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# 14 Inflation, Tax Rules, and Investment: Some Econometric Evidence

My subject here is one to which Irving Fisher devoted considerable analytic and econometric effort: the effect of inflation on financial markets and capital formation.[1] Nowadays, every student learns of Fisher's conclusion that each percentage point increase in the steady-state inflation rate eventually raises the nominal interest rate by 1 percent, leaving the real rate of interest unchanged. Moreover, since the supply of saving depends on the *real* rate of interest and the demand for investable funds also depends on the *real* rate of interest, a change in the rate of inflation would have essentially no effect on the economy's real equilibrium. I say "essentially" no effect because another great Yale economist, James Tobin, reminded us in his 1964 Fisher Lecture that an increase in the nominal interest rate could cause households to substitute capital for money in their portfolios, thereby reducing the real interest rate.

The Fisher-Tobin analysis, like most theoretical analyses of macroeconomic equilibrium, ignores the role of the taxes levied on capital income. While this may have been a reasonable simplification at some time in the past, it is quite inappropriate today. Taxes on capital income with marginal rates that are often between one-third and two-thirds can have

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1. See, for example, Fisher (1896, 1930).

profound effects on the real macroeconomic equilibrium and on the way in which inflation affects that real equilibrium.

A simple example will illustrate the potential for substantial departures from Irving Fisher's famous neutrality result. Consider an economy in which saving and the demand for money are both perfectly interest inelastic, in which there is no inflation, and in which the marginal product of capital is 10 percent. If we ignore risk and assume that all marginal investments are debt financed,[2] the rate of interest in the economy will also be 10 percent. A permanent increase in the expected rate of inflation from zero to 5 percent would raise the nominal internal rate of return on all investments by 5 percent, which would, in turn, raise the equilibrium rate of interest in the economy from 10 percent to 15 percent. All of this is just as Irving Fisher would have it.

But now consider the introduction of a corporate tax of $100\tau$ percent on the profits of the business with a deduction allowed for the interest payments. It is easily shown that, if economic depreciation is allowed, the interest rate that firms can afford to pay remains 10 percent in the absence of inflation. But inflation now raises the interest rate not by any increase in the inflation rate but by that increase in inflation divided by $(1 - \tau)$.[3] If $\tau$ is 50 percent, the 5 percent increase in expected inflation raises the interest rate by 10 percent to 20 percent. This is easily understood since the 10 percent increase only costs a firm a net-of-tax 5 percent, just the amount by which inflation has raised the nominal return on capital.

In this example, the effect of a 5 percent inflation rate is to raise the *real* rate of interest received by savers from 10 percent to 15 percent. Their real *net-of-tax* rate of interest will, however, depend on the extent to which the interest income is subject to personal tax. If every lender's tax rate is exactly equal to the corporate rate, the real net rate of interest will be unaffected by the rate of inflation.[4] But more generally, individual tax rates differ substantially[5] and the real net-of-tax return rises for those individuals with tax rates below the corporate rate and falls for the others. If saving is sensitive to the real net return, these changes will alter the capital intensity of the economy which in turn will change the marginal product of capital. The effect on the final equilibrium of a change in the

2. Intramarginal investments may be financed by the equity resulting from the extrepreneurs' original investment and from subsequent retained earnings. See Stiglitz (1973) for such a model.

3. Feldstein (1976; chap. 3 above) examines this simple case as well as the more general situation in which both saving and money demand are sensitive to the rate of return. If $f'$ is the marginal product of capital and $\pi$ is the rate of inflation, the nominal interest rate satisfies $i = f' + \pi/(1 - \tau)$.

4. If lenders are taxed at $100\,\theta$ percent, the net-of-tax nominal interest rate rises by $(1 - \theta)/(1 - \tau)$ times the increase in the rate of inflation. With $\theta = \tau$, this is one and the real net interest rate therefore remains unchanged.

5. Individual tax rates include not only the statutory personal tax rates but the tax rates on savings channelled through pension funds, insurance, and other financial intermediaries.

expected rate of inflation will depend on the capital-labor substitutability, on the distribution of individual and business tax rates, and on the interest sensitivity of saving and money demand (as well as on the correlation between these sensitivities and the personal tax rates). In general terms, inflation will raise capital intensity in this model if the rate at which savers are taxed is less than the tax rate on borrowers.

Introducing a more realistic description of depreciation radically alters this conclusion. In calculating taxable profits, firms are generally allowed to deduct the cost of capital investments only over several years. Because these deductions are usually based on the original or "historic" cost of the assets, the real value of these depreciation deductions can be substantially reduced during a period of inflation. This raises the real tax rate on investment income and therefore lowers the real interest rate that firms can afford to offer. The change in the nominal interest rate may be greater or less than the change in inflation and depends on the balance between the positive effect of interest rate deductibility and the adverse effect of original cost depreciation. This conclusion can be extended directly to an economy with equity as well as debt finance (Feldstein, Green, and Sheshinski, 1978; chap. 4 above) and to an economy with government debt (Feldstein, 1980; chap. 5 above).

In short, the impact of inflation and of monetary policy depends critically on the fiscal setting. It is therefore unfortunate, but all too common, that theoretical analyses of inflation and of monetary policy ignore the tax structure and assume that all taxes are lump sum levies.

Because capital tax rules differ substantially among countries, inflation can have very different effects in different countries on the rate and composition of capital accumulation. In the past several years, I have tried to explore the theoretical relationship between inflation and tax rules and to measure the impact of inflation in the United States on effective tax rates (Feldstein and Summers, 1979; chap. 8 above) and on the yields on real capital, on debt, and on equity.[6] Those studies, together with the results presented in the current paper, have led me to conclude that the interaction of inflation and the existing tax rules has contributed substantially to the decline of business investment in the United States.

The rate of business's fixed investment in the United States has fallen quite sharply since the mid-1960s. The share of national income devoted to net nonresidential fixed investment fell by more than one-third between the last half of the 1960s and the decade of the 1970s: the ratio of net fixed nonresidential investment to GNP averaged 0.040 from 1965

6. See Feldstein and Poterba (1980*b*) with respect to yields on real capital; Feldstein and Summers (1978; chap. 9 above), Feldstein and Eckstein (1970), and Feldstein and Chamberlain (1973) with respect to yields on debt; and Feldstein (1980*b*, *d*; chaps. 10 and 11 above) with respect to equity yields.

through 1969 but only 0.025 from 1970 through 1979.[7] The corresponding rate of growth of the nonresidential capital stock declined by an even greater percentage: between 1965 and 1969, the annual rate of growth of the fixed nonresidential capital stock averaged 5.5 percent; in the 1970s, this average dropped to 3.2 percent.[8]

The present paper shows how U.S. tax rules and a high rate of inflation interact to discourage investment. The nature of this interaction is complex and operates through several different channels. For example, while nominal interest rates have been unusually high in recent years, the deductibility of nominal interest costs in the calculation of taxable profits implies that the real net-of-tax interest rates that firms pay have actually become negative! In itself, this would, of course, encourage, an increased rate of investment. But, since existing tax rules limit the depreciation deduction to amounts based on the original cost of the assets, a higher rate of inflation reduces the maximum real rate of return that firms can afford to pay. The effect of inflation on the incentive to invest depends on balancing the change in the cost of funds (including equity as well as debt) against the change in the maximum potential return that firms can afford to pay. This explanation of investment behavior, which is close to Irving Fisher's own approach, is developed more precisely in section 14.4 and then related to the observed variation of investment since 1955.

The interaction of tax rules and inflation can also be seen in a simpler and more direct way. The combined effects of original cost depreciation, the taxation of nominal capital gains, and other tax rules raises the effective tax rate paid on the capital income of the corporate sector by the corporations, their owners, and their creditors. This reduces the real net rate of return that the ultimate suppliers of capital can obtain on nonresidential fixed investment. This in turn reduces the incentive to save and distorts the flow of saving away from fixed nonresidential investment. Even without specifying the mechanism by which the financial markets and managerial decisions achieve this reallocation, the variations in investment during the past three decades can be related to changes in this real net rate of return. This approach is pursued in section 14.3.

In addition to these two approaches, I have also examined the implications of inflation in a capital stock adjustment model of the type developed by Jorgenson and his collaborators.[9] Those results are presented in section 14.5.

7. Data on net fixed nonresidential investment is presented in table 5.3 of the National Income and Product Accounts. The full time series is presented in table 14.1 below. All data and estimates in this paper are from the National Income and Product Accounts before the December 1980 revision.

8. See table 14.1 below for the annual values. Data on the net stock of fixed nonresidential capital is presented in the *Survey of Current Business*, April 1976 and subsequent issues.

9. See Jorgenson (1963), Hall and Jorgenson (1967), Gordon and Jorgenson (1976), and Hall (1977) among others.

## 14.1 On Estimating False Models

My focus in this paper is on assessing the extent to which investment responds to changes in the incentives that are conditioned by tax rules. Separate calculations based on previous research are then used to evaluate the effect on investment of the interaction between inflation and the tax rules.

Despite the extensive amount of research that has been done on investment behavior, there are still many economists who question whether investment does respond significantly to what might generally be called "price incentives" and not just to business cycle conditions.[10] One important reason for these doubts is the failure of previous studies to reflect correctly the impact of inflation. When the price incentive variable is significantly mismeasured, it is not surprising that its impact on investment is understated. A further reason, and, I believe, a more fundamental one, is that the investment process is far too complex for any single econometric model to be convincing. Moreover, making a statistical model more complicated in an attempt to represent some particular key features of "reality" or of rational optimization often requires imposing other explicit and implausible assumptions as maintained hypotheses.

The problem posed for the applied econometrician by the complexity of reality and the incompleteness of available theory is certainly not limited to studies of investment. In my experience, there are relatively few problems in which the standard textbook procedure of specifying "the correct model" and then estimating the unknown parameters can produce convincing estimates. Much more common is the situation in which the specifications suggested by a rich economic theory overexhaust the information in the data. In time series analysis, this exhaustion occurs rapidly because of the limited degrees of freedom. But even with very large cross-section samples, collinearity problems reduce the effective degrees of freedom and make it impossible to consider all of the variables or functional forms that a rich theory would suggest. These problems are exacerbated by the inadequate character of the data themselves. Even when information is available and measurement errors are small, the accounting measures used by business firms and national income accounts rarely correspond to the concepts of economic theory.

The result of all this is that in practice all econometric specifications are necessarily "false" models. They are false models not only in the innocuous sense that the residuals reflect omitted variables but also in the more serious sense that the omissions and other misspecifications make it impossible to obtain unbiased or consistent estimates of the parameters

10. See, e.g., the article by Clark (1979) and the book by Eisner (1979) for recent examples of studies that conclude that price incentive effects are economically insignificant or, at most, are quite small.

even by sophisticated transformations of the data. The applied econometrician, like the theorist, soon discovers from experience that a useful model is not one that is "true" or "realistic" but one that is parsimonious, plausible, and informative.

Unfortunately, econometric research is not often described in such humble terms. The resulting clash between the conventional textbook interpretation of econometric estimates and the obvious limitations of false models has led to an increasing skepticism in the profession about the usefulness of econometric evidence. While some of this skepticism may be a justifiable antidote to naive optimism and exaggerated claims, I believe it is based on a misunderstanding of the potential contribution of empirical research in economics.

I am convinced that econometric analysis helps us to learn about the economy and that better econometric methods help us to make more reliable inferences from the evidence. But I would reject the traditional view of statistical inference that regards the estimation of an econometric equation as analogous to the "critical experiment" of the natural sciences that can, with a single experiment, provide a definitive answer to a central scientific question. I would similarly reject an oversimplified Bayesian view of inference that presumes that the economist can specify an explicit prior distribution over the set of all possible true models or that the likelihood function is so informative that it permits transforming a very diffuse prior over all possible models into a very concentrated posterior distribution.

Although I am very sympathetic to the general Bayesian logic, I think that such well specified priors and such informative likelihood functions are incompatible with the "false models" and inadequate data with which we are forced to work. I think that the learning process is more complex. Perhaps the phrase "expert inference" best captures what I have in mind. The expert sees not one study but many. He examines not only the regression coefficients but also the data themselves. He understands the limits of the data and the nature of the institutions. He forms his judgments about the importance of omitted variables and about the plausibility of restrictions on the basis of all this knowledge and of his understanding of the theory of economics and statistics. In a general way, he behaves like the Bayesian who combines prior information and sample evidence to form a posterior distribution, but, because of the limitations and diversity of the data and the models that have been estimated, he cannot follow the formal rules of Bayesian inference.[11]

As a practical matter, we often need different studies to learn about different aspects of any problem. The idea of estimating a single complete

11. Leamer (1978) presents very insightful comments about the problems of inference and specification search as well as some specific techniques that can be rigorously justified in certain simple contexts.

model that tells about all the parameters of interest and tests all implicit restrictions is generally not feasible with the available data. Instead, judgments must be formed by studying the results of several studies, each of which focuses on part of the problem and makes false assumptions about other parts.

The basic reference on this type of "expert inference" isn't Jeffreys, Zellner, or Leamer. It is the children's fable about the five blind men who examined an elephant. The important lesson in that story is not the fact that each blind man came away with a partial and "incorrect" piece of evidence. The lesson is rather that an intelligent maharajah who studied the findings of these five men could probably piece together a good judgmental picture of an elephant, especially if he had previously seen some other four-footed animal.

The danger, of course, in this procedure is that any study based on a false model may yield biased estimates of the effects of interest. Although informed judgement may help the researcher to distinguish innocuous maintained hypotheses from harmful ones, some doubt will always remain. *In general, howerer, the biases in different studies will not be the same.* If the biases are substantial, different studies will point to significantly different conclusions. In contrast, a finding that the results of several quite different studies all point to the same conclusion suggests that the specification errors in each of the studies are relatively innocuous.

When the data cannot be used to distinguish among alternative plausible models, the overall economic process is underidentified. This may matter for some purposes but not for others. Even if the process as a whole is underidentified, the implications with respect to some particular variable (i.e., the conditional predictions of the effect of changing some variable) may be the same for all models and therefore unaffected by the underidentification. This "partial identification" is achieved, because the data contain a clear message that is not sensitive to model specification.

Of course, not all issues can be resolved in this satisfying way. For many problems, different plausible specifications lead to quite different conclusions. When this happens, the aspect that is of interest (i.e., the predicted effect of changing a particular variable) is effectively underidentified. No matter how precisely the coefficients of any particular specification may appear to be estimated, the relevant likelihood function is very flat. In these cases, estimating alternative models to study the same question can be a useful reminder of the limits of our knowledge.[12]

12. For a simplified formal analogy, consider the problem of estimating the elasticity of demand for some product with respect to permanent income. Since permanent income is not observed, some proxy must be used. Each potential proxy is, however, likely to introduce a bias of its own. If the estimated elasticity is similar for several quite different proxies, there is a reasonable presumption that each bias is relatively small.

## 14.2 Using Alternative Models of Investment Behavior

The potential advantage of using several alterative parsimonious models is well illustrated by the analysis of investment behavior. There is a wide variety of empirical issues that are of substantial importance both for understanding the economy and for assessing the importance of different government policies. How sensitive is investment to tax incentives? To interest rates? To share prices? To the expectation of future changes in tax rules or market conditions? And what is the time pattern of the response to these stimuli? While an estimate of "the correct model" of investment behavior could in principle answer all of these questions at once, it is in practice necessary to pursue different questions with different studies. The purpose of the present study, as I indicated in the introduction, is to assess the extent to which changes in tax incentives and disincentives—and particularly those changes that are due to inflation—alter the flow of investment. Focusing on this issue means that some assumptions must explicity or implicitly be made about the other issues and that the estimated effect of the tax changes is conditional on those assumptions. I find it quite reassuring therefore that estimates based on three quite different kinds of models all point to the same conclusion about the likely magnitude of the response to inflation and to effective tax rates.

The current state of investment theory also indicates the need to examine alternative models. While there is probably considerable agreement about the essential features of a very simple theoretical model of investment behavior, there is much less consensus about the appropriate framework for applied studies of investment behavior. The disagreements about empirical specification can conveniently be grouped in four areas.[13]

### 14.2.1 Technology

The traditional capital stock adjustment models assume that capital is homogeneous and that the purpose of investment is to increase the size of this homogeneous stock until, roughly speaking, the return on the last unit of capital is reduced to the cost of funds. An alternative and more realistic view sees capital as quite heterogeneous. There are two aspects of such heterogeneity. First, capital consists of a large number of different kinds of equipment and structures. At any point in time there may be too much of one kind of capital and too little of another. A simple aggregate relationship loses this potentially important information. A much more fundamental kind of heterogeneity is associated with the *flow* of new investment opportunities. Each year, new investment possibilities

13. No attempt is made here to survey the existing empirical research on investment or to examine all of the arguments about specification. For recent surveys, see Nickell (1978) and Rowley and Trivedi (1975).

are created by innovations in technology, taste, and market conditions. This exogenous flow of new investment opportunities with high rates of return can induce investment even when the total stock of capital is too large in the sense that the marginal product of an equiproportional increase in all types of capital is less than the cost of funds or the value of Tobin's $q$-ratio is less than one.[14]

Even within the framework of homogeneous capital models, there has been much debate about the choice between putty-putty models in which all investment decisions are reversible and the putty-clay models in which invested capital has a permanently fixed capital-labor ratio.[15] While the truth no doubt lies somewhere between these extremes (old equipment and processes can be modified but not costlessly "melted down" and reformed), the more complex putty-clay model is undoubtedly a more realistic microeconomic description than the putty-putty model.

Closely related is the issue of replacement investment, a quite significant issue since roughly one-half of gross investment is absorbed in replacement. The simplest model of replacement is that a constant fraction of the homogeneous capital stock wears out each period. A more realistic description would recognize that output decay is not exponential but varies with the age of the equipment. More generally, the timing of replacement and the level of maintenance expenditure are economic decisions that will respond to actual and anticipated changes in the cost of capital and other inputs.[16]

### 14.2.2 Market Environment

The conventional Keynesian picture of investment that motivates the accelerator model of investment and most other capital stock adjustment models assumes that each firm's sales are exogenous. The firm is assumed to take the price of its product and the level of its sales as given, and then to select the capacity to produce this level of output. A more general specification would recognize that the firm sets its own level of output, taking as given either the market price of its product or the demand function for its product.

There are analogous issues about the nature of the markets in which the firms buy inputs. The simplest assumption is that these markets are perfect and that the market prices do not depend on the quantities purchased. A more realistic description would recognize that the short-run supply function of labor to the individual firm is likely to be less than infinitely elastic and that, for the economy as a whole, the short-run

14. This is quite separate from the reason for investing when $q$ is less than one that is implied by the analysis of Auerbach (1979*a*), Bradford (1979), and King (1977).

15. See Nickell (1978) for an extensive discussion of putty-clay specifications.

16. See Feldstein and Rothschild (1974) for a critique of the constant proportional replacement hypothesis and an analysis of the potential effects on replacement investment of changes in tax rates and interest rates.

supply price of capital as well as labor is an increasing function of the quantity purchased.[17]

Closely related is the sensitivity of adjustment costs to the volume of investment. The simplest assumption is that there are no adjustment costs and that the total cost of any total investment is independent of the speed at which it is done. In contrast, the managerial and planning costs may be a significant part of the cost of capital acquisition and may rise exponentially with the rates of net and gross investment. Abel (1978) has shown how a capital stock adjustment model can be extended to include adjustment costs and how doing so can explain why the firm increases its rate of investment only slowly even when the marginal return on installed capital substantially exceeds its cost.

### 14.2.3 Financial Behavior

There remains much controversy about the role of internal and external finance and about the related issue of the factors determining the cost of funds to the firm. The simplest model assumes that the costs of debt and equity funds are independent of both the debt-equity ratio and the volume of the firm's external finance. More general analyses reject the extreme Modigliani-Miller result and recognize that, beyond a certain point, increases in the debt-equity ratio raise the cost of funds. Similarly, it is frequently argued that the availablility of retained earnings lowers the cost of funds (at least in the eyes of management) and therefore affects the timing even if not the equilibrium level of investment.[18]

Tax rules significantly affect the costs to the firm of debt and equity finance. The implications of this obvious statement have been the subject of much research and debate in the past few years.[19] At one extreme is the conclusion of Stiglitz (1973) that U.S. firms should finance marginal investments exclusively by debt, retaining earnings to avoid the dividend tax and using the retained earnings to finance intramarginal investments. Auerbach (1979*a*), Bradford (1979), and King (1977) have argued that retaining earnings does not avoid the dividend tax but only postpones it without lowering its present value; this implies that retained earnings are substantially less costly than new equity funds and that the capital stock should be expanded even if the market valuation of additional capital is less than one-for-one.[20] These types of conclusions reflect a world of

17. Keynes (1936) emphasized that rising cost of inputs is a principal reason for the declining marginal efficiency of investment in the short run. See Brechling (1975) on the empirical importance of this.

18. See, e.g., Coen (1968) and Feldstein and Flemming (1971) for evidence on this point.

19. See, among others, Auerbach (1979*a*), Bradford (1979), Feldstein, Green, and Sheshinski (1979), King (1977), Miller (1977), and Stiglitz (1973).

20. For an application of this to the empirical study of investment behavior, see Summers (1980*a*).

certainty and one in which all individual investors have the same personal income tax rates. Although complete models with uncertainty and diverse individual tax rates have not yet been fully worked out, it is clear from partial studies (e.g., Feldstein and Green, 1979, and Feldstein and Slemrod, 1980) that these extensions can significantly alter conventional results.

### 14.2.4 Expectations and the Decision Process

With a putty-putty technology and reversible investment, expectations are irrelevant. But when an investment commits the firm to a future capital stock with a fixed capital-labor ratio, expectations about the future are crucial. Although simple moving averages of past variables are the most common representation of the process by which expectations are formed, this simplification may cause serious misspecification errors in some contexts. Helliwell and Glorieux (1970) and Abel (1978) have developed forward-looking models of expectations. Lucas (1976) has emphasized the potential instability of all such fixed-coefficient average representations while Sargent (1978) and Summers (1980*d*) have shown both the possibility and the difficulty of developing even quite simple models of factor demand that are consistent with rational expectations.

Even when investment models acknowledge that expectations are uncertain, the assumption of risk neutrality is usually invoked to simplify the analysis. In fact, investment behavior may be substantially influenced by risk aversion, changes in risk perception, and the pursuit of strategies that reduce the risk of major capital commitments.

In each of the cases that I have been describing, the researcher must choose (implicitly or explicitly) between a more tractable but usually less realistic assumption and an assumption that is more realistic but also more difficult to apply satistically. In general, the choice has gone in favor of the more tractable but less realistic specification. Moreover, implementing any one of the more complex assumptions often makes it too difficult to implement some other more realistic assumption, thus inevitably forcing the researcher to choose among false models.

The work of Jorgenson and his collaborators[21] well illustrates this problem of choice. In each case, Jorgenson and his colleagues have selected the more tractable but less realistic assumption. Because they impose the further restriction that the technology of each firm is Cobb-Douglas, the data are required only to determine the time pattern of the response of investment to prior changes in the desired capital stock.[22]

21. See the references cited in note 9 above.

22. The Jorgenson procedure also estimates a further parameter that should equal the capital coefficient in the Cobb-Douglas production function, i.e., the share of capital income in total output. Estimates of this parameter are also invariably far too low; although this indicates that the model is "false," it does not necessarily imply that the estimated effects of tax rules and inflation are misleading.

There is no separate estimation of the effect of tax rules and no specific tests of the implied effect on investment of changes in tax rules and inflation. In section 14.5, I adopt the general Jorgenson specification but relax the constraint that the technology is Cobb-Douglas and also the constraint that the response of firms to the tax-induced changes in the user cost of capital is the same as their response to other sources of variation in the user cost of capital. The results indicate that a correct measurement of the impact of inflation in the context of this model substantially increases its explanatory power and that with the correctly measured variables the data are consistent with an elasticity of substitution of one and with the assumption that firms respond in the same way to all changes in the user cost of capital.

Of course, the support for this conclusion is conditioned on all of the other false maintained assumptions. I have, however, also examined two other quite different models that do not impose these constraints. The analysis of section 14.3, which relates investment to the real net-of-tax rate of return received by the suppliers of capital, avoids any reference to financial market variables. While it is therefore obviously completely uninformative about many potentially interesting issues, it avoids conditioning the estimated responsiveness of investment on any theory of corporate finance. The specification in terms of the flow of investment avoids the assumption of homogenous capital or a putty-putty technology. Again, this makes the model uninformative about important issues but avoids constraining the results by some obviously strong assumptions of a false model. There are, of course, potential biases in this approach since it fails to distinguish different reasons for changes in investment and omits variables that may be significant (e.g., changes in government debt, international capital flow, or other factors that would in principle be reflected in financial variables).

The third approach, presented in section 14.4, avoids some of these problems but, of course, at the cost of introducing new ones. This specification relates the flow of investment to the difference between the cost of funds to the firm and the maximum potential rate of return that the firm can afford to pay on a standard investment project. The financial cost of funds is thus explicitly included. This, however, requires specifying the "true" cost of debt and equity funds and their relative importance. The specification does, however, avoid restrictive assumptions about technology and other aspects of investment behavior. But, like the other two specifications, this return-over-cost specification is a false model whose coefficients might well be biased.

The strength of the empirical evidence therefore rests on the fact that all three quite different specifications support the same conclusion that the heavier tax burden associated with inflation has substantially depressed nonresidential investment in the United States. The magnitude of the effect implied by each of these three models indicates that the adverse changes in the tax variables since 1965 have depressed investment by more than 1 percent of GNP, a reduction which exceeds 40 percent of the rate of investment in recent years.

## 14.3 Investment and the Real Net Rate of Return

Individuals divide their income between saving and consuming and, to the extent that they save, those resources are distributed among housing, inventories, plant and equipment, and investments abroad. Individuals make these decisions not only directly, but also through financial intermediaries, and through the corporations of which they are direct and indirect shareholders.

The most fundamental determinant of the extent to which individuals channel resources into nonresidential fixed investment should be the real net-of-tax rate of return on that investment, a variable that I will denote RN.[23] Although the idea of the real net-of-tax return is conceptually simple, its calculation involves a number of practical as well as theoretical difficulties. Because of data limitations, the calculation is restricted to nonfinancial corporations even though total nonresidential fixed investment refers to a somewhat broader set of firms. The real net return is defined as the product of the real pretax return on capital (R) and one minus the effective tax rate (1-ETR) on that return.

The pretax return is estimated as the ratio of profits plus interest expenses to the value of the capital stock. Profits are based on economic depreciation and a currect measure of inventory costs; capital gains and losses on the corporate debt are irrelevant since the calcuation deals with the combined return to debt and equity. The value of the capital stock includes the replacement cost value of fixed capital and inventories and the market value of land. The pretax rate of return is shown in column 3 of table 14.1.[24]

The effective tax rate on this capital income includes the taxes paid by the corporations, their shareholders, and their creditors to the federal government and to the state and local governments. The shareholders and creditors consist not only of individuals but also of various financial intermediaries including banks, pension funds, and insurance companies.

23. The rate of return on other types of investments might also matter. Since the interaction of inflation and tax rules raised the potential return on owner-occupied housing (Feldstein, 1980*a*; Poterba, 1980), the effect of *RN* may be overestimated but this overstatement only reflects another way in which inflational and tax rules interact to reduce nonresidential fixed investment.

24. Feldstein and Summers (1977) discuss the conceptual problems in measuring the capital income and rate of return. Feldstein and Poterba (1980*a*) use the new capital stock data provided by the Commerce Department and Federal Reserve Bank to calculate the pretax rate of return shown in table 14.1.

**Table 14.1 Investment and the Real Net Return to Capital**

| Year | Investment GNP Ratio ($I^n/Y$) (1) | Investment Capital Ratio ($I^n/K^n$) (2) | Pretax Return ($R$) (3) | Effective Tax Rate ($ETR$) (4) | Net Return ($RN$) (5) | Cyclically Adjusted Return: Pretax ($RA$) (6) | Cyclically Adjusted Return: Effective Tax Rate ($ETRA$) (7) | Cyclically Adjusted Return: Net Return ($RNA$) (8) |
|---|---|---|---|---|---|---|---|---|
| 1953 | 0.027 | 0.040 | 0.114 | 0.745 | 0.029 | 0.105 | NA | NA |
| 1954 | 0.023 | 0.033 | 0.107 | 0.687 | 0.034 | 0.117 | 0.754 | 0.029 |
| 1955 | 0.028 | 0.041 | 0.132 | 0.665 | 0.044 | 0.130 | 0.712 | 0.037 |
| 1956 | 0.031 | 0.044 | 0.114 | 0.724 | 0.032 | 0.117 | 0.714 | 0.034 |
| 1957 | 0.029 | 0.040 | 0.105 | 0.717 | 0.030 | 0.114 | 0.715 | 0.032 |
| 1958 | 0.017 | 0.023 | 0.090 | 0.707 | 0.026 | 0.113 | 0.713 | 0.032 |
| 1959 | 0.020 | 0.028 | 0.112 | 0.673 | 0.036 | 0.125 | 0.694 | 0.038 |
| 1960 | 0.022 | 0.030 | 0.104 | 0.665 | 0.035 | 0.122 | 0.714 | 0.035 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1961 | 0.019 | 0.027 | 0.103 | 0.664 | 0.035 | 0.124 | 0.689 | 0.038 |
| 1962 | 0.023 | 0.033 | 0.117 | 0.615 | 0.045 | 0.130 | 0.643 | 0.046 |
| 1963 | 0.023 | 0.033 | 0.124 | 0.606 | 0.049 | 0.136 | 0.629 | 0.050 |
| 1964 | 0.029 | 0.041 | 0.134 | 0.562 | 0.059 | 0.141 | 0.591 | 0.057 |
| 1965 | 0.040 | 0.057 | 0.145 | 0.551 | 0.065 | 0.145 | 0.573 | 0.062 |
| 1966 | 0.045 | 0.064 | 0.145 | 0.560 | 0.064 | 0.137 | 0.595 | 0.055 |
| 1967 | 0.038 | 0.052 | 0.130 | 0.564 | 0.057 | 0.126 | 0.603 | 0.050 |
| 1968 | 0.037 | 0.051 | 0.130 | 0.626 | 0.049 | 0.123 | 0.663 | 0.041 |
| 1969 | 0.038 | 0.051 | 0.117 | 0.673 | 0.038 | 0.113 | 0.762 | 0.027 |
| 1970 | 0.031 | 0.040 | 0.096 | 0.705 | 0.028 | 0.106 | 0.792 | 0.022 |
| 1971 | 0.025 | 0.032 | 0.100 | 0.677 | 0.032 | 0.112 | 0.782 | 0.025 |
| 1972 | 0.028 | 0.037 | 0.108 | 0.625 | 0.041 | 0.113 | 0.720 | 0.032 |
| 1973 | 0.034 | 0.046 | 0.105 | 0.701 | 0.031 | 0.102 | 0.795 | 0.021 |
| 1974 | 0.031 | 0.040 | 0.082 | 0.901 | 0.008 | 0.096 | 1.079 | −0.008 |
| 1975 | 0.014 | 0.017 | 0.086 | 0.724 | 0.024 | 0.115 | 0.852 | 0.017 |
| 1976 | 0.015 | 0.019 | 0.095 | 0.681 | 0.030 | 0.114 | 0.850 | 0.017 |
| 1977 | 0.020 | 0.026 | 0.097 | 0.683 | 0.031 | 0.109 | NA | NA |
| 1978 | 0.025 | 0.033 | 0.097 | 0.722 | 0.027 | 0.104 | NA | NA |

In an earlier study, Lawrence Summers and I did a detailed analysis of the distribution of corporate equity and debt among the different classes of shareholders and creditors and of the relevant marginal federal tax rates for each such investor (Feldstein and Summers, 1979; chap. 8 above). More recently, James Poterba and I refined this analysis and extended it to include the taxes paid to state and local governments. The effective rate of tax is shown in column 4 of table 14.1. The resulting net-of-tax rate of return is shown in the fifth column.

The pretax rate of return varies cyclically as well as from year to year but has experienced no overall trend.[25] The average return from 1953 through 1979 was 11.0 percent. The effective tax rate was quite high in the 1950s and then declined sharply in the 1960s; at the individual level this reflected a significant reduction in personal tax rates while at the corporate level this reflected changes in depreciation rules and the statutory corporate tax rate. Since the mid-1960s, the effective tax rate has moved sharply and somewhat erratically upward, primarily reflecting the overstatement of capital income that occurs when inflation distorts the measurement of depreciation, inventory profits, interest payments, and capital gains.[26] The growth of state and local taxes and various changes in personal tax rates contributed somewhat to this overall increase. The real net rate of return shows a general pattern that reflects the changing effective tax rate as well as the cyclical and year-to-year fluctuations in the pretax rate of return. This key rate of return varied around 3.3 percent in the 1950s, rose by the mid-1960s to 6.5 percent, averaged 5.0 percent for the 1960s as a whole, and then dropped in the 1970s to an average of only 2.8 percent.

Since the net rate of return varies cyclically, its estimated impact on investment can reflect cyclical as well as more fundamental influences. To separate these effects, the equations in this section relate the investment rate to a lagged cyclical measure of aggregate demand as well as to the real net return. It is also useful to consider two more explicit ways of focusing on the more fundamental changes in the real rate of return. A cyclically adjusted measure of the real net return was calculated as follows. First, the real pretax rate of return (R) is adjusted by regressing it on the difference between GNP and capacity GNP and then calculating the rate of return for each year at a standard GNP gap of 1.7 percent; this variable, denoted RA (for adjusted) and shown in column 6 of table 14.1, eliminates cyclical but not year-to-year variations in the pretax return. Since there is no trend in the pretax return, eliminating random as well as cyclical variations in the pretax return would leave only a constant.

25. Feldstein and Summers (1977) showed that the apparent downward trend in the first half of the 1970s was not statistically significant. For more recent supporting evidence, see Feldstein and Poterba (1980*b*).

26. This impact of inflation is discussed in Feldstein, Green, and Sheshinski (1978; chap. 4 above) and calculated in detail in Feldstein and Summers (1979; chap. 8 above).

The cyclical and random fluctuations in the effective tax rate were eliminated in a more fundamental way by using the explicit statutory provisions. Using a method developed in an earlier study (Feldstein and Summers, 1978; chap. 9 above) and described in section 14.4, I calculated the real net rate of return that a firm could afford to pay on the debt and equity used to finance a new investment that, in the absence of all taxes, would have a real yield of 12 percent. This net rate of return varies from year to year because of changes in the tax rules and in the anticipated rate of inflation. The ratio of the net rate of return on a mix of debt and equity to the assumed 12 percent real pretax return measures the changes in the effective tax rate that are not due to fluctuations in the pretax rate of return, the rate of current investment, or other year-to-year fluctuations. More formally, this ratio equals 1-ETRA and the ETRA value is shown in column 7 of table 14.1.[27]

Combining the adjusted pretax return and the adjusted effective tax rate gives the adjusted net return (*RNA* = *RA* (1-ERTA)) shown in column 8 of table 14.1.

Although this variable is purged of cyclical variation, it still reflects year-to-year variation in the pretax return. Eliminating all such variation and treating the pretax return as a constant implies that all of the variation in the net return comes from the effective tax rate variable. This possibility is tested below in the context of a more general specification in which both *RNA* and 1-*ETRA* are included separately.

The basic specification relates the ratio of real net investment to real GNP ($I^n/Y$) to the real net rate of return (*RN*) and the Federal Reserve Board's measure of capacity utilization (*UCAP*).[28] I use annual data and lag both regressors one year:[29]

$$(1) \qquad \frac{I_t^n}{Y_t} a_0 + a_1\, RN_{t-1} + a_2\, UCAP_{t-1} + u_t$$

where $u_t$ is a random disturbance about which more will be said below.

Although quarterly data could have been constructed, much of the basic information that is used to calculate the net return variable is available only annually; the within-year variations in a quarterly series

27. This measure of the effective tax rate differs conceptually from the unadjusted measure in a number of ways. It is an *ex ante* concept for new investment rather than an *ex post* measure on existing capital. No account is taken of the important effect of inflation on the taxation of artificial inventory profits or of the changing rates of state and local taxes. The tax rates on shareholders and creditors are also measured much more crudely.

28. This specification in terms of investment flows represents a disequilibrium process rather than an equal stock adjustment. The special problems of capital heterogeneity and putty-clay technology may make this direct disequilibrium specification more appropriate, especially for explaining and predicting changes in investment over a period of ten to twenty years.

29. Note that since the equation refers to net investment, the past capital stock is not included. I return to this issue below.

would therefore be largely interpolations of doubtful economic meaning.[30]

A lag in response has been found in all previous investment studies and reflects the delays in decision making and in the production and delivery of plant and equipment. The lag also avoids the obvious problem of simultaneity between concurrent investment and capacity utilization or other measures of business cycle activity. More general lag structures and other possible explanatory variables have been considered; those results are also described below.

All of the specifications are estimated by least squares with a first-order autocorrelation correction. The autocorrelation correction algorithm estimates the first-order autocorrelation parameter simultaneously with the other coefficients using a procedure that is equivalent to maximum likelihood if the disturbances are normally distributed. The correction adds to the efficiency of the estimates and, more importantly, avoids the potentially serious downward bias in the estimated standard errors about which Granger and Newbold (1974) have so persuasively warned. For many of the basic specifications I have also checked the constraint implied by the first-order transformation and found that it cannot be rejected; I have also estimated the specification in first difference form and found similar coefficients. The evidence on this is presented below. (I might also add that simple OLS estimates without autocorrelation correction also produce essentially the same results.)

The basic result is shown in equation (2):

$$\frac{I_t^n}{Y_t} = \underset{}{-0.014} + \underset{(0.095)}{0.459\, RN_{t-1}} + \underset{(0.025)}{0.028\, UCAP_{t-1}} + \underset{(0.25)}{0.29 u_{t-1}} \tag{2}$$

$$\bar{R}^2 = 0.754 \quad DWS = 2.04 \quad SSR = 3.438(10^{-4}) \quad 1954\text{–}78$$

with standard errors shown in parentheses and the coefficient of $u_{t-1}$ indicating the first-order autocorrelation parameter. Before looking at other specifications, it is useful to consider briefly the magnitude of the estimated coefficients. Since the net return variable had a standard deviation of 0.013 for the sample period, a move of $RN$ from one standard

30. Extending the analysis to quarterly observations might nevertheless provide more information about the time pattern of response and about the effect of changes in capacity utilization. Of course, the combination of measurement problems and the inherent autocorrelation of the data imply that using quarterly observation would not increase the *effective* degrees of information by anything like a factor of four.

deviation below the mean to one standard deviation above would increase the investment ratio by about 0.012, approximately 1.5 times its standard deviation and 45 percent of its 25-year average value. Since the capacity utilization variable has a standard deviation of 0.044, a two-standard deviation increase in this variable would raise the investment ratio by about 0.0025 or only one-fifth of the change induced by a similar change in $RN$.[31]

Reestimating equation (2) in first-difference form (for 1955 through 1978) shows that the estimated coefficient of $RN$ is quite robust: its coefficient is 0.471 with a standard error of 0.113. The capacity utilization coefficient falls to 0.008 with a standard error of 0.021 and the Durbin-Watson statistic indicates negative serial correlation. To test the constraints imposed by the first-order autocorrelation adjustment, I estimated the ordinary least squares regression of the investment ratio on its own lagged value and on one- and two-period lags in $RN$ and $UCAP$. The reduction in the revised sum of squares was only 6 percent and the corresponding $F$-statistic of 0.54 was far less than the 5 percent critical value of 3.55.

Using the cyclically adjusted measure of the net return ($RNA$) gives greater weight to the cyclical capacity utilization variable and slightly lowers the estimated effect of changes in the fundamental determinants of the net return:[32]

$$(3) \qquad \frac{I_t^n}{Y_t} = \underset{}{-0.023} + \underset{(0.106)}{0.386\, RNA_{t-1}} + \underset{(0.023)}{0.045\, UCAP_{t-1}} + \underset{(0.20)}{0.63 u_{t-1}}$$

$$\bar{R}^2 = 0.746$$
$$DWS = 2.076$$
$$SSR = 3.442(10^{-4})$$
1955–77

Several different more general distributed lag specifications were also estimated. There is some weak evidence that the mean lag between $RN$ and the investment ratio is longer than a year and that the cumulative effect of $RN$ on the investment ratio is larger than equation (2) implies. For example, when the variable $RN_{t-2}$ is added to the earlier specification, its coefficient is 0.20 with a standard error of 0.14; the sum of the coefficients on $RN_{t-1}$ and $RN_{t-1}$ becomes 0.60. Second-order polynomial distributed lags with a four- or five-year span and a final value constrained

31. Since the standard error of the capacity utilization coefficient is relatively large, the coefficient of 0.028 should be regarded as subject to considerable error.

32. The sample is two years shorter because the information required to calculate ETRA is not available before 1954 or after 1976.

to be zero imply that the coefficients of $RN_{t-1}$ and $RN_{t-2}$ are significantly different from zero but that further coefficients are not; the sum of the coefficients varies between 0.45 and 0.55, depending on the exact specification. Further lags on the capacity utilization variables are never both positive and significantly different from zero.

Redefining the investment variable as the ratio of net investment to *capacity* GNP has essentially no effect; the coefficient of $RN$ rises to 0.50 (standard error 0.10) and the capacity utilization coefficient remains essentially unchanged at 0.026 (s.e. = 0.026).

All of the equations are estimated using the *net* rate of investment because I believe that the Commerce Department's very disaggregated procedure for calculating economic depreciation, while far from perfect, is better than the alternative of studying gross investment and assuming that depreciation is a constant fraction of the past year's capital stock. Nevertheless, as a further test of the robustness of the conclusion that $RN$ is important, I have estimated such a gross investment equation:

$$(4)\qquad \frac{I_t^g}{Y_t} = -0.123 + \underset{(0.082)}{0.314}\ RN_{t-1} + \underset{(0.028)}{0.106}\ UCAP_{t-1} + \underset{(0.030)}{0.163}\ \frac{K_{t-1}^n}{Y_{t-1}} + \underset{(0.295)}{0.050}u_{t-1}$$

$\bar{R}^2 = 0.715$
$DWS = 1.98$
$SSR = 2.70(10^{-4})$
1954–78

These coefficients confirm the importance of $RN$ but suggest that the net investment specification overstates the importance of $RN$ relative to $UCAP$. However, the very large coefficient of the lagged capital variable, implying an implausible 16 percent annual depreciation rate for plant and equipment, is a warning against giving too much weight to this specification.[33]

The results are not sensitive to the use of capacity utilization to measure the effect of aggregate demand. Using the unemployment rate for men over 19 years old leaves the coefficient of $RN$ at 0.454 (standard error = 0.077) while using the proportional gap between GNP and capacity GNP leaves the coefficient of $RN$ at 0.405 (s.e. = 0.070). A one percentage point decline in this unemployment rate raises the investment ratio by a relatively small 0.0016; similarly, a one percentage point decline in the GNP gap raises the investment ratio by only 0.0010. Additional accelerator variables (i.e., a distributed lag of proportional

33. Further evidence in favor of using the net investment series is present in section 14.4 below.

changes in GNP) were insignificant when capacity utilization was included in the equation.

Several additional variables that are sometimes associated with investment were added to equation (2). Three of these variables were each insignificant and changed the coefficient of *RN* by less than 0.02: the ratio of corporate cash flow to GNP lagged one year; the ratio of the federal government deficit to GNP lagged one year;[34] and a time trend. When the one-year lagged value of Tobin's $q$ variable is included,[35] its coefficient is 0.011 (with a standard error of 0.074) and the coefficient of *RN* drops slightly to 0.391 (s.e. = 0.117).

The actual inflation rate (lagged one year), and the predicted long-term inflation rate[36] (also lagged one year) were completely insignificant and had very little effect on the coefficient of *RN*. Including both the actual and expected inflation rates did not change this conclusion. The full effect of inflation on investment is captured in the current specification by the *RN* variable itself.

All of the specification experiments described in the past several paragraphs have also been repeated with the cyclically adjusted RNA variable with very similar results.

The specification in terms of the net return assumes that investment responds equally to changes in the pretax return and in the effective tax rate. Two tests of this assumption indicate that it is consistent with the data. If, instead of using $RN_{t-1}$, equation (2) is reestimated with $R_{t-1}$ and $1\text{–}ETR_{t-1}$ as separate variables, the sum of squared residuals actually rises; i.e., the two variables actually explain less than their product does. An explicit statistical test is possible if *RN* in equation (2) is replaced by its logarithm; since $ln\ RN = ln\ R + ln\ (1-ETR)$, the equality of the two coefficients of $ln\ R$ and $ln\ (1-ETR)$ can be tested explicitly.[37] Neither coefficient is estimated very precisely (each has a $t$-statistic of less than 1.5) and the equality of the two coefficients is easily accepted (the $F$-statistic is only 0.51).

Estimating the analogous decomposition for the cyclically adjusted variables, i.e., replacing RNA by *RA* and $1-ETRA$, is interesting be-

34. When the concurrent ratio of the federal deficit to GNP is included, its coefficient is −0.26 (with a standard error of 0.06) and the coefficient of RN drops to 0.21 (s.e. = 0.10). This may be evidence of crowding out or it may merely reflect the tendency of more investment to increase concurrent national income and thereby reduce the government deficit.

35. This variable is the Holland and Meyers (1979) measure, defined as the ratio of the aggregate market value of nonfinancial corporations to the net replacement cost of plant, equipment, and inventories. Essentially the same result is obtained with their broader measure in which all other nonfinancial assets are included.

36. The predicted inflation rate is based on a rolling series of ARIMA regressions; see Feldstein and Summers (1978, pp. 170–74).

37. The switch from *RN* to *ln RN* causes a small decrease in the explanatory power of the equation.

cause it sheds light on the question of whether the year-to-year noncyclical variations in the pretax return matter. Two things should be noted. First, this substitution reduces the explanatory power of the equation as measured by the corrected $\bar{R}^2$; this favors keeping the simple specification in terms of RNA. Second, if both variables are included separately, the coefficient of the *RA* variable is much less than its standard error (0.033 with a standard error of 0.172) while the coefficient of the ETRA variable is statistically significant and economically important: $-0.044$ with a standard error of 0.017. This suggests that year-to-year fluctuations in the pretax return have not been important but that the rise in ETRA from about 0.57 in the mid-1960s to about 0.85 in the mid-1970s was enough to reduce the investment ratio by more than one percentage point.

An important indication of the plausibility and reliability of any simple model is the stability of the coefficients in different subperiods. Equations (5) and (6) show the result of splitting the sample in half:

$$(5)\qquad \frac{I_t^n}{Y_t} = \underset{}{-0.066} + \underset{(0.078)}{0.448\, RN_{t-1}} + \underset{(0.024)}{0.090\, UCAP_{t-1}} + \underset{(0.25)}{0.62 u_{t-1}}$$

$$\bar{R}^2 = 0.784 \quad DWS = 2.20 \quad SSR = 1.291\,(10^{-4}) \quad 1954\text{–}66$$

$$(6)\qquad \frac{I_t^n}{Y_t} = \underset{}{-0.222} + \underset{(0.108)}{0.443\, RN_{t-1}} + \underset{(0.025)}{0.041\, UCAP_{t-1}} + \underset{(0.32)}{0.58 u_{t-1}}$$

$$\bar{R}^2 = 0.839 \quad DWS = 1.48 \quad SSR = 0.930\,(10^{-4}) \quad 1967\text{–}78$$

The coefficients of *RN* are remarkably similar and the relevant *F*-statistic indicates that the hypothesis of equal coefficients for the two subperiods cannot be rejected at the 5 percent level.[38]

A further test of the robustness and usefulness of an equation is its performance in out-of-sample forecasts. The basic specification was reestimated for the period 1954–70 and this equation was then used to predict the investment ratio for each year from 1971 through 1978. These

38. Even the two coefficients of the capacity utilization variable do not differ in a statistically significant way; the difference between them of 0.049 has a standard error of 0.035.

**Table 14.2** **Actual and Predicted Investment Ratios**

| | Ratio | | | Change in Ratio | | |
|---|---|---|---|---|---|---|
| Year | Actual (1) | Predicted ($RN$) (2) | Predicted ($MPNR$-$COF$) (3) | Actual (4) | Predicted ($RN$) (5) | Predicted ($MPNR$-$COF$) (6) |
| 1971 | 0.025 | 0.019 | 0.024 | — | — | — |
| 1972 | 0.028 | 0.020 | 0.027 | 0.003 | 0.001 | 0.003 |
| 1973 | 0.034 | 0.028 | 0.033 | 0.006 | 0.008 | 0.006 |
| 1974 | 0.031 | 0.027 | 0.026 | −0.003 | −0.001 | −0.007 |
| 1975 | 0.014 | 0.015 | 0.004 | −0.017 | −0.012 | −0.022 |
| 1976 | 0.015 | 0.012 | 0.012 | 0.001 | −0.003 | 0.008 |
| 1977 | 0.020 | 0.020 | 0.016 | 0.005 | 0.008 | 0.004 |
| 1978 | 0.025 | 0.022 | — | 0.005 | 0.002 | — |

NOTE: Predictors are based on equations fitted through 1970 only. Columns 2 and 5 are based on the specification of equation (1) while columns 3 and 6 are based on the specification of equation (12).

predictions are based on the two lagged variables only ($RN_{t-1}$ and $UCAP_{t-1}$) and do not use the lagged disturbance ($u_{t-1}$) or any lagged dependent variable. The results shown in table 14.2 are remarkably good. The mean absolute prediction error (0.0035) is only two-thirds of the mean year-to-year change (0.0050) in the investment ratio. The year-to-year changes are also predicted quite well, with the correct sign in 6 of the 7 years and a mean error that is only one-third of the average change.

To conclude the discussion of the net return model of investment behavior, it is useful to consider its implication for understanding the decline in the investment ratio since 1966. The first column of table 14.3 shows that the investment ratio fell from 0.045 in 1966 to less than half that value in the last four years of the sample period. The 1965 value of $RN$ was 0.065, the highest of any year in the sample, and the 1965 value of $UCAP$ was 0.896, the second highest value and only slightly below the 1966 $UCAP$ value of 0.911. Column 2 uses the estimated effect of changes in $RN$ (i.e., 0.459 from equation 2) to calculate the investment ratio for each of the 25 sample years conditional on $RN = 0.065$; i.e., each figure in column 2 equals the corresponding figure in column 1 plus 0.459 times $(0.065 - RN_{t-1})$. Similarly, column 3 uses the estimated effect of changes in $UCAP$ to calculate the investment ratio conditional on $UCAP = 0.896$.[39] It is clear from the figures in column 2 that the fall in $RN$ can account for most of the decline in the investment ratio since 1966 and that the fluctuations in $UCAP$ after 1966 cannot account for much of the decline. If $RN$ had been kept at its 1965 level, net investment from 1970 to

39. Columns 5 and 6 will be considered in section 14.4.

Table 14.3 Actual and Conditional Ratios of Net Nonresidential Investment to GNP

| Year | Actual (1) | Conditional on[a] *RN*= 0.065 (2) | *UCAP*= 0.896 (3) | *INF*= 0.0 (4) | *MPNR-COF*= 0.043 (5) | *UCAP*= 0.896 (6) |
|---|---|---|---|---|---|---|
| 1954 | 0.023 | 0.040 | 0.023 | — | — | — |
| 1955 | 0.028 | 0.043 | 0.031 | 0.031 | 0.039 | 0.035 |
| 1956 | 0.031 | 0.041 | 0.032 | 0.035 | 0.041 | 0.033 |
| 1957 | 0.029 | 0.045 | 0.030 | 0.035 | 0.036 | 0.032 |
| 1958 | 0.017 | 0.033 | 0.019 | 0.023 | 0.024 | 0.021 |
| 1959 | 0.020 | 0.038 | 0.024 | 0.024 | 0.024 | 0.031 |
| 1960 | 0.022 | 0.035 | 0.024 | 0.026 | 0.026 | 0.028 |
| 1961 | 0.019 | 0.033 | 0.022 | 0.023 | 0.023 | 0.026 |
| 1962 | 0.023 | 0.037 | 0.027 | 0.026 | 0.024 | 0.032 |
| 1963 | 0.023 | 0.033 | 0.026 | 0.025 | 0.025 | 0.029 |
| 1964 | 0.029 | 0.036 | 0.030 | 0.032 | 0.030 | 0.033 |
| 1965 | 0.040 | 0.043 | 0.041 | 0.042 | 0.040 | 0.043 |
| 1966 | 0.045 | 0.045 | 0.045 | 0.048 | 0.045 | 0.045 |
| 1967 | 0.038 | 0.038 | 0.037 | 0.042 | 0.041 | 0.036 |
| 1968 | 0.037 | 0.041 | 0.038 | 0.041 | 0.038 | 0.039 |
| 1969 | 0.038 | 0.046 | 0.039 | 0.043 | 0.042 | 0.040 |
| 1970 | 0.031 | 0.043 | 0.032 | 0.038 | 0.038 | 0.033 |
| 1971 | 0.025 | 0.042 | 0.028 | 0.031 | 0.033 | 0.032 |
| 1972 | 0.028 | 0.044 | 0.032 | 0.033 | 0.034 | 0.037 |
| 1973 | 0.034 | 0.046 | 0.036 | 0.039 | 0.038 | 0.039 |
| 1974 | 0.031 | 0.047 | 0.032 | 0.041 | 0.041 | 0.033 |
| 1975 | 0.014 | 0.040 | 0.015 | 0.030 | 0.038 | 0.018 |
| 1976 | 0.015 | 0.034 | 0.019 | 0.024 | 0.028 | 0.027 |
| 1977 | 0.020 | 0.036 | 0.023 | 0.028 | 0.033 | 0.027 |
| 1978 | 0.025 | 0.041 | 0.027 | 0.034 | — | — |

a. Columns 2, 3, and 4 are based on equation (2); columns 5 and 6 are based on equation (13).

1978 would have taken an average of 4.1 percent of GNP instead of the actual average of only 2.5 percent, an increase of two-thirds. By contrast, maintaining the high 1965 level of capacity utilization would only have raised the average investment-GNP ratio by 0.5 percentage points. It is also worth noting that if the 1965 level of *RN* had been reached a decade earlier, investment during that decade would have averaged an additional 1.2 percent of GNP. Equation (2) can also be used to estimate an approximate but explicit effect of inflation on the investment ratio. In an earlier study, Lawrence Summers and I estimated the change in the tax liability on corporate source income that is caused by the interaction of inflation and the tax laws.[40] For example, in 1977 (the last year of our study) inflation raised the tax liability by $31.9 billion or 1.9 percent of the corresponding capital stock.[41] The estimate of $RN_{t-1}$ in equation (2) implies that a 1.9 percentage point increase in $RN$ for 1977 would raise the 1978 investment ratio by 0.009 to 0.034; this value is shown in column 4 of table 14.3. Similarly calculated values for earlier years indicate that the interaction between inflation and the tax rules reduced investment in the 1970s by an average of 0.8 percent of GNP or about one-third of the actual level of net investment.

## 14.4 Investment and the Rate of Return over Cost

In the absence of taxes, the simplest specification of a firm's investment behavior is that it invests whenever the rate of return on an available project exceeds the cost of additional funds.[42] More generally, the costs of changing the rate of investment and the uncertainty associated with investment returns make the firm's decision problem more complex.[43] It is, nevertheless, useful to describe the firm's rate of investment as responding to the difference between potential rates of return and the cost of funds.

In terms of the traditional marginal efficiency of investment schedule that Keynes borrowed from Irving Fisher, an upward shift of the marginal efficiency schedule or a downward shift in the cost of funds will increase the rate of investment. If we select a particular rate of investment, we can measure the upward shift of the marginal efficiency schedule by what happens to the internal rate of return at that rate of investment.[44] A rise in the difference between the internal rate of return and the cost of funds should induce a higher rate of investment.

This idea can be extended to an economy with a complex tax structure and with inflation. A change in the tax rules or in the expected rate of inflation alters the rate of return on all projects (in a sense that I will make more precise below). These fiscal and inflation changes therefore act in a way that is equivalent to shifting the marginal efficiency of investment schedule in a simpler economy.

When we switch from a taxless economy to one with company taxes and depreciation rules, the concept of the internal rate of return must be

40. See chap. 8 above (Feldstein and Summers, 1979), table 8.4, col. 9 for the series of inflation-induced tax increases.

41. For the capital stock figures, see Feldstein and Poterba (1980*a*, table A-1, col. 8.

42. I have borrowed Irving Fisher's phrase "the rate of return over cost" but not his exact meaning. The model in the current section is nevertheless very close in spirit to Fisher's analysis.

43. See Abel (1978) for an explicit derivation of the optimum rule when there are endogenous adjustment costs.

44. Unless the shift is a uniform one, the answer will depend on the initial point that is selected. This is a typical index number type problem.

extended to what I shall call the maximum potential net return (MPNR). For simplicity, I shall describe this first for the case in which the firm relies exclusively on debt finance. I shall then note how the analysis is easily extended to include equity finance as well.

In a taxless economy, the internal rate of return on a project is the maximum rate of return that a firm can afford to pay on a loan used to finance that project. If $L_t$ is the loan balance at time $t$ and $x_t$ (for $t = 1,2, \ldots, T$) is the internal rate of return is the interest rate $r$ that satisfies the difference equation:

$$L_t - L_{t-1} = rL_{t-1} - x_t \tag{7}$$

where $L_0$ is the initial cost of the project and $L_T = 0$. Solution of equation (7) is exactly equivalent to the familiar definition of $r$ as the solution to the polynomial equation:

$$L_0 = \sum_{t=1}^{T} \frac{x_t}{(1+r)^t} \tag{8}$$

When a tax at rate $\tau$ is levied on the net output minus the sum of the interest payment and the allowable depreciation ($d_t$), the maximum potential interest rate (MPIR) is defined according to

$$L_t - L_{t-1} = rL_{t-1} - x_t + \tau(x_t - d_t - rL_{t-1}) \tag{9}$$

where $L_T = 0$ and $L_0$ equals the initial cost of the project minus any investment tax credit.

If $x_t$ is the *real* cash flow of the project, inflation at a constant rate $\pi$ has the effect of increasing the nominal cash flow to $(1 + \pi)^t x_t$ and the MPIR rises to the value of $r$ that solves:

$$\begin{aligned} L_t - L_{t-1} &= rL_{t-1} - (1+\pi)^t x_t \\ &\quad + \tau[(1+\pi)^t x_t - d_t - rL_{t-1}] \end{aligned} \tag{10}$$

Although in a taxless world the MPIR would rise by the rate of inflation, the relative importance of historic cost depreciation and the deductibility of nominal interest payments determines whether $r$ rises by more or less than the increase in $\pi$.

The calculation of the MPIR is made operational by specifying the real cash flow from a hypothetical project and the associated series of allowable tax depreciation. I adopt here the same specifications that I used in Feldstein and Summers (1978; chap. 9 above). The hypothetical project is a "sandwich" of which 66.2 percent of the investment in the first year is a structure that lasts 30 years and the remainder is an equipment investment that is replaced at the end of 10 years and 20 years.[45] The internal

45. The 66.2 percent ratio is selected to produce a steady-state investment mix corresponding to the average composition over the past twenty years. Note that this specification ignores inventories and therefore the very substantial extra tax burden caused by inflation

rate of return in the absence of taxes is set at 12 percent for both the equipment and structure components. The net output of the equipment is subject to exponential decay at 13 percent until it is scrapped while the net output of the structure is subject to 3 percent decay. The depreciation rules, tax rate, and credits are then varied from year to year as the law changes.

The expected rate of inflation in each year is calculated from the consumer expenditure deflator using the optimal ARIMA forecasting procedure of Box and Jenkins (1970).[46] The calculation assumes that forecasts made at each date are based only on the information available at that time and that the ARIMA process estimated at each date is based only on the most recent 10 years of quarterly data. The calculation of the MPIR is based on the entire sequence of forecast future inflation rates and not on any single average long-term expected inflation rate.[47]

It firms did finance marginal projects exclusively by debt, it would be sufficient to relate the net rate of investment to the difference between the MPIR and the long-term nominal interest rate (as well as to capacity utilization or some other measure of cyclical demand). More generally, however, since firms do not use only debt finance, the concept of the MPIR must be extended to the maximum potential net return (MPNR), defined as the maximum net-of-corporate-tax nominal yield that the firm can afford to pay. The net rate of investment can then be related to the difference between the MPNR and the net-of-corporate-tax nominal cost of funds.

The method of calculating the MPIR in the all-debt case can be applied directly to find the value of the MPNR. In the special all-debt case, the MPNR $= (1 - \tau)r$; the solution of a difference equation like (10) is therefore equivalent to finding MPNR/$(1 - \tau)$ in the all-debt case. More generally, however, regardless of the mix of debt and equity finance, the solution of (10) can be interpreted as equivalent to MPNR/$(1 - \tau)$. Since $\tau$ is known, this yields MPNR directly. Annual values for MPNR are presented in column 1 of table 14.4

Note that the MPNR is defined in terms of a hypothetical project with a fixed pretax yield of 12 percent. All of the year-to-year variation in the MPNR is due to changes in tax rules and expected inflation. An alternative MPNR series has also been calculated in which the pretax rate of return is allowed to vary; more specifically, MPNRVP (VP for varying

with FIFO inventory accounting. While this need not affect decisions to subsitute capital for labor, it does influence the return on capital expansion to the extent that this involves greater inventories.

46. The calculation of expected inflation series is described in chap. 9 (Feldstein and Summers, 1978), pp. 170–74.

47. To meet the need for a series of expected long-term inflation rates for other purposes, Feldstein and Summers (1978; chap. 9 above) calculate a weighted average of these future inflation rates where the weights are equivalent to discounting at a fixed interest rate.

**Table 14.4** Potential and Actual Net Costs of Funds

| Year | *MPNR* (1) | *MPNRVP* (2) | *COF* (3) | *MPNR-COF* (4) | *MPRNVP-COF* (5) |
|---|---|---|---|---|---|
| 1954 | 0.087 | 0.078 | 0.078 | 0.009 | 0.000 |
| 1955 | 0.089 | 0.084 | 0.077 | 0.012 | 0.007 |
| 1956 | 0.089 | 0.074 | 0.067 | 0.023 | 0.008 |
| 1957 | 0.091 | 0.073 | 0.070 | 0.020 | 0.002 |
| 1958 | 0.090 | 0.075 | 0.058 | 0.032 | 0.017 |
| 1959 | 0.090 | 0.081 | 0.060 | 0.031 | 0.022 |
| 1960 | 0.090 | 0.078 | 0.059 | 0.031 | 0.018 |
| 1961 | 0.090 | 0.081 | 0.049 | 0.041 | 0.032 |
| 1962 | 0.093 | 0.088 | 0.056 | 0.037 | 0.032 |
| 1963 | 0.094 | 0.091 | 0.056 | 0.038 | 0.035 |
| 1964 | 0.099 | 0.098 | 0.055 | 0.044 | 0.043 |
| 1965 | 0.102 | 0.102 | 0.058 | 0.043 | 0.043 |
| 1966 | 0.101 | 0.097 | 0.067 | 0.034 | 0.030 |
| 1967 | 0.101 | 0.092 | 0.061 | 0.040 | 0.031 |
| 1968 | 0.097 | 0.087 | 0.066 | 0.030 | 0.021 |
| 1969 | 0.093 | 0.075 | 0.074 | 0.020 | 0.001 |
| 1970 | 0.097 | 0.073 | 0.078 | 0.019 | −0.006 |
| 1971 | 0.102 | 0.081 | 0.075 | 0.027 | 0.006 |
| 1972 | 0.105 | 0.082 | 0.071 | 0.034 | 0.010 |
| 1973 | 0.106 | 0.072 | 0.095 | 0.011 | −0.022 |
| 1974 | 0.111 | 0.062 | 0.144 | −0.034 | −0.082 |
| 1975 | 0.110 | 0.083 | 0.108 | 0.002 | −0.025 |
| 1976 | 0.109 | 0.080 | 0.107 | 0.002 | −0.027 |

profitability) replaces the 12 percent assumption with a cyclically adjusted profitability series for each year's new investment that is very similar to the *RA* variable discussed in section 14.3.[48] The MPNRVP series is presented in column 2 of table 14.4.

The MPNR is the net nominal amount that firms can potentially afford to pay for funds. The actual net nominal cost of funds depends on the marginal mix of debt and equity funds. The correct assumption about this marginal mix is not clear. In the current analysis, I have assumed that firms use debt and equity at the margin in the same ratio that they do on average, i.e., that debt accounts for only one-third of total finance. This implies that the net nominal cost of funds is:

$$(11) \qquad COF = \frac{1}{3}(1-\tau)i + \frac{2}{3}(e+\pi)$$

where $i$ is the long-term bond interest rate and $e$ is the real equity earnings

48. See chap. 9 (Feldstein and Summers, 1978) for a description of the cyclically adjusted return series used in the present calculation.

per dollar of share value.[49] The cost of funds series is presented in column 3.

This section examines a model that makes the rate of net investment a function of (1) the difference between the potential and actual cost of funds and (2) the rate of capacity utilization:

$$\frac{I_t^n}{Y_t} = b_0 + b_1(MPNR - COF)_{t-1} + b_2 UCAP_{t-1} + u_t \tag{12}$$

Columns 4 and 5 of table 14.4 present the time series of this yield difference. These figures indicate that the incentive was low in the 1950s, became quite powerful in the mid-1960s, began to fail in the early 1970s and then dropped very sharply in the mid-1970s.

The pattern of the past decade reflects the fact that, because of historic cost depreciation, inflation raised the MPNR rather little while the cost of funds rose substantially.[50] Between 1966 and 1976, the cost of funds rose by four percentage points while the MPNR rose by less than one percentage point.[51]

As in section 14.2, the current analysis uses annual data and lags both regressors one year. Equation (12) and a variety of related specifications have been estimated by least squares with a first-order autocorrelation correction. Specific tests for the basic specifications show that the implied constraints are not binding, i.e., that the first-order autocorrelation correction is not inferior to a more general first-order ARMA process. Estimates in first-difference form also produce coefficients very similar to those obtained with the autocorrelation transformation.

The basic parameter estimates

$$\frac{I_t^n}{Y_t} = -\underset{}{0.040} + \underset{(0.066)}{0.316}\ (MPNR\text{-}COF)_{t-1} + \underset{(0.020)}{0.073}\ UCAP_{t-1} + \underset{(0.17)}{0.70}u_{t-1} \tag{13}$$

$$\bar{R}^2 = 0.784$$
$$DWS = 1.79$$
$$SSR = 2.936(10^{-4})$$
1955–77

49. The inverse of $e$ is the product of (1) the Standard and Poor's price-earnings ratio and (2) the ratio of "book profits" to "economics profits" with correction for inflationary affects on reported depreciation, inventory profits, and debt.

50. Inflation also raised the cost of funds because the cost of equity funds was raised more than the cost of debt funds fell.

51. This is roughly consistent with a regression equation that indicates that, for the sample as a whole, each one percentage point increase in the long-term expected inflation rate reduced the difference MPNR-COF by about 1.25 percentage points. Between 1966 and 1976, the long-term expected inflation rate (demand from the ARIMA forecasts) rose 3.2 percentage points.

indicate the yield differential has a powerful effect and the variations in capacity utilization are also important.[52]

Since the return-over-cost variable had a standard deviation of 0.017 over the sample period, a move from one standard deviation below the mean to one standard deviation above would raise the investment ratio by 0.011, approximately 1.3 times its standard deviation and 40 percent of its 25-year average value. A two-standard deviation move in capacity utilization would raise investment by 0.006, or only about half as much.

Using the varying-profitability measure of the potential net return reduces the corresponding coefficient:

$$(14) \qquad \frac{I_t^n}{Y_t} = -\,0.031 + \underset{(0.049)}{0.219}\ (MPNRVP - COF)_{t-1} + \underset{(0.020)}{0.069}\ UCAP_{t-1} + \underset{(0.17)}{0.71}\ u_{t-1}$$

$$\bar{R}^2 = 0.784$$
$$DWS = 2.02$$
$$SSR = 2.931(10^{-4})$$
1955–77

However, since this measure is much more variable (the standard deviation of $MPNRVP - COF$ is 0.028), a two-standard deviation move implies a slightly bigger change of 0.012 in the investment ratio.

Lagged values of the regressors were insignificant and polynomial distributed lags of different lengths for the return-over-cost variable did not alter the implications of equations (12) and (13). Redefining the investment variable as a ratio to capacity GNP had no effect on the coefficients. Similarly, substituting for capacity utilization the unemployment rate for men over age 19 or the GNP gap ratio did not significantly alter the coefficient of the return-over-cost variable. Moreover, a distributed lag of proportional changes in past output was insignificant when capacity utilization was included in the equation.

The switch from the net investment equation to a gross investment equation caused some reduction in the coefficient of the return-over-cost variable (to 0.215 with a standard error of 0.072), but the extremely small and totally insignificant coefficient of the lagged capital stock variables (0.002 with a standard error of 0.093) makes this gross investment specification implausible.

A time trend and a lagged ratio of corporate cash flow to GNP were tried as additional variables; neither was significant and the coefficient of the return-over-cost variable remained unchanged. A lagged ratio of retained earnings to GNP was "mildly significant" (a $t$-statistic of 1.3) but

52. Because MPNR does not reflect cyclical variations in the rate of return, these parameter values are most appropriately compared with those of equation (3) rather than equation (1).

left the coefficient of the return-over-cost variable unchanged. The lagged ratio of the federal government deficit to GNP had a surprisingly positive coefficient but its inclusion did not alter the coefficient of the return-over-cost variable. The one-year lagged value of Tobin's $q$ ratio had a coefficient of 0.012 (with a standard error of 0.009), while the coefficient of the return-over-cost variable remained essentially unchanged at 0.289 (with a standard error of 0.068). Neither the current inflation rate nor the expected inflation rate was statistically significant.

A powerful test of the appropriateness of equation (13) is obtained by estimating separate coefficients for the rate of return ($MPNR$) and cost of funds ($COF$) variables:

$$\text{(15)} \qquad \frac{I_t^n}{Y_t} = -0.055 + \underset{(0.261)}{0.469}\ MPNR_{t-1} - \underset{(0.068)}{0.319}\, COF_{t-1} + \underset{(0.021)}{0.074}\ UCAP_{t-1} + \underset{(0.20)}{0.66}u_{t-1}$$

$$\bar{R}^2 = 0.775 \quad DWS = 1.81 \quad SSR = 2.895(10^{-4}) \quad \text{1955–77}$$

A comparison of the sum of squared residuals of equations (13) and (15) shows that the coefficients of $MPNR$ and $COF$ do not differ significantly. The separate coefficient of $COF$ in equation (15) is almost identical to the combined return-over-cost coefficient in equation (13); the coefficient of the return variable is larger but so too is its standard error.

The separate estimate of the $MPNR$ coefficient in equation (15) is also particularly important because the $MPNR$ variable reflects only the interaction of tax rules and inflation but not the market interest rate or equity yield. The finding that the $MPNR$ coefficient is even larger than the $COF$ coefficient is therefore powerful evidence of the effect of the tax-inflation interaction.[53]

A test of the stability of the basic coefficients over time also provides reassuring support about the plausibility and reliability of the model. Equations (16) and (17) show the result of splitting the sample in half:

$$\text{(16)} \qquad \frac{I_t^n}{Y_t} = -0.036 + \underset{(0.266)}{0.465}\ (MPNR - COF)_{t-1} + \underset{(0.040)}{0.065}\ UCAP_{t-1} + \underset{(0.21)}{0.81}u_{t-1}$$

$$\bar{R}^2 = 0.599 \quad DWS = 1.24 \quad SSR = 2.276(10^{-4}) \quad \text{1955–66}$$

53. A similar analysis with the varying profitability measure of return provides even more striking confirmation: the coefficient of MPNRVP is 0.253 (s.e. = 0.155) while the coefficient of COR is −0.202 (s.e. = 0.084).

$$(17) \qquad \frac{I_t^n}{Y_t} = -\underset{}{0.044} + \underset{(0.030)}{0.300}\ (MPNR - COF)_{t-1} + \underset{(0.011)}{0.081}\ UCAP_{t-1} - \underset{(0.43)}{0.02}u_{t-1}$$

$\bar{R}^2 = 0.963$
$DWS = 1.75$
$SSR = 0.201(10^{-4})$
1967–77

The coefficients are quite similar and the $F$-statistic of 0.695 indicates that the hypothesis of an unchanged structure cannot be rejected at any conventional level of significance. The results for the varying-profitability specification are even more striking: the coefficient of the return-over-cost variable is 0.206 (s.e. = 0.089) in the first half of the period and 0.200 (s.e. = 0.033) in the second half.

Out-of-sample forecasts based on estimating equation (12) for 1955 through 1970 are shown in table 14.2. The agreement between the actual and predicted investment ratios is quite close. The mean absolute prediction error (0.0035) is the same as with the net return equation of section 14.2 and only two-thirds of the mean year-to-year change in the investment ratio. The year-to-year changes are predicted even more closely and both turning points are correctly indentified.

The parameter estimates of equation (13) can be used to analyze the sharp decline in net investment since 1966. Column 5 of table 14.3 shows the investment ratio which in principle would have been observed if the return over cost had remained at its 1965 value of 0.043. Instead of dropping to an average of only 0.025 from 1970 through 1977, it would have averaged 40 percent higher, 0.035. By contrast, even if the capacity utilization rate could have been kept at the overheated level of 0.896, the investment ratio in the 1970–77 period would only have increased 20 percent to 0.030.

The specific contribution of inflation to the decline in the value of the return-over-cost variable is difficult to determine. One simple way of measuring this effect is by a regression of the return-over-cost variable on the predicted long-term inflation rate. The coefficient in this regression (− 1.27 with a standard error of 0.11) and the rise in the long-term inflation variable by 0.034 between 1965 and 1976 together imply that inflation reduced the return over cost by 0.0432 during this period. The coefficient of the return-over-cost variable (0.316 in equation 13) implies that inflation reduced the investment ratio by 0.14 over this period. This equals almost all of the 0.015 fall in the investment ratio caused by the decline in the return over cost[54] and more than half of the observed decline in the investment ratio between 1966 and 1977.

## 14.5 The Flexible Capital Stock Adjustment Model

The flexible capital stock adjustment model developed by Jorgenson and his collaborators is the direct descendant of that great workhorse of investment equations, the accelerator. Instead of the accelerator's assumption of a fixed capital-output ratio, the more general model allows the capital-output ratio to respond to changes in the cost of capital ownership and therefore to changes in tax rules and inflation. Implicit in the simplest version of this model are a number of very strong and generally undesirable assumptions, including homogeneous capital, a putty-putty technology, constant proportional replacement, myopic and risk-neutral decision making, and a known, exogenous financial mix. This section accepts these assumptions in order to focus on the problem of measuring the effect of inflation in the framework of this popular and influential model. The analysis shows that the traditional implementation of the model has not given adequate attention to inflation and that any attempt to analyze the recent investment experience on the basis of that implementation would be misleading

The analysis here is limited to investment in equipment. The procedure of estimating separate investment equations for equipment and structures is traditional in this framework because the tax rules differ from the two types of equipment. The implicit assumption of two independent investment demand functions, one for equipment-capital and the other for structure-capital, is clearly a poor description of reality. To the extent that investments in structures and equipment are decided as a package, the model of section 14.4 is a preferable specification.[55]

The basic model is well known and can be summarized briefly. Each firm has a desired capital stock at each time ($K_t^*$) and, to the extent that its actual capital falls short of the desired capital, the firm immediately orders capital goods to eliminate the difference. The sum of installed capital and capital on order is thus equal to the desired capital stock at the end of each period. This implies that in each period the net stock of outstanding orders is increased or decreased by exactly the change in the desired capital stock, $K_t^* - K_{t-1}^*$. Since there are delivery delays, the

54. This 0.015 is the difference between the actual 1977 investment ratio of 0.020 and the predicted ratio of 0.035 conditional on maintaining the 1965 level of the return over cost.

55. This specification also ignores the adverse effect of inflation through the taxation of artificial inventory profits. This will matter to the extent that inventories, equipment, and structures are part of a combined investment-output decision.

observed net investment can be represented by a distributed lag distribution of these orders:

$$(18) \qquad I_t^n = \sum_{j-1}^{T} w_j \, (K^*_{t-j} - K^*_{t-j-1}).$$

This specification is based on an implicit assumption about replacement investment: The existing stock decays exponentially at a constant rate $d$, requiring replacement investment of $dK_{t-1}$ to be made in year $t$ to maintain the capital stock. Since firms know the delivery lag distribution exactly, they can anticipate the replacement investment that will be required in each future year (up to the length of the longest delivery lag) and can therefore order replacement investment far enough in advance to make exactly the required replacement. Gross investment is therefore given by:

$$(19) \qquad I_t^g = \sum_{j=1}^{T} w_j \, (K^*_{t-j} - K^*_{t-j-1}) + dK_{t-1}$$

With a constant elasticity of substitution production function, the first-order conditions of profit maximization imply that the desired capital stock is related to the level of output ($Q$), the price of output ($p$) and the annual cost of capital services ($c$) according to:[56]

$$(20) \qquad K_t^* = a^\sigma \, (p/c)_t^\sigma \, Q_t$$

where $\sigma$ is the elasticity of substitution between capital and labor and $a$ is the capital coefficient in the production function. Substituting (20) into (19) yields:

$$(21) \qquad I_t^g = a^\sigma \sum_{j=1}^{T} w_j \, [(p/c)_{t-j}^\sigma \, Q_{t-j} - (p/c)_{t-j-1}^\sigma \, Q_{t-j-1}] + dK_{t-1}$$

The accelerator model implicity assumes $\sigma = 0$ while the Cobb-Douglas technology assumed by Jorgenson and his collaborators implies $\sigma = 1$. In this section, I shall show that the flexible model with $\sigma > 0$ is more strongly supported by the data than the simpler accelerator model. The maximum likelihood estimate of $\sigma$ is less than one but the likelihood function is too flat to reject the Cobb-Douglas assumption.[57]

The annual cost of capital services reflects the price level for investment goods ($p_I$), the real net cost of funds ($R$), the exponential rate of

56. Output is measured by the gross domestic product of nonfinancial corporations and $p$ is the implicit price deflator for that output. The value of $c$ is defined below.

57. I should again stress that these interferences are all conditional on very strong and obviously "false" assumptions. For example, it seems very likely that the assumption of a "putty-putty" technology causes an understatement of the true long-run elasticity of substitution if the true technology is putty-clay.

depreciation ($d$), the corporate tax rate ($\tau$), the investment tax credit[58] ($X$) and the present value of the depreciation allowances per dollar of investment ($Z$):

$$c = \frac{p_I(1 - \tau Z - X)\ (R + d)}{1 - \tau} \tag{22}$$

Inflation affects the value of this crucial variable in two important ways, through the cost of funds ($R$) and through the present value of depreciation ($Z$). In their original study, Hall and Jorgenson (1967) assumed a fixed nominal interest rate of 20 percent for the cost of funds. In the most recent of the Jorgenson studies, this assumption was replaced by the specification that $R = (1 - \tau)i$ where $i$ is a long-term bond interest rate (Gordon and Jorgenson, 1976). This overstates the cost of debt capital (by ignoring inflation) and ignores the role of equity capital. The expected real net cost of debt capital is $(1 - \tau)i - \pi$ (where $\pi$ is expected inflation) since the debt is repaid in depreciated dollars.[59] Column 1 of table 14.5 presents this measure of the real net cost of debt. Despite the rapid rise in the Baa rate itself, the real net cost of debt funds actually declined since the mid-1960s.

The cost of equity capital (e) is the ratio of equity earnings per dollar of share price. The conventional earnings-price ratio can be misleading when there is inflation since it is based on book earnings rather than real economic earnings. Book earnings overstate real earnings by using historic cost depreciation and some FIFO inventory accounting but also understate real earnings by excluding the real reduction in the value of outstanding debt that occurs because of inflation.[60] The correct earnings price ratio is presented in column 2 of table 14.5. The cost of equity funds clearly rose substantially since the mid-1960s even when the conventional series is appropriately corrected.

Defining the real net cost of funds ($R$) as a fixed-weight average with one-third debt (the average ratio of debt to capital for the past two decades) implies:[61]

58. To simplify notation, I use $X$ to refer to the investment tax credit with the Long-amendment adjustment when appropriate. Data on the investment tax credit refer to actual practice and were supplied by Data Resources, Inc.

59. The putty-putty technology allows all decisions to be myopic and therefore in principle makes the short-term interest rate and short-term inflation rate the relevant variable (Hall, 1977). A more realistic description of finance and technology makes a long-term interest rate and inflation the appropriate variables. I have in fact used the Baa corporate bond rate and the long-term inflation expectation derived from the "rolling"—ARIMA estimates presented in Feldstein and Summers (1978; chap. 9 above).

60. Equivalently, book earnings are net of nominal interest payments rather than real interest payments. In my calculation, the debt is the net financial capital supplied by the creditors of the nonfinancial corporations and inflation is measured by the change in the consumer price index.

61. Note that $R + \pi$ equals the COF variable of section 14.4.

**Table 14.5** Correct and Incorrect Measures of the Cost of Capital Services

| Year | Real Net Cost of Funds | | | Net Nominal Cost of Funds | Depreciation Allowances | | Relative Cost of Capital Services | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Debt (1) | Equity (2) | Combined (3) | (4) | Correct (5) | Incorrect (6) | Correct (7) | Incorrect (8) | No Inflation No. 1 (9) | No Inflation No. 2 (10) |
| 1954 | −0.013 | 0.067 | 0.040 | 0.069 | 0.644 | 0.549 | 0.241 | 0.221 | 0.211 | 0.237 |
| 1955 | −0.010 | 0.066 | 0.041 | 0.068 | 0.677 | 0.582 | 0.236 | 0.218 | 0.207 | 0.233 |
| 1956 | −0.008 | 0.059 | 0.037 | 0.063 | 0.713 | 0.604 | 0.230 | 0.223 | 0.211 | 0.233 |
| 1957 | −0.004 | 0.065 | 0.042 | 0.068 | 0.703 | 0.613 | 0.246 | 0.234 | 0.216 | 0.242 |
| 1958 | 0.000 | 0.053 | 0.035 | 0.057 | 0.745 | 0.620 | 0.227 | 0.228 | 0.214 | 0.235 |
| 1959 | 0.001 | 0.051 | 0.034 | 0.057 | 0.749 | 0.625 | 0.226 | 0.234 | 0.215 | 0.235 |
| 1960 | 0.000 | 0.055 | 0.037 | 0.061 | 0.739 | 0.629 | 0.233 | 0.233 | 0.216 | 0.237 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1961 | 0.005 | 0.044 | 0.031 | 0.050 | 0.781 | 0.633 | 0.215 | 0.230 | 0.214 | 0.231 |
| 1962 | 0.006 | 0.064 | 0.044 | 0.061 | 0.756 | 0.652 | 0.231 | 0.218 | 0.205 | 0.230 |
| 1963 | 0.006 | 0.062 | 0.043 | 0.060 | 0.776 | 0.671 | 0.224 | 0.214 | 0.203 | 0.225 |
| 1964 | 0.006 | 0.058 | 0.041 | 0.058 | 0.782 | 0.673 | 0.206 | 0.203 | 0.190 | 0.210 |
| 1965 | 0.006 | 0.062 | 0.043 | 0.061 | 0.774 | 0.674 | 0.204 | 0.197 | 0.204 | 0.204 |
| 1966 | 0.009 | 0.076 | 0.053 | 0.073 | 0.740 | 0.675 | 0.226 | 0.206 | 0.190 | 0.213 |
| 1967 | 0.012 | 0.067 | 0.049 | 0.068 | 0.757 | 0.676 | 0.217 | 0.208 | 0.189 | 0.210 |
| 1968 | 0.008 | 0.068 | 0.048 | 0.071 | 0.749 | 0.676 | 0.221 | 0.214 | 0.185 | 0.213 |
| 1969 | 0.004 | 0.075 | 0.052 | 0.083 | 0.718 | 0.677 | 0.253 | 0.239 | 0.204 | 0.234 |
| 1970 | 0.011 | 0.084 | 0.059 | 0.092 | 0.695 | 0.677 | 0.263 | 0.241 | 0.205 | 0.234 |
| 1971 | 0.006 | 0.061 | 0.042 | 0.078 | 0.762 | 0.714 | 0.214 | 0.216 | 0.190 | 0.207 |
| 1972 | 0.008 | 0.062 | 0.044 | 0.076 | 0.767 | 0.714 | 0.206 | 0.206 | 0.182 | 0.199 |
| 1973 | −0.003 | 0.085 | 0.056 | 0.099 | 0.717 | 0.714 | 0.222 | 0.202 | 0.176 | 0.198 |
| 1974 | −0.034 | 0.116 | 0.066 | 0.146 | 0.629 | 0.714 | 0.244 | 0.202 | 0.169 | 0.195 |
| 1975 | −0.001 | 0.100 | 0.067 | 0.119 | 0.678 | 0.714 | 0.236 | 0.203 | 0.168 | 0.196 |
| 1976 | −0.005 | 0.080 | 0.052 | 0.104 | 0.707 | 0.714 | 0.214 | 0.200 | 0.169 | 0.190 |
| 1977 | −0.012 | 0.114 | 0.072 | 0.127 | 0.663 | 0.715 | 0.245 | 0.197 | 0.168 | 0.198 |

$$(23) \qquad R = \frac{1}{3}\,[(1-\tau)i - \pi] + \frac{2}{3}\,e$$

This series, presented in column 3 of table 14.5, shows no trend from the mid-1950s through the mid-1960s but then a gradual but substantial rise to the mid-1970s.

The second important way in which inflation affects the cost of capital services is through the value of depreciation. Since depreciation allowances are fixed in nominal terms, the real present value of the depreciation ($Z$) is reduced when the rate of inflation rises. This present value should be calculated using a nominal cost of funds or, equivalently, the future depreciation allowances should be restated in real terms and then discounted at the real cost of funds. Column 4 of table 14.5 presented the nominal cost of funds; this is the real cost of funds (shown in column 3) plus the expected rate of inflation.[62] The values of $Z$ presented in column 5 reflect changes in this discount rate as well as changes in the depreciation rules.[63] In the early years, $Z$ rose significantly but, after 1964, $Z$ drifted down because of the rising discount rate despite the continuing acceleration of depreciation.

The importance of specifying this discount rate correctly can be seen by comparing these $Z$ values with the alternative "$Z10$" values presented in column 6; the $Z10$ values are calculated with a constant 10 percent discount rate, the procedure used by Jorgenson and his collaborators. With a constant discount rate, the evolution of the $Z10$ variable reflects only the increasingly favorable statutory rules and therefore has actually increased during the past decade while the true value has been declining.

The composite relative cost of capital services (i.e., the $c$ variable defined in equation (22) deflated by the output price) is presented in column 7 of table 14.5. This measure of the relative cost of capital services falls gradually from the 1950s to a low point in the mid-1960s and then begins rising again. By the end of the sample period (1977), the relative cost of capital is back to its level of the 1950s. This reversal of the incentive to invest is not observed if the inflation induced changes in $Z$ and $R$ are ignored; column 8 presents a false relative cost series that incorporates $Z10$ (i.e., a constant 10 percent discount rate to value depreciation) and that measures the cost of funds by the net nominal interest rate.

The Cobb-Douglas technology assumed by Jorgenson and his collaborators is a convenient place to begin testing the significance of the relative cost of capital services. I have estimated equation (21) subject to the restriction that the elasticity of substitution is one and compared it to the

62. In the pure debt case, this would just be the net-of-tax nominal interest rate.

63. The calculation of $Z$ reflects the introduction of accelerated depreciation and the several reductions in the allowable depreciation life.

simpler accelerator model in which the elasticity of substitution is zero. In both specifications, the distributed lag weights were constrained to fit a third-degree polynomial (with four years of lags and a fifth year constrained to zero).

By purely statistical criteria, the evidence clearly favors the Cobb-Douglas price sensitivity model to the accelerator model. With the Cobb-Douglas technology, the $\bar{R}^2$ is 0.980 and the sum of squared residuals is 112.3. By contrast, for the accelerator model the $\bar{R}^2$ is only 0.961 and the sum of squared residuals is 215.9. An approximate likelihood ratio test strongly rejects the restriction to a zero substitution elasticity.[64]

Misspecifying the cost-of-capital series by failing to represent correctly the effect of inflation also reduces the explanatory power of the model. Following the Jorgenson procedure of evaluating depreciation allowances with a fixed 10 percent interest rate and defining the cost of funds in terms of the net nominal rate (i.e., using the incorrect *c/p* series presented in column 8 of table 14.5) cause the $\bar{R}^2$ to fall to 0.970 (from 0.980) and raises the sum of squared residuals to 167.4 (from 112.3).

Although relaxing the Cobb-Douglas assumption and estimating the elasticity of substitution could in principle indicate the sensitivity of investment to the cost of capital services, the data are not informative enough to provide a precise value for this parameter. With the correctly measured value of the user cost of capital, the maximum likelihood estimate of the substitution elasticity is 0.9 but the reduction in the sum of squared residuals to 112.2 is trivial.[65]

Further tests of the cost-sensitivity assumption can in principle be achieved by allowing separate elasticities with respect to the different components of the cost of capital services. In place of equation (20), the more general specification is:

$$K_t^* = Q_t \left[\frac{p}{p_I}\right]^{-\sigma_1} \left[\frac{d+R}{1-\tau}\right]^{-\sigma_2} (1 - Z - X)^{-\sigma_3} \tag{24}$$

Instead of trying to estimate all these elasticities, three different forms of (24) were tried. The first constrains $\sigma_1 = 1$. The resulting estimates for $\sigma_2$ and $\sigma_3$ were 1.8 and 3.2, respectively, but the reduction in the sum of squared residuals to 100.4 from 112.3 in the Cobb-Douglas case is not significant. The second specification, which constrains $\sigma_1 = \sigma_3$, implies

64. In both the Cobb-Douglas and accelerator specifications, the estimated value of the depreciation rate (i.e., the coefficient of the lagged capital stock variable) is approximately 0.18, a reasonable value for equipment capital although higher than the value of 0.138 used in the cost of capital services formula and the Department of Commerce depreciation rate.

65. The value of 0.9 is obtained by searching over a grid at intervals of 0.1. It is worth noting that a mismeasurement of the cost of capital series distorts the estimate of the elasticity of substitution. Using the incorrect c/p series of column 8 leads to an estimated elasticity of substitution of 0.6. The reduction in the sum of squared residuals to 157.4 (from 167.4 in the Cobb-Douglas case) is, however, small and not statistically significant.

estimates of $\sigma_2 = 0.6$ and $\sigma_1 = \sigma_3 = 1$ but the sum of squared residuals (106.6) is again not significantly lower than in the Cobb-Douglas specification. Finally, the constraint that $\sigma_1 = \sigma_2$ implies estimates of $\sigma_1 = \sigma_2 = 0.5$ and $\sigma_3 = 1.0$; the sum of squared residuals of 97.0 is again not sufficiently low to cause a rejection of the Cobb-Douglas assumption.

The Chow test for the stability of the coefficients easily sustains the hypothesis of no change between the first and second halves of the sample, but that is more a reflection of the small sample than of any close agreement in parameter values.

It should be clear from the remarks earlier in this paper that I believe that the assumptions involved in the present model are far too restrictive and implausible for the model to be regarded as "true" in any sense. It is, however, of some importance that, even within the highly constrained assumptions of the present model, the data provide clear support for a responsiveness of investment to changes in a correctly measured cost of capital services in general and to the changes caused by inflation in particular. Although the data are not rich enough to provide precise estimates of the responsiveness of investment to the individual components of the cost of capital, it is worth noting that the evidence shows that a correct accounting of the impact of inflation substantially improves the ability of the analysis to explain the variation in investment over the past 25 years.

On the assumption of a Cobb-Douglas technology, the fall in the relative cost of capital services between the mid-1950s and the mid-1960s was enough to raise the desired ratio of equipment capital to output by nearly 12 percent.[66] Since net equipment investment averaged only about 3 percent of the equipment capital stock at the beginning of the period, the desired increase in capital would require a rise of more than 40 percent in the ratio of equipment investment to capital to achieve the desired capital output ratio within a decade and a bigger rise to achieve the adjustment sooner. In fact, the investment-capital ratio in 1966–69 was 0.065, more than double its average in 1956–65.

The subsequent rise in the value of $c/p$ to an average of 0.235 for the years 1974–77 reversed the previous change in the desired capital-output ratio. A Cobb-Douglas technology implies a reduction in the desired capital-output ratio of nearly 10 percent between the mid-1960s and the mid-1970s. Achieving this 10 percent change in the capital-output ratio required a much larger portional fall in investment during the transition period. In fact, the rate of growth of the net equipment capital stock fell sharply, from 0.065 in 1966–69 to 0.036 in 1976–79. This in turn implied a

66. The value of c/p in column 7 of table 14.5 fell from an average of 0.238 in 1954–57 to 0.213 in 1964–67. The Cobb-Douglas technology implies (see equation 20) that the optimal capital-output ratio is increased by a factor of 238/213 = 1.117.

one-third fall in the ratio of equipment investment to GNP, from 2.0 in the mid-1960s to 1.3 percent in the mid-1970s.

The specific impact of inflation in this model operates through two channels. First, inflation increases the cost of capital services by reducing the present value of depreciation allowances ($Z$), a reduction that reflects the increasing *nominal* cost of funds. Second, inflation can increase the cost of capital services directly by raising the real cost of funds ($R$).[67] The combined effect of both of these changes can be seen by comparing the actual cost of capital services (column 7 of table 14.5) with the cost of capital services calculated with the real and nominal costs of funds held constant at their 1965 levels (column 9). Instead of rising between the mid-1960s and the mid-1970s, the cost of capital falls sharply, reflecting the favorable changes in statutory tax rules. A similar, although less dramatic, conclusion appears even if the effect of inflation in raising the real cost of funds is ignored. The figures in column 10 calculate $Z$ by using a nominal cost of funds constructed as the actual real cost of funds plus the 1965 expected inflation rate of 1.8 percent. Although the difference between columns 7 and 10 understates the adverse effect of inflation, even this measure shows that without the increase in inflation the incentive to investment would have become stronger rather than weaker in the decade after the mid-1960s.

## 14.6 Concluding Remarks

I began this paper by emphasizing that theoretical models of macroeconomic equilibrium should specify explicitly the role of distortionary taxes, especially taxes on capital income. The failure to include such tax rules can have dramatic and misleading effects on the qualitative as well as the quantitative properties of macroeconomic theories. The statistical evidence presented later in the paper bears out the likely importance of these fiscal effects in studying the nonneutrality of expected inflation.

In discussing the problem of statistical inference, I noted that the complexity of economic problems, the inadequacies of economic data, and the weakness of the restrictions imposed by general economic theory together make it impossible to apply in practice the textbook injunction to estimate a "true" model within which all parameter values can be inferred and all hypotheses tested. Learning in economics is a more complex and imperfectly understood process in which we develop judgments and convictions by combining econometric estimates, theoretical insights and institutional knowledge. The use of several alternative "false" models can strengthen our understanding and confidence because the *same* biases are not likely to be present in quite different models.

67. Inflation raises $R$ to the extent that the required equity yield rises by more than the real cost of debt capital falls.

This view of the problem of statistical inference in econometrics leads me to conclude that as practicing econometricians we should be both more humble and more optimistic than is currently fashionable. We should have the humility to recognize that each econometric study is just another piece of information about a complex subject rather than *the* definitive estimate of some true model. But we should also be more optimistic that the accumulating and sifting of this econometric information will permit specialists to make better and more informed judgments.

I illustrated these theoretical and statistical ideas by estimating alternative models of investment behavior with a focus on understanding how the interaction between inflation and existing tax rules has influenced investment behavior. The results of each of these models show that the rising rate of inflation has, because of the structure of existing U.S. tax rules, substantially discouraged investment in the past 15 years.

A more general implication of these results is that monetary policy is far from neutral with respect to economic activity, even in the long run when the induced change in inflation is fully anticipated. Because of the nonindexed fiscal structure, even a fully anticipated rate of inflation causes a misallocation of resources in general and a distortion of resources away from investment in plant and equipment in particular.[68] The traditional idea of "easy money to encourage investment" that has guided U.S. policy for the past 20 years has backfired and, by raising the rate of inflation, has actually caused a reduction in investment.[69]

It would, of course, be useful to extend the current analysis in a number of ways. I am currently examining how the interaction of inflation and tax rules affects the demand for consumption in general and for housing capital in particular. Further studies should be done on the effects of inflation and tax rules on the demand for government debt, on financial markets, and on international capital flows.[70] More information about investment behavior could be developed by applying the three models of the current paper on a more disaggregated basis.

I began this paper by commenting that Irving Fisher's analysis of inflation had ignored the effects of taxation. Even so, Fisher favored the very tax reform that would eliminate the distorting effects of inflation on

68. This conclusion stands in sharp contrast to the early view of Hayek and others that inflation encourages investment by raising profits or the appearance of profits. That view not only ignored fiscal effects but also was essentially a short-run theory since wages and other costs, as well as expectations, would naturally adjust to inflation.

69. On the role of the fiscal structure in the mismanagement of monetary policy, see Feldstein (1980*a*).

70. Poterba (1980) and Summers (1980*a*) discuss the theoretical impact of inflation on the demand for housing capital. Hartman (1979) presents an analysis of the effect on international capital flows and Feldstein (1980c; chap. 5 above) treats the demand for government debt. Empirical applications are, however, still lacking.

the taxation of capital income. In a lecture published in the January 1937 issue of *Econometrica* entitled "Income in Theory and Income Taxation in Practice," Fisher advocated a progressive expenditure or consumption tax. Although his reasons for preferring such a tax did not include its inflation neutrality, my remarks today give a further reason for thinking that Fisher was right.