Journal of Resources Development and Management www.iiste.org
ISSN 2422-8397 An International Peer-reviewed Journal
Vol.17, 2016

The Interest Rate Ratchet in an Accelerator-Cash Flow Model of Gross Nonresidential Fixed Investment for the USA between 1950 and 1988

Ibrahim Alloush,
Zaytouneh University, Amman, Jordan

Abstract
Despite the reliance of most macroeconomic theories on the premise of an inverse relationship between investment and interest rates, such an ostensibly self-evident relationship rarely proves to be significant in econometric tests particularly with reference to plant, equipment, and non-residential fixed investment in the long-run. Thus, this paper tests a new model of the relationship between the rate of interest and long-term industrial investment, using both classical and Keynesian components, based on a data set from the U.S. economy between 1950 and 1988. The sample is restricted to these years to examine this relationship in a semi-open economy before the onset of globalization. This study henceforth concludes that the profitability of productive capacity currently in use and the rate of growth of the economy in previous years are much more important in explaining long-term fluctuations in the industrial investment than the rate of interest. It also concludes that the institutional and economic environment plays an important role in explaining the decision to expand existing productive capacity. Eventually, the way interest rates contribute to long-term fluctuations in industrial investment is complex, non-linear, and intermingled with other variables which take away from its explanatory power.

Table of Contents:

I – Introduction

Nonresidential business investment in new plant and equipment remains a crucial factor in the functioning of the economy. It has been perceived as an instigator of actual and potential output growth as the rise in capital formation due to increased investment leads to expanding the capital component K in a production function for the whole economy. Given other things, an increase in output brings a lower rate of inflation (Klingaman and Koshal, 1982, p.100). Furthermore, an increase in the rate of investment for whatever reason, e.g., external aid, in an economy characterized by constant technology and aggregate demand may reduce unemployment, and augment the supply of capital goods thereby lowering their prices and indirectly the prices of consumer goods.

Bearing in mind that investment in plant and equipment is the origin of productive physical capital, Denison (1980) estimated that "capital had been the source of 19% of the 1948-73 growth rate" (p.223). Eleven percent of the decline in the average growth rate of national income, from 3.65% in period 48-73 to 2.38% in the period 73-78, has been accounted for by the drop in the rate of capital accumulation, of which the drop in investment expenditure for new plant and equipment represents about three-fifths (Denison, 1980, p.222). According to the same author, "capital was the source of 18-percent of the growth rate in potential national income", and the "use of an alternative classification that reallocates gains from economies of scale among other growth sources instead of considering them a separate growth source would raise the percentages for the contribution of capital, those for nonresidential business by as much as one-eighth. They would then range from 16 to 23 percent in 1948 – 73", depending on how the series is defined (Denison, 1980, p.221). Hence, the statistics cited above emphasize the importance of nonresidential fixed investment to growth in national income through the impact of investment on the capital stock and the rate of accumulation.

International economic competition, such as between the U.S. and China, has bestowed upon the issue of nonresidential fixed investment added importance to the extent that competition has to do with productivity. Since productivity is related to increases in the capital-labor ratio, i.e., capital deepening, and hence to the capital-output ratio which is in its own turn dependent on the ratio of net investment to GNP, the whole question of nonresidential fixed investment assumes added relevance. Of particular importance was the fact that "the ratio of gross investment to GNP has been relatively stable while net investment has declined significantly between 1948 and 1979, and that "the fall in net nonresidential investment has been particularly sharp" (Feldstein, 1983, p.144). Furthermore, in estimating quantitatively the potential productivity path of the U.S. economy between 1955 and 1978, Coen and Hickman (1980) found that capital "deepening was second only to technical progress as a source of … growth during the postwar years and is projected to remain so along the natural path" (p.218). Table 1 below provides the historical estimates of Coen and Hickman of potential annual rates of change of man-hour productivity.

Table 1: Contributing Sources and Annual Rates of Change of Potential Man-Hour Productivity

Period	***Productivity***	***Technical* Progress**	***Capital* Deepening**	***Capital* Utilization**	***Labor* Quality**	***Labor* Utilization**
55-68	2.82	1.62	1.09	0.10	0.01	0.00
68-73	1.46	1.03	0.69	- 0.11	- 0.19	0.04
73-78	1.04	1.03	0.40	- 0.41	0.00	0.01

The main conclusion to be drawn from Table 1 is that productivity has been increasing at a decreasing rate between 1955 and 1978, and that has been accompanied by an increase at a decreasing rate in capital accumulation and a decrease in the rate of capacity utilization as well. In either case, the implication is that variations in capital, especially nonresidential fixed capital, and therefore variations in investment in this form of capital affect productivity as much as they do GNP growth, employment, and inflation. Consequently, the purpose of this paper is to understand these variations by *constructing a theory of nonresidential fixed investment and testing it empirically.*

In section II of this paper, the most important trends in the investment literature are reviewed. Since most models of nonresidential fixed investment start from the relationship between investment and the capital stock, this relationship between the two is analyzed in the beginning of section II and then applied throughout the rest of the Review of Literature.

Section III provides an evaluation of the literature reviewed extracting those elements used to build the model described in section IV.

The thesis of section IV is that nonresidential fixed investment is a function of aggregate demand, the ratchet interest rate, the rate of profit per capacity utilized, and the level of nonresidential fixed investment in the previous period. The assumption of the relationship is that all these variables correlate positively with gross nonresidential fixed investment, except for the ratchet interest rate which should correlate negatively with investment.

Eventually, the results of the statistical test of the model are discussed in section V.

II – Review of the Literature:

A – The Accelerator Model

In 1917, J.M. Clark formulated the first accelerator model relating changes in investment to changes in aggregate output. The relationship was postulated to be linear with the capital stock as a constant multiple of the level of output, such that:

(1) $K_t^{\,d} = \alpha\, Y_{t-s}$,

Where $K_t^{\,d}$ is the desired capital stock in period t, and Y_{t-s} is the level of aggregate demand in the period t – s where s is the number of lags. A base of productive capacity, K, would be necessary to support the level of output demand, Y, in the capital goods sector or the whole economy (J.M. Clark, 1917, pp.217-35). The capital stock is adjusted, however, through "net investment, which, in turn equals (the flow of) gross investment – that is, the production of investment goods – minus (the flow of) depreciation" (G. Ackley, 1978, p.612). Thus,

(2) $K_t = K_{t-1} + I_{t-1} - \delta\, K_{t-1}$

where K_t is the capital stock in period t, K_{t-1} is the capital stock of the previous period, I_{t-1} is the level of gross investment in the previous period, and δ is the rate of depreciation of the capital stock.

Since the original accelerator model is implicitly assuming that $K_t^{\,d} = K_t$, meaning that the actual capital stock adjusts completely to the desired capital stock, substitute (2) into (1):

(1a) $K_t = K_{t-1} + I_{t-1} - \delta\, K_{t-1} = K_t^{\,d} = \alpha\, Y_{t-s}$

$$\Rightarrow I_{t-1} = \alpha\, Y_{t-s} - (1 - \delta)\, K_{t-1}$$

Adding one time period to all the variables,

(1b) $I_t = \alpha\, Y_{t-s+1} - (1 - \delta)\, K_t$

Thus, the relationship between the desired capital stock and the level of aggregate demand specified in equation (1) could be extended to the relationship between the desired level of gross investment, the level of output demand, and the stock of capital:

(3) $I_t^d = \alpha Y_{t-s+1} - (1 - \delta) K_t$

(Since the capital stock is always adjusted through changes in the level of net investment and the rate of depreciation, the relationship between the desired capital stock and the desired level of gross investment will henceforth be applied to all the models reviewed in this section of the paper).

P.K.Clark (1979) points out, nevertheless, that economists were not satisfied with this simple accelerator model because it suffered from the unrealistic built-in assumption that the "capital stock could be instantaneously adjusted to the desired level at no additional cost … as if net additions to capital were instantaneously available at a constant price" (P.K. Clark, 1979, p.77). In addition, adjustment may be incomplete because the rising supply prices for capital goods, installation costs, and production lags may increase costs to the point where only partial adjustment is optimal (P.K. Clark, 1979, p.78).

A capital stock adjustment model of a dynamic nature was, henceforth, developed by Roy F. Harrod in his "Essay in Dynamic Theory" in 1939 under the influence of Keynes' The General Theory of Employment, Interest, and Money (Rima, 1978, p.416). Following Harrod's model, an adjustment-cost approach was fully constructed by Eisner and Strotz (P.K. Clark, 1979, p. 78), the pertinent version of which would be:

(4) $I_t - I_{t-1} = \lambda (I_t^d - I_{t-1}) + u_t$,

Where the difference between actual and optimal gross investment is eliminated at the speed of the adjustment coefficient, λ. Substituting equation (3) into model (4), we get

(5) $I_t^d = \lambda \alpha Y_{t-s} - \lambda (1 - \delta) K_t + (1 - \lambda) I_{t-1} + u_t$,

Which states that desired gross investment, I_t^d, is a function of output in period s, Y_{t-s}, the level of gross investment in the previous period, I_{t-1}, and the capital stock in period t, K_t, subject to an adjustment coefficient, λ. Model (5), however, is never used in this form. It is rather the basis upon which Keynesian, neoclassical, or a synthesis of Keynesian-neoclassical models are built. Other variables, such as Keynesian cash flow variables or neoclassical production functions are usually substituted into the model. These variations are analyzed in the subsequent parts of this section.

B – Keynesian Flow Variables

One variation combines the original simple accelerator model, $K_t^d = K_t = \alpha Y_{t-s}$, with cash flow variables first laid out by Keynes as determinants of investment. In chapter 11 of his General Theory, Keynes linked investment spending to the present value of stream of profit flows expected from an extra built unit of capital accumulation. For a given investment decision, Keynes considered cost and the flow of net returns from period 1 to period n. Then, he evaluated the marginal efficiency of an investment project which he defined as the rate of interest that will discount the present value of the project to zero. Kalecki (1969) developed this approach most fully after economists had been working on the influence of flow variables on various aspects of investment throughout the sixties. These economists emphasized, following in the footsteps of Keynes, flow variables like the present value of profit flows, the ability of firms to generate investment funds from profits and through debt finance, and the level of net annual interest expense. In the eighties, it has been suggested that accelerator variables like output, sales, or capacity utilization and flow variables like after-tax profit that affect the finances of the firm and therefore its ability to invest, would have a strong positive influence on nonresidential fixed investment. The flow form of interest, i.e., interest commitments of firms, would have a negative impact (e.g., see Fazzari and Mott, 1986, p.173). This school's specification of model (5) then would be:

(6) $I_t^d = I_t = \alpha Y_{t-s} + \beta \Pi_{t-s} + \gamma \Gamma_{t-s} + u_t$,

Such that $\alpha > 0$, $\beta > 0$, and $\gamma < 0$, and where Π equals after-tax profit plus depreciation allowance minus dividends, and Γ is the annual interest expense. As is obvious from model (6), all independent variables are lagged by the period s. Finally, since the levels of optimal and actual investment are implicitly assumed to be always equal ($I_t^d = I_t$), no adjustment term, λ, is included.

C – The Accelerator-Flow Model

The simple accelerator-flow model described in part B of this section has evolved in several directions in recent literature. Although cash flow variables are considered amongst the main sources of internal funding of investment since they are generally cheaper than external finance as proposed by Duesenberry in his book Business Cycles and Economic Growth (McGraw-Hill, 1958), and although they predict the direction of future output and profitability, flow variables would perform better when integrated in the adjustment-cost framework. The purpose of such integration would be to combine flow variables with an adjustment-cost approach. And the resulting accelerator-flow model has the additional advantage of capturing the restraint imposed by the increasing marginal cost of supplying capital, and the effect of the irreversibility of investments projects over and above the simple flow model. Eisner (1978) is a leading proponent of this type of model.

Adding a profit variable to model (4), we obtain,

(7) $I_t - I_{t-1} = \lambda (I_t^d - I_{t-1}) + \beta \Pi_{t-s} + u_t$,

Then substituting equation (3) into model (7), we get,

(8) $I_t = \lambda\, \alpha\, Y_{t-s} - \lambda\,(1 - \delta)\, K_t + (1 - \lambda)\, I_{t-1} + ß\, \Pi_{t-s} + u_t$.

D – The Neoclassical Model

In the Classical tradition of Adam Smith and David Ricardo, profits are the source of all capital accumulation. Investment is seen to respond to output demand, but increases in output demand are the result of increases in capital accumulation. That's because according to Say's Law supply creates its own demand. Technically, the output of any industry is a function of that industry's inputs. Thus, the optimization of profits becomes dependent on input prices in the classical model. The capital goods industry is no exception to that rule and is therefore sensitive to the rental price of capital. Henceforth, many economists argued that any model of nonresidential fixed investment, and all investment for that matter, should incorporate some measure of the cost of capital. Jorgenson (1967) and others maintain that the stock adjustment model should incorporate "the neoclassical principle that the optimal combination of factor inputs should be a function of their relative prices" (P.K. Clark, 1979, p.82). Several measures of the cost of capital were thus devised. Elliott (1980) provides a summary of four of those measures with econometric tests for them. Most of these measures, in fact, include terms for the interest, inflation, depreciation, and tax rates, or some combination thereof.

Nevertheless, the inclusion of measures of the cost of capital in model (5) did not complete the neoclassical model. Both Keynesian and neoclassical economists, such as Lawrence and Siow (1985), and Taylor (1982), pointed out the so-called aggregation problem. Capital is not a homogeneous entity. Different types of capital have different demand parameters, and may not respond in the same manner to changes in the average index of capital cost. Such an index might turn out to be empirically irrelevant in spite of the theoretical validity of its inclusion in the model. The role of interest rates, for example, as one such index has been particularly controversial in the investment literature as is expounded in section III.

Furthermore, the assumption of a Cobb-Douglas production function does not necessarily describe accurately the actual technical conditions of production in the capital goods industry. In fact, the production structure was found to have flexible functional forms by Berndt and Wood (1975), Griffin and Gregory (1976), and Garofalo and Malhotra (1984).

To correct for these unrealistic assumptions, a modified neoclassical model emerged. The work of Garofalo and Malhorta (1985) addresses the above two criticisms by:

1) disaggregating investment into two separate categories, one for structures and another for equipment, and
2) assuming a translog production function with no restrictions on the magnitude of the elasticities of substitution.

Their model is summarized in the following system of equations (Garofalo and Malhorta, 1985, p. 53):

(9) $I_{tN} \approx K_t - K_{t-1}$

(10) $K_t = f\,(K_t^{\,d}, K_{t-1})$

(11) $K^d = g\,(P_{it}, Y_t, T_t)$

where I_{tN} is net investment in period t; K_t is the capital stock in period t; $K_t^{\,d}$ is the desired capital stock in period t; P_{it} is the price index of the ith input in period t; and T_t is an index of technology.

And, "although a single model is developed, two specifications of the model are estimated. First, a four-factor model with building capital (K_B), machinery capital (K_M), labor (L), and energy (E) as inputs is estimated… Second, a three-factor model is estimated with K_B and K_M aggregated into a single index of capital (K_A)" (Garofalo and Malhorta, 1985, p. 53). Each of these forms of investment accounts, hence, for the role of other inputs*. Then, each of K_B, K_M, K_A are considered separately by Garofalo and Malhorta (1985) who found the disaggregated model to outperform the standard aggregated model (p.61).

*Note: [Garofalo and Malhorta develop their reasoning in several pages of mathematical derivations. To exemplify the influence of the production function on the stock of optimum capital without reproducing Garofalo and Malhorta's mathematics, a simplified summary of Jorgenson's pioneering analysis (1967) is provided.

Given the Cobb-Douglas production function, $y = \alpha K^{\gamma} L^{(1-\gamma)} \Rightarrow$

$$\partial y / \partial K = \alpha \gamma K^{(\gamma-1)} L^{(1-\gamma)}$$

$$\Rightarrow \partial y / \partial K = [\alpha \gamma K^{\gamma} L^{(1-\gamma)}] / K$$

$$\Rightarrow \partial y / \partial K = \gamma y / K$$

Setting the value of this marginal product (γy/K times p) equal to the rental price of capital, c, and rearranging gives:

$K = (p\, \gamma y) / c = K^*$, where K^* is the optimum capital stock (G. Ackley, 1978, p.634) (end of note)].

Following the line of reasoning developed earlier in part A of this section on the relationship between the capital stock and the level of investment, K_t is substituted with the level of gross investment I_t , and $K_t^{\,d}$ with the level of desired gross investment $I_t^{\,d}$. Disregarding equation (9), and substituting equation (11a) into (10a) below, we get

the following functional form for the modified neoclassical model in equation (12):
(10a) $I_t - I_{t-1} = \lambda (I_t^d - I_{t-1}) + u_t$, i.e., model (4),
(11a) $I_t^d = \alpha P_{it} + \beta Y_t + \gamma T_t - (1- \delta) K_t$,
Now substituting (11a) into (10a) we get:
(12) $I_t = \lambda\alpha P_{it} + \lambda\beta Y_t + \lambda\gamma T_t - \lambda(1- \delta) K_t + (1 - \lambda)I_{t-1} + u_t$.

E – The Q-Theory of Investment

While all the preceding four variations of investment models use a combination of real variables relating to output, interest, and after-tax profits, the q-theory of investment, first expounded by Jamis Tobin (1967), is modeled in a financial formula. "If the market value of a firm exceeds the replacement cost of its assets, it can increase its market value by investing in more fixed capital. Conversely, if the market value of a firm is less than the replacement cost of its assets, it can increase the value of shareholders equity by reducing the stock of fixed assets" (P.K.Clark, 1979, p.84). Thus, variations in investment will be dependent on variations in Q, where Q equals the ratio of a firm's value to its replacement cost of capital.

Thus, given
(4) $I_t - I_{t-1} = \lambda (I_t^d - I_{t-1}) + u_t$, where according to the q-theory of investment,
(13) $I_t^d = a Q_{t-s}$.
Substituting equation (13) above into model (4), we obtain
(14) $I_t = \lambda a Q_{t-s} + (1 - \lambda) I_{t-1} + u_t$.

Subsequently, the q-theory of investment became a rival of cash flow variables in investment models (Fazzari and Mott, 1986, p.172). This is because "marginal q is the expectation of a present value of a stream of marginal profit" (Abel and Blanchard, 1986, p. 250). And that concept is very similar to cash flow variables like after-tax profit flows except that is has been situated in a context of a finance-based model.

Nevertheless, models using average Q, which has been used as a proxy for marginal Q and which is defined as the value of firm divided by the replacement cost of its capital, continued to flourish (e.g., vonFurtenberg 1977, and Summers 1980). These have been criticized on a theoretical basis because "the capital stock is not homogenous, so that the estimate of replacement cost in the denominator of Q may have only a tenuous connection with the true cost of replacing existing capacity" (P.K. Clark, 1979, p.85). They have also been criticized because Q does not "separate out interest rate from output effects" (Lawrence and Siow, 1985, p.360).

Abel and Blanchard (1986) tried to correct for these criticisms by estimating marginal Q instead of average Q, where marginal Q is arithmetically the ratio of the valuation of an additional unit of capital to the cost of this unit. They found that marginal Q, like average Q, "leaves unexplained a large serially correlated fraction of investment", and "output and profit variables still enter significantly when added to our investment equations" (Abel and Blanchard, 1986, p.250).

III – Theoretical Premises

A – THE SYNTHESIS

Most econometric studies of investment today are not strictly Keynesian or neoclassical. Rather, the main body of the literature presents models that are a synthesis of elements from both schools. A synthesis of a neoclassical orientation could be exemplified by Coen and Hickman (1980) who assuming a Cobb-Douglas production function estimated a log-linear relationship that "expresses the demands for capital and labor inputs as functions of their own lagged values, of expected output, the expected wage-rental ratio, and the trend rate of technical progress" (p. 215). A synthesis with a Keynesian leaning is that of Lawrence and Siow (1985) where investment is a function of its own lagged value, expected output, nominal interest rate, and the rate of inflation (p. 365). Thus, even though both studies emphasize the role of some measure of cost of capital, the wage-rental ratio in the first case, and nominal interest in the second, Lawrence and Siow attribute the explanatory power of nominal interest rates not to interest rates as the rental price of capital per se, but to its predictive value with respect to GNP.

It is the opinion of the present writer that from a purely theoretical point of view, a synthesis model can describe more accurately the dynamics of the investment process than any of individual models examined. For while the simple accelerator model and the flow models both lack an adjustment parameter for the capital stock, the accelerator-flow model includes both a stock adjustment parameter and a crucial cash flow variable. And while the simple neoclassical model suffers from unrealistic assumptions regarding aggregation and the technical conditions of the production structure, it provides a measure of the cost of capital which is lacking in most alternative models. Yet, neither does the accelerator-flow model have a capital cost index, nor does the modified neoclassical model have a cash flow variable so essential for internal funding and as an index of the expectations of the firm. Therefore, it seems that a synthesized model that combines some measure of the cost of capital with the accelerator-flow model may be the most adequate theoretical formulation of the relationship between investment and its determining variables.

The question here immediately arises as to the specific nature of the index of cost of capital that should be adopted in such a model. This is the question to be explored next.

B – THE INTEREST RATE CONTROVERSY

Despite the standard assumption that investment and interest rates are inversely related, much controversy surrounds this issue on the empirical level. Benanke (1983), using a q-theory of investment approach to test date for the years 1947 – 79, found that an increase in real interest rates of one-percent (holding nominal interest rates constant) decreases net equipment investment by 12.1%, while investment in net structures decreased by only 6.3%. By contrast, Feldstein (1983) found after using data for the years 1948 – 79 that "high interest rates may have caused firms to reduce investment in long-lived structures by more than the reduction in equipment investment" (p.148). To complicate things further, Lawrence and Siow (1985) found while studying investment in producer equipment in the years 1947 –80 that "higher nominal interest rates would be inversely related with new investment expenditure decisions, despite the fact that real interest rates remained constant" (p.361). They, however, concluded that even though "the real cost of capital does matter in explaining investment initially… this effect is relatively small and becomes insignificant after two quarters in the case of producer equipment" (p.374).

Other writers led by Clark (1979) state that the rental price of capital services "is not very helpful in explaining quarterly data on business fixed investment in the United States over the past twenty-five years", 1954-1978 (p. 104). Clark, nevertheless, does not formally reject the inverse relationship between interest rates and investment, but claims it must be estimated "with more comprehensive data than quarterly aggregates" (1979, p.104). Clark then proceeds to contradict Lawrence and Siow writing that this relationship is "likely to be felt gradually, over long periods of time" (1979, p.104).

Consequently, the present writer agrees with Lawrence and Siow that "because of all these conflicting results, how interest rates affect investment behavior remains inconclusive although this is an important question in macroeconomic modeling and the theory of the business cycle" (1985, p.360). Thus, it seems that the nature of the relationship between interest rate and investment depends on whether tax and depreciation rates are included in the rental price of capital services term, how the model is specified mathematically, and the number of distributed lags, to choose a few among many possibilities.

Moreover, in view of the fact that most models use quarterly data, it appears appropriate to take Clark's advice regarding the need of "using more comprehensive data than quarterly aggregates" in building a new model of investment. Hence, this paper examines historical trends rather than quarter-to-quarter variations in an effort to focus on some of the more long term and substantive causal factors.

Finally, this model will test the hypothesis presented in some recent articles that assert that the relationship between real interest rates and investment is subject to a ratchet effect (Larkins and Gill, 1985). The ratchet principle emphasizes the impact of the last highest value of real interest rate on investment. Thus, as real interest rates rise, the cost of investing grows larger which triggers shifts to new investment techniques designed to diminish cost. When interest rates recede from their previous peak, the new technology remains installed until a still higher interest rate is recorded. One example would be a rise in the cost of inputs compounded by a higher rate of interest that induces businesses to invest in and adopt a new technology which is neither labor nor energy-intensive (Feldstein, 1983, p. 148).

IV – Model and Data

In the preceding pages it was suggested that a synthesis of the accelerator-flow model that incorporates some measure of interest rate would be more justified theoretically than the other alternative models. It was also pointed out that since the exact relationship between interest rates and investment is not yet established, the choice of any particular measure of interest rate as a cost of capital goods is still open to experimentation. In this paper, interest rates are included as a ratchet variable in an attempt to test its effect on business expenditure for new plant and equipment, as proposed by Larkins and Gill (1985). In accordance with Clark's suggestion (1979, p. 104), annual data are used estimation purposes for the years 1950 – 1988.

Theoretically, the ratchet interest rate, R_t, and the level of real output, Y_t, are hypothesized to determine the level of the optimal or desired new business spending for plant and equipment, I_t^d. This relationship could be written as follows:

(15) $I_t^d = a_0 + (a_1 - a_2 R_t)\, Y_t,$

Whereby the impact of the ratchet real interest rate increases as the level of real output increases; and where Y_t is equal to real personal consumption, C_t, plus real gross investment, I_t, plus real government spending, G_t, plus real net exports, X_t, i.e., Y_t is equal to GNP_t, thus the identity:

(16) $Y_t \approx C_t + I_t + G_t + X_t = GNP_t$

In defining Y_t as real demand in the economy, we have adopted the principle that investment in the capital goods sector is undertaken to support the activities of the rest of the economy, which is an adaptation of the principle used by Larkins and Gill to describe the relationship between inventories and final business sales (1985, p.18).

Model (4) which as be recalled states that the difference between actual and desired investment is eliminated at the speed of the partial adjustment coefficient λ,

(4) $I_t - I_{t-1} = \lambda (I_t^d - I_{t-1}) + u_t$,

where $0 \leq \lambda \leq 1$. Hence, if λ = 1, the gap between actual and desired investment is narrowed in the current period, whereas if λ = 0, the gap remains unbridged.

Substituting equation (15) into model (4),

(17) $I_t - I_{t-1} = \lambda [(a_0 + (a_1 - a_2 R_t) Y_t - I_{t-1}] + u_t$

In addition our model includes factors that impinge on the investment process without being part of the accelerator or adjustment mechanisms. The most important among these are:

1) a cash flow variable as it is the source of internal funding for investment, and as it is the source of future output and profitability. Since profit is targeted by economists as the prime cash flow variable, we use real after-tax profits of non-financial corporate business without inventory valuation adjustment and capital consumption allowance, π_t. Profits, π_t , are then divided by a proxy for capacity utilization, the total manufacturing capacity utilization rate, CP_t. The resulting series, (π_t / CP_t), is technically a measure of the average profit per one-percent of capacity utilized, where profit is measured in real billion dollars. It is expected that the term (π_t / CP_t) will have a strong positive impact on the level of investment as the latter is theorized to be a function of profits (vonUngern-Sternberg, 1980, p.747).
2) a dummy variable for recession years, DR, as it is expected the level of investment will fall disproportionately in recession years due to bleak expectations on profits and output demand.
3) A dummy variable, DT, to capture the change in tax parameters after the Economic Recovery Tax Act, ERTA, which was signed into law in August 1981, but which began to exert its impact on investment expenditure in 1983 – 1984. "The corporate income tax was … reduced from 48 to 46 percent, and ERTA allowed accelerated depreciation of new capital assets and a system of tax credits for investment. Both of these provisions decreased the effective tax burden on new investment" (Schnitzer, 1987, p.134). Thus, the variable, DT, is expected to have a positive impact on investment as a lower tax burden will increase after-tax profits, and thereby shift the investment function upward.

Substituting π_t , DR, and DT above into model (17), we obtain:

(18) $I_t - I_{t-1} = \lambda [(a_0 +(a_1 - a_2 R_t)Y_t - I_{t-1}] + a_3 (\pi_t / CP_t) + a_4 DR + a_5 DT + v_t$,

where v_t is the disturbance term.

Solving for the level of gross investment in the current period, I_t , we get:

(18a) $I_t = \lambda a_0 + \lambda a_1 Y_t - \lambda a_2 R_t Y_t + (1 - \lambda) I_{t-1} + a_3 (\pi_t / CP_t) + a_4 DR + a_5 DT + v_t$,

which is the final equation to be estimated with the OLS procedure. It should be noted, however, that the coefficient of output demand, Y_t, and that of the ratchet interest rate, R_t, represent only short-run estimations of the impact of changes in these independent variables on the level of investment. To calculate the long-run estimations, a_1 and a_2, λa_1 and λa_2 have to be divided by λ which represents the speed of adjusting the actual to the desired level. How λ is arithmetically obtained from the coefficient of the lagged investment variable, I_{t-1} , will be shown in the next section.

The data used in the estimation of model (18a) are all obtained from the Economic Report of the President. Output demand, gross investment, and profits are all annual rates measured in billions of current dollars then deflated by the Producer Price Index, base year – 1982. The capacity utilization variable is represented by the output-capacity ratio for the manufacturing sector annual rates.

The generation of numerical values for the ratchet interest rate variable is fairly simple. First, the rate of change in the Producer Price Index, base year, 1982, is subtracted from commercial paper rate (6 months) to derive real interest rates. The first value of the real rate of interest is set equal to the first value in the ratchet series. If the second value of the real rate of interest is greater than the first, the second value is recorded after the first ratchet value. If not, the first ratchet value is retained throughout the subsequent years until the next higher real interest rate comes along. Thus, the last highest value for the real interest rate is recorded so long as it is above that of the preceding years. When this procedure is completed, we should end up with a real interest rate series where the last highest value of the ratchet series where the highest value of the ratchet series is the same as the last highest in the interest rates series.

V – RESULTS

Applying the OLS method to model (18a), and using the above annual data, the following results are obtained:

$I_t = - 22.86 - 0.039 Y_t - 0.052 R_t Y_t + 0.59 I_{t-1} + 23.06 \pi_t/CP_t - 14.57 DR + 13.98 DT$

Table 2: Estimated Coefficients and Associated T-Values

	Constant	Y_t	R_tY_t	I_{t-1}	π_t/CP_t	DR	DT
Coefficient	-22.86	-0.039	-0.052	0.59	23.06	-14.57	13.98
T-Value	*-4.29*	*4.27*	*-0.9*	*9.61*	*2.87*	*-2.87*	*4.3*

Table 3: Vital Statistics for the Estimated Model

Period of Fit	R-Squared	Adjusted R^2	Durbin-Watson, D-W	Number of Observations, n	F-Value	Prob > F	h-statistic
1950-1988	0.99	0.99	2.17	39	1053.139	0.0001	- 0.575

Thus, the estimated model explains more than 99 percent of the variations in real investment in plant and equipment during the period 1950 – 1988. The F-statistic suggests that the overall fit is statistically significant at the 1 percent level. The Durbin-Watson test is not applicable in this case since we are using a lagged dependent variable as an independent variable. Therefore, the h-statistic is calculated instead, and it is found to be well below the critical value of 1.67. This signifies that the estimated equation does not suffer from an autocorrelation problem.

All the coefficients have the expected signs. And except for the scaled ratchet variable, all the estimated coefficients are significant at least at the 1-percent level for the one-tailed test.

The statistically insignificant t-value for the scaled ratchet shows that albeit its coefficient enters the model with the right sign, its impact on the level of investment is statistically invalid. One reason for that could be tax exemptions on interest payments for nonresidential fixed investment (Abel and Blanchard, 1986, p.255). Indeed, “the Modigliani – Miller work shows that for certain well specified capital market conditions the only impact of debt financing upon the cost of capital arises from the tax deductibility of interest payments” (Elliott, 1980, p.985). “Tax laws and depreciation allowances offset some of the higher cost of capital” (Garofalo and Malhorta, 1985, p.58). Nonetheless, definitions for the rental price of capital that accounted for tax parameters and depreciation have not yet produced uncontroversial conclusions. And neither does the inclusion of the new ratchet rate of interest salvage this relationship from its empirical inconclusiveness. In other words, there is still room for further experimentation, maybe with a ratchet that accounts for the tax deductibility of interest payments on investment.

In the interpretation of the estimated coefficients, it should be remembered that the coefficients of both output demand, Y_t, and the scaled ratchet variable, R_tY_t, stand only for the immediate short-run impact of their change on the level of gross investment. To obtain the short-run impact of an increase in real output demand by one billion dollars, we should get the partial derivative of I_t with respect to Y_t:

$\partial I_t/\partial Y_t = 0.039 – 0.052\ R_t$.

At the point of means of R, which is equal to 0.054, meaning that the average ratchet interest rate between 1950 and 1988 is 5.4%, the numerical value of the short-run of the partial derivative is:

$\partial I_t/\partial Y_t = 0.039 – (0.052)(0.054) = 0.036$.

Thus, an increase of one billion dollars in real output elicits an increase in real business expenditure for new plant and equipment by $36 million in the short-run.

And even though the t-value of the ratchet interest rate is insignificant, we will calculate its short and long run coefficients, and the ratchet interest elasticity of gross nonresidential fixed investment for comparative purposes. Similarly, $\partial I_t/\partial R_t = -0.052\ Y_t$, which at the mean of Y equals –121.212. Hence, if the coefficient of the interest ratchet had been significant we would have said that an increase in the scaled ratchet by 1 percent leads to a decrease in real gross investment by $121 billion in the short-run.

To obtain the long-run impact, both coefficients have to be divided by λ which is equal to one plus the coefficient of the lagged dependent variable I_{t-1}. Hence, $1 + (-0.59) = \lambda = 0.41$, which means that the speed of adjusting the actual to the desired or optimal level of gross investment is 41% in one year, which is very slow since it implies that it takes about two and a half years to eliminate a given discrepancy.

Dividing the estimated coefficients of output demand and the scaled ratchet by λ = 0.41, we derive their long-run estimates. Thus, $\partial I_t/\partial Y_t = (0.039/\lambda) – (0.052/\lambda)\ R_t = 0.88$ at the mean of R. As real output demand increases by $1 billion, the long-run overall response of real gross investment would be an increase of $88 million. Similarly, $\partial I_t/\partial R_t = (-0.052/\lambda)\ Y_t = -295.64$ at the mean of Y. If the coefficient of the ratchet interest rate had been significant, as the ratchet interest rate increases by 1 percent, real gross investment would decline by $295 billion in the long-run. Below, coefficients and elasticities are compared in Table 4:

Table 4: The Elasticity of Investment with Respect to Output Demand and the Ratchet Interest Rate, and their Estimated Coefficients in the Short and Long Runs

	Coefficients		Elasticities	
	Short-run	Long-run	Short-run	Long-run
Output D	0.036	0.088	0.41	0.995
Ratchet	-121.2	-295.64	-0.032	-0.077

The elasticities for real gross investment with respect to real output demand and the ratchet interest rate were calculated at the point of means. The mean of gross real investment is \$206.18 billion, that of output demand, \$2331 billion, both in 1982 prices, that of the scaled ratchet, R_tY_t, \$126.85 billion, and that of the interest rate ratchet, 0.054, or 5.4%.

The calculated elasticities of output demand are inelastic in the short-run and unitary elastic in the long-run. Given other things, this implies that an increase in total demand by one-percent would probably increase gross nonresidential fixed investment in new plant and equipment by about one-percent in the long-run.

On the other hand, generalizations are not possible about the ratchet elasticity of nonresidential fixed investment because its t-value is insignificant. But if it has been significant, it could have been said, then, that gross investment is inelastic with respect to interest in the short and the long-run.

The cash flow variable, π_t/CP_t, enters the equation positively as predicted. Its coefficient implies that as the average real profit per one-percent of capacity utilized increases by \$ 1 billion, firms would undertake the expansion of their productive capacity further by spending an extra \$ 23.06 billion on new plant and equipment. This could be explained by the fact that increased profits provide firms with cheaper sources of investment funding, and that higher profit rates indicate higher potential total demand.

Finally, the dummy variable for recession years shifts the intercept term downwards by 14.57, so that the intercept becomes (-22.86) + (-14.57) = -37.43. This means that during recession years low expectations shift the investment function disproportionately downward in the short-term. Dividing the intercept by λ = 041, we get the long-term intercept of (–55.75). The intercept would then be in the long-run, during recession years, (-55.75) + (-14.57) = -70.32, which shows that a recession would shift investment downward in the long-run even further.

By comparison, the dummy variable denoting the change in tax rules shifts the intercept term upwards by 13.98, so that it becomes in the short-run (-22.86) + (13.98) = - 8.57, which shows that the tax laws introduced in the beginning of the eighties have had a positive impact on nonresidential fixed investment. The same institutional change in tax rules has a long-run effect that is also positive albeit weaker. Thus in the long-run, (-55.75) + (13.98) = -41.77 is the intercept of the investment function in the aftermath of the change in tax parameters.

The statistical results analyzed above show that while no exact relationship, if any, could be established between the ratchet interest rate, on one hand, and gross nonresidential fixed investment on the other, investment is mostly influenced by total output demand and the average profit rate per unit of capacity utilized. The influence of output demand in the whole economy is both short-run and long-run with the long-run impact well above than twice the short-run effect. The potent effect of the profit variable corroborates the findings of other papers, e.g., Eisner, 1978, and Fazzari and Mott, 1986, which emphasize the role of cash flow variables, like profit, to investment.

The output demand elasticity of gross investment which is almost unitary elastic in the long-run suggests that policy recommendations oriented towards stimulating output might better stimulate investment than policies that seek to control investment through interest rates. This is because according to this paper, and many others, a definite causality could not be established between interest rates and gross nonresidential fixed investment in new plant and equipment. A ratchet interest rate variable does not clear the ambiguity that shrouds this relationship even in the context of an accelerator-cash flow model.

Bibliography

Abel, A.B. and Blanchard, O.J., "The Present Value of Profits and Cyclical Movements in Investment", *Econometrica*, March 1986, 54(2), pp. 249 –73.

Ackley, G., "Macroeconomics: Theory and Policy", London: Macmillan, 1978.

Bernanke, B.S., "The Determinants of Investment: Another Look", *American Economic Review*, May 1983, 73(2), pp.71-75.

Berndt, E.R. and Woods, D.O., "Technology, Prices, and the Derived Demand for Energy", *Review of Economics and Statistics*, 1975, 57(3), pp. 259 – 68.

Clark, J.M., "Business Acceleration and the Law of Demand: A Technical Factor in Economic Cycles", *Journal of Political Economy*, March 1917, 25, pp.217 – 35.

Clark, P.K., "Investment in the 1970's: Theory, Performance, and Prediction", *Brookings Papers on Economic Activity*, 1979, (1), pp. 73 –117.

Coen, R.M. and Hickman, B.G., "Investment and Growth in an Econometric Model of the United States", *American Economic Review*, May 1980, 70(2), pp. 214-9.
Denison, E.F., "The Contribution of Capital to Economic Growth", *American Economic Review*, May 1980, 70(2), pp.220-4.
Duesenberry, J.S., "Business Cycles and Economic Growth", New York: McGraw-Hill, 1958.
Eisner, R., "Factors in Business Investment", Cambridge, Mass.: National Bureau of Economic Research, 1978.
Elliott, J.W., "The Cost of Capital and U.S. Capital Investment: A Test of Alternative Concepts", *Journal of Finance*, September 1980, 35(4), pp. 981-99.
Fazzari, S.M. and Mott, T.L., "The Investment Theories of Kalecki and Keynes: An Empirical Study of Firm Data, 1970-1982", *Journal of Post-Keynesian Economics*, Winter 1986-87, 9(2), pp. 171-87.
Feldstein, M., "Has the Rate of Investment Fallen?", *Review of Economics and Statistics*, February 1983, 65(1), pp.144-9.
vonFurstenburg, G.M., "Corporate Investment: Does Market Valuation Matter in the Aggregate?", *Brookings Papers on Economic Activity*, 1977, (2), pp. 347-97.
Garofalo, G.A. and Malhorta, D.M., "Input Substitution in the Manufacturing Sector during the 1970's: A Regional Analysis", *Journal of Regional Science*, 1984, 24(1), pp. 51-63.
-- "The Impact of Changes in Input Prices on Net Investment in U.S. Manufacturing", *Atlantic Economic Journal*, December 1985, 13(4), pp. 52-62.
Griffin, J.M. and Gregory, P.R., "An Inter-Country Translog Model of Energy Substitution Responses", *American Economic Review*, 1976, 66(5), pp. 845-57.
Harrod, R.F., "An Essay in Dynamic Theory", *Economic Journal*, March 1939, 49.
Jorgenson, D.W., "The Theory of Investment Behavior", in *Determinants of Investment Behavior*, edited b Robert Ferber, New York: National Bureau of Economic Research, 1967.
Kalecki, M., "The Theory of Economic Dynamics", New York: Kelly, 1969.
Keynes, J.M., "The General Theory of Employment, Interest, and Money", London: MacMillan, 1936.
Klingaman, D. and Koshal, R.K., "A Model of United States Inflation, 1959 – 80", *Atlantic Economic Review*, September 1982, 10(4), pp.100.
Larkins, D. and Gill, G.S., "Interest Rates and Aggregate Inventory Investment", *Survey of Current Busines*, June 1985, 65(6), pp.17-20.
Lawrence, C. and Siow, A., "Interest Rates and Investment Spending: Some Empirical Evidence for Postwar U.S. Producer Equipment, 1947 –1980", *Journal of Business*, October 1985, 58(4), pp. 359-75.
Rima, I.H., "Development of Economic Analysis", Illinois: Irwin, 1978.
Schnitzer, M.C., "Comparative Economic Systems", Cincinati: South-Western, 1987.
Summers, L., "Taxation and Corporate Investment: A q Theory Approach", *Brookings Papers on Economic Activity*, 1980, (1), pp. 57-107.
Taylor, J., "The Swedish Investment Funds System as a Stabilization Rule", *Brookings Papers on Economic Activity*, 1982, (1), pp.57-107.
Tobin, J., "A General Equilibrium Approach to Monetary Theory", *Journal of Money, Credit, and Banking*, 1969, 1(1), pp.15-30.
VonUngen-Sternberg, T., "Current Profits and Investment Behavior", *Bell Journal of Economics*, Autumn 1980, 11(2), pp.745-8.