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Net Investment and Disaggregated Investment Demand Functions

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ABSTRACT

Few topics in the field of economics have been as extensively researched as private business fixed investment. This paper examines investment using regression analysis and descriptive statistics. This study focuses on investment in structures and investment, with these two broad categories ultimately being further disaggregated into eleven relatively narrow categories.

The approach to modeling investment taken in this paper differs from the approach typically seen in economic literature in three important ways: this paper models net, rather than gross, investment; this paper uses a broad general econometric model, rather than a narrow theoretical model like the majority of papers modeling investment; and this paper looks at investment at a much more disaggregated level than is usually seen in econometric studies of investment.

The results presented here indicate that disaggregation, a generalized model, and the use of net investment as a dependent variable can produce superior econometric models of investment behavior.

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Introduction

One of the most examined topics in economics, and justifiably so, is private domestic investment spending. A valid starting point for a discussion of investment may simply be to define what is meant by *investment* in the context of economics. In common usage, *investment* refers to the purchase of assets in two broad categories. In finance, *investment* may refer to the purchase of financial assets, such as stocks and bonds. *Investment* may also refer to the purchase of real assets and capital goods, such as plant and equipment. However, in economics, *investment* generally refers to the purchase of new real assets and capital goods exclusively. Asset transfer, the sale of preexisting assets, and the purchase of financial assets are excluded from this definition of investment (Davidson 1994). This definition of investment can be disaggregated into three broad categories: residential investment, inventory investment, and business fixed investment. The focus of this study will be exclusively on business fixed investment.

Business fixed investment represents about three-quarters of investment spending and is of tremendous interest to economists and policymakers for two key reasons. First, business fixed investment is generally considered to be one of the most volatile components of current aggregate demand, with some economists arguing that fluctuations in the determinants of investment are the main sources of cyclical instability in the economy (Gordon 1955). Second, business fixed investment plays a significant role in determining the future growth of real income. Business fixed investment can increase the capacity of firms to provide goods and services, which, in turn, increases growth in output.

Business fixed investment consists of the structures and equipment that firms purchase in order to produce goods and services (Mankiw 2003; Froyen 2005). Business fixed investment can be disaggregated into non-residential structures and equipment. For the purposes of this paper, structures and equipment will be further disaggregated. Nonresidential structures can be disaggregated into five categories: manufacturing, utilities, mining, commercial, and other nonresidential structures. Equipment business investment can be disaggregated into investment in: information-processing, industrial, transportation, and other equipment. In this study, computers and software, both components of information-processing equipment, will also be examined.

Econometric studies have seldom examined investment at such a disaggregated level. It is hoped that this study will produce some valuable information on the determinants of each component of disaggregated business fixed investment, as well provide some useful insights into how each disaggregated component affects the overall demand for investment. This study will begin with a brief review of some of the economic literature available on private domestic investment. The study will then specify a series of equations used to estimate disaggregated business fixed investment.

There are advantages and disadvantages to adopting this disaggregated approach. Stacey Tevlin and Karl Whelan (2003) adopted a disaggregated approach in their article "Explaining the Investment Boom of the 1990s." The article describes how the results of econometric studies conducted since the investment boom of the 1990s suggest that the old aggregated approach to business fixed investment no longer produces especially efficient results. It is suggested that much of this loss of efficiency in aggregated models was due to the rapid increase of computers and software as components of aggregate business fixed investment since computers depreciate faster and are more sensitive to interest rates than most types of business investment. Tevlin and Whelan were able to produce more effective results by separating investment into computers and noncomputers. The disaggregation appeared to address the distortions caused by the special circumstances surrounding computers. This paper will test to see what new insights into the demand for investment can be gained by applying a disaggregated approach to all of business fixed investment.

However, there are potential pitfalls to the disaggregated approach. Investment can be split into two broad categories: structures and equipment. It is a logical assumption that structures and equipment are strongly interdependent. Firms construct new buildings with the intention of filling them with new equipment (Greenspan 1979). From this viewpoint, disaggregation may result in the loss of information and effectiveness.

This study will attempt to create an effective model of disaggregated investment by combining elements of the most widely accepted theoretical investment models. A somewhat similar approach was taken by Fazzari, Hubbard, and Petersen, who combined the securities value model with the cash flow accelerator model to achieve some impressive insights into the behavior of manufacturing firms (1988). However, this paper will expand that approach to consider several major theoretical models. Additionally, the unemployment rate and the relative price of investment, two potentially important variables not usually included in theoretical investment models, will also be examined.

Literature Review

Five Theoretical Models

This project will estimate a series of equations for disaggregated business fixed investment using OLS models using quarterly U.S. data. The time series models used in this paper are not dependent on any single explicit theory of investment. However, a review of the major theoretical models provided a starting point for the final disaggregated time series equations used in this project.

Despite the extensive research dedicated to business fixed investment, surprisingly little consensus has developed on what determinants and models best explain fluctuations in business fixed investment. No one model of investment behavior has been able to establish itself as the definitive choice of economists. There are five major theoretical models of investment behavior: the neoclassical, modified neoclassical, cash flow, securities value (Q), and accelerator. It is agreed that all models of investment are based on the assumption that firms invest with the intention of gaining increased profits. However, to quote Richard Kopcke: "…the models express this common theme in distinctive ways as they describe the influence of economic conditions on investors' perceptions of future profits and, in turn, on their demand for capital goods" (2001).

The relatively simple accelerator model can trace its origins back to J. Maurice Clark's 1917 article, "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles." The original accelerator model theorized that a linear relationship exists between output growth and investment (1917).

The key assumption of the basic accelerator model is that the desired capital stock is a fixed multiple of output. This can be represented by the equation, 1.) $K^d = \alpha Y$

where K^d is the desired capital stock, or the capital stock that firms would choose given instantaneous adjustment and fixed prices, Y is output, and α is a constant (Clark 1917; Bischoff 1971; Clark 1979; Kopcke and Brauman 2001). In the simplest form of this model, output cannot be increased by substituting labor for capital, and both inputs would need to be increased together. If a firm believes profits can be gained by increasing output, it is necessary for the firm to increase its capital stock. In the accelerator model, firms are assumed to base their expectations of future demand and profits on past output.

The accelerator model has been extensively modified and refined since its introduction in 1917, and the generalized accelerator model, which allows for a more gradual adjustment of the capital stock to changes in output, is now more commonly presented in economic literature than the original accelerator. The generalized accelerator explains investment as a distributed lag relationship involving output and the capital stock.

The lagged capital stock is often included as an explanatory variable in the generalized accelerator models. The inclusion of the lagged capital stock serves two purposes. First, the lagged capital stock captures the difference between the existing capital stock and the desired capital stock. Additionally, the lagged capital stock captures the level of investment required to replace capital lost via deprecation so that firms maintain their existing capital stock (Kopcke 2001). This second role for the capital stock variable results from the traditional approach of estimating investment functions using gross investment, which includes depreciation, rather than net investment, which does not.

Closely related to the accelerator model is the accelerator-cash flow model of investment behavior. The accelerator-cash flow model adds a profits term to the accelerator model. Past and present profits provide information on possible future profits. Firms are assumed to base their investment decisions on the expectations of future profits. Additionally, investment programs paid for with retained earnings are not subject to the difficulties and expenses associated with acquiring outside financing (Bischoff 1971; Clark 1979). However, some have suggested that profits serve only as a proxy for variables that measure the market value of the firm (Griliches 1965).

A common criticism of the accelerator and cash flow models is that they do not take into account the cost of capital. Dale Jorgenson addressed this by suggesting a model of investment behavior based on the neoclassical theory of capital accumulation. The neoclassical theory of capital accumulation states that the demand for capital is determined to maximize net worth. It must be emphasized that the demand for capital is not the same as the demand for investment. However, the neoclassical model suggests that it is possible to derive the short run demand for investment from lagged changes in the demand for capital (Jorgenson 1963).

The neoclassical model is essentially a variation of the generalized accelerator model. In the accelerator model, the capital stock is assumed to be proportional to output. However, the neoclassical model assumes that firms use profit maximization to determine their optimal capital stock. The optimal capital stock is a ratio of output to the cost of capital. Given a certain level of output, firms will choose an optimal stock of capital that will allow them to minimize the cost of production. The neoclassical model allows the relative price of inputs to change, which will lead to the substitution of inputs.

The neoclassical model attempts to capture the effects on the demand for investment of the cost of capital as well as the return on capital. The neoclassical model assumes that the optimal capital stock is a function of output, the price of output, and the user cost of capital. The user cost of capital measure used by Jorgenson was defined as a function of the relative price of capital goods, the depreciation rate, interest rates, taxes, and the proportion of the cost of capital deductible from income for tax purposes (Jorgenson 1963; Jorgenson, Hunter, and Nadiri 1970; Griliches and Wallace 1965).[1]

Charles Bischoff suggested using a "putty-clay" production function to modify the neoclassical model. Bischoff suggested this modification to account for the empirical observation that most adjustments in the capital-output ratio are the result of the addition of capital. The modified neoclassical model assumes that firms adjust toward a desired level of production, rather than an optimal capital stock. The modified neoclassical model assumes that when input prices change, only new capital is affected. The factor intensity (labor to capital ratio) of existing capital is not affected by changes in factor prices. The modified neoclassical model assumes that the factor intensity of a capital unit cannot be adjusted after completion (Bischoff 1971; Ando, Modiglinai, Rasche, and Turnovsky; Oliner, Rudebush, and Sichel 1995).

Unlike the accelerator and neoclassical models, the securities value model does not attempt to explain business investment behavior by examining output. The securities value model suggests that financial considerations are the main determinant of business fixed investment. James Tobin, an important proponent of the securities value model,

[1] Jorgenson used fixed interest rates in his calculation of the cost of capital.

wrote that “the principal way in which financial policies and events affect aggregate demand is by changing the valuations of physical assets relative to their replacement costs (1968, 29).”

In securities value models, the demand for business fixed investment is often assumed to be the ratio of the market value of the firm to the replacement cost of the firm’s capital assets. As a consequence, demand for business fixed investment and this ratio vary together. If the market value of the firm is held constant and the replacement cost of the firm’s capital assets decreases, the ratio and the demand for business fixed investment will increase. When the ratio, or Q, is above unity, investment spending will increase. However, if Q is below unity, investment spending will decline (Tobin 1969, 1982; Kopcke 2001).

There are several possible drawbacks to employing the securities value model of business fixed investment. It is necessary to distinguish between a firm’s physical and nonphysical assets, and this can be very difficult to complete in a satisfactory way. Nonphysical assets would include intellectual property rights, firm reputation, and possibly monopoly power. Nonphysical assets often cannot easily be assigned definite cash values or useful lifespans. Additionally, the capital stock is hardly homogenous, and the estimated replacement cost and the actual replacement cost of existing physical assets may differ greatly.

Another problem is presented by the lack of information about the marginal effects of business fixed investment on the market value of the firm. This is unfortunate because rational firms are assumed to base their investment decisions on marginal considerations. Often the best that can be done is to use an average ratio of the market value of the firm to the replacement cost of its physical assets (Bischoff 1971; Clark 1979; Kopcke and Brauman 2001).

Overview of Prior Empirical Results.

Table 1.

Statistics for Bischoff (1971); Clark (1979); and Kopcke and Brauman (2001).

	Equipment		**Structures**	
	Standard Error of the Estimate	**Root Mean Squared Error**	**Standard Error of the Estimate**	**Root Mean Squared Error**
Bischoff (1971): Reported in Billions of 1958 Dollars				
Accelerator	956(3)	-	553(5)	-
Cash-Flow	841(2)	-	515(2)	-
Neoclassical	995(4)	-	551(4)	-
Modified Neoclassical	800(1)	-	459(1)	-
Securities Value	1016(5)	-	540(3)	-
Clark (1979): Reported in Percent of Potential GNP				
Accelerator	0.23(2,3)	-	0.19(3)	-
Cash-Flow	0.23(2,3)	-	0.18(2)	-
Neoclassical	0.3(4)	-	0.26(4)	-
Modified Neoclassical	0.19(1)	-	0.13(1)	-
Securities Value	1.5(5)	-	0.81(5)	-
Kopcke-Brauman (2001): Reported in Percent				
Accelerator	-	0.32(3)	-	0.13(6)
Cash-Flow	-	0.41(6)	-	0.12(3,4,5)
Neoclassical	-	0.4(5)	-	0.12(3,4,5)
Modified Neoclassical	-	0.31(2)	-	0.1(2)
Securities Value	-	0.35(4)	-	0.12(3,4,5)
Time Series	-	0.07(1)	-	0.04(1)

Note: rankings from best (1) to worst shown in ( ).

There have been several studies that attempted to determine which theoretical model best explains business fixed investment by estimating the five theoretical models over a common time period with a common data set. Studies along these lines by

Kopcke and Brauman (2001), Clark (1979), and Bischoff (1971) are of particular interest. Kopcke and Brauman used quarterly investment data for disaggregated investment into equipment and nonresidential structures over a sample period from 1961 to 1990. Clark used quarterly data for durable equipment and nonresidential structures from 1954 to 1973. Bischoff employed quarterly data for construction and equipment expenditures for a period between 1953 and 1968.

The relative efficiency of the theoretical models in explaining investment can perhaps be gauged by ranking the regressions by the standard error of the estimate.[2] These are reported in Table 1. All three papers found the modified neoclassical model to be the most effective in explaining investment in both equipment and structures.[3] Kopcke and Brauman's neoclassical model is relatively ineffective in explaining structures and is very ineffective for equipment. Clark and Bischoff's neoclassical models produced similar results.

After the modified neoclassical model, Clark found the accelerator and cash flow models to be the most effective models.[4] There is little difference in efficiency between Clark's accelerator and cash flow regressions for equipment, and the accelerator cash flow is only marginally more effective than the simple accelerator for structures. Bischoff found the cash flow model to be slightly more effective than the accelerator for both construction and equipment expenditures. The cash flow model performs about the same as the neoclassical model for structures. The simple accelerator is only slightly less

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[2] Kopcke and Brauman's results are ranked using the root mean squared error.

[3] Bischoff was one of the first to suggest a modified neoclassical model. Bischoff refers to a Federal Reserve-MIT-Penn model. Later authors adopted the designation of modified neoclassical model.

[4] It may be worth noting that Clark considered the modified neoclassical and simple accelerator models to be the most promising in explaining business fixed investment.

effective, although this still makes it the least effective of Kopcke and Brauman's models for structures. The simple accelerator is relatively effective in Kopcke and Brauman's equipment regression, second among the theoretical models only to the modified neoclassical model. However, the cash flow model performs very poorly in Kopcke and Brauman's equipment regression and is their least effective model for explaining equipment.

On average, the securities value models performed poorly for both equipment and structures for Clark, Bischoff, and Kopcke and Brauman. Clark's securities value model produced especially poor results for both equipment and structures. The standard error of the estimate for Clark's securities value equipment regression was five times as large as the standard error of the estimate for the neoclassical equipment equation and almost eight times that of the modified neoclassical equipment equation.

Kopcke and Brauman discussed how well the results of their regressions fit the actual data. They found the modified neoclassical model to be a relatively good fit for investment in equipment and software, as well as nonresidential structures. Kopcke and Brauman found their simple accelerator model explained only slightly less variation than the modified neoclassical model for investment in equipment and software, but found it to be a very poor fit for the nonresidential structures data.

Kopcke and Brauman found that the securities value model fit the data for equipment and software investment less well than the modified neoclassical and simple accelerator models but better than the cash flow or classical models. The Q model, like most of the theoretical models examined by Kopcke and Brauman, was considerably less effective in explaining variation in nonresidential structures.[5]

Kopcke and Brauman presented mixed results for the cash flow model. Of the theoretical models, it explained the least amount of variation for investment in equipment and software. However, the cash flow model was second only to the modified neoclassical model in explaining nonresidential structures investment.

In addition to the five theoretical models, Kopcke and Brauman estimate a non-theoretical, time series equation for both equipment and structures. The time series equation performs remarkably well when compared to the five theoretical models. The time series regression explained almost all of the variation in both structures and equipment, with the peaks and troughs for the fitted values leading actual investment by about one quarter.[6] For Kopcke and Brauman's equipment and software regressions, the root mean squared error for the neoclassical model, their most effective theoretical model, is nearly four times that of the time series regression.

An Integrated Model of Investment

Based on discussions of prior theoretical models of investment, this study seeks to combine key elements of these competing models into an integrated model of investment. A similar approach was used by Fazzari, Hubbard, and Petersen (1988), who were able to address some of the weaknesses of the securities values, accelerator, and cash flow models by combining them to produce some very impressive results.

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[5] The amount of insight that can be taken from the q model and used in the specification of a forecasting model may unfortunately be limited. While creating a forecast of investment is not a goal of this project, it is hoped that the end equations will be appropriate for such an endeavor. The difficulties associated with predicting the stock market, a key determinant of q in many models, exceed those of investment (Kopcke and Brauman 2001).

[6] It should be understood that if the data is not shown to be stationary for a time series regression, then the possibility of a spurious regression cannot be eliminated, and causality cannot be definitively established.

Additionally, this study seeks to address the observation that the composition of investment has changed considerably over the past several years. The effects of increased investment in rapidly depreciating equipment, like computers, may require an alteration in the usual modeling approach. In the past, researchers split business fixed investment into structures and equipment in the belief that the differences in those variables had become irreconcilable. Due to the changing technologies and conditions firms have faced in recent years, it may now be desirable to adopt an even more disaggregated approach to modeling business fixed investment (Kopcke and Brauman 2001; Tevlin and Whelan 2003).

Output, Cash Flow and Investment

Basic economic theory suggests that output should be included in any practical model of investment demand. With the exception of the securities value model, all of the theoretical models discussed above include either output or profits as possible determinants of investment. Output possibly affects investment in two ways. Firms base their investment plans on their expectations of future profits, and firms often base their expectations of future profits on past output. If firms expect continued output growth based on past output growth, the demand for investment should also increase based on the accelerator model of investment.

Output can also provide a measure of internally generated funds available to the firm for investment programs. When there exists asymmetrical information, firms that are able to pay for new capital purchases with retained earnings effectively face a lower price of capital than firms that must borrow to purchase capital (Fazzari, Hubbard, and

Petersen 1988). If asymmetrical information exists, then growth in profits or output may result in an increased demand for business fixed investment.

Tobin's Q

Attempts to test the securities values model usually employ some variation of Tobin's Q variable. Tobin's Q is usually defined as the ratio of the nominal value of equities to the price of the capital stock. Tobin's Q provides an indicator of how the required rate of return for an investment project compares to the actual rate of return for an investment project. When the ratio is greater than unity, firms will be encouraged to invest in capital. However, when Tobin's Q is less than one, firms will be less likely to invest.

Interest Rates, Taxes, Inflation, and Investment

The inclusion of interest rates, as well as taxes, as determinants in models of investment "is based on the plausible argument that business(men) in pursuit of gain will find the purchase of capital goods more attractive if they cost less" (Hall and Jorgenson 1967, 391). The real rate of interest is one of the most commonly cited determinants of business fixed investment. The Keynesian investment demand schedule suggested that investment demand would have a negative relationship to interest rates, other things equal. Keynes suggested that the demand for investment would increase or decrease in such a way that the marginal efficiency of capital would stay equal to the real rate of interest (Keynes 1991). Put simply, as interest rates rise, the demand for business fixed investment declines, all other things equal, and vice versa.

Most observers would agree that the real interest rate is an important measure of the cost of capital and the discount rate for future returns (Bernanke 1983). Given the theoretical importance of the interest rate, it is somewhat surprising that relatively few researchers have examined the direct effect of interest rates on investment demand. This is not to say researchers have ignored the importance of interest rates in determining investment demand; rather, they have adopted an approach of including the interest rates in aggregate measures of the cost of capital. The cost of capital variable used by Jorgenson in his neoclassical model and Tobin's Q variable are both functions of the real interest rate (Jorgenson 1963; Tobin 1969).

In the article "The Determinants of Investment," Griliches and Wallace found the interest rate to have a significant independent effect on investment (1965).[7] Agnar Sandmo (1971) and Ben S. Bernanke (1983) were also able to show that the real interest rate was a significant determinant of investment.[8] Other researchers have placed a particular emphasis on the importance of the interest rate in determining the rate at which firms invest in new technologies (Ando, Modigliani, Rasche, and Turnovsky 1974).

Like interest rates, taxes affect investment mainly through the cost of capital. Taxes have often been treated as a component of a cost of capital variable, rather than examining taxes for an independent effect on investment demand. Tax policy relating to investment generally takes three forms: the corporate income tax, investment tax credits, and the rate of depreciation allowed for tax purposes. A change in any of these three factors will change the desired level of capital stock, and firms can be expected to

[7] Griliches and Wallace noted that their results resembled those of Jorgenson's neoclassical model, and that the main difference between the models was that the determinants of Jorgenson's cost of capital variable, including the interest rate, were treated as separate independent variables in their paper. Griliches and Wallace used an average AAA bond rate. (1965).
[8] Sandmo suggested that in the short run, when the capital stock is fixed, the interest rate has a real effect on investment. However, Sandmo draws the rather less conventional conclusion that there is no stable long run relationship between interest rates and investment (1971).

increase, or decrease, their rate of investment (Hall and Jorgenson 1967; Kopcke 1981; Bosworth 1984).

If tax rates are increased, the cost of capital will increase and firms will be discouraged from investing in projects with relatively low rates of return. The reverse is true if tax rates are decreased. The cost of capital will be reduced, and increased investment will be encouraged. The allowance of investment tax credits or increases in the rate of depreciation have the effect of reducing the cost of capital and stimulating investment.

Many studies considering the effect of inflation on private fixed investment take the view that by increasing uncertainty, increases in the rate of inflation will drive down the demand for private fixed investment (Kopcke 1981; Ando, Modigliani, Rasche, Tunovsky 1974). However, Bosworth (1984) adopts the opposite position that increases in the rate of inflation may result in increased demand for private fixed investment. Since inflation reduces the real value that must be paid back for investment goods purchased on credit, inflation effectively reduces the cost of capital.

Distributed Lags

A complicating factor in any econometric study of investment behavior is inertia. It is often estimated that two to three years, or equivalently eight to twelve quarters, may pass between an event prompting firms to increase their demand for investment and the effects of this increase becoming apparent in aggregate GDP. This can create serious problems for researchers attempting to explain investment behavior with regression analysis. There are several possible reasons for the relatively slow response of aggregate investment to changes in its determinants.

The permanent income hypothesis provides one possible explanation for the apparent sluggish response of business fixed investment to changes in economic variables. The permanent income hypothesis suggests that the cautious managers and directors of firms will not alter their investment plans until they are certain that the new conditions created by changes in the determinants of investment are a new equilibrium and not simply short run fluctuations in demand (Eisner 1978). Alternatively, the sluggish response of investment may be attributable to the "adjustment costs" of changing inputs and the related concern about the irreversible nature of the investment due to the lack of a resale market for most used capital (Hubbard 1998).

Nervous corporate officers may adopt a wait-and-see position on whether or not apparent changes in output and demand are indeed permanent. Firms may also attempt to assure themselves that altering their investment behavior is a prudent course of action by commissioning reports and assessments, which the firm's officers must review before deciding to invest or not. The process that firms use to arrive at the decision to invest after the determinants of income change can be quite cumbersome and time-consuming (Hamermesh and Pfann 1996).

Even after a firm decides to invest in a new project, a significant delay may occur between the commissioning of a project and the outlays for the project being reflected in the national accounts. This could be due to the accounting procedures used to calculate business fixed investment in the national accounts. Business fixed investment in the national accounts consists only of finished new real assets and goods. The value of a new asset or good is not factored into aggregate investment until all work has been completed (Mankiw 2003; Froyen 2005). Much business fixed investment, such as the manufacturing of a Boeing 747, can be active for years before they are completed and factored into GDP. However, it should be noted that many structures are counted as inventory in GDP as construction occurs, and then as fixed investment when completed.

The typical econometric solution to this gradual response of investment to economic variables has been the inclusion of distributed lag variables. Many common distributed lag structures assume a lag of long length that requires estimates of different coefficients for each of the lagged periods. However, this can make estimating the lag structure difficult due to the problems of degrees of freedom and of multicollienarity among the lagged values. In her landmark article on manufacturing appropriations, Shirley Almon (1965) developed an alternative distributed lag structure that could greatly reduce the number of coefficients to estimate. To accomplish this, Almon imposed the assumption that the distributed lag coefficients will lie on a polynomial, and coefficients needed to be estimated only to determine the shape of the polynomial weights given to each lagged value. The regressions presented later in this paper will employ Almon distributed lags in order to simplify the equations by limiting the number of explanatory variables appearing in each regression.[9]

There are some potential difficulties associated with using the Almon distributed lag structure. If the lag coefficients do not lay on a polynomial, the key assumption of the Almon lag structure, then the coefficient estimates will be biased and inconsistent, and tests using these estimates maybe invalid (Godfrey 1975). Additionally, it is possible

[9] Peter Schmidt (1974) found it “conceptually difficult, in most applications, to justify a lag of finite length.” Schmidt preferred lag structures that assumes that the influence of particular variable on another variable approaches zero over time, but never actually reaches zero. Schmidt argued that such lag structures also provided an indication of how quickly the influence of a variable fades out, while the influence of one variable over another is simply assumed to be over after a certain point in the Almon specification.

that placing the dependent variable in change form will greatly reduce the need for long distributed lags.

The New Regressions

The General Model

Fazzari, Hubbard, and Petersen (1988) noted that from a theoretical standpoint, the securities value model was a very appealing model, but that other models, including simple accelerator models, tended to produce superior econometric results. However, by combining Tobin's Q with the accelerator and cash flow model, they were able to produce some very impressive results. This paper will attempt a similar approach. Rather than selecting a single theoretical model or estimating all five theoretical models individually, this paper will attempt to combine elements of all of the theoretical models into a single estimating equation.

In addition to the high level of disaggregation and the combining of theoretical models, the approach used in this paper will differ significantly from most prior research in another important way. Due to the easy availability of data on gross investment, investment expenditures are commonly used in econometric research. The dependent variable will be real net investment, not real gross investment as is the case with most investment studies. The use of changes in the real capital stock, or net investment, instead of gross investment expenditures separates expansion of productive equipment and structures from investment to replace existing capital.

In the model used for this study, the dependent variable is in first-difference natural log form. Most of the explanatory variables are also put into logged first-difference form. However, the lagged-levels forms of the same explanatory variables are also included in the regression. A key benefit of employing this structure is that it makes it possible to examine the effects of both the short run dynamics and long run relationships between the dependent and explanatory variables. The first-difference form of the explanatory variables captures the short run dynamics of investment behavior, while the lagged-levels capture the long run impacts (Salmon 1982; Engle and Granger 1987).[10]

All change form variables are initially estimated with four quarterly lags. The current values for most of the explanatory variables were excluded. This is partially due to econometric concerns about simultaneity and partially due to the theoretical assumption of decision lags.

Given the relatively large number of equations that will be examined in this paper, only a general estimating equation is presented. Appropriate variables will be substituted into the actual equations for the specific capital stock equations. The general estimating equation is presented in Equation 2.

2.) $DLOG(K\$x) = \beta_0 + \beta_1 DLOG(K\$x_{t-1}) + \beta_2 D(CORPTAX_{t-1}) + \beta_3 DLOG(GDP_{t-1} / K\$x_{t-1}) + \beta_4 DLOG(DPROFITS_{t-1} / K\$x_{t-1}) + \beta_5 D(RDIF_{t-1}) + \beta_6 DLOG(INF_{t-1}) + \beta_7 DLOG(TQ_{t-1}) + \beta_8 DLOG(RPx_t) + \beta_9 D(UR_t) + \beta_{10} LOG(GDP_{-1} / K\$x_{t-1}) + \beta_{11} LOG(PROFIT_{-1} / K\$x_{-1}) + \beta_{12} (RDIF_{-1}) + \beta_{13}(INF_{-1}) + \beta_{14} LOG(TQ_{-1}) + \beta_{15} LOG(RPx_{-1}) + \beta_{16}(UR_{-1}) + \beta_{17}(CORPTAX_{-1}) + \beta_{18} (ITC_{-1}) + \mu_t$[11]

For each equation, the dependent variable will be a component of the natural log change in the real capital stock (K$x). The lagged dependent variable will be included in each equation as an explanatory variable. The lagged dependent variable shows

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[10] This model bears some passing similarities to the two-step error correction model, and it may be argued that a two-step error correction model would be a more effective model. However, explicit error values cannot be known in the forecasting context, precluding the use of the two-step error correction model.

[11] For explanatory variables as "x" within a variable name indicates the same industry as shown for the dependent variable. For example, LOG(RPx) in the LOG(K$E) equation signifies the relative price of equipment. Explanatory variables with the -1 subscript are lagged one quarter.

adjustments to past changes in explanatory variables not captured in the lags of the explanatory variables. The lagged dependent variable is expected to have a positive coefficient in the regressions reflecting the time lags inherent in many investment projects. This approach should greatly reduce the potential need to include extensive values of lagged explanatory variables.

The ratio of real GDP to the real capital stock should capture the accelerator effect (Clark 1917; Bischoff 1971; Clark 1979; Kopcke and Brauman 2001). The coefficient of the real GDP to real capital stock ratio is expected to be positive (GDP / K$x).

The cash flow model indicates that the inclusion of a profits variable may provide valuable insight into investment behavior (Bischoff 1971; Clark 1979). Since net investment is the dependent variable, real after tax corporate profits can be used to capture the effects of cash flow on investment. In most equations, real after tax domestic corporate profits (DPROFIT) is used as an explanatory variable. However, for some investment categories, such as industrial equipment, where profits of financial firms are unlikely to have any significant effect, real after tax nonfinancial corporate profits (NFPROFIT) are substituted into the equation. The coefficient of the real domestic profits to real capital stock ratio is also expected to be positive ($DPROFIT_{-1}$ / K$x).

The cost of capital, a key characteristic of neoclassical models, is usually treated as a function of taxes and interest rates (Jorgenson 1963; Jorgenson, Hunter, and Nadiri 1970).[12] Rather than follow the traditional approach of using an aggregate measure of the cost of capital variable, this study will follow the example of Griliches and Wallace (1965) and treat the determinants of the cost of capital as independent variables in the investment function. The interest rate differential (RDIF) is calculated as the difference

[12] Jorgenson used fixed interest rates in his calculation of the cost of capital.

between a real long-term interest rate and a real short-term interest rate, in this case the real BAA bond rate and the real Federal Funds Rate. The interest rate differential captures the spread between long-term and short-term interest rates, which indicates the credit conditions in the market. The sign of the coefficient for the interest differential can be either positive or negative. A positive coefficient indicates that the investment category is responsive when long-term rates are high relative to short-term rates, indicating responsiveness to loose credit conditions. A negative coefficient for the interest rate differential indicates that the investment category is most responsive to long-term rates, indicating sensitivity to tight credit conditions.

The corporate income tax (CORPTAX) should have a negative coefficient. The investment tax credit (ITC) is expected to have a positive effect on investment in equipment. However, by making equipment relatively cheaper, the investment tax credit may have a negative effect on investment in structures. The statutory rates are used for the investment tax credit and the corporate tax rate. Increases in the inflation rate (INF) are assumed to have a positive effect on private fixed investment. A high rate of inflation has the effect of lowering the real cost of goods that are purchased on credit (Bosworth 1984).

Proponents of the securities value model argue that financial considerations are the main determinant of business fixed investment. Tobin's Q (TQ) is expected to have a positive effect on investment. Tobin's Q is calculated as the ratio of the market value of outstanding equities to the net worth of nonfarm, nonfinancial corporate business.

Although they are seldom included in purely theoretical models, it seems reasonable to assume that the relative price of an investment category (RPx) and the unemployment rate (UR) are important determinants of investment. The relative price of an investment component is the ratio of the price index for a particular investment category to the price index for total GDP. The coefficient for the relative price is assumed to be negative. If the relative price of a particular investment good increases, then that good has become relatively more expensive, discouraging investment in that sector. If the relative price declines, however, that particular good has become relatively less expensive, encouraging investment. The unemployment rate should capture the effect of business cycles on investment. While some cyclical impacts are captured by the ratio of real GDP and real profits to capital, there may be trends in these ratios that make them less reliable indicators of cyclical activity than the UR. The coefficient for the unemployment rate is expected to be negative.

There are a number of potential pitfalls in the OLS model. Autocorrelation can be a significant concern in many OLS regressions but is often not a problem with equations estimated in change form. A possibly more significant concern is multicollinearity for both levels and change form over time. Multicollinearity may result in standard errors being overestimated and in some highly correlated explanatory variables being incorrectly dropped from the model. OLS models may also be adversely affected by simultaneity and reverse causality.

Table 2.

Correlation Matrix: Equipment Capital Stock. 1959q1-2005q4.[13]

	D(CORPTAX)	DLOG(DPROFITS/K$E)	DLOG(GDP/K$E)	D(INF)	DLOG(RPE)	DLOG(TQ)	D(UR)	D(RDIF)
D(CORPTAX)	1							
DLOG(DPROFITS/K$E)	-0.02(0.74)	1						
DLOG(GDP/K$E)	0.003(0.96)	0.62(0.00)	1					
D(INF)	-0.015 (0.83)	0.02(0.78)	-0.12(0.10)	1				
DLOG(RPE)	-0.06(0.43)	-0.06(0.39)	-0.15(0.03)		1			
DLOG(TQ)	-0.131(0.07)	0.10(0.16)	0.10(0.18)	-0.076*(0.29)	0.05(0.51)	1		
D(UR)	-0.018 (0.45)	-0.36(0.00)	-0.56(0.00)	-0.103 (0.27)	0.33(0.00)	0.112 (0.41)	1	
D(RDIF)	-0.02 (0.78)	-0.18(0.01)	-0.25(0.00)	-0.047 (0.51)	0.21(0.00)	0.033 (0.64)	0.472 (0.00)	1

Table 3.

Correlation Matrix: Structures Capital Stock. 1959q1-2005q4.[14]

	D(CORPTAX)	DLOG(DPROFITS/K$S)	DLOG(GDP/K$S)	D(INF)	DLOG(RPS)	DLOG(TQ)	D(UR)	D(RDIF)
D(CORPTAX)	1							
DLOG(DPROFITS/K$S)	-0.019 (0.79)	1						
DLOG(GDP/K$S)	0.04 (0.59)	0.60 (0.00)	1					
D(INF)	-0.015 (0.83)	0.03 (0.74)	-0.08 (0.29)	1				
DLOG(RPS)	0.05 (0.47)	-0.062 (0.39)	-0.31 (0.00)	-0.08 (0.29)	1			
DLOG(TQ)	-0.131(0.07)	0.1(0.17)	0.03 (0.67)	-0.076*(0.29)	-0.28 (0.00)	1		
D(UR)	-0.018 (0.45)	-0.38 (0.00)	-0.68 (0.00)	-0.103 (0.27)	0.01 (0.94)	0.112 (0.41)	1	
D(RDIF)	-0.02 (0.78)	-0.19 (0.01)	-0.32 (0.00)	-0.047 (0.51)	-0.06 (0.40)	0.033 (0.64)	0.472 (0.00)	1

A correlation matrix can be used to provide an indication of how severe multicollinearity may be in an econometric model. An Examination of the correlation matrices in Tables 2 and 3 shows that several variables in the equipment and structures capital stock equations are highly correlated; perhaps most notably the unemployment rate and real GDP to capital ratio are very highly correlated for both the equipment and structures capital stocks. The differenced unemployment rate is also highly correlated with the differenced real logged domestic profits to capital ratio for both equipment and structures. GDP to capital and domestic profits to capital ratios are also highly correlated for the real logged difference of the equipment and structures capital stock. The logged difference of Tobin's Q and the differenced corporate income tax are also highly

[13] P-values in parenthesis.
[14] P-values in parenthesis.

correlated, as are the differenced unemployment rate and the differenced interest rate differential. It seems reasonable to assume that high levels of correlation are present between explanatory variables in the remaining equations as well, so it is likely that some variables that are dropped as insignificant may in fact have been significant.

Data

Quarterly data for a sample period between the first-quarter of 1959 and the fourth-quarter of 2005 will be employed in the regressions. The majority of the data to be used in this paper was taken from various publications released by the Bureau of Economic Analysis. Some variables were constructed using data made available by the Federal Reserve Board and the Bureau of Labor Statistics. All expenditure and income variables are in chained dollars with 2000 as the base year. The descriptive statistics for the differenced natural log of the thirteen real capital stock categories are presented in Tables 4 and 5.

Table 4.

Descriptive Statistics: Equipment Capital Stock. 1959q1-2005q4.[15]

	DLOG(K$EIND)	DLOG(K$EO)	DLOG(K$ET)	DLOG(K$EIP)	DLOG(K$ESW)	DLOG(K$ECP)
Mean	0.007	0.007	0.007	0.025	0.026	0.050
Median	0.006	0.007	0.006	0.025	0.027	0.042
Maximum	0.017	0.019	0.023	0.038	0.048	0.0998
Minimum	0	-0.006	-0.006	0.009	0.006	0.009
Std. Dev.	0.003839	0.005	0.007	0.007	0.0125	0.026
Observations	196	196	196	196	72	72

An examination of the descriptive statistics in Table 4 shows that industrial equipment (K$EIND), transportation (K$ET), and other equipment (K$EO) all have growth rates slightly below that of the aggregate equipment capital stock (K$E). Information-processing equipment (K$EIP) is the fastest growing capital stock category

[15] Software and Computer capital stocks sample periods are 1990q1-2007q4.

for the 1959q1-2005q4 equipment capital stock period, with a growth rate nearly twice that of the total equipment capital stock. Ranked by the standard deviation, information-processing equipment is also the most volatile equipment capital stock category for the 1959q1-2005q4 sample. Industrial equipment is the least volatile equipment capital stock component.

Computers (K$ECP) and software (K$ESW) were not important investment categories until relatively recently. To avoid modeling and data problems, the sample period used for the computers and software capital stock is 1990q1-2005q4. The growth rate of the capital stock for computers is more than twice that of software and more than four times that of the total equipment capital stock. The computers capital stock is very volatile; with a standard deviation nearly six times that of the total equipment capital stock.

Table 5.

Descriptive Statistics: Structures Capital Stock. 1959q1-2005q4.

	DLOG(K$S)	DLOG(K$SC)	DLOG(K$SMA)	DLOG(K$SMI)	DLOG(K$SO)	DLOG(K$SU)
Mean	0.006	0.010	0.005	0.004	0.004	0.006
Median	0.006	0.011	0.005	0.004	0.004	0.006
Maximum	0.011	0.018	0.018	0.031	0.007	0.010
Minimum	0.002	0.003	-0.004	-0.006	0.001	0.001
Std. Dev.	0.002	0.004	0.005	0.007	0.001	0.003
Observations	196	196	196	196	196	196

In Table 5, commercial structures (K$SC) is the fastest growing component of the structures capital stock. The other structures capital stock (K$SO) and the Mining structures capital stock (K$SMI) are slowest growing capital stocks. Utilities (K$SU) is in the middle of the structures capital stocks in terms of growth rate and volatility. Mining structures is the most volatile component of the structures capital stock. Mining structures are followed by manufacturing structures (K$SMA) in terms of volatility based on the standard deviation.

The capital stock of equipment (K$E) has grown at approximately twice the rate of the capital stock of structures (K$S). Based on the standard deviation, structures are much less volatile than equipment at the aggregate level. Unsurprisingly, computers and software were the fastest growing and most volatile components of the capital stock. Other structures were the most stable component of the capital stock. Other structures and mining structures were the slowest growing elements of the capital stock.

Aggregated Equipment and Structures Regressions

Initially, a general equation for each capital stock variable was regressed. Variables with incorrect signs were dropped from the equations one at a time and each equation was then further refined by dropping the least significant variable, until only variables with statistically significant and correctly signed coefficients remained. The reduced equations for the aggregate equipment and structures capital are reported in Table 6. Results are first reported for total equipment and for total structures, then for more detailed components for each. After discussing the regression results for a particular component of investment, results from dynamic simulations are discussed for that component. In the dynamic simulations, the simulation is started in the first-quarter of the sample period and predicted rather than actual values of the dependent variable from a period are then used in generating the predicted value for the next period. This is an extremely demanding test for a model, for there is a tremendous potential for errors to accumulate to large values over an extended sample period. In general, most of the simulations track quite closely to actual values of each investment component.

Table 6.

Equipment and Structures Capital Stock. 1959q1-2005q2.

	DLOG(K$E)	DLOG(K$S)
C	0.002***(0.0004)	0.0007***(0.0002)
DLOG(K$x(-1)	0.89***(0.02)	0.94***(0.02)
D(CORPTAX(-1))	-0.005*(0.003)	
DLOG(GDP(-3)/K$x(-3))	0.01*(0.008)	
DLOG(GDP (-4)/K$x(-4))		0.01***(0.004)
D(RDIF(-1))		0.0002***(0.00004)
D(RDIF(-2))		0.0001***(0.00004)
D(RDIF(-3))		0.0007 (0.00007)
D(RDIF(-4))		0.00007*(0.00004)
SUM OF D(RDIF) LAGS		0.0005***(0.0001)
DLOG(RPx(-1))	-0.03**(0.01)	
DLOG(RPx(-3))	-0.03**(0.01)	
Sum of DLOG(RPX) LAGS	-0.06[t]	
DLOG(TQ(-2))	0.003***(0.001)	0.0006*(0.0004)
D(UR)	-0.002***(0.0002)	-0.0005***(0.0001)
D(UR(-1))		-0.0005***(0.0002)
D(UR(-2))		-0.0001(0.0001)
D(UR(-3))		-0.0003***(0.0002)
D(UR(-4))	-0.0004**(0.0002)	
SUM OF D(UR) LAGS		-0.001***(0.0002)
INF(-1)	0.0002**(0.00004)	
Log(DPROFITS (-1)/K$x(1))	0.001***(0.0002)	
LOG(TQ(-1))	0.0005**(0.0002)	
RDIF(-1)		-0.0001***(0.00003)
R-squared	0.97	0.97
Adjusted R-squared	0.96	0.96
SER	0.001	0.0004
DW	2.04	1.78
DH	1.00	1.60

Where: *** = statistically significant at .01.
** = statistically significant at .05.
* = statistically significant at .10
t = Lags were regressed separately and standard errors are not available

The lagged dependent variable is statistically significant and positive in the equipment capital stock equation.[16] The coefficients for Tobin's Q and the relative price of equipment were both found to be statistically significant in first-difference form. The coefficients for the first and third lags of the relative price of equipment had the expected negative signs and were statistically significant in first-difference form. The coefficients for the unemployment rate were statistically significant and negative for the first and fourth lags in first-difference form. Inflation, Tobin's Q, and the ratio of real domestic profits to the real capital stock all had statistically significant and positive coefficients in levels form. The coefficient for the real GDP to real capital ratio and the corporate tax rate are both weakly significant in first-difference form. The real GDP to the real equipment capital stock ratio has a positive effect on equipment, while the corporate tax rate has the expected negative effect. The adjusted R-squared indicates that an impressive 96% variation in the equipment capital stock is explained in the model. The Durbin's H statistic indicates that autocorrelation is not a concern.

[16] In every equation, the lagged dependent variable had coefficient values of between 0.7 and 0.94, with this variable being the most highly significant in each equation.

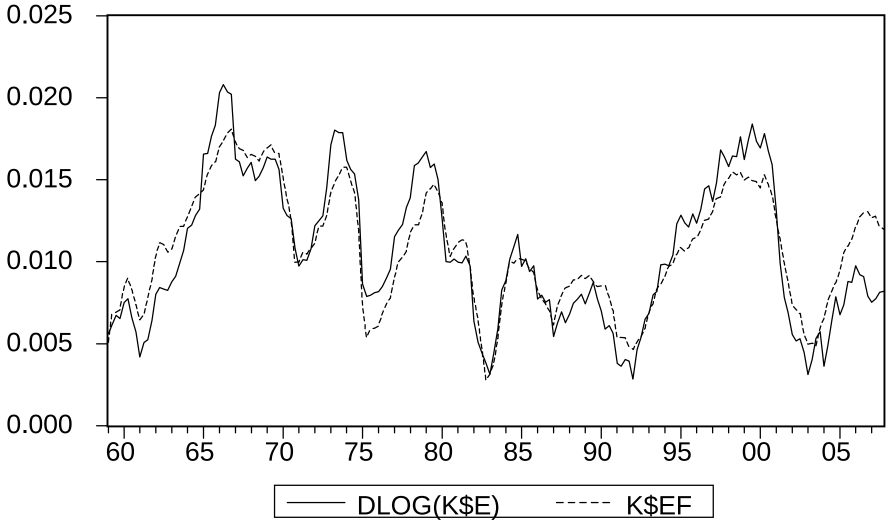

Figure 1. Dynamic Forecast and Actual Equipment Capital Stock Growth Rate. 1959q1-2007q4.

Figure 1 shows that the fitted values from a dynamic forecast (K$EF) track the actual values (DLOG(K$E)) surprisingly well given the highly aggregated data.

As in the equipment regression, the lagged capital stock dominates the aggregate structures regression. The coefficient for the ratio of real GDP to the real capital stock is highly significant and positive in the fourth lag of the first-difference form. The interest rate differential has highly significant and positive coefficients for several of the first-difference form. In lagged-levels the interest rate differential had a negative but still highly significant coefficient. The differenced Tobin's Q had a weakly significant and positive coefficient for the second lag of the first-difference form. The change in the unemployment rate appears to have a strong negative effect on the structures capital stock. The sum of unemployment rate lags is second only to the lagged dependent variable in significance. The adjusted R-squared is again very large at 0.97, indicating a large percentage of the variation in the structures capital stock is explained in the model. The Durbin's H again indicates that auto correlation is not a major concern in the model.

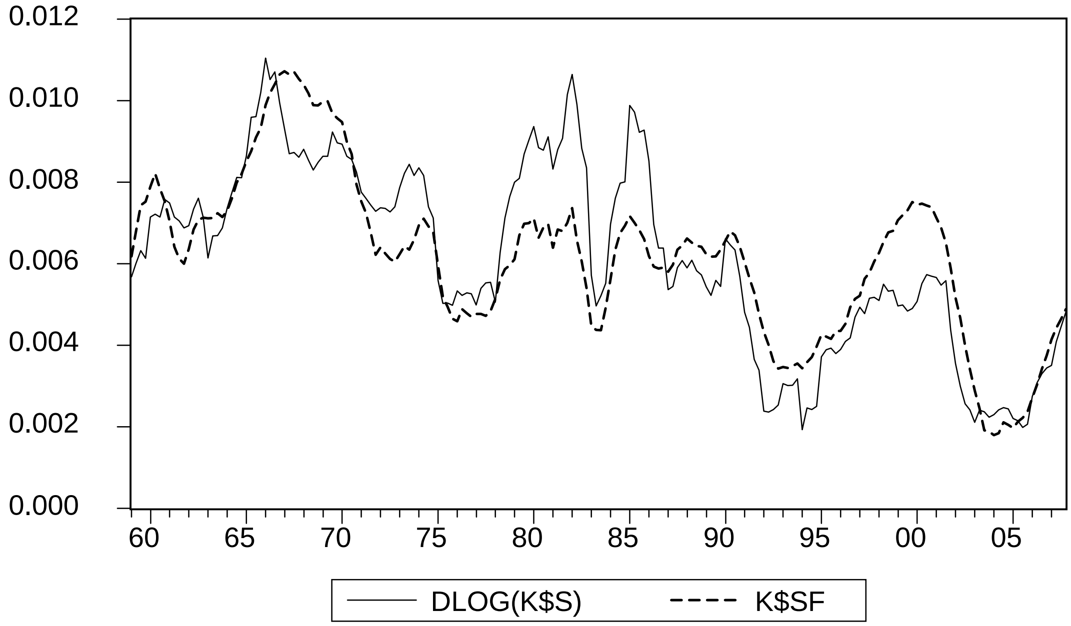

Figure 2. Dynamic Forecast and Actual Structures Capital Stock Growth Rate. 1959q1-2007q4.

Figure 2 shows that the predicted values mirror the actual values fairly closely, although not as closely as in the equipment capital stock equation. It is worth noting that the model severely underpredicts between 1978 and 1987 but then badly overpredicts between 1997 and 2002.

Summary: Aggregated Equipment and Structures Regressions

The determinants of equipment and structures are noticeably different. There is strong evidence for relative price and the ratio of real domestic profits to the real equipment capital stock having a significant effect on equipment investment. There is weak evidence of the corporate income tax rate affecting equipment investment. However, there is no evidence for these three variables having a significant effect on structures. There is very strong evidence for the interest rate differential having a significant effect on structures, but no evidence of interest rates significantly affecting equipment investment.

However, equipment and structures do share some determinants, most notably the unemployment rate is highly significant and negative in both regressions. The real GDP to real capital ratio and Tobin's Q are also significant in both equations.

Disaggregated Equipment Regressions

A procedure similar to the one used for aggregated structures and equipment was again employed to estimate and refine the disaggregated equipment equations. General equation (2) was estimated, and then the equation was refined by dropping incorrectly signed and insignificant variables one by one until only statistically significant and correctly signed variables remained.

The results for the industrial, transportation, and other equipment equations are reported in Table 7. As was the case for the aggregated equations, the lagged dependent variable has a positive coefficient that is very large and highly significant in all of the equipment equations. The equation for the real industrial equipment capital stock is no different. The corporate interest rate has a statistically significant and negative

Table 7.

Disaggregated Equipment Capital Stock. 1959q1-2005q4.

	DLOG((K$EIND)	DLOG(K$EO)	DLOG(K$ET)
C	0.0006(0.0004)	0.001***(0.0003)	0.002***(0.001)
DLOG(K$x(-1))	0.94***(0.03)	0.84***(0.035)	0.49***(0.07)
DLOG(K$x(-2))			0.21***(0.07)
Sum of D(K$ET) lags			-0.70[t]
D(CORPTAX(-2))	-0.011*(0.007)	-0.01**(0.005)	
DLOG(GDP(-1)/K$x(-1))	0.021***(0.007)	0.03**(0.01)	
DLOG(GDP(-3)/K$x(-3))	0.01*(0.007)		
Sum of DLOG(GDP/K$x) lags	-0.031[t]		
D(INF(-3))			0.0002**(0.0001)
DLOG(NFPROFITS(-1)) /K$*(-1))	0.001**(0.0007)		
DLOG(RPx)	-0.022***(0.009)		-0.032**(0.02)
D(UR)	-0.0008***(0.0002)	-0.002***(0.0004)	-0.003***(0.001)
D(UR(-3))			-0.001**(0.0006)
D(UR(-4))	-0.0006***(0.0002)	-0.001***(0.0003)	
Sum of D(UR) lags	-0.001[t]	-0.003[t]	-0.004[t]
INF(-1)	0.00007**(0.00003)	0.0001**(0.00007)	0.0004***(0.0001)
ITC(-1)		0.008***(0.003)	0.02***(0.01)
LOG(DPROFITS(-1)/K$x(-1))		0.001**(0.0006)	
LOG(NFPROFITS(-1)/K$x(-1))	0.0004*(0.0003)		0.004***(0.001)
LOG(RPx(-1))	-0.002**(0.001)	-0.01***(0.0004)	
LOG(TQ(-1))	0.0002*(0.0002)	0.001***(0.0004)	0.004***(0.001)
RDIF(-1)	-0.00006*(0.00004)		0.02***(0.0001)
SEPTD			-0.002***(0.001)
R-squared	0.97	0.94	0.91
Adjusted R-squared	0.97	0.94	0.90
SER	0.001	0.001	0.002
DW	1.94	2.12	2.09
Durbin's H	0.46	-0.96	-3.17

Where: *** = statistically significant at .01.
** = statistically significant at .05.
* = statistically significant at .10
t = Lags were regressed separately and standard errors are not easily available.

coefficient in change form. The relative price of industrial equipment and the unemployment rate have statistically significant and negative coefficients in change form as well. The relative price of industrial equipment also has a statistically significant and negative coefficient in levels form, as does the interest rate differential. Nonfinancial profits (NFPROFITS) were used in the place of domestic profits for industrial equipment.

The real nonfinancial profits to the real industrial equipment capital stock ratio (NFPROFITS/K$x) had a statistically significant and positive coefficient in both levels and change form. Investment in industrial equipment also appears to respond positively to changes in the real GDP to the real industrial equipment capital stock ratio. The real GDP to real capital ratio has a positive and statistically significant coefficient in change form. The inflation rate and Tobin's Q both have statistically significant and positive coefficients in levels. The Durbin's H statistic indicates that autocorrelation is not a concern.

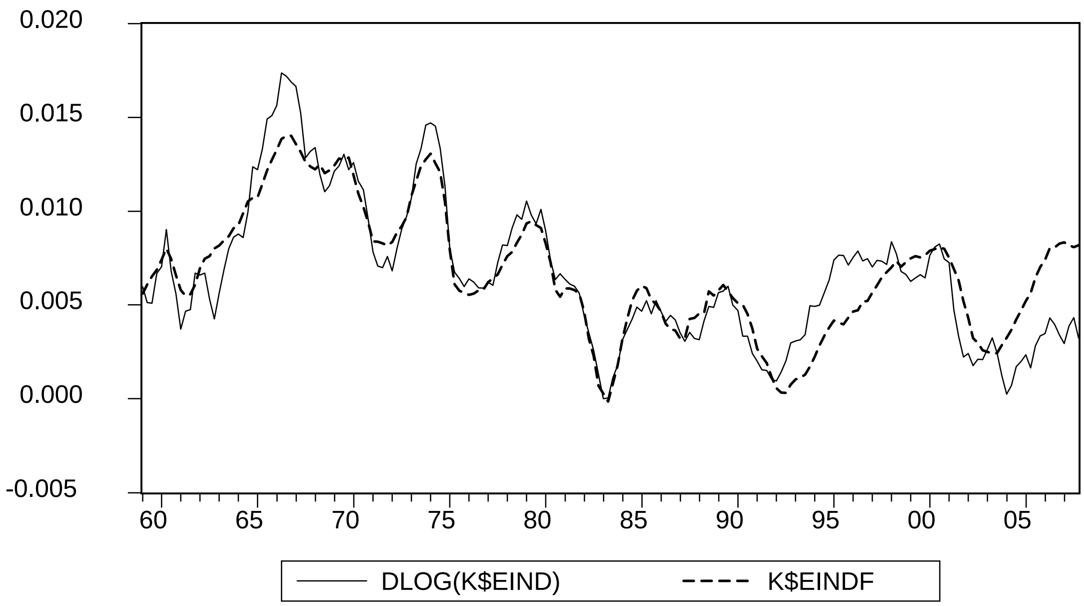

Figure 3. Dynamic Forecast and Actual Industrial Equipment Capital Stock Growth Rate. 1959q1-2007q4.

Figure 3 indicates that the model predicts fairly well, although it appears to lose some efficiency towards the end of the forecast period.

The coefficient for the lagged dependent variable is again positive and highly significant in the real other equipment capital stock equation. There is strong evidence that changes in the unemployment rate have a negative effect on investment in other equipment. The current period and fourth-quarter lag of the unemployment rate have statistically significant and negative coefficients. The relative price of other equipment has a negative and statistically significant coefficient. There is some evidence supporting the cash flow model in the regression. The real domestic profit to the real other equipment stock ratio has a coefficient that is statistically significant and positive in lagged-levels. The change form of the real GDP to the real other equipment capital stock ratio has a statistically significant and positive coefficient, providing some support for the accelerator theory. Tobin's Q has a statistically significant and positive coefficient in levels form. The significance of several variables indicates the importance of the cost of capital in determining investment in other equipment. The corporate tax has a statistically significant and negative coefficient. The investment tax credit and the inflation rate both have statistically significant and positive coefficients. The Durbin's H statistic indicates that autocorrelation is not a major concern.

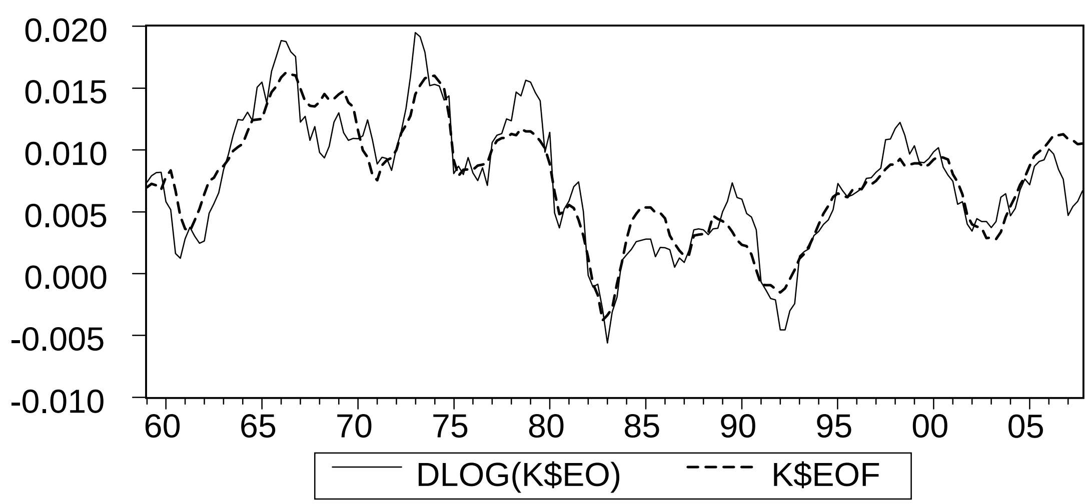

Figure 4. Dynamic Forecast and Actual Other Equipment Capital Stock Growth Rate. 1959q1-2007q4.

Figure 4 shows that the predicted values track the actual values fairly closely, although the model does appear to have a tendency to underpredict peaks in investment.

The coefficient for the one quarter lag of the real transportation equipment capital stock is highly significant and positive. The coefficient for the two quarter lagged real transportation equipment capital stock is also highly significant and positive. In change form the unemployment rate has negative and statistically significant coefficients for the current and fourth-quarters. The relative price of transportation equipment has a statistically significant and negative coefficient in levels form. Aircraft are a very important component of transportation equipment, and a dummy variable (SEPTD) was included to capture the effect of the September 11, 2001 attacks[17]. The September 11 variable is statistically significant and negative. The real nonfinancial profits to the transportation equipment capital stock ratio had a statistically significant positive coefficient in levels, providing some support for the cash flow theory of investment. Tobin's Q has a statistically significant coefficient, with the expected positive sign. The cost of capital appears to be a very important factor in transportation equipment investment. Inflation has statistically significant and positive coefficients in levels and change form. The investment tax credit and interest rate differential also have statistically significant positive coefficients in levels. The Durbin's H statistic indicates that autocorrelation is not a serious concern.

Figure 5 indicates that the predicted values again follow the actual values fairly closely.

[17] The September 11 dummy variable is zero until the third-quarter of 2001, when it becomes one.

Computers and software are components of the information-processing equipment capital stock. The massive business expenditures on computers and software in the 1990s have sometimes been blamed for the apparent loss of efficiency in some investment models. It may be instructive to take a detailed look at the real information-processing

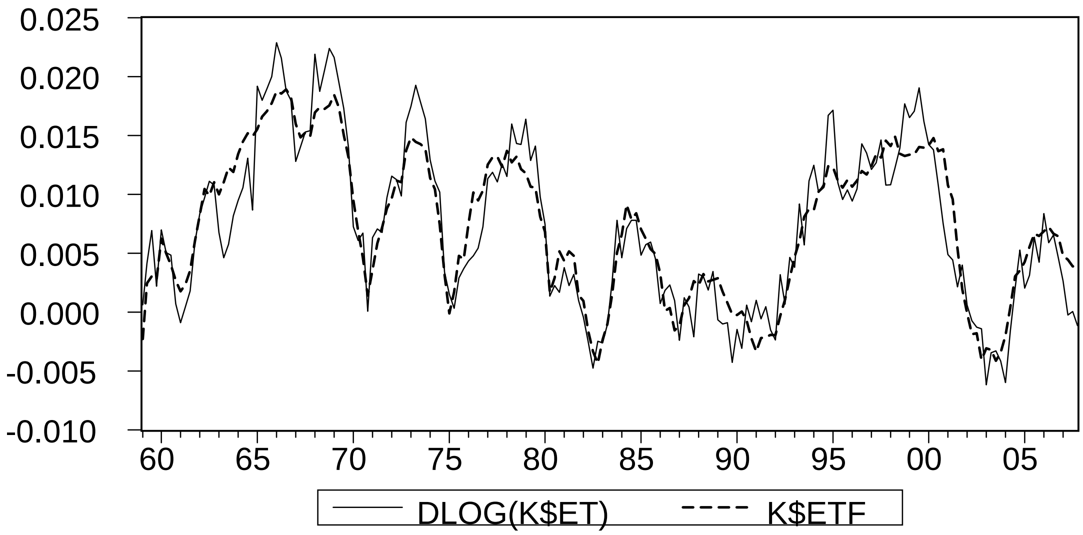

Figure 5. Dynamic Forecast and Actual Transportation Equipment Capital Stock Growth Rate. 1959q1-2004q4.

equipment, computers, and software capital stocks.[18] The results of the real information-processing equipment, computers, and software capital stock regressions are presented in Table 8. In the real information-processing equipment capital stock equation, the lagged dependent variable once again has a highly significant positive coefficient. The results of the information-processing equipment regression provide some support for the accelerator model. The real GDP to the real information-processing equipment ratio variable has a positive and highly statistically significant coefficient in change form. The coefficient for the real domestic profits to the real information-processing equipment

[18] The information-processing equipment capital stock has more components than computers and software, such as communication equipment. However, given the relative stability of these elements, a further disaggregation of the information-processing equipment capital stock was not considered necessary.

capital stock is also highly significant and positive, providing some support for the cash flow model. Tobin's Q has a positive, but only weakly significant, coefficient in lagged-levels. Inflation has a positive and statistically significant coefficient in levels. There

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Table 8.

Disaggregated Information-processing Equipment Capital Stock. 1959q1-2005q4.[19]

	DLOG(K$EIP)	DLOG(K$ECP)	DLOG((K$ESW)
C	0.0002(0.0004)	-0.213***(.052)	-0.167***(.050)
DLOG(K$x(-1))	0.91***(0.03)	0.72***(0.18)	0.80***(0.08)
D(CORPTAX(-1))		-1.099**(0.566)	
D(CORPTAX(-3))		-1.645***(.548)	
Sum of D(CORPTAX) lags		-2.744t	
DLOG(DPROFITS(-2)/K$x(-2))		0.016*(0.011)	
DLOG(GDP(-1)/K$x(-1))		0.256*(0.158)	
DLOG(GDP(-3)/K$x(-3))	0.04***(0.01)		0.152***(0.041)
D(INF(-3))		0.003***(0.001)	0.001***(0.0003)
D(RDIF(-4))		0.005***(0.002)	0002***(0.001)
DLOG(RPx)		-0.280***(.047)	
DLOG(RPx(-1))	-0.05**(0.02)		-0.078**(0.038)
DLOG(RPx(-3))	-0.05**(0.02)		
DLOG(RPx(-4))		-0.129***(.051)	
Sum of D(RPx) lags	-0.10t	-0.409t	
DLOG(TQ(-2))		0.014**(0.008)	
D(UR)	-0.002***(0.0005)		
D(UR(-4))	-0.001***(0.0004)	-0.010**(.0005)	
Sum of D(UR) lags	-0.003t		
INF(-1)	0.0002**(0.00005)		
LOG(DPROFITS(-1)/K$x(-1))	0.001***(0.0001)		
LOG(GDP(-1)/K$x(-1))		0.052***(0.013)	0.035***(0.010)
LOG(K$ECP(-1))			0.009***(0.003)
LOG(RPx(-1))		-0.050***(0013)	
LOG(TQ(-1))	0.0005*(0.0004)	0.021***(0.006)	0.013***(0.003)
RDIF(-1)		-0.002*(0.001)	
R-squared	0.95	0.97	0.97
Adjusted R-squared	0.95	0.97	0.96
SER	0.002	0.005	0.002
DW	1.98	1.62	1.41
Durbin's H	0.15	Undefined	3.41

Where: *** = statistically significant at .01.
** = statistically significant at .05.
* = statistically significant at .10
t = Lags were regressed separately and standard errors are not easily available.

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[19] Software and Computer capital stocks sample periods are 1990q1-2005q4.

is strong evidence for the unemployment rate having a negative effect on information-processing equipment investment. In change form, the unemployment rate has a statistically significant and negative coefficient in the current quarter and the fourth-quarter lag. The relative price of information-processing equipment also has a statistically significant and negative coefficient in multiple quarters. The Durbin's H statistic indicates that autocorrelation is not a concern.

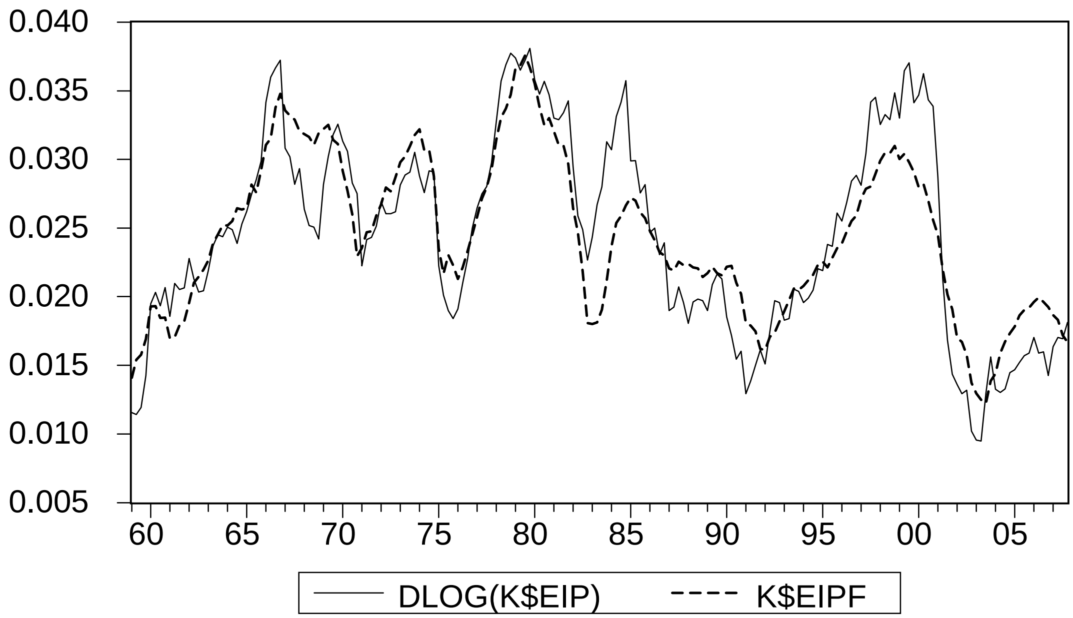

Figure 6. Dynamic Forecast and Actual Information-processing Equipment Capital Stock Growth Rate. 1959q1-2007q4.

Figure 6 shows the predicted information-processing equipment capital stock growth rate and the actual growth rate. The predicted values stay fairly close to the actual values for the most part, which is perhaps somewhat surprising considering that highly volatile computers and software equipment are included in the information-processing equipment capital stock.

Computers have become an important component in GDP only relatively recently. For this reason a much shorter sample period had to be used. The sample period for both the computer and software capital stock equations is 1990q1 to 2005q4. In the real computer equipment capital stock equation, the lagged dependent variable again has a positive coefficient of considerable magnitude and high statistical significance. There is strong evidence for the accelerator model in the computer equipment equation. The real GDP to real capital ratio has a highly significant and positive coefficient in levels and a weakly significant positive coefficient in change form. Tobin's Q has a statistically significant and positive coefficient in levels and change form. The interest rate differential has a highly significant and positive coefficient in change form. This may indicate that computers are responsive to changes that create loose credit conditions. However, there is weak evidence for the opposite effect in levels form. The inflation rate has a highly significant and positive coefficient in change form. The real domestic profit to real capital stock ratio has a positive, but only weakly significant, coefficient in change form. Computers appear to be very sensitive to changes in the corporate tax rate. The corporate tax rate has statistically significant negative coefficients in the first-quarter and fourth-quarter lags in first-difference form. The relative price of computers is highly significant and negative in levels and change form. The coefficient for the unemployment rate is statistically significant and negative in change form.

Figure 7 shows that the predicted computer values track the actual values very well. The possibility of autocorrelation cannot be dismissed; as it is not possible to calculate the Durbin's H statistic for this equation.

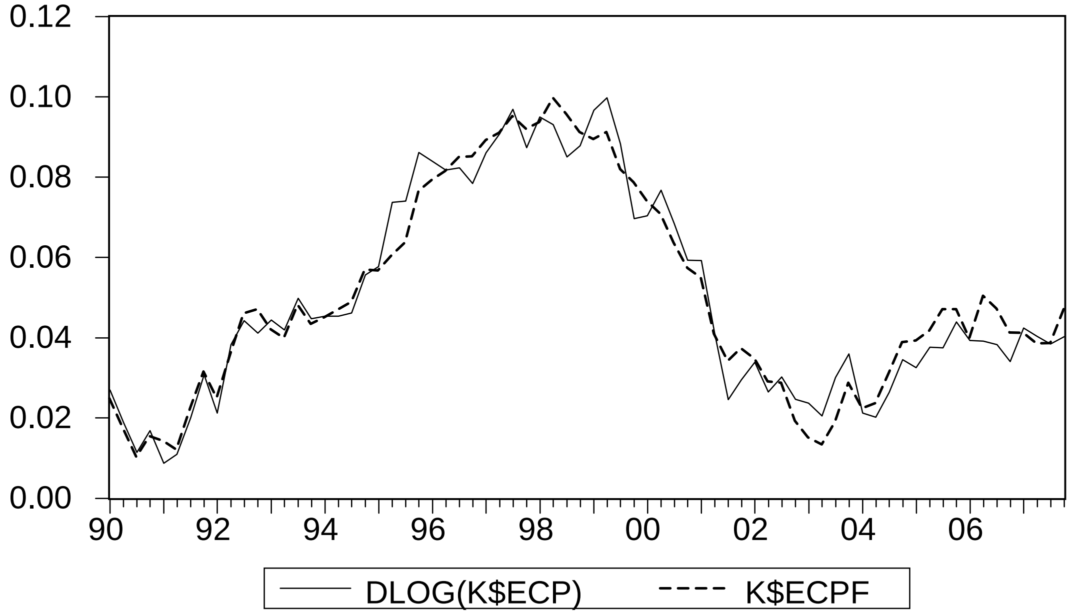

Figure 7. Dynamic Forecast and Actual Computer Equipment Capital Stock Growth Rate. 1990q1-2007q4.

The lagged dependent variable is once again an important explanatory variable in the software capital stock equation. The lagged real computer capital stock was included as an explanatory variable in the software investment equation. Although the software capital stock does not include software installed on computers at the time of purchase, it seems likely that many businesses will not be satisfied with the factory-installed software alone and will purchase additional software to install on their computers. The lagged real computer capital stock has a highly significant and positive coefficient in levels form. The real GDP to the real software capital stock ratio appears to be a highly significant factor in software investment. The real GDP to capital ratio has positive and statistically significant coefficients in the first- and third-quarter lags in change form and in levels form. The interest rate differential has a positive and highly significant coefficient in change form. Tobin's Q has a statistically significant positive coefficient in levels. The relative price of software was the only explanatory variable to have a statistically significant negative coefficient in the software equation. The Durbin's H statistic indicates that autocorrelation is not a concern in the equation.

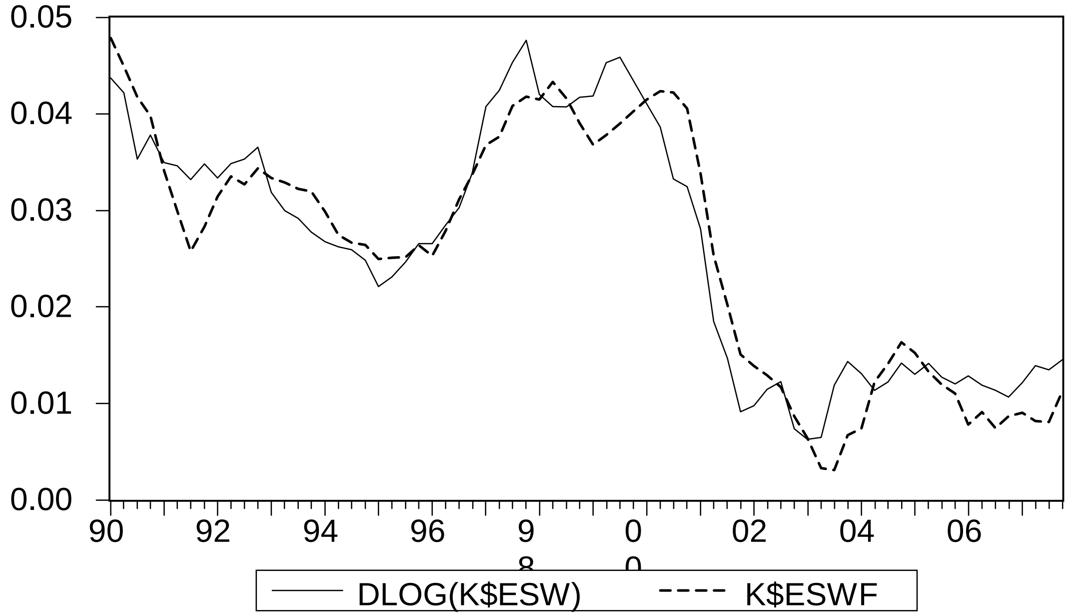

Figure 8. Dynamic Forecast and Actual Software Equipment Growth Rate. 1990q1-2007q4.

Figure 8 shows the predicted software capital stock growth rate following the same general trends as the actual software values, but not as closely as in some of the more successful regressions.

Summary: Disaggregated Equipment Regressions

The results of the equipment regression show a wide range of variables affecting equipment investment. It is worth noting that elements of all of the basic investment models were supported in at least some of the equations. Tobin's Q had a coefficient that was statistically significant in levels form in every equation, providing support for the securities value theory. Multiple elements affecting the cost of capital were significant in every equation as well, providing strong support for the neoclassical theory. The inflation rate has statistically significant coefficients in every equipment equation. There is also extensive evidence supporting the accelerator model. The change in the real GDP to capital ratio has a statistically significant coefficient in every equipment equation except for the real transportation equipment capital stock. There is a similar level of evidence for the cash flow model. Some form of the profits to capital ratio has a statistically significant and positive coefficient in every equation except the real other equipment capital stock.

The variables not directly attached to one of the major investment models were also shown to have a significant effect on equipment investment. The change in the unemployment rate had a negative effect in every equation except for the real software equipment capital stock. The relative price also appears to be important in equipment investment. Some form of the relative price had a statistically significant negative coefficient in every equation except for the real transportation equipment capital stock.

The results of the equipment regressions are encouraging. The high adjusted R^2 and reasonably close forecasts seem to indicate that equations present a fairly accurate portrait of equipment investment. The results of the equipment regression support the belief that additional insights into investment behavior can be gained through disaggregation. Additionally, as in Fazzari, Hubbard, and Petersen (1988), the equipment investment results indicate that elements of all of the theoretical models can be combined together into a more effective whole and that net investment is an acceptable alternative to gross investment as a dependent variable in econometric models of investment.

Disaggregated Structures Regressions

The results of the real commercial structures regressions are presented in Table 9. As was the case for all of the equipment equations, the lagged dependent variable has a coefficient that is large, highly significant, and positive in all of the structures regressions. In addition to the lagged dependent variable, there is evidence for Tobin's Q having a positive effect on the real commercial structures capital stock. Tobin's Q variable has statistically significant and positive coefficients for the second and third-quarter lags of the change form. There is also evidence supporting the interest rate differential, a cost of capital variable, having an effect commercial structures investment. The sum of lags in change form is statistically significant and positive, indicating that commercial structures respond to changes that produce loose credit conditions. However, in lagged-levels the interest rate differential has a statistically significant negative coefficient, indicating sensitivity to long-term interest rates. The only other variable shown to have a statistically significant effect on the real commercial structures capital stock is unemployment rate. Although the change form coefficients are, at best, weakly significant individually, the sum of unemployment rate lags has a highly significant negative coefficient. The Durbin's H statistic indicates that autocorrelation is not a major concern in the real commercial structures equation.

Table 9.

Disaggregated Structures Capital Stock. 1959q1-2005q4.[20]

	DLOG(K$SC)	DLOG((K$SMA)	DLOG(K$SMI)	DLOG(K$SO)	DLOG(K$SU)
C	-0.001(0.001)	0.002**(0.001)	0.002***(0.001)	0.0005***(0.0001)	0.001***(0.0003)
DLOG(K$x(-1))	0.97***(0.02)	0.86***(0.03)	0.82***(0.04)	0.91***(0.02)	0.95***(0.02)
DLOG(GDP(-4)/K$x(-4))		0.028***(0.009)			
D(INF(-1))				0.00005**(0.00003)	
D(INF(-2))				0.00004*(0.00003)	
D(INF(-3))			0.0002**(0.0001)	0.00003 (0.00003)	0.00005*(0.00003)
D(INF(-4))		0.0001**(0.00005)			
Sum of D(INF) lags				0.0001**(0.00007)	
DLOG(OILP/PA)			0.002*(0.001)		
DLOG(OILP(-1)/PA(-1))			0.003***(0.001)		
DLOG(OILP(-2)/PA(-2))			0.003***(0.001)		
DLOG(OILP(-3)/PA(-3))			0.002*(0.001)		
DLOG(OILP(-4)/PA(-4))			0.003***(0.001)		
Sum of DLOG(OILP/PA) lags			0.012***(0.003)		
D(RDIF(-1))	0.0001*(0.00008)		0.001***(0.0001)	0.00006 (0.00004)	
D(RDIF(-2))	0.0002*(0.00009)			0.00005(0.00004)	
D(RDIF(-3))	0.0001(0.0001)			0.00005 (0.00004)	
D(RDIF(-4))	0.0002**(0.0001)				
Sum of D(RDIF) lags	0.0006**(0.0002)			0.0002*(0.0001)	
DLOG(RPx)		-0.02**(0.01)		-0.01**(0.005)	-0.021***(0.006)
DLOG(RPx(-4))			-0.009*(0.005)		
DLOG(TQ(-1))				0.001***(0.0003)	
DLOG(TQ(-2))	0.001*(0.0008)				
DLOG(TQ(-3))	0.002**(0.001)				
DLOG(TQ(-4))			0.0002**(0.0001)		
Sum of Dlog(TQ) lags	0.003***(0.001)				
D(UR)	-0.0003*(0.0003)	-0.001***(0.0002)	-0.0007*(0.0005)	-0.0003***(0.0001)	
D(UR(-1))	-0.0004*(0.0003)			-0.0004***(0.0001)	
D(UR(-2))	-0.0001(0.0003)	-0.001***(0.0002)		0.0001(0.0001)	
D(UR(-3))	-0.0004(0.0003)			-0.0003***(0.0001)	
Sum of D(UR) lags	-0.001***(0.0004)	-0.002[t]		-0.001***(0.0001)	
CORPTAX(-1)		-0.003**(0.002)			
INF(-1)		0.0001***(0.00004)			
IRAN(-1)			0.001***(0.0006)		
LOG(DPROFITS(-1)/K$x(-1))			0.002***(0.0006)		
LOG(OILP(-1)/PA(-1))			0.002***(0.0008)		
LOG(RP*(-1))		-0.005***(0.001)			
RDIF(-1)	-0.0001*(0.00005)	-0.0002***(0.0002)		-0.0001***(.00003)	
UR(-1)					-0.0002***(.00004)
UTC(-1)					0.003***(0.001)
1986			-0.003***(0.001)		
R-squared	0.96	0.96	0.94	0.92	0.96
Adjusted R-squared	0.96	0.96	0.94	0.92	0.96
SER	0.001	0.001	0.002	0.0004	0.0005
DW	1.9	1.9	2	2.13	2.07
Durbin's H	0.73	0.77	0	-1	-0.51

Where: *** = statistically significant at .01.
** = statistically significant at .05.
* = statistically significant at .10
t = Lags were regressed separately and standard errors are not easily available.

[20] The sample period for mining structures capital stock is 1959q2-2005q4.

Figure 9 shows the dynamic forecast values and the actual real commercial structures capital stock growth rates. Unfortunately, the predicted values do not track the actual values all that closely for the most part, and the forecast performs especially poorly between 1980 and 1990. It seems likely that the poor performance during the 1980s is due to the model's failure to capture contemporary changes to the tax code implementing accelerated deprecation allowances.

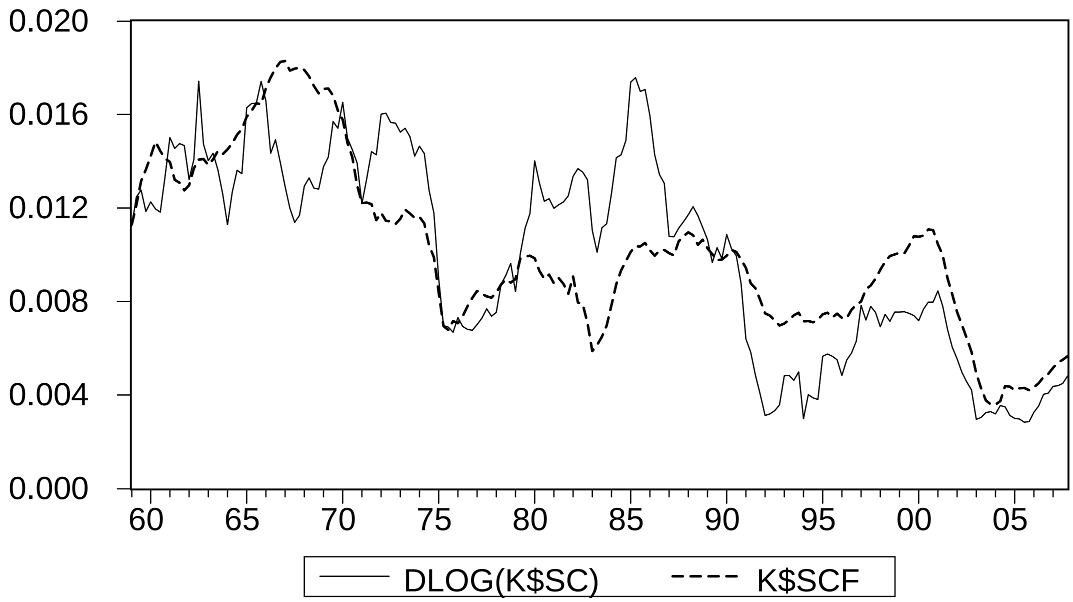

Figure 9. Dynamic Forecast and Actual Commercial Structures Capital Stock Growth Rate. 1959q1-2007q4.

In the real manufacturing structures capital stock, the lagged dependent variable has a highly significant and positive coefficient. Several costs of capital variables are significant in manufacturing structures equations. The inflation rate has a statistically significant and positive coefficient in both change form and levels. The coefficients for the corporate tax rate and the interest rate differential are both negative and statistically significant in levels form. The real GDP to the real manufacturing structures capital stock ratio has a statistically significant and positive coefficient in the real manufacturing structures capital stock equation, providing support for the accelerator theory. The unemployment rate has statistically significant and negative coefficients in change form. The relative price of manufacturing structures has a statistically significant and negative coefficient in change form and levels. Durbin's H indicates that autocorrelation is not a concern.

In Figure 10, the dynamic predicted values track the actual manufacturing structures growth rate very closely.

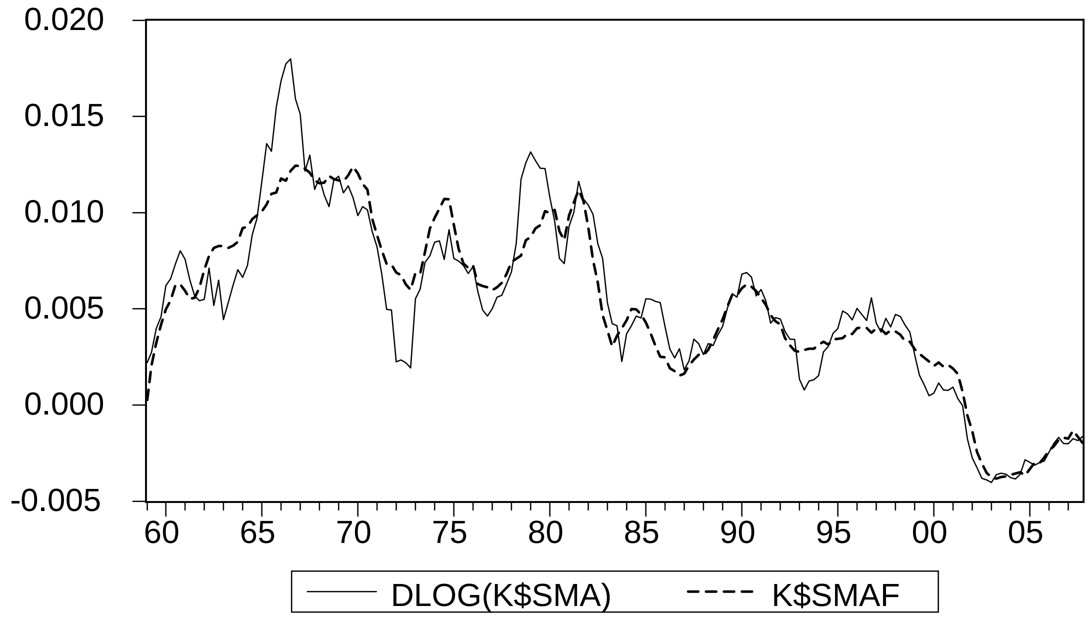

Figure 10. Dynamic Forecast and Actual Manufacturing Structures Capital Stock Growth Rate. 1959q1-2007q4.

The lagged dependent variable has a statistically significant and positive coefficient in the real mining structures capital stock equation. Oil has tremendous influence over investment in mining structures, and several oil-related variables were added to the mining structures equation. A dummy variable was included to capture the effect of Iranian Revolution (IRAN) that resulted in a massive increase in global oil prices. The Iran variable had a statistically significant and positive coefficient. A dummy variable was also included to capture the effect of the mid-eighties oil collapse (1986). The 1986 variable had a statistically significant negative coefficient. The relative price of oil (OilP/PA), calculated as a ratio of the producer price index for petroleum to the producer price index for all items, was also included. The relative price of oil had coefficients that were highly significant and positive in change form and levels. The unemployment rate had statistically significant and negative coefficients in change form. The relative price of mining structures had statistically significant negative coefficients in levels and change form. The real domestic profits to the real mining structures capital stock ratio had a statistically significant positive coefficient in lagged-levels, providing evidence for the cash flow model. The interest rate differential and the inflation rate both had statistically significant positive coefficients in change form. Last, Tobin's Q was statistically significant and positive in change form, providing support for the securities values model. The Durbin's H statistic indicates the autocorrelation is not a concern.

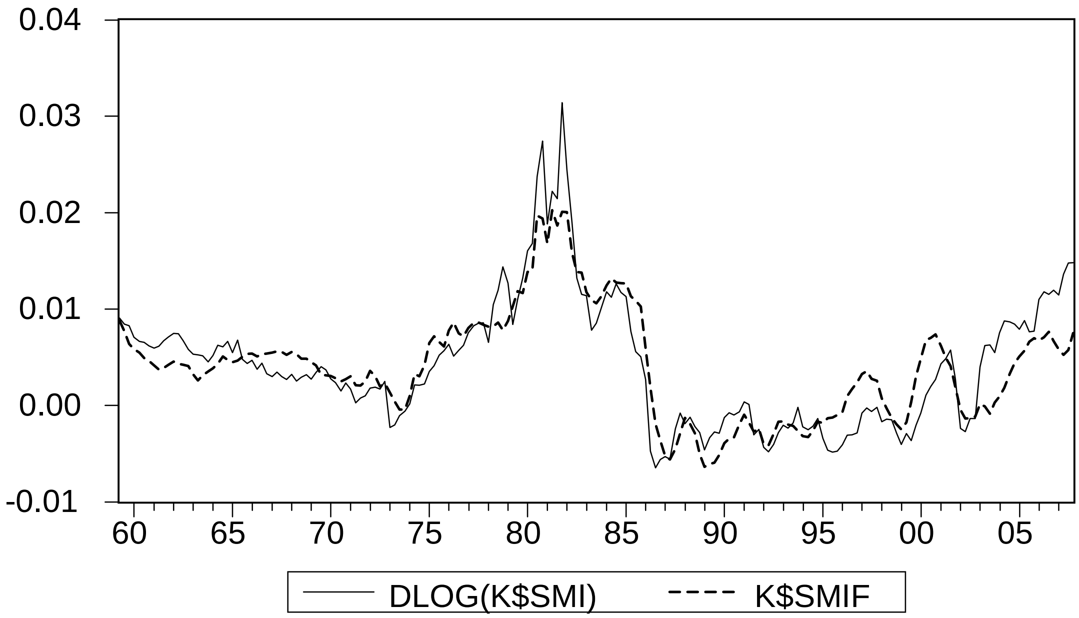

Figure 11. Dynamic Forecast and Actual Mining Structures Capital Stock Growth Rate. 1959q1-2007q4.

Figure 11 indicates that the predicted values follow the actual values fairly well, although the model again appears to lose efficiency in the later part of the forecast.

In the real other structures equation, the lagged dependent variable once again has a statistically significant positive coefficient. There is strong evidence for the unemployment rate having an effect on investment in other structures. The unemployment rate has statistically significant negative coefficients for several quarterly lags of the first-difference form. The relative price of other structures also has a statistically significant negative coefficient in change form. Tobin's Q has a statistically significant positive coefficient in change form. There are mixed results for the interest rate differential, a cost of capital variable. The interest rate differential had statistically significant positive coefficient for the sum of lags but no individually significant quarterly lags. The insignificance of the individual lags is most likely due to multicollinearity among them. The interest rate differential had a highly significant negative coefficient in lagged-levels. The regression indicated that the inflation rate, another cost of capital variable, also had a positive affect on other structures in change form. The Durbin's H statistic indicates that autocorrelation is likely not a concern in the other structures equation.

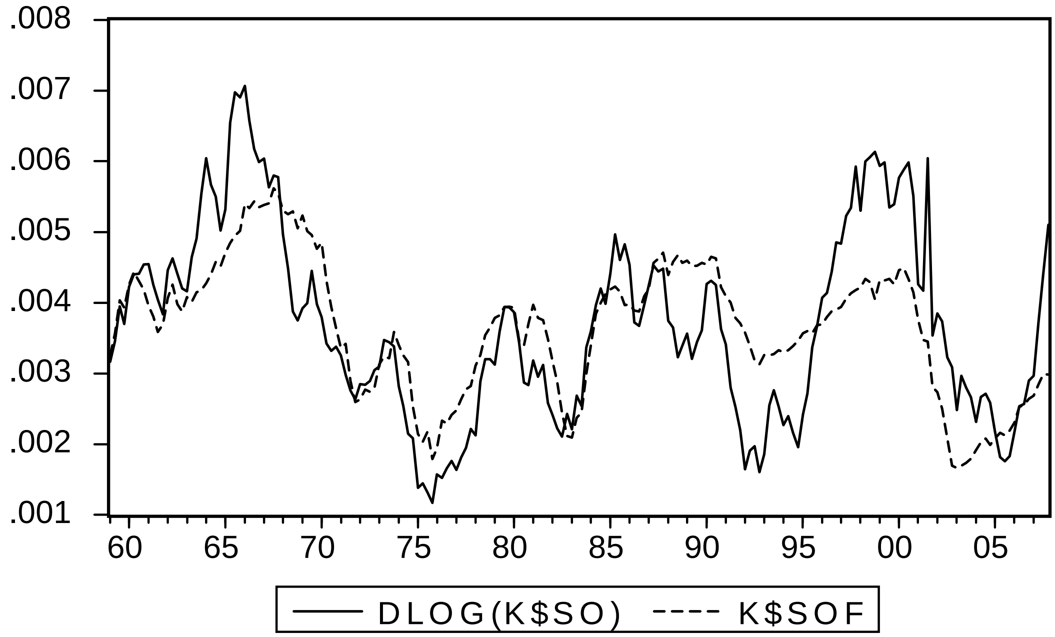

Figure 12. Dynamic Forecast and Actual Other Structures Capital Stock Growth Rate. 1959q1-2007q4.

In the real utilities structures equation, the lagged dependent variable has a statistically significant positive coefficient. The unemployment rate has a statistically significant negative coefficient in levels. The relative price of utilities structures has a statistically significant negative coefficient in change form. The other significant variables in the utilities structures equation are related to the cost of capital. The inflation rate has a statistically significant positive coefficient in change form. The utilities tax credit (UTC), calculated as a statutory rate, has a coefficient that is statistically significant and positive in levels. The Durbin's H statistic indicates that autocorrelation is not a major concern.

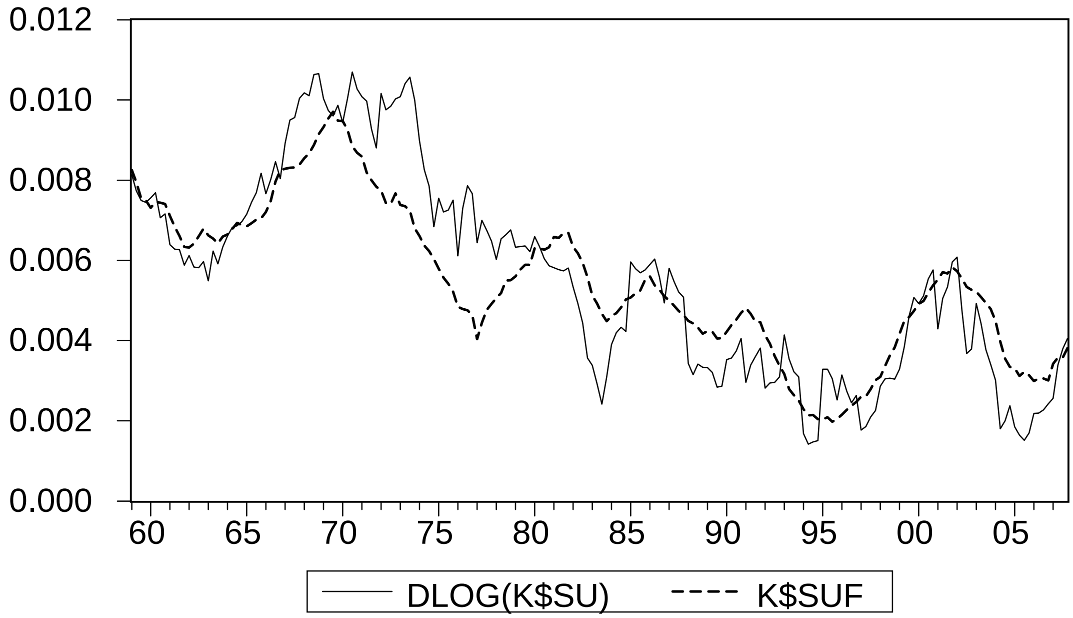

Figure 13. Dynamic Forecast and Actual Utilities Structures Capital Stock Growth Rate. 1959q1-2007q4.

Figure 13 shows the dynamic forecast of utilities structures to have a relatively poor fit, although the predicted values do appear to follow the same general trends of the actual utilities structures capital stock values.

Summary: Disaggregated Structures Regressions

As expected, the lagged dependent variable was highly significant and positive in every structure's capital stock equation. Other than the lagged dependent variable, the only explanatory variable to have a statistically significant and correctly signed variable in every equation was the unemployment rate. The relative price had a statistically significant and correctly signed coefficient in every equation except for commercial structures.

The cost of capital variables also performed very well in several of the equations. The interest rate differential had at least one statistically significant coefficient in every structures capital stock equation except for real utilities structures. It is worth noting that while the interest rate differential consistently had a positive coefficient in change form, it had a negative effect in all three equations where it had a statistically significant coefficient in levels. The inflation rate had statistically significant coefficients in every equation except for real commercial structures. The utilities tax credit and corporate tax rate were both significant in one equation each: the real utilities and manufacturing structures capital stocks, respectively.

Tobin's Q produced mixed evidence for the securities values approach to investment modeling in the structures equations. Tobin's Q was statistically significant and correctly signed in three of the five structures equations: real commercial, mining, and other structures.

The accelerator and cash flow elements performed poorly in the structures capital stock equations. The real GDP to real capital stock ratio was statistically significant and correctly signed only in the real manufacturing structures equation. The cash flow variable, the ratio of real domestic profits to the real capital stock, was also statistically significant in only one equation: real mining structures.

The real structures capital stock equations on average appear to have performed fairly well, but perhaps not quite as well as the disaggregated equipment equations. Autocorrelation does not appear to be a concern in any of the real structures equations. The adjusted R^2 statistic is high for every real structures capital stock equation. The predicted values produced by the dynamic forecasts appear to track the actual values fairly well with exception of the real commercial structures capital stock equation.

Conclusions

This study incorporates three key innovations in modeling investment behavior. First a more general model of investment behavior was estimated than is usually employed in econometric studies. Second is the more disaggregated approach to investment. The third, and perhaps most important innovation, is the use of net investment rather than gross investment as the dependent variable.

Tevlin and Whelan had suggested that the massive investment in computers had contributed to a decline in efficiency in econometric models of investment and suggested increased disaggregation as a potential solution (2003). Unexpectedly, the aggregate equipment and information-processing equipment equations, the two equations whose efficiency seems most likely to be negatively affected by the tremendous growth in computers and software, both performed very satisfactorily in this study. This suggests that more detailed and nuanced econometric models of investment behavior are a viable alternative to disaggregation when it comes to econometric efficiency. It is also possible that the use of net investment as the dependent variable contributed to the efficiency of the results. While disaggregation did not produce the expected increases in efficiency, mainly because the aggregates preformed much better than expected, this study still produced several illuminating insights into investment behavior.

On average, combining elements of all of the major theoretical models into a single composite equation worked quite well for most of the disaggregated investment categories. Autocorrelation does not appear to be a significant concern in any of the equations, with the possible exception of the computer equipment capital stock equation. All of the equations seem to explain an impressive amount of the variation in their respective dependent variables. Based on the adjusted R^2 statistics, at least 90% of the variation in the dependent variable is explained in each equation. Additionally, the predicted values of the dynamic forecasts tracked very closely to the actual values for most of the investment equations, with the most notable exception being the commercial structures capital stock.

Elements of the accelerator, cash flow, securities value, and neoclassical models were important in most of the equipment equations. The real GDP to capital ratio, an element derived from the accelerator model, is included in every equipment equation except real transportation. A real profit to real capital ratio, an element derived from the cash flow model, is included in every equipment equation except for real software. Some form of Tobin's Q, an element of the securities value model, is included in every equipment capital stock equation.

The cost of capital, a neoclassical concept, had multiple components with statistically significant coefficients in every equipment equation. The inflation rate, a cost of capital variable, had statistically significant coefficients in every equipment equation. The interest rate differential, another cost of capital variable, had statistically significant variables in every equation except for information-processing and other equipment. At least one tax variable appeared in every equipment equation except for industrial and information-processing equipment.

In contrast to disaggregated equipment investment, cash flow and accelerator principles seem relatively unimportant in disaggregated structures. The real profits and

GDP ratios appear in only one disaggregated structures equation each: real mining and real manufacturing respectively.

There is mixed evidence for Tobin's Q in the disaggregated structures equations. Tobin's Q appears in three structures equations: real commercial, mining, and other structures. However, Tobin's Q drops out of two structures equations as well: real manufacturing and utilities.

Elements of the cost of capital appear to be very important to the determining the rate of investment in structures. An inflation variable appears in every equation except for real commercial structures. The interest rate differential appears in every disaggregated structures equation except utilities. Taxes have a slightly weaker presence in the disaggregated structures equations than in the equipment equations, with tax variables appearing in only two structures capital stock equations. The corporate tax rate has a statistically significant coefficient only in the real manufacturing structures equation. The utilities tax credit has a statistically significant coefficient in the utilities structure equation.

The explanatory variables not derived from theoretical models should not be overlooked. The lagged dependent variable had a statistically significant positive coefficient in every equation. This concurs with the findings of Kopcke and Brauman (2001), that a time-series model of investment tended to outperform the neoclassical and other economics based investment models. The study supports the notion that business cycles, represented by the unemployment rate, are an important determinant of disaggregated investment in both structures and equipment. The unemployment rate variable has a statistically significant coefficient in every disaggregated investment equation except for real software equipment. The unemployment rate outperforms other cyclically sensitive variables such as the GDP to capital and profits to GDP ratios. There are similar strong results for relative price. A relative price variable appears in every disaggregated investment equation except for real commercial structures.

On average the results of this study are very satisfactory. However, there are some potential problems with the results presented in this study. The appropriateness of mixing levels and first-difference form data has been questioned (Kennedy 2003). It should be noted that the regressions used in this study are OLS and are subject to the many problems associated with that form. Multicollinearity, autocorrelation, simultaneity, and reverse causality are among the possible problems associated with using OLS. The Durbin's H statistics indicate that autocorrelation is not a concern. Simultaneity and reverse causality are potential problems that could be addressed through the use of more complex models. Additionally, more rigorous tests of stationary could be employed. However, although these possible shortcomings must be acknowledged, this study has produced some interesting insights into investment models and behavior.

There are several avenues rising from this paper that could be pursued in future studies. Several of the equations presented in this study could be further refined, notably the real commercial and utilities structures capital stock equations. Some of the equations could benefit from the inclusion of special component specific variables, such as was done with inclusion of the price of oil variables in the real mining structures equations.

In a few areas, the level of aggregation used in this paper is still quite high. It could be informative to disaggregate investment still farther in these areas. For example, transportation equipment could potentially be disaggregated aircraft, ships, trucks and automobiles, and trains. Further disaggregation could provide a still more detailed and nuanced picture of investment behavior. Additionally, further disaggregation could reduce the possibly distorting effect of aggregation bias in the data.

Despite a few potential problems, the results of this study indicate that net investment is an appropriate dependent variable from an economic modeling perspective. The strong results of this study suggest that net investment is in some ways superior to gross investment as a dependent variable in the economic modeling context. The use of net investment as a dependent variable, in combination with the general model approach and disaggregation, produced very satisfactory results. On average, the regression explained a high level of variation in the disaggregated investment components, and the dynamic predicted values tracked the actual values quite closely.

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