has been some heterogeneity among firms according to the depreciation formula used, accelerated methods have been predominant. Since the sum-of-the-year's-digits formula is often used and provides a fairly good approximation for the double declining balance formula, we have used it to generate the series for z for 1960-75. The present value formula for the sum-of-the-year's-digits method is:

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[2] Ibid, p. 25.

$$z_t = [2/r_t T] \, [1-(1-e^{-r_t T})/r_t T]$$

where T is the average lifetime of the asset and r_t is the appropriate rate of discount, in quarter t. The value for T was taken as 18 years, for 1960-70, based on the service lives given in Bulletin "F", a Treasury Department tax publication.[3] Due to a liberalization of depreciation allowances, T was lowered to 14.5 years for 1971-75. The appropriate discount rate in this case is the corporate industrial bond yield.

Presented in Table 1 are the values used in constructing the rental price variable for 1960-75. Values for c for the period 1947-59 are available upon request.

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[3]Internal Revenue Service, Bulletin F: "Tables of Useful Lives of Depreciable Property," IRS Publication No. 173 (Washington: Department of the Treasury, 1955), pp. 31-34.

TABLE D.1

COMPONENT DATA FOR RENTAL PRICE VARIABLE, 1960–1975

Quarter	q	δ^a	r^a	k	u	z	c
1960-I	0.709	0.132	0.0470	0	0.52	0.7690	0.0407
II	.710	.132	.0463	0	.52	.7715	.0406
III	.710	.132	.0452	0	.52	.7761	.0401
IV	.710	.132	.0452	0	.52	.7761	.0401
1961-I	.707	.132	.0446	0	.52	.7785	.0397
II	.712	.132	.0449	0	.52	.7773	.0401
III	.716	.132	.0460	0	.52	.7727	.0408
IV	.720	.132	.0459	0	.52	.7732	.0410
1962-I	.718	.132	.0455	0	.52	.7747	.0407
II	.718	.132	.0444	0	.52	.7792	.0403
III	.718	.132	.0449	0	.52	.7772	.0405
IV	.718	.132	.0440	.07	.52	.7811	.0373
1963-I	.719	.132	.0438	.07	.52	.7819	.0373
II	.720	.132	.0440	.07	.52	.7810	.0375
III	.723	.132	.0445	.07	.52	.7791	.0378
IV	.725	.132	.0447	.07	.52	.7780	.0380
1964-I	.725	.132	.0449	.07	.50	.7773	.0375
II	.728	.132	.0454	.07	.50	.7754	.0378
III	.731	.132	.0452	.07	.50	.7761	.0379
IV	.733	.132	.0453	.07	.50	.7755	.0380
1965-I	.737	.132	.0452	.07	.48	.7759	.0376
II	.741	.132	.0453	.07	.48	.7758	.0378
III	.743	.132	.0463	.07	.48	.7715	.0383
IV	.748	.132	.0472	.07	.48	.7679	.0389
1966-I	.750	.138	.0494	.07	.48	.7594	.0411
II	.756	.138	.0515	.07	.48	.7510	.0422
III	.763	.138	.0551	.07	.48	.7375	.0438
IV	.771	.138	.0562	0	.48	.7335	.0480
1967-I	.777	.138	.0539	0	.48	.7420	.0475
II	.781	.138	.0549	.07	.48	.7382	.0447
III	.789	.138	.0585	.07	.48	.7248	.0465
IV	.796	.138	.0624	.07	.48	.7109	.0484
1968-I	.801	.138	.0633	.07	.48	.7079	.0490
II	.807	.138	.0648	.07	.48	.7024	.0500
III	.814	.138	.0633	.07	.48	.7076	.0498
IV	.822	.138	.0651	.07	.48	.7015	.0510
1969-I	.832	.138	.0687	.07	.48	.6891	.0530
II	.843	.138	.0707	.07	.48	.6825	.0544
III	.855	.138	.0733	.07	.48	.6739	.0563
IV	.865	.138	.0717	0	.48	.6617	.0629
1970-I	.879	.138	.0808	0	.48	.6505	.0655
II	.891	.138	.0825	0	.48	.6454	.0672
III	.903	.138	.0848	0	.48	.6383	.0691
IV	.925	.138	.0822	0	.48	.6461	.0696
1971-I	.936	.138	.0739	0	.48	.7212	.0642
II	.946	.138	.0764	0	.48	.7140	.0660
III	.948	.138	.0776	.07	.48	.7104	.0626
IV	.946	.138	.0749	.07	.48	.7184	.0611
1972-I	.956	.138	.0736	.07	.48	.7220	.0615
II	.961	.138	.0740	.07	.48	.7208	.0622
III	.968	.138	.0737	.07	.48	.7218	.0623
IV	.970	.138	.0729	.07	.48	.7242	.0621
1973-I	.978	.138	.0735	.07	.48	.7224	.0630
II	.993	.138	.0744	.07	.48	.7196	.0647
III	1.008	.138	.0780	.07	.48	.7095	.0670
IV	1.021	.138	.0780	.07	.48	.7093	.0679
1974-I	1.040	.138	.0803	.07	.48	.7029	.0669
II	1.069	.138	.0854	.07	.48	.6889	.0711
III	1.107	.138	.0918	.07	.48	.6720	.0767
IV	1.170	.138	.0934	.07	.48	.6678	.0819
1975-I	1.248	.138	.0939	.07	.48	.6665	.0876
II	1.270	.138	.0949	.10	.48	.6640	.0852
III	1.277	.138	.0950	.10	.48	.6637	.0858
IV	1.304	.138	.0947	.10	.48	.6645	.0874

[a] The rate of depreciation and the corporate bond yield are presented here in the customary annual terms but were converted to quarterly form for the construction of c.

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