JOHN B. TAYLOR
Princeton University

The Swedish Investment Funds System as a Stabilization Policy Rule

An important development in the methodology of policy evaluation research in macroeconomics is the growing emphasis on the effects of policy systems—operating either by institutional arrangement or formal policy rules—rather than on the effects of one-time changes in the policy instruments. For instance, many studies on monetary policy in recent years have focused on the effect of a system in which the money supply systematically responds to the state of economic activity; previously the focus was on the effect of a change in the money supply at a particular date. Recent examples of policy proposals resulting from such research include rules for the Federal Reserve to increase interest rates by a certain amount whenever the consumer price index rises above a fixed target or, alternatively, rules to hold the growth rate of money constant except for temporary countercyclical deviations keyed to the unemployment rate or to the growth rate of nominal GNP.[1] As these examples

1. For discussions of proposals along these lines see Robert E. Hall, "A Free-Market Policy to Stabilize the Purchasing Power of the Dollar" (Hoover Institution and Stanford

illustrate, proposals emerging from recent research do not necessarily entail fixed settings for the policy instruments as with earlier proposals for policy rules.[2] Revived interest in gold or general commodity standards also reflects the recent emphasis on policy systems.

There are a number of reasons for this new emphasis. Increased attention to expectations has led to the need to specify future as well as current policy actions and hence to the specification of policy rules.[3] The problem of time inconsistency and the closely related credibility issue have underlined the advantages of maintaining policy rules even when there are short-term advantages to their suspension.[4] Finally, advances in the technical area of stochastic analysis of business cycle fluctuations have made it feasible to study the systems effects of policy rules on the behavior of economic systems.[5]

Much of this shifting emphasis, however, has been in the more theoretical areas of macroeconomic research and as yet there have been relatively few empirical evaluations of alternative policy systems. One reason, perhaps, is the lack of historical episodes in which an empirical study of a macroeconomic policy rule is clear-cut. It is unfortunate that there appear to be few instances with a well-publicized systematic macroeconomic policy rule in operation for a sufficiently long time for firms or consumers to become familiar with how the rule operates.

The Swedish investment funds system used for countercyclical pur-

University, December 1981); John B. Taylor, "Establishing Credibility: A Rational Expectations Viewpoint," *American Economic Review*, vol. 72 (May 1982, *Papers and Proceedings, 1981*), pp. 81–85; and Rudiger Dornbusch and Stanley Fischer, "A Framework for Price Stability" (Massachusetts Institute of Technology, January 1982).

2. Milton Friedman, *A Program for Monetary Stability* (Fordham University Press, 1959).

3. The importance of expectations for policy evaluation is a central argument of the Lucas critique. See Robert E. Lucas, Jr., "Econometric Policy Evaluation: A Critique," in Karl Brunner and Allan H. Meltzer, eds., *The Phillips Curve and Labor Markets*, Carnegie-Rochester Conference Series on Public Policy, vol. 1 (Amsterdam: North-Holland, 1976), pp. 19–46.

4. Finn E. Kydland and Edward C. Prescott discuss the relation between time inconsistency and rules in "Rules Rather Than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, vol. 85 (June 1977), pp. 473–91. Time inconsistency arises when it is optimal to change policy in the future from what is announced today. This optimality raises doubts about the credibility of the announced policy.

5. This point is discussed in detail in Robert E. Lucas, Jr., "Methods and Problems in Business Cycle Theory," *Journal of Money, Credit and Banking*, vol. 12, pt. 2 (November 1980), pp. 696–715.

poses during the 1950s and 1960s provides a rare opportunity to study a policy rule in operation. Widely publicized and consistently operated as a policy institution to stabilize cyclical fluctuations in business investment by making capital expenditures cheaper during recessions, it is ideal for an empirical investigation of the systems effect of policy. Moreover, as a fiscal policy rule, the Swedish system permits an investigation that complements existing research on monetary systems and that can potentially provide useful information about the appropriate mix of monetary and fiscal policy rules. The main objective of this paper is to reexamine the Swedish investment funds system from the perspective of the new methodology of policy evaluation research.

The analysis proceeds in four stages. First, I describe the institutional features of the investment funds system during its countercyclical period in the 1950s and 1960s and characterize its operation in a way suitable for quantitative policy evaluation. Second, I develop a model of cyclical investment behavior oriented toward countercyclical policy evaluation. The model emphasizes investment in structures, the form of investment at which much of the investment funds system was aimed, and uses heterogeneous gestation lags rather than adjustment costs to account for the lags in investment spending. The cyclical behavior of investment is characterized by a distributed lag accelerator equation in which the lag coefficients depend on the gestation periods and the investment funds system. According to the model, the effect of the investment funds system would show up in the coefficients of this accelerator model: the system would shrink the coefficients and thereby alter the cyclical behavior of investment. Third, I look at the effects of the system empirically by examining reduced-form accelerator parameters for manufacturing investment in Sweden. Finally, I calculate the impact of the system using numerical parameter values for the structural investment model.

The Swedish Investment Funds System

Beginning with new legislation in 1955, the Swedish investment funds system was specifically designed as a countercyclical stabilization policy aimed at reducing fluctuations in nonresidential investment, and was in

fact used actively for that purpose for nearly two decades.[6] The explicitly announced policy was that the funds system would as a rule "release funds" to firms for investment purposes during recession periods. Beginning with the recession of 1958, such a release actually took place, confirming the announced policy. Subsequent releases occurred in 1962 and 1967, both periods of reduced growth or declining economic activity. Funds were only released on a limited basis in certain geographical regions of Sweden in the recession of 1971, and it now appears the system had begun to lose its countercyclical characteristics by then. Clearly by 1975 the investment funds system had become an essentially permanent investment stimulus, with releases of funds regularly extended each year, not merely during recessions.

Because this paper focuses on the investment funds system as a stabilization policy rather than as a permanent stimulus, the analysis is limited to the earlier period from the mid-1950s to the early 1970s, when the system was well understood by firms and the government to operate countercyclically and in reality operated that way. At least during this period it seems accurate to assume that firms' expectations about the investment policy were rational in the sense that they "knew the policy rule."

ALLOCATION AND RELEASES FROM THE INVESTMENT FUNDS

The investment funds system is a component of the general corporate tax system in Sweden.[7] Swedish corporations pay a corporate profits tax at both the local and the national levels. The local tax rate varies by region but averaged about 20 percent in the 1960s.[8] The national rate

6. An investment funds system was first enacted in 1938 in Sweden, but it was not effective as a countercyclical device until 1955 when the provisions (described below) were enacted, requiring firms to deposit a fraction of their allocation at the central bank (Bank of Sweden). This provision turned the releases into explicit subsidies. See Gunnar Eliasson, "Investment Funds in Operation," Occasional Paper 2 (Stockholm: National Institute of Economic Research, 1955), pp. 9–10.

7. Useful references on the investment funds system include Eliasson, "Investment Funds"; Assar Lindbeck, *Swedish Economic Policy* (University of California Press, Berkeley, 1974); Villy Bergström, "Studies in Swedish Post-War Industrial Investments" (Ph.D. Dissertation, Uppsala University, 1981); Thomas Lindberg and Jan Södersten, *Taxation of Income from Capital: An International Tax Comparison,* unpublished (National Bureau of Economic Research, 1981), chap. 7.

8. Martin Norr, Claes Sandels, and Nils G. Hornhammar, *The Tax System in Sweden* (Stockholm: Stockholms Enskilda Bank, 1969), p. 16.

Table 1. Variables Affecting Investment Incentives in Nonresidential Structures, Sweden, 1955–72[a]

Percent unless otherwise specified

Year	Statutory tax rate, t_s	Effective tax rate, t_e	Interest rate, r	Present value of tax depreciation, x	Fraction of time that funds are released, w	Effective discount on investment expenditures[b]
1955	52	47	4.6	42	0.00	20
1956	56	50	4.7	41	0.00	21
1957	56	50	5.1	39	0.00	20
1958	57	50	5.1	39	0.67	37
1959	57	50	5.2	39	0.75	39
1960	49	45	6.0	35	0.00	16
1961	49	48	6.0	35	0.00	17
1962	49	48	5.5	38	0.50	35
1963	49	48	5.0	40	0.33	30
1964	50	48	6.1	35	0.00	17
1965	51	49	6.4	34	0.00	17
1966	51	49	6.8	33	0.00	16
1967	51	49	6.2	35	0.67	40
1968	52	50	6.5	34	0.50	34
1969	52	50	7.2	31	0.25	24
1970	53	50	7.5	31	0.00	15
1971	54	51	7.5	31	0.00	16
1972	54	51	7.4	31	0.00	16

Sources: The variables t_s, t_b, r, and δ were provided by Villy Bergström as part of the data set used to compute capital costs in his "Studies in Swedish Post-War Industrial Investments" (Ph.D. dissertation, Uppsala University, 1981). The fraction, w, was computed from release dates reported in the *OECD Economic Surveys: Sweden* (Paris: OECD, April 1963), p. 20, and (Paris: OECD, March 1969), p. 28; and in Gunnar Eliasson, "Investment Funds in Operation," Occasional Paper 2 (Stockholm: National Institute of Economic Research, 1955), p. 31.

a. The statutory tax rate is an average of the national and local tax rates on corporate profits. The effective tax rate is given by $t_e = 0.6t_s + 0.4t_b$, where t_b is the percent of investment fund allocations that must be deposited at the central bank ($t_b = 0.40$ from 1955 through 1960 and 0.46 from 1961 through 1972). The interest rate is the yield on long-term industrial bonds. The present value of tax depreciation as a percent of investment is approximated by $x = \delta/(\delta + r)$, where r is the interest rate and $\delta = 3.3$ percent, an estimate of tax depreciation on nonresidential structures. The fraction of the year, w, that the investment funds were released is given by the total number of months during which funds were released divided by twelve. (The release in 1971–72 was assumed to be too restricted to affect investments at the margin.)

b. The formula for the discount on new investment expenditures is $(1 - w)xt_e + w(t_b + 0.1t_e)$. This is a weighted average of the present value of the tax savings due to depreciation, xt_e, and the investment subsidy available when funds are released ($t_b + 0.1t_e$), the latter reflecting the 10 percent investment deduction on release-financed expenditures.

was 40 percent. In Sweden local income taxes are deductible from the national tax; hence the total statutory profits tax rate on corporations averaged about 52 percent during the period of study. Annual values are shown in table 1.

Tax deductions from profits for depreciation on fixed capital are generally accelerated relative to economic depreciation (ignoring the

effects of inflation on replacement costs), but the acceleration is signifi-
cantly greater for equipment than for buildings. The tax depreciation for
equipment is 30 percent a year on a declining balance basis, while the
depreciation for buildings is approximately 4.5 percent a year. Economic
depreciation is approximately 7.7 percent and 2.6 percent for equipment
and buildings used in manufacturing, respectively.[9]

The investment funds system permits firms to deduct an amount in
addition to depreciation from profits before computing tax. During the
1950s and 1960s when the investment funds system operated counter-
cyclically, firms could deduct (in good times and bad) up to 40 percent
of their profits before tax by "allocating" this amount to an investment
fund. However, 46 percent of this deduction (40 percent before 1961)
had to be deposited interest free at the central bank. This allocation
provides no direct inducements for current investment because the firm
is free to use the additional after-tax profits generated by the deduction
less the deposit at the central bank for any purpose. Since the tax savings
is not contingent on the firm's behavior in any way, it is best viewed as
an attractive alternative (even if the firms could never use the funds
again) to paying the profits tax: 46 percent "tax" is paid to the central
bank rather than 52 percent to the local and national governments. Hence
firms would use the investment funds allocation up to the limit of 40
percent, and the tax rate on corporations is effectively reduced from 52
percent to $(0.4)(46) + (0.6)(52) = 49.6$ percent, even if the funds are
never used again. In general, the effective tax rate assuming the funds
are not used later for investment is given by $t_e = 0.6t_s + 0.4t_b$, where t_e
is the effective rate, t_s is the statutory rate, and t_b is the amount paid to
the central bank. Note that $t_b = 0.4$ from 1955 to 1960 and 0.46 from 1961
to 1975.

The part of the investment funds system that is related to the timing
of investment comes in the "release of funds" procedure. During periods
of recession, firms were permitted to withdraw funds (tax free) from the
central bank allocation up to 46 percent of their investment purchases
(40 percent before 1961). In addition, firms using the funds would be
permitted a tax deduction of 10 percent of the value of the investment
expenditure. However, firms could not also deduct depreciation for such

9. See Lindberg and Södersten, *Taxation of Income from Capital*. For equipment,
firms can switch to straight-line depreciation when it becomes profitable to do so. The
figure for buildings is an approximation of straight-line rules.

investments. The release of funds can therefore be interpreted as a change in the effective price of investment goods. During periods of release the price paid by the firms would be reduced by the 46 percent subsidy and the tax deduction and would be increased by tax savings forgone by not using the depreciation allowance. The net effect was usually a reduction in the effective price paid.[10]

It is important to distinguish between the allocation and the release of funds from the investment funds system when determining its effects on investments. The allocation of profits to the funds is equivalent to a reduction in the tax rate on corporate capital, which is unrelated to the timing and level of investment, but which influences the desired level of capital in the corporate sector in the long run. On the other hand, the release of funds that reduces the price paid for investment goods during the period of release, but not at other times, will influence the timing of investment expenditures as firms attempt to take advantage of the discount on investment goods during the release periods. Only this second part of the investment funds system is relevant for the purposes of investigating its countercyclical effects.

EFFECTS ON THE PRICE PAID FOR INVESTMENT GOODS

Because of the loss of tax depreciation when the funds are used, the extent of the effective price reduction depends on the type of investment

10. The upper limit on the use of the investment funds during a release period is the total amount of funds that the firm set aside but did not previously withdraw from its own allocation. This limit is a function of the past profitability of the firm, which previously determined how much it paid to the central bank. Clearly the impact of the system depends on the proportion of firms that are over their limits.

Lindberg and Södersten assume that firms are over their limits when the system is permanently releasing funds. They cite survey evidence supporting this assumption and hence treat the releases as a general reduction of the profits tax unrelated to the timing of investment behavior. I assume that at least a significant fraction of firms are not over their limits when the system is used for cyclical purposes only.

The effective rate, t_e, should also be reduced by the (unconditional) expected discounted value of the tax savings from future releases of funds. For example, if the funds are always expected to be released in T years, the effective tax rate is

$$0.6t_s + 0.4t_b \left[1 - \left(\frac{1}{1+r} \right)^T \right] + 0.4D \left(\frac{1}{1+r} \right)^T,$$

where r is the discount rate and D is the present value of lost tax depreciation starting T years from today.

expenditure and the tax laws for depreciation purposes. Moreover, it depends on the discount rate used to capitalize the depreciation deductions. Using the depreciation rates of 30 and 4.5 percent a year for machinery and buildings and a discount rate of 6 percent implies that the present value of the lost depreciation is 83 and 43 percent, respectively, for these two types of investment.[11] At an effective tax rate of 50 percent, these values indicate capitalized tax losses of 41.5 percent for machinery and 21.5 percent for buildings. The subsidy for using the funds is 46 percent plus the effective tax rate multiplied by the investment tax deduction of 10 percent. That is, 46 + (0.50)(10) = 51 percent. Hence the net reduction in the price of investment goods is 51 − 41.5 = 9.5 percent for machinery, and 51 − 21.5 = 29.5 percent for plants and buildings. If the discount rate is 3 percent, the net reduction in price is 5.5 percent and 16.4 percent for machinery and buildings, respectively.

The price reductions are thus considerably larger for structures than for equipment investment. In fact, the calculations for equipment investment overstate the reduction because the Swedish depreciation rules permit firms to switch to a straight-line depreciation from the declining balance method when it becomes favorable to do so. By contrast, the effect of the system on the cost of construction goods is likely to be understated by these calculations. According to Swedish depreciation rules during this period, depreciation on buildings and plants cannot begin until the project is completed, while the investment funds can be used as soon as "the value is put in place." For construction projects with long gestation periods this would reduce the present value of the depreciation significantly. In fact, it appears that the investment funds were used largely for building projects during the period under investigation.[12] For this reason, the quantitative evaluation that follows concentrates on construction investment.

11. Using exponential depreciation at rate δ and a discount rate of r percent a year, the capitalized value of the lost depreciation is given by $\delta/(\delta + r)$.

12. According to Norr, Sandels, and Hornhammar, "Most of the projects involved the construction of buildings and plants, since the liberal rules governing the valuation of inventory and the depreciation of machinery provide little incentive to charge inventory or machinery acquisitions to an investment reserve." See their *The Tax System in Sweden*, p. 41. Eliasson's survey study indicates that the effect of the 1962–63 release on construction was five times the effect on equipment. See his "Investment Funds," p. 107. The first release in 1958 was directed entirely toward construction.

ADDITIONAL INVESTMENT INCENTIVES IN SWEDEN

There are a number of additional aspects of the system to keep in mind when evaluating its effects. In addition to a general countercyclical release of funds, money can be withdrawn from the system in several other ways. After a five-year period, for example, 30 percent of the funds can be withdrawn. This is called the free sector of the funds. There have also been special releases of funds for investment in particular projects, industries, or regions. Moreover, in some instances, inventory investment has been financed by the investment funds system. These other categories of withdrawals appear to be minor compared with releases for fixed investment, at least during the countercyclical period of the system, and their impact has not been included in this study. It should be noted, however, that data on funds withdrawals include amounts withdrawn through these other provisions and hence do not equal zero during "nonrelease" periods.

A number of other investment incentives have been in operation in Sweden that may have had countercyclical effects. For example, investment taxes were used to reduce investment demand in 1952–53 and 1955–57, but these were not used during the rest of the period in which the investment funds system was used countercyclically. Monetary policy may also have had a countercyclical influence. To the extent that other investment effects do operate countercyclically, and are expected to operate this way, they will influence the interpretation of the impact of the investment funds system. It turns out, however, that the counter-cyclical behavior of the investment funds system dominated these other influences on investment during the period, at least in the case of investment in structures.

Table 1 presents a tabulation of the main variables that influence decisions to invest in nonresidential structures. The movement in the effective tax rate on corporations is very small, and the interest rate, and consequently the present value of depreciation, have a relatively smooth trend with only minor cyclical movements. But the effective discount on investment expenditures, computed as described above (taking into account the fraction of the year that funds are released), has large fluctuations. It is clear from table 1 that the major reason for cyclical variation in these measures of investment incentives is the

investment funds system. As a working hypothesis, it is not unrealistic to assume that all the cyclical variability in investment incentives in structures occurred because of the investment funds in this period.
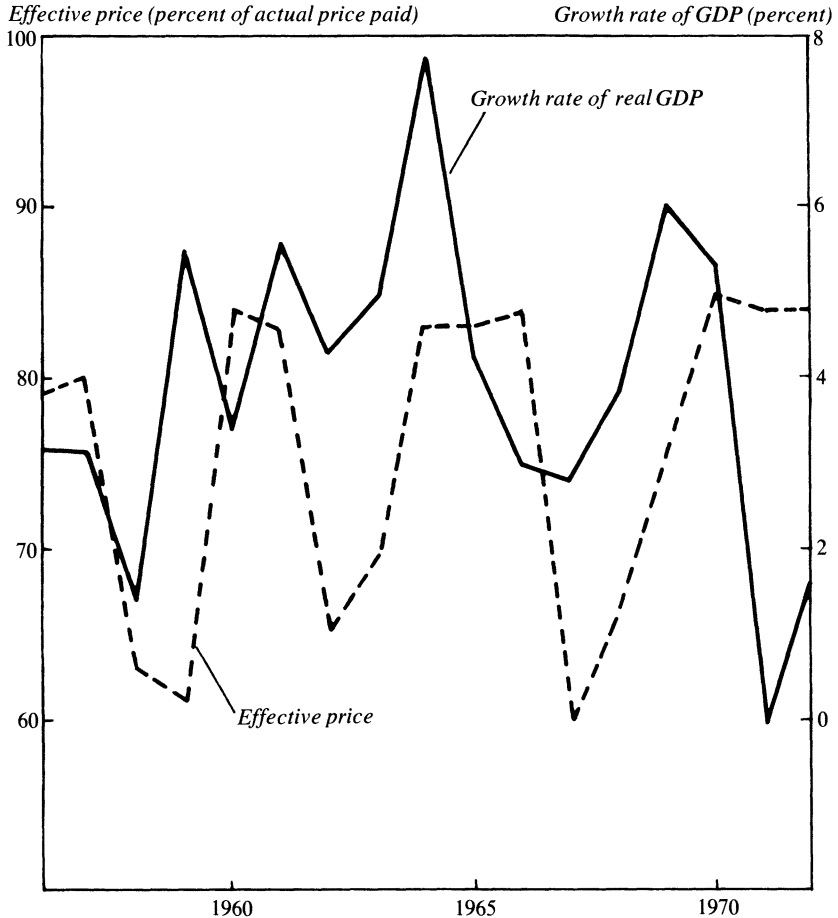
Figure 1 shows the price discount variable during the period along with the growth rate of real GDP. It is apparent from the figure that policy-induced shifts in the price of investment goods were generally related to cyclical fluctuations. In the 1957–58 and 1966–67 periods, however, it appears that the release may have lasted too long, and the movements in the 1962–63 recession appear large relative to the decline in growth at that time. Note also that the annual averages in the figure tend to smooth the fluctuations in the price.

As is shown in the theoretical development that follows, it is the expected change in the price of investment that is relevant for investment decisions: an expected increase in the price stimulates purchases today. If the movements in figure 1 were perfectly anticipated by firms, a large disincentive to invest would occur just before the price falls, which is just when the recessions are starting; conversely, there would be a large incentive to invest just before the price rises, which is when the next boom has begun. Clearly these price changes would be destabilizing if they were perfectly foreseen, and any stabilizing influence of the system must occur because firms are not able to forecast the price movements perfectly. Alternative forecasting rules are considered when I examine these stabilization issues below.

INSTITUTIONAL DISCRETION IN FOLLOWING THE RULE

To understand the institutional aspects of the investment funds system it is useful to study the chronology of a typical release of funds from the system. When the 1962–63 release was activated, for example, the Labor Market Board, an agency of the central government, was responsible for monitoring the state of the economy and determining when a release of funds was appropriate. In early 1962, when the usual signals of recession were appearing, the Labor Market Board contacted firms holding investment funds to tell them that a release in the near-term was likely. On May 11, 1962, the release of funds for investment in construction was announced. To use the funds the firms had to start the projects before November 1, 1962, and only expenditures on work performed and materials purchased during the interval from July 1, 1962, through

Figure 1. Cyclical Effects of the Investment Funds System on the Price of Investment in Structures, 1956–72

Effective price (percent of actual price paid)   *Growth rate of GDP (percent)*

Source: See tables 1 and B-1.

April 30, 1963, could be subsidized by investment funds. (Later in 1962 there was a similar release of funds for investment in machinery and equipment). There was evidently open discussion near the original announcement date concerning an extension of the release, at least for those firms that had not used up their account, if the recession continued beyond April 1963. In fact, this extension did not occur since the economy was already into a strong recovery by that time.

The 1962–63 release is typical because conditions for a release of

funds were not determined by a mechanical formula or trigger mechanism. Government officials were left with some discretion to determine when a recession had begun. Nevertheless, the responsibilities of the government officials were stipulated with sufficient precision that their behavior during most of the countercyclical phase of the system could accurately be characterized as a policy rule, despite this discretion.[13]

A Model of Cyclical Investment Fluctuations

This section develops a formal quantitative model for the evaluation of countercyclical investment stabilizers. Although the model is general enough to be applicable in other situations, the actual operation of the investment funds during the late 1950s and 1960s has influenced the choice of its major features in a number of ways. Before describing the model in detail, it will be useful to summarize these features and relate them to the investment funds system.

OVERVIEW

Because the primary objective of the investment funds during this period was to stabilize cyclical fluctuations in investments, it is essential to have a mechanism generating such fluctuations in order to evaluate the effect of the funds. Such fluctuations in investment are assumed here to be caused by exogenous fluctuations in the demand for an individual firm's products. These demand fluctuations give rise to "accelerator-type" behavioral equations for investment in which the level of investment is a distributed lag function of the changes in exogenous demand. As demand growth accelerates and decelerates over the cycle, it generates fluctuations in investment. Econometric studies have shown that fluctuations in demand explain a large fraction of the fluctuation in investment so that potentially the model of investment behavior will be

13. The phasing out of the countercyclical features of the system was probably made easier by these discretionary features. If a trigger formula had been legislated, this conversion of the system to a permanent investment stimulus might have come more slowly, but the general consensus developing in the 1970s that long-run capital formation dominated countercyclical goals would have made even a legislated change likely.

able to capture this cyclical regularity empirically.[14] Except for the influence of the investment stabilizers, fluctuations occur in the model solely because of fluctuations in demand. In this sense the model is one of short-term fluctuations rather than long-term growth. Although the cyclical fluctuations in demand are taken to be exogenous, firms will attempt to forecast them when deciding how much to invest for the future.

A second characteristic of the model is its orientation toward invest-ment in structures rather than equipment investment. As described above, the investment funds had their primary effect on structures investment. The investment theory used here emphasizes the relatively long gestation period for structures and the fact that actual value-put-in-place is distributed over time according to relatively rigid technological constraints. In the recent investment literature such gestation theories have been offered as an alternative to the more typical cost-of-adjustment theories.[15] Both types of theories have been motivated by empirical considerations and in particular by the fact that actual investment series are smoother than what would be implied by reasonable estimates of changes in the desired capital stock. The cost-of-adjustment models achieve the smoothing by assuming a convex cost of adjusting capital. The smoothing occurs naturally in the gestation theories because only a fixed fraction of the desired change in capital is put in place each period. The gestation theories are clearly empirically relevant for investments in structures, and perhaps for investment in many types of machinery as

14. See Peter K. Clark, "Investment in the 1970s: Theory, Performance, and Predic-tion," *BPEA, 1:1979,* pp. 73–113 for evidence of this in the United States.

15. Recent studies using the gestation approach include Finn E. Kydland and Edward C. Prescott, "Time to Build and Aggregate Fluctuations," Working Paper 28 (Carnegie-Mellon University and University of Minnesota, September 1981), and "Rules Rather Than Discretion"; and Robert E. Hall, "The Macroeconomic Impact of Changes in Income Taxes in the Short and Medium Runs," *Journal of Political Economy,* vol. 86, pt. 2 (April 1978), pp. S71–S85. A much earlier reference to this type of investment theory is M. Kalecki, "A Macrodynamic Theory of Business Cycles," *Econometrica,* vol. 3 (July 1935), pp. 327–44; the Kalecki model is also described in R. G. D. Allen, *Macro-Economic Theory: A Mathematical Treatment* (MacMillan, 1968), pp. 369–72. The cost of adjustment model has been used much more extensively in recent years. For some examples with references to earlier work, see Thomas J. Sargent, *Macroeconomic Theory* (Academic Press, 1979), Fumio Hayashi, "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica,* vol. 50 (January 1982), pp. 213–24; and Lawrence H. Summers, "Taxation and Corporate Investment: A q-Theory Approach," *BPEA, 1:1981,* pp. 67–127.

well. One advantage of the gestation approach when applied to structures investment is that it is possible to use microeconomic survey data on construction periods for different types of capital as a constraint on the aggregate lag distributions in the investment equations. Because there is no explicit accounting interpretation of the "costs" in the cost of adjustment model, this extra information is not available. Moreover, one must rely solely on econometric estimates of the lag distributions when using that approach.

A third characteristic of the model is the heterogeneity of investment due to differences in the completion times for various types of capital projects. Such heterogeneity is realistic because in the real world all investment projects do not take the same time to complete. The model emphasizes this heterogeneity for two reasons. First, heterogeneity alters the interpretation of the investment function in a way that appears to be empirically significant. The lag distribution of the aggregate investment function depends on the proportion of the various types of capital in the total capital stock. If this heterogeneity is ignored when evaluating the effect of policy, significant errors can be made. Second, one would like to be able to estimate how an investment stabilization policy altered the choice of firms' investment projects, and, in particular, whether it caused shifts to shorter projects. In fact, there is some evidence that the investment funds had such a "cost-shifting" effect whereby firms adjusted their investment policies toward projects with shorter construction periods.[16] This is in addition to the "time shifting" effect, whereby investment activity is shifted from one period to another: forward because of an anticipated release of funds or backward because of the anticipation that the release would stop after a specific period.

The description of the model begins with the simplest case in which there is only one type of capital that takes a single period to build. It then goes on to consider two-period and more generally n-period projects, and finally the aggregation of projects of different lengths.

SINGLE-PERIOD PROJECTS

Assume that a typical firm minimizes the expected value of the following cost function:

16. The survey of firms in Eliasson's study gives some evidence of this. See especially his "Investment Funds," p. 36.

(1)
$$\sum_{t=1}^{\infty} b^t \left[\frac{d}{2} (vY_t - K_t)^2 + c_t I_t \right],$$

where

b = discount factor
Y_t = exogenously given demand for the firm's products
K_t = capital stock of the firm at the start of period t
I_t = investment during period t
v = desired capital-output ratio
c_t = cost of investment goods during period t.

Capital depreciates at rate h. Projects started at the beginning of period t are added to the capital stock when they are completed at the end of t in the single-period model. Let S_t be projects started in period t. Then

(2)
$$K_{t+1} = K_t + S_t - hK_t.$$

In the case in which all the value of the project is put in place during one period, then

(3)
$$I_t = S_t.$$

The quadratic term in the cost function can be interpreted in a number of ways. In general it simply represents the U-shaped cost of having either too little or too much capital relative to demand, given the production function and the relative price of capital versus other factors of production. Because only temporary changes are considered here in the relative cost of investment goods, c_t, that occur through investment stabilization policies, it is assumed that the desired capital-output ratio, v, is constant. The main reason for fluctuations in the desired level of capital will come through fluctuations in Y_t as described below.

Since this paper is concerned with cyclical variations in investment, the variables in equations 1 through 3 should be thought of as deviations from a long-run secular growth trend. These deviations, with zero mean, are measures of cyclical variations in investment, output, and capital costs. The econometric analysis that follows considers empirical counterparts to these detrended cyclical variables.

The cost function of equation 1 can be minimized by differentiating

with respect to K_t after substitution for I_t in 1 using 2 and 3.[17] This results in

(4) $$I_t = v\hat{Y}_{t+1} - (1 - h)K_t - \frac{c_t - b(1 - h)\hat{c}_{t+1}}{bd},$$

where the hat over a variable indicates its forecast during the period after the project is started. Recall that K_t is predetermined at time t. Equation 4 simply shows that investment is an increasing function of expected sales in the next period and a decreasing function of the quasi first difference in cost of investment goods. Note that if the cost of investment goods is expected to fall in the future, investment will be reduced today as firms attempt to postpone their investment projects. The potential for this to be destabilizing is discussed below.

To eliminate the expectations variable in 4 one must specify how firms forecast demand conditions in their own markets. Here it is assumed that firms forecast according to the simple autoregressive model,

(5) $$Y_{t+i} = a^i Y_t,$$

where $0 \le a \le 1$. Because demand fluctuations are interpreted here as deviations from trend, the long-run average value of Y_t is zero. According to 5, when demand conditions are above normal, firms expect them to return to normal gradually over time. A similar return to normal conditions is expected in bad times. One property missing from 5, which may seem serious from a business cycle perspective, is forecasts of turning points or even of transitions from boom times to recessions. Equation 5 implies that cyclical fluctuations in demand come from a simple first-order autoregressive process, $Y_t = aY_{t-1} + u_t$. An alternative would be to use a higher-order process such as $Y_t = \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + u_t$, which is sometimes thought to be characteristic of business cycles. The case in which firms forecast output using a second-order process is described below to illustrate the potential for an investment policy to be destabilizing.

As described in the previous section, the investment funds system can be interpreted as reducing the effective price of investment expenditures (value put in place) during recessions. The price will be higher during booms and lower during recessions relative to the average price

17. See appendix A for a derivation.

over an entire business cycle fluctuation. The extent to which this is true empirically is indicated in table 1 and figure 1. An algebraic policy rule approximating the investment funds system is therefore written as

$$(6) \qquad\qquad c_t = g Y_t,$$

where g is a positive policy parameter. As demand fluctuates, the effective price of investment goods fluctuates in the same direction. Note that 6 implies that the investment funds system affects the price with more continuity than it does in reality. In fact, the funds are either in a state of release or not. However, as table 1 indicates, the use of annual averages effectively smooths the price series. As the empirical analysis focuses on annual data, 6 may serve as a reasonable approximation. An alternative approach would be to approximate the system with a two-state switching model, but this would significantly complicate the analysis. Moreover, even if a switching rule were a more accurate description of the system, firms' forecasts of the cost, c_t, would be a relatively smooth function of the state of demand as they forecast whether the government would release funds. That is, the lower the forecast of demand, the greater the probability that the release will occur and lower the price. The use of 6 is then accurate for an appropriate probability model of the government's action. In actuality, except for very short periods, there always appeared to be some uncertainty about when a release would occur and whether it would be extended.

Returning now to the problem of deriving investment decisions of the firm, substitute 6 and the forecasting rule 5 into 4 to obtain

$$(7) \qquad I_t = \left[va - \frac{g}{db}(1 - ab(1 - h)) \right] Y_t - (1 - h)K_t.$$

If one takes first differences and uses 2 and 3, the result is

$$(8) \qquad\qquad I_t = A_1 z_t + h K_t,$$

where

$$z_t = Y_t - Y_{t-1} \quad \text{and} \quad A_1 = va - \frac{g}{db}(1 - ab(1 - h)).$$

Equation 8 expresses gross investment as the sum of two components: $h K_t$, or replacement of the portion of this period's capital stock that

depreciates between periods, and A_1z_t, or net investment. The latter is determined by a linear accelerator mechanism, with an accelerator coefficient, A_1, that depends positively on the desired capital-output ratio, v, and negatively on the depreciation rate, h (because faster depreciation makes it more expensive to maintain a capital stock of any given size).

The accelerator coefficient also depends on the investment funds policy as reflected in the parameter g. It can be seen from 8 that the introduction of an investment stabilization policy reduces the size of the accelerator (because $ab(1 - h) < 1$), and that if g can be set accurately by policymakers, the optimal value from the point of view of reducing fluctuations in investment is $g = dvab/(1 - ab(1 - h))$. The optimal policy parameter is an increasing function of the capital-output ratio, the persistence of demand fluctuations, and the discount factor.

It is clear from 8 how an investment stabilizer affects the timing of investment. In boom periods when output is rising, investment will be less than it would be without the stabilizer, and in recessions investment is more than it would otherwise be. Hence the stabilizer shifts investment from recovery periods to recessions and in this sense would be expected to smooth cyclical swings in investment. The average level of investment over an entire cycle is not changed by the policy.

TWO-PERIOD PROJECTS

The introduction of capital with longer gestation periods does not change the objective function of the firm, but it does alter the timing between starts and capital accumulation as well as between starts and value put in place. When the gestation time is two periods, equation 2 becomes

$$(9) \qquad\qquad K_{t+2} = (1 - h)K_{t+1} + S_t,$$

so that a construction project that begins today augments the capital stock two periods later. The timing of the value put in place during each of the two years depends on the type of capital being produced. Let w_1 be the fraction of expenditure on the project during the first year of construction, and w_2 be the remaining fraction of expenditures that occur in

the second year. Then value put in place during any period t is given by

(10) $\qquad I_t = w_1 S_t + w_2 S_{t-1} \qquad (w_1 + w_2 = 1),$

which replaces equation 3 when projects take two years to complete. According to equation 10, investment in the current period consists of two components: $w_1 S_t$, which is the value put in place during the first year of projects started in the current period, and $w_2 S_{t-1}$, the value put in place during the second year of projects started in the previous period.

Minimizing the function 1 for a time path of capital K_t, as in the previous case, results in the expression

(11)
$$S_t = v\hat{Y}_{t+2} - (1 - h)K_{t+1} - \frac{1}{b^2 d}[w_1(c_t - (1 - h)b\hat{c}_{t+1}) + bw_2(\hat{c}_{t+1} - (1 - h)b\hat{c}_{t+2})],$$

which shows how the number of projects started today depends on expected demand conditions when the project is completed two periods later, and on the quasi-change in the cost of investment during each of the two periods. The latter costs are discounted and weighted by the value-put-in-place weights. Note that K_{t+1} is predetermined at the time that S_t is being decided by the firm, so that 11 is a legitimate decision rule. Equation 11 shows that the impact on investment today of an anticipated decline in the cost of investment goods in the next period is more complicated than in the one-period case. This impact is negative if and only if $w_1(1 - h) > w_2$. According to the U.S. survey data reported below, $w_1 = 0.84$ and $w_2 = 0.16$, so that this inequality is satisfied for reasonable economic depreciation rates. Hence the possibilities for destabilizing effects of anticipated policies remain. The impact of a fall in capital costs two periods in the future is also negative on today's investment decisions.

To obtain expressions for the forecasted demand and cost terms one can continue to assume that firms' forecasts of demand are determined by 5 and that c_t varies according to the investment stabilization policy 6. Then $\hat{Y}_{t+2} = a^2 Y_t$ and $\hat{c}_{t+1} = agY_t$ so that starts are given by

(12) $\qquad\qquad S_t = A_2 z_t + hK_{t+1},$

where

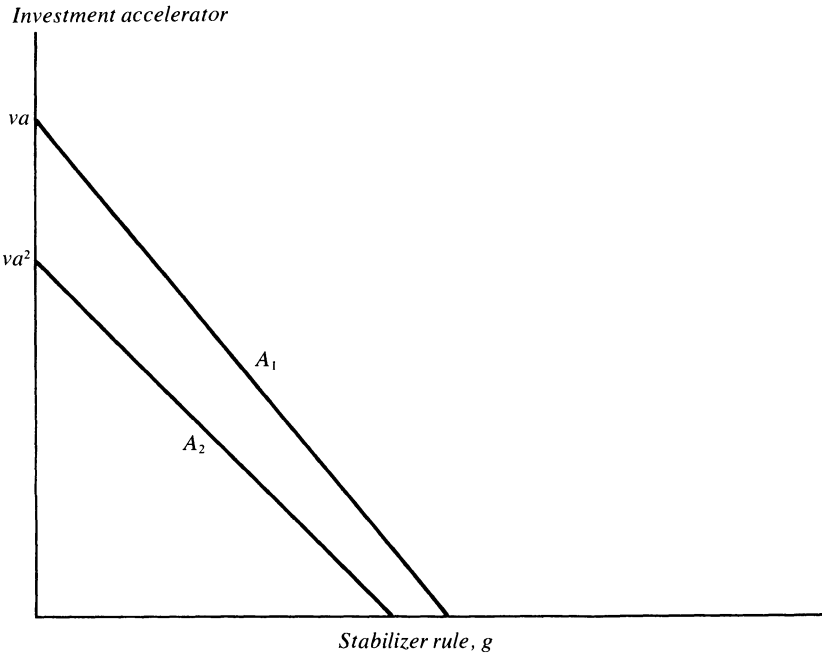$$A_2 = va^2 - g\frac{b^{-2}}{d}(abw_2 + w_1)(1 - ab(1 - h)).$$

Finally, total investment in period t is obtained from 10, which results in

(13) $\qquad I_t = A_2(w_1 z_t + w_2 z_{t-1}) + w_1 h K_{t+1} + w_2 h K_t.$

Gross investment is now the sum of two net investment terms and two replacement terms. In replacing depreciating capital, the firm has to look ahead one period because it must invest now to bring replacement capital on line after the end of the next period. Its replacement expenditures today are the sum of the first-period costs of newly started replacement capital, $w_1 h K_{t+1}$, and second-period expenditures on replacement capital whose construction began last period, $w_2 h K_t$.

Similarly, the firm's net investment expenditures are the sum of first-period costs of new net investment projects, stimulated by today's change in demand, $w_1 A_2 z_t$, and the second-period costs of yesterday's net investment, which was stimulated by yesterday's demand change, $w_2 A_2 z_{t-1}$. Thus equation 13 is a distributed lag accelerator equation for net investment, where the lag distribution has the same shape as the value-put-in-place weights. As before, the magnitude of the accelerator coefficient, A_2, depends negatively on the investment stabilizer parameter, g.

The impact of the investment policy parameter on the accelerator coefficients for one- and two-period projects is shown in the diagram below, where it is assumed that the value v is the same for both projects. Both accelerators decline linearly with g. The two-period accelerator, A_2, is smaller for all values of g than the one-period accelerator, A_1, as long as demand disturbances are not permanent ($a < 1$). However, the slopes of the relations depend on the weighting, discount, and persistence parameters. The impact of g on A_1 is greater than its effect on A_2 if $a + w_1 (1 - ab)b^{-1} < 1$. Thus shifting toward the shorter projects during recessions will be more likely the shorter is the expected duration of the recession, the smaller is the value put in place in the first period of the two-period projects, and the larger is the discount factor. These are exactly the circumstances under which firms could get more out of the temporarily low price for investment goods by switching to quicker construction projects. For example, if the value-put-in-place weights are uniform ($w_1 = 0.5$), the above condition reduces to $0.5(a + b^{-1}) < 1$ or $r < 1 - a$, where r is the discount rate ($b = (1 + r)^{-1}$). Hence shifting toward shorter building projects will occur only if the discount rate is small relative to the transience of demand stocks. For $r = 0.1$ and

Investment accelerator

Stabilizer rule, g

$a = 0.9$ there is no cost shifting in this case. Note that regardless of the relative marginal effects of g on A_1 and A_2, the value of g that makes A_2 equal to zero leaves A_1 positive. Thus if g is chosen to eliminate the accelerator in two-period projects, there will still be fluctuations in single-period projects.

GENERAL MULTIPERIOD PROJECTS

An extension to the more general case of projects with longer construction times is relatively straightforward. The capital accumulation equation for projects that take n periods to complete is given by

$$(14) \qquad K_{t+n} = K_{t+n-1} + S_t - hK_{t+n-1}.$$

The level of starts that minimizes the cost function is given by

$$(15) \quad S_t = v\hat{Y}_{t+n} - (1 - h)K_{t+n-1}$$
$$- \frac{b^{-n}}{d} \sum_{i=0}^{n-1} b^i w_{i+1}(\hat{c}_{t+i} - b(1 - h)\hat{c}_{t+i+1}),$$

where K_{t+n-1} is predetermined at time t. (Note in the summation notation that $\hat{c}_t = c_t$.) Starts at time t depend on demand conditions n periods later and on the discounted and expenditure-weighted sum of investment costs during the next n periods.[18]

Assuming the forecasting model and investment funds policy given in the previous section, the expected future level of demand and expected future costs can be calculated. These are $\hat{Y}_{t+n} = a^n Y_t$ and $\hat{c}_{t+i} = ga^i Y_t$, $i = 1, 2, \ldots$. Substituting these expressions into the starts equation, one obtains

$$(16) \qquad\qquad S_t = A_n z_t + h K_{t+n-1},$$

where

$$A_n = va^n - \frac{b^{-n}}{d} g \sum_{i=0}^{n-1} a^i b^i w_{i+1} (1 - ab(1 - h)).$$

This is just a generalization of the one- and two-period cases considered above. In period t the firm starts constructing capital to replace the depreciation that will occur between periods $t + n - 1$ and $t + n$. It also starts to construct net additions to the capital stock on the basis of the latest change in demand, z_t. The accelerator coefficient, A_n, is a general formula that includes the previously derived expressions for A_1 and A_2 as special cases.

Because A_n is a function of n, and the response of A_n to g is also dependent on n, one finds as before that the investment stabilization policy has different total and marginal effects for each value of the gestation period.

Investment expenditures in period t are now a distributed lag of starts over n periods, where the lag weights are just the value-put-in-place weights for n-period capital:

$$(17) \qquad\qquad I_t = w_1 S_t + w_2 S_{t-1} + \ldots + w_n S_{t-n+1},$$

where again the value-put-in-place weights sum to 1.

This expression for investment, together with 16, gives the n-period

18. By multiplying through on the right-hand side of 15 by b^n, it can be seen that the expected capacity gap n periods in the future is being discounted by the appropriate discount factor. The optimal level of starts is a weighted average of the expected capacity gap and the costs of investment expenditures needed to close that gap.

investment equation,

$$I_t = A_n(w_1 z_t + w_2 z_{t-1} + \ldots + w_n z_{t-n+1})$$
$$(18) \qquad + h(w_1 K_{t+n-1} + \ldots + w_n K_t)$$
$$= A_n \sum_{i=0}^{n-1} w_{i+1} z_{t-i} + h \sum_{i=1}^{n} w_i K_{t+n-i}.$$

Just as before, this is a distributed lag accelerator equation because investment expenditures are a weighted sum of n periods' starts, each determined by the contemporaneous change in demand.

INVESTMENT WITH CONSTRUCTION PROJECTS OF DIFFERENT LENGTHS

In reality the capital stock is heterogeneous and composed of types of capital that take many different time periods to complete. It is necessary to disaggregate capital according to the time it takes to build each unit and then consider the empirical problem of determining the effects of this disaggregation on total investment.

To interpret the approach to aggregation used here, it is helpful to suppose that the economy consists of M heterogeneous classes of firms, each making investment decisions according to the investment equations derived above: type n firms would use capital with n-period construction times. Aggregate investment would then consist of the sum of each of these investment expenditures. If the cost functions for these firms differ only by the capital output ratio and the value-put-in-place weights, and if the shares of each of these firms in total economy-wide output is constant, the aggregation is particularly straightforward.

Let v_n be the capital-output ratio for type n firms. With constant output shares, the measure of output in these capital-output ratios can be total economy-wide output. Let w_{nj} be the value-put-in-place weights for type n firms where $j = 1, \ldots n$ (with $w_{11} = 1$). Denote the capital stock of type n firms in period t by $K_{n,t}$. Then the starts by type n firms are given by equation 15 with v_n replacing v, w_{nj} replacing w_j, and $K_{n,t+n-1}$ replacing K_{t+n-1}. Total starts are a sum of starts by each type of firm, adding over M classes of firms:

$$(19) \qquad S_t = \sum_{n=1}^{M} S_{n,t} = \sum_{n=1}^{M} (A_n z_t + h K_{n,t+n-1}).$$

Total investment is now a double-weighted sum. Investment by type n firms is a weighted sum of starts over n periods, and total investment is a further weighted sum of investment over M classes of firms. Adding M equations analogous to 18, one obtains

$$(20) \qquad I_t = \sum_{n=1}^{M} I_{n,t} = (A_1 w_{11} + A_2 w_{21} + \ldots + A_M w_{M1})z_t$$

$$+ (A_2 w_{22} + \ldots + A_M w_{M2})z_{t-1}$$

$$\cdot$$
$$\cdot$$
$$\cdot$$

$$+ A_M w_{MM} z_{t-M+1}$$
$$+ h(w_{11} K_{1,t} + w_{22} K_{2,t} + \ldots + w_{MM} K_{M,t})$$
$$+ h(w_{21} K_{2,t+1} + \ldots + w_{M,M-1} K_{M,t+1})$$

$$\cdot$$
$$\cdot$$
$$\cdot$$

$$+ w_{M1} K_{M,t+M-1}$$
$$= \sum_{j=1}^{M} \sum_{i=j}^{M} w_{ij} (A_i z_{t-j+1} + h K_{i,t+i-j}).$$

where A_i is the accelerator coefficient for investment in capital goods that take i periods to build.

The accelerator mechanism in 20 has the same functional form as 18 but its interpretation is substantially different. The distributed lag weights depend on the investment policy rule but these weights, and hence the impact of policy on investment, are a convolution of the distributional weights for value put in place for each type of capital and the distributional weights of each type of capital in the total capital stock. To assess the impact of investment stabilization policy, it is necessary to be able to distinguish between these two distributions. Clearly a reduced-form estimation of regression coefficients using an aggregated accelerator function for investment will not reveal the decomposition of each coefficient into the two weighting schemes. Moreover, such aggregate estimates will not reveal how the policy rule affects investment.[19]

19. This is the problem emphasized in Lucas, "Econometric Policy Evaluation: A Critique."

However, by directly obtaining the parameters a, b, w_{ij}, and v_i it is possible to evaluate the effect of a change in stabilization policy, as I show below for the investment funds system.[20]

Anticipating Recessions and Destabilization

The above treatment of the investment funds system has emphasized its potential for stabilization. The effect of such a system was shown unambiguously to reduce the size of the accelerator coefficients and thereby reduce the procyclical fluctuations in investment. No possibility of a perverse increase in the procyclical fluctuations—a destabilizing effect—was found. Destabilization might occur if the forecasting model used by firms allowed for the possibility of forecasting recessions in advance. As discussed above, replacing the first-order forecasting model with a second-order model is one way to do this. With such a forecasting process, firms might forecast a deepening recession and a lower price for investment goods and thereby reduce investment expenditures during the early part of a recession, perhaps making investment expenditures more procyclical.

Suppose demand follows a second-order process,

$$(21) \qquad Y_{t+1} = \alpha_1 Y_t + \alpha_2 Y_{t-1} + u_{t+1}.$$

For a typical model of business cycle fluctuations, $\alpha_1 > 0$, $\alpha_2 < 0$ and $\alpha_1 + \alpha_2 < 1$. To see how this formulation can lead to forecasts of continued recession or expansion, imagine that the economy was at full employment $(Y_{t-1} = 0)$. Then the beginning of a recession in period $t(Y_t < 0)$ will lead to a forecast of worse recession in the next year

20. An alternative aggregation approach that also leads to equation 20 is to suppose that the firm uses capital that is heterogeneous by gestation lag, and therefore must make a capital investment decision for each type of capital. A particularly simple generalization of equation 1 represents the cost minimization problem of such a firm by

$$\sum_{t=1}^{\infty} b^t \left[\frac{d}{2} \sum_{i=1}^{n} (v_i Y_t - K_{it})^2 + \sum_{i=1}^{n} c_{it} I_{it} \right],$$

where $(v_1, v_2, \ldots, v_n)$ is the minimum point on the U-shaped cost curve. If there are no cross effects between K_{it} and K_{jt} as in this expression, and if $c_{it} = c_{jt}$ for all i and j, the optimal decision rules for investment are given by 18 with v_i replacing v for each type of investment. Thus the aggregate investment equation 20 is consistent with this cost minimization.

$(Y_{t+1} < Y_t)$ if $\alpha_1 > 1$. Similarly, the start of a boom $(Y_t > 0)$ will lead to a forecast of a continued expansion in the next year $(Y_{t+1} > Y_t)$ if $\alpha_1 > 1$. In both these examples the economy is forecast to move further away from full employment for a while, a feature that the first-order model cannot capture and that could lead to destabilization.

This possibility can be examined for the case of single-period projects. A decision rule for investment expenditures is obtained by substituting the forecasts from 21 into 4, using the policy function 6 to obtain

$$(22) \qquad\qquad I_t = B_1 z_t + B_2 z_{t-1} + h K_t,$$

where

$$B_1 = v\alpha_1 - \frac{g}{bd}(1 - \alpha_1 b(1 - h))$$

$$B_2 = \alpha_2\left(v + \frac{g}{d}(1 - h)\right).$$

The accelerator coefficient, B_1, is much like the accelerator coefficient, A_1, in 8. However, with $\alpha_1 > 1$ it is possible for $\alpha_1 b(1 - h) > 1$ and hence for an increase in g to raise this accelerator coefficient.

In the case of a decline in demand, for example, investment falls off because firms expect a further decline in the next year, but this fall is magnified by the expected decline in capital costs that the investment funds system will generate. This in itself is clearly destabilizing.

Compared with the previous accelerator formulation, however, there is now an additional lagged effect, B_2. If α_2 is negative, B_2 will be negative also, so that a positive change in output in the previous period reduces investment. The coefficient B_2 is also affected by the investment funds system, g. In the case in which $\alpha_1 > 1$ so there is a possibility of destabilization, the effect of g on B_2 offsets the effect on B_1. The net effect is summarized by the sum of the accelerator coefficients, $B_1 + B_2$. This sum is a linear *decreasing* function of g as long as $\alpha_1 + \alpha_2 < b^{-1}(1 - h)^{-1}$, a condition that is insured by the stability of the output process. Thus if the output process itself is stable, the investment funds system will reduce the sum of the accelerator parameters.

FEEDBACK AND ENDOGENOUS OUTPUT

Throughout this analysis it has been assumed that the demand process facing firms is exogenous. This would be a reasonable approximation if

the industry was relatively small, or if the demand process was truly external, generated by fluctuations in the demand for exports for example. In the empirical applications I focus on manufacturing industries whose investment decisions represent a relatively small component of total demand; these industries also have large export markets, so that the exogeneity assumption is reasonable.

The most satisfactory way to deal with this endogeneity question would be to model the other components of aggregate demand (such as consumption) and to use the national income identity to develop a dynamic process for aggregate demand that depends on investment expenditures. This dynamic process should then be the same as the one firms use to forecast demand. Without examining in detail a full macro model, it seems clear that the major qualitative conclusions about investment stabilization developed by assuming that demand is exogenous would not change. (This can easily be shown in the context of a first-order model.) But one result that would clearly emerge from a full macro analysis is that the fluctuations in GDP are reduced as a consequence of a more stable investment process. Given that one of the aims of such a stabilization scheme is to reduce the fluctuations in total demand and employment, this is an important fact to be kept in mind when assessing its welfare implications. The assumption that demand is exogenous is made in this paper merely for convenience. Although it is probably a reasonable approximation in the empirical work, it is not meant to suggest that the feedback effects of such a system on total demand are necessarily negligible.

The Effects of Policy on Investment Fluctuations

The central qualitative result of the theoretical analysis is that the countercyclical impact of the investment funds system should show up in the parameters of a regression equation of investment on the changes in real output. As is clear in 18, if the system is working successfully, these accelerator parameters should be small in absolute value or even negative. In nonparametric terms, if the system is effective, it should reduce business cycle fluctuations in investment by breaking the correlation between investment and the cyclical components of demand.

In testing for these results, it is important to use an investment series that does not include public investment because it is possible that public

expenditures would be countercyclical and thereby offset some of the
business cycle fluctuation in private investment. I concentrated on
annual expenditures on nonresidential structures in the manufacturing
industries.

In figure 2 the time-series behavior of total manufacturing investment
in structures during the 1959–78 period in Sweden is plotted along with
the change in total real GDP and real output originating in manufactur-
ing—two alternative measures of demand. (Note that the variables in
figure 2 are not detrended.) Even allowing for the distributed lag between
changes in demand and investment, there does not appear to be evidence
of a positive accelerator mechanism in the data during the period through
the early 1970s. If anything, the relation seems negative during this
period. In the late 1970s, however, after the investment funds system
had ceased to be countercyclical, there does appear to be evidence of a
positive accelerator mechanism.

For comparison, in figure 3 the same variables for the United States
are plotted for the same sample period. Although the U.S. data are
dominated by a boom in manufacturing structures investment in the mid-
1960s, the figure provides evidence of a lagged accelerator mechanism
at work. The boom in investment follows the higher growth rates in the
1960s; and though much smaller, the swings in investment in the 1970s
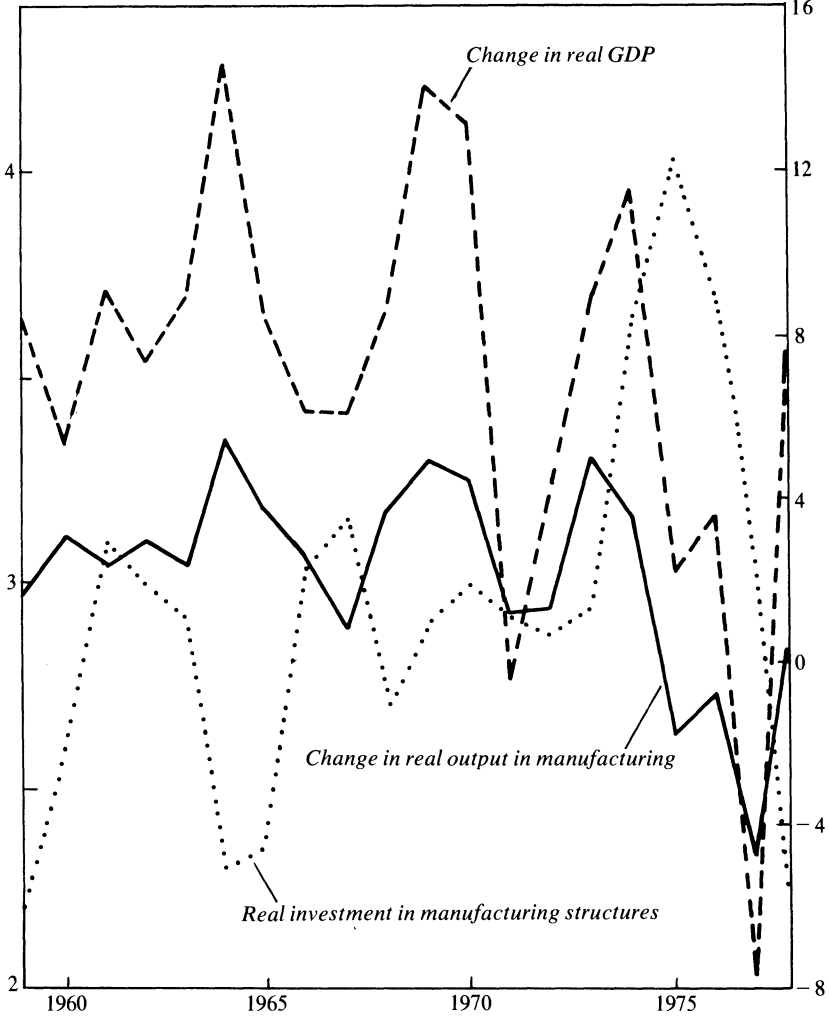follow the fluctuations in demand.

Because of the dynamic relation between investment and output, the
accelerator coefficients estimated by regression methods offer a more
systematic way to examine the cyclical variability of investment.
Table 2 reports several alternative accelerator-type regressions esti-
mated for Sweden during the 1960s and 1970s. To correspond with the
structural model considered in the next section, the length of the
distributed lag is three periods for all the regressions. However, the
general findings are not affected by extending the lag length beyond three
periods. Both real GDP and manufacturing output are used as demand
variables.[21] Regardless of which measure of demand is used, in the 1961–
75 period very little of the variation in investment is explained by demand

---

21. For these regression equations I have not included a measure of depreciation,
which is a function of future values of the capital stock. The lagged capital stock entered
with the wrong sign when estimated without constraints in the Swedish equations.
Moreover, the decomposition of variables into cyclical and secular components using a
simple detrending procedure seems particularly strained when applied to the capital stock.

Figure 2. Investment and Output Change in Sweden, 1959–78

Real investment in manufacturing
structures (billions of 1975 kronor)

Change in real GDP and real manufacturing
output (billions of 1975 kronor)

Source: Table B-1.

Table 2. Reduced-Form Accelerator Equations for Investment in Manufacturing Structures, Sweden, Annual Data, 1961–75 and 1966–78[a]

Output variable and sample period	Independent variable — Change in output				Statistic			
	Current	One-year lag	Two-year lag	Sum	t-ratio for sum	Rho	Durbin-Watson	R^2
Real GDP								
1961–75	−0.0219	0.0023	−0.0102	−0.0298	−0.50	...	1.00	0.04
1961–75	−0.0122	−0.0007	0.0095	−0.0034	−0.06	0.33	...	0.05
1966–78	−0.0062	0.0462	0.0131	0.0531	1.51	...	0.98	0.42
1966–78	0.0035	0.0441	0.0248	0.0724	2.00	0.46	...	0.48
Real manufacturing output								
1961–75	−0.1657	0.0484	−0.1279	−0.2452	−1.81	...	1.48	0.44
1961–75	−0.1424	0.0456	−0.0933	−0.1901	−1.35	0.18	...	0.41
1966–78	−0.0672	0.0986	0.0559	0.0873	1.69	...	1.10	0.57
1966–78	−0.0409	0.0908	0.0620	0.1119	1.91	0.40	...	0.59

Sources: Same as table B-1.
a. The dependent variable is real investment in manufacturing structures. All variables have been detrended linearly over the 1958–75 and 1963–78 sample periods corresponding to the two sample periods in the table.

fluctuations, and the accelerator coefficients are small. In some cases the coefficients are negative, as is possible according to the interpretation in this paper of the countercyclical effects of the investment funds system. Table 2 also reports regressions for a later sample period that includes more of the 1970s and less of the 1960s. The sum of the coefficients in this period, which is dominated by a permanent funds system, is positive reflecting the procyclical behavior evident in figure 2.

Similar regressions are reported in table 3 for the United States during 1961–75. The accelerator coefficients are all positive and much larger than those for Sweden. Clearly the accelerator mechanism was operating much more strongly in the United States than in Sweden during this period. Given the evidence in table 1 of the large policy-induced cyclical swings in the price of investment goods in Sweden and the fact that a similar mechanism was not operating in the United States, it appears that the investment funds system did succeed in smoothing out the cyclical swings in investment.[22]
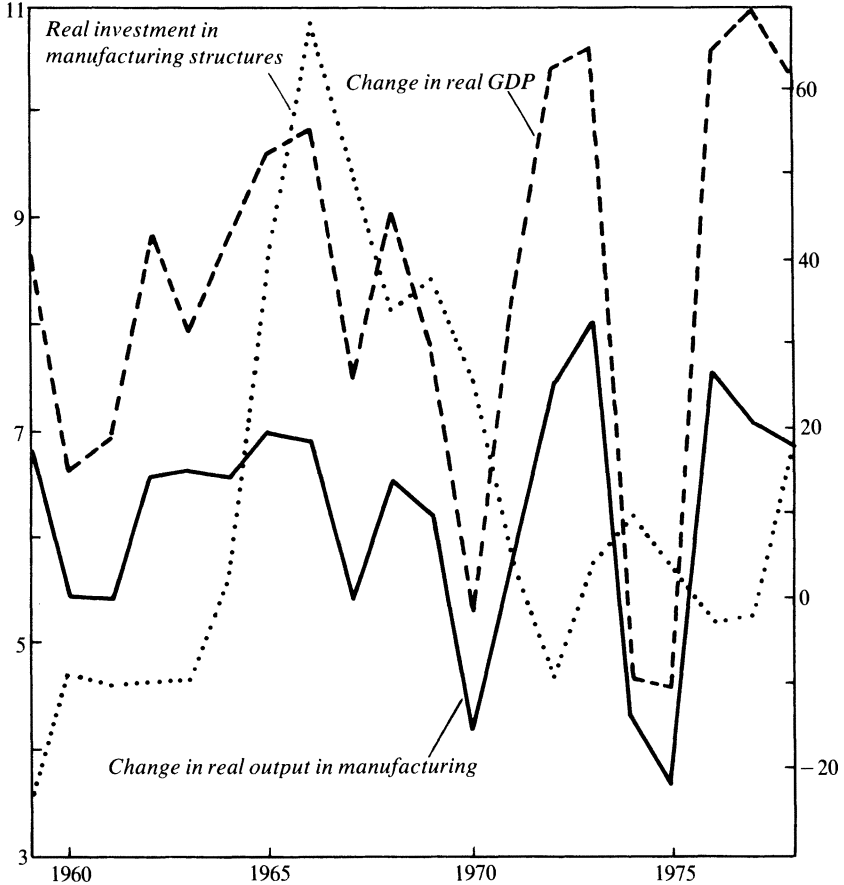
The estimate of the effect of the system implied in these comparisons is quite large. It is possible that the observed accelerator coefficients

22. On a purely formal basis this characterization of the investment funds system has a number of similarities with the investment tax credit used in the United States during this period. During a release of investment funds the price of investment goods paid by firms is reduced much as a tax credit on investment expenditures would reduce the effective price paid by firms. Although there is no direct correspondence in an investment tax credit system to the allocation component of the investment funds system, this latter component does not appear to have any countercyclical influence anyway and is more like a permanent reduction in the corporate tax rate.

However, there were a number of differences between the investment funds system and the operation of the investment tax credit in practice. Most important for a comparison of structures investment in Sweden and the United States was that the tax credit did not apply to structures in the United States, as defined in the tax code. Thus, except for the fact that much equipment investment is tied to structures investment, the tax credit would not be expected to affect investment in manufacturing structures. Although there were some countercyclical changes in the credit, it is difficult to determine whether such changes were expected by firms. Because there was no explicit announcement that the credit would change countercyclically, firms' forecasts of such changes would be subject to considerable uncertainty. In fact, the credit was first enacted during a period of below-normal economic activity in 1962, suspended temporarily in 1966 during a boom, and eventually repealed later in that same boom in 1969. It was reinstated during a period of low economic activity in 1971, and was increased during the 1975 recession from 7 to 10 percent before becoming essentially permanent. Although in its early stages the credit had many of the same ex post countercyclical features as the investment funds system, it is unlikely that firms had a countercyclical expectation about its behavior ex ante.

Figure 3. Investment and Output Change in the United States, 1959–78

Real investment in manufacturing
structures (billions of 1972 dollars)

Change in real GDP and real manufacturing
output (billions of 1972 dollars)

Source: National income and product accounts.

attributable to the system could be the result of measurement errors in the output data. The use of two alternative measures of demand is an attempt to check for the effects of measurement error. It is interesting to note, however, that the general finding that the procyclical movement in investment was offset by the system is similar to the results of Eliasson's survey of individual firms undertaken in 1962–63. The survey attempted to determine the net effect of the release of 1962–63 by asking firms what projects would have been undertaken if the funds had not

Table 3. Reduced-Form Accelerator Equations for Investment in Manufacturing Structures, United States, Annual Data, 1961–75[a]

Output variable and sample period	Independent variable				Statistic			
		Change in output						
	Current	One-year lag	Two-year lag	Sum	t-ratio for sum	Rho	Durbin-Watson	R^2
Real GDP								
1961–75	0.0382	0.0257	0.0620	0.1259	2.31	. . .	0.81	0.35
1961–75	0.0133	0.0232	0.0266	0.0631	1.64	0.58	. . .	0.23
Real manufacturing output								
1961–75	0.0465	0.0358	0.0827	0.1650	1.47	. . .	0.54	0.22
1961–75	0.0166	0.0318	0.0364	0.0848	1.22	0.69	. . .	0.18

Sources: Same as table B-1.
a. The dependent variable is real investment in manufacturing structures. All variables have been detrended linearly over the 1958–75 sample period.

been available. According to this survey, the net effect in the 1962–63 release was just about enough to smooth out what would have appeared to be a typical accelerator reaction of investment expenditures to the changes in demand during that cycle.[23]

Although the theoretical discussion shows that one cannot distinguish between the demand effect and the policy effect in these accelerators without knowledge of g(c_t and Y_t are collinear), for completeness I report in table 4 the results of directly including c_t in the accelerator equations. Movements in c_t that are not perfectly linearly tied to Y_t could show up in the regression and change the accelerator coefficients. The sample period is extremely short and not strictly comparable with the results in table 2 (c_t is only tabulated through 1972), and the standard errors are large; but the results offer some additional evidence that the system stabilized investment. The cost variable, c_t, enters with a negative sign, and the sum of the accelerator coefficients increases in a procyclical direction. When current and lagged c_t are in the equation, the change in c_t is shown to predominate and the accelerator coefficients move more in a procyclical direction when GDP is the demand variable.

To investigate the extent to which movements in c_t were approximated by a simple linear function of Y_t, c_t was regressed on Y_t over 1958–75, with Y_t again the deviation of GDP from trend. The coefficient on Y_t was 0.00125 with a t-ratio of 1.3. Regressing c_t on Y_t and Y_{t-1} over the same sample period gave coefficients of 0.0017 and 0.0001 with an F-ratio for the regression of 1.7. The R^2 were only 0.15 and 0.27 in these regressions. Although the signs of these coefficients confirm the countercyclical behavior of the investment funds system, these seemingly poor fits probably reflect the bad timing of some of the movements in c_t shown in figure 1 (the largest residual occurs in 1959) as well as the linear approximation to the operation of the system. A nonlinear switching model for c_t might fit the data better.

Structural Analysis and Policy Evaluation

While the above regressions give some quantitative evidence that the investment funds system was working, they are incapable of providing

23. See Eliasson, "Investment Funds," diagram III:2, p. 73, or Lindbeck, *Swedish Economic Policy*, chart 6:1A, p. 101.

Table 4. Reduced-Form Accelerator Equations with Investment Funds-Induced Changes in Investment Cost, Sweden, 1961–72[a]

Output variable	Independent variable						Statistic	
	Change in output				Investment funds cost effect			
	Current	One-year lag	Two-year lag	Sum	Current	One-year lag	Durbin-Watson	R^2
Real GDP								
	−0.0219	−0.0161	−0.0253	−0.0633	...	...	1.37	0.11
	−0.0032	−0.0104	0.0123	−0.0013	−12.65	...	1.13	0.16
	0.0249	−0.0123	0.0207	0.0333	−19.87	18.87	1.46	0.33
Real manufacturing output								
	−0.1427	0.0196	−0.0983	−0.2304	...	...	1.55	0.30
	−0.1255	0.0409	−0.0754	−0.1600	−7.98	...	1.66	0.33
	−0.0856	0.0185	−0.0855	−0.1526	−10.39	10.39	1.90	0.37

Sources: Same as tables 1 and B-1.
a. The dependent variable is real investment in manufacturing structures. The output and investment variables have been detrended linearly over the 1958–72 sample period. The investment funds price effect is defined as 100 minus the effective discount given in table 1.

estimates of how much the system reduced investment fluctuations. For this, one needs an estimate of what the cyclical variability of investment would have been under a different policy regime in which the investment funds system was not in operation ($g = 0$). Moreover, for policy design questions it is important to know how investment would behave for other values of g. If a scheme like the investment funds system was being considered at another time or place, it would be important to choose g appropriately. For example, one would want to avoid choosing a g so large that investment became significantly countercyclical. To address these issues, estimates are needed of the structural parameters of the model: value-put-in-place weights, capital-output ratios, depreciation rates, discount rate, and parameters of the forecasting rules used by firms.

The focus here is on the heterogenous capital model with building projects of one, two, and three periods (the U.S. survey data suggest that a large fraction of industrial building is completed in three years) and on the accelerator models with GDP as the measure of demand. The first-order model for firms' forecasts of demand conditions is used, and it is assumed that the linear policy rule is a good approximation. Using the equations derived in the theoretical discussion, the full three-period model is then summarized in the following system of equations:

$$(23) \quad S_{1t} = v_1 \hat{Y}_{t+1} - \frac{1}{bd}(c_t - b(1 - h)\hat{c}_{t+1}) - (1 - h)K_{1t},$$

$$S_{2t} = v_2 \hat{Y}_{t+2} - \frac{1}{b^2 d}[w_{21}c_t + b(w_{22} - w_{21}(1 - h))\hat{c}_{t+1}$$

$$- b^2(1 - h)w_{22}\hat{c}_{t+2}] - (1 - h)K_{2t+1},$$

$$S_{3t} = v_3 \hat{Y}_{t+3} - \frac{1}{b^3 d}[w_{31}c_t + b(w_{32} - w_{31}(1 - h))\hat{c}_{t+1}$$

$$+ b^2 (w_{33} - w_{32}(1-h))\hat{c}_{t+2} - b^3(1-h)w_{33}\hat{c}_{t+3}] - (1-h)K_{3t+2},$$

$$I_{1t} = S_{1t},$$

$$I_{2t} = w_{21}S_{2t} + w_{22}S_{2t-1},$$

$$I_{3t} = w_{31}S_{3t} + w_{32}S_{3t-1} + w_{33}S_{3t-2},$$

$$I_t = I_{1t} + I_{2t} + I_{3t},$$

$$\hat{Y}_{t+i} = a^i Y_t,$$

$$c_t = g Y_t.$$

Substituting the forecasting formulas and the policy rule into the starts equations and substituting those in turn into the investment equation, the accelerator model is obtained:

(24) $$I_t = \beta_1 z_t + \beta_2 z_{t-1} + \beta_3 z_{t-2},$$

where $\beta_1 = w_{11}A_1 + w_{21}A_2 + w_{31}A_3,$

$\beta_2 = w_{22}A_2 + w_{32}A_3,$

$\beta_3 = w_{33}A_3,$

$A_1 = v_1 a - \dfrac{g}{bd}(1 - ab(1 - h)),$

$A_2 = v_2 a^2 - \dfrac{g}{b^2 d}(w_{21} + abw_{22})(1 - ab(1 - h)),$

$A_3 = v_3 a^3 - \dfrac{g}{b^3 d}(w_{31} + abw_{32} + a^2 b^2 w_{33})(1 - ab(1 - h)),$

with the depreciation terms omitted from the investment equation. The parameters of the model are fourteen in number—w_{11}, w_{21}, w_{31}, w_{22}, w_{32}, w_{33}, h, v_1, v_2, v_3, a, g, b, and d. However, the value-put-in-place weights sum to one for each type of project so that there are effectively eleven free parameters.

The estimates of the value-put-in-place weights were obtained from a survey of nonresidential construction conducted by the U.S. Bureau of the Census. The results of several separate census surveys are shown in table 5, after aggregation into three gestation classes as explained in the notes to the table. The weights are fairly stable for the three surveys.[24] The 1978 survey was used for estimates of the value-put-in-place weights in the model.

The average ratio of the net real stock of manufacturing plants to total real GDP in Sweden in the 1958–75 period was 0.20. In a model with only one type of capital, this would be a reasonable value to choose for

---

24. The finding that the weights are stable is potentially important in itself because there is a possibility that these weights could change as projects are completed more quickly or more slowly, depending on the stage of the cycle. This has been raised as a criticism against the gestation approach to investment behavior. (See, for example, my comments on Finn E. Kydland and Edward C. Prescott, "A Competitive Theory of Fluctuations and the Feasibility and Desirability of Stabilization Policy," in Stanley Fischer, ed., *Rational Expectations and Economic Policy* (the University of Chicago Press, 1980), pp. 191–94). If the stability observed in this survey holds up, this criticism is incorrect.

Table 5. Completion Time and Value Put in Place for Nonresidential Building Projects, 1976–79[a]

Duration of project	Fraction of value put in place each year[b]								
	Projects completed in 1976–77			Projects completed in 1978			Projects completed in 1979		
	First Year	Second Year	Third Year	First Year	Second Year	Third Year	First Year	Second Year	Third Year
One year	1.00	. . .	. . .	1.00	. . .	. . .	1.00	. . .	. . .
Two years	0.79	0.21	. . .	0.82	0.18	. . .	0.83	0.17	. . .
Three years	0.50	0.39	0.11	0.49	0.37	0.14	0.54	0.35	0.11

Sources: U.S Bureau of the Census, *Construction Reports,* series C30, *Value of New Construction Put in Place,* December 1978, August 1979, and August 1980. A supplement to each issue contains survey data on completion time and progress payments for construction projects in the United States.

a. The data are constructed by aggregating eight cost classes into three completion time classes: projects costing more than $5 million were placed in the three-year class; those from $3 million to $5 million, in the two-year class; and those that were less than $3 million, in the one-year class. The annual value-put-in-place data for the two- and three-year projects were constructed from monthly data. When less than 100 percent of the projects was installed by the end of the assumed two- or three-year horizon, the value put in place was adjusted upward to reach the 100 percent value (the lowest percent in the three surveys was 93).

b. In 1976–77, 8,000 projects were completed; in 1978, there were 5,000; and in 1979, there were 5,700.

v, the desired capital-output ratio. In a disaggregated model the sum of the individual v_i should also equal this total aggregate capital-output ratio. In the model, I therefore set $v_1 + v_2 + v_3 = 0.20$. Without data on the type of capital used in manufacturing in Sweden, it is not possible to calculate the individual v_i. Since the composition of manufacturing output could be quite different in Sweden than in the United States, the U.S. survey data used to construct the value-put-in-place weights could be misleading.[25] For this reason U.S. survey data were not used to estimate the v_i parameters.

An estimate for a was obtained by regressing detrended GDP on its lagged value (a first-order autoregression) over the 1961–75 sample period. The value was 0.44 with a t-ratio of 1.6. (It should be noted that a second-order autoregression estimated over the same sample gives coefficients of 0.64 and -0.44 with t-ratios of 2.2 and -1.5, respectively. This same approach could be used for the second-order model.)

An estimate of $g = 0.00125$ was obtained from the regression of c_t on Y_t described earlier. The value of the discount factor b was taken to be 0.94, corresponding to the average nominal interest rate of 6.5 percent

25. This problem was pointed out by Stanley Fischer in his comments on an early version of this paper. The problem seems more severe for v_i than for w_{ij}, but in principle could also raise problems for w_{ij}. Hence the policy evaluation results reported here are by no means final and might be improved in future research using similar surveys for Sweden.

during 1961–72. The value of the depreciation rate, h, was taken to be 0.026, the value reported earlier and calculated from actual estimates of depreciation.

This leaves three parameters: d, v_1, and v_2, with $V_3 = 0.20 - v_1 - v_2$. These are calculated by setting the three coefficients of the accelerator model, β_1, β_2, and β_3, to zero, which reflects the general finding from the unconstrained accelerator models reported in table 2 for the 1961–75 sample for the case in which demand is measured by GDP.[26] Given the β values, the expressions following equation 24 can then be solved for v_1, v_2, and d. The results are $v_1 = 0.03$, $v_2 = 0.06$, and $d = 0.07$. Hence $v_3 = 0.11$.

Given these numerical values, the effect of the investment funds system on the distributed lag accelerator coefficients can be evaluated by setting $g = 0$ and calculating the values of the β coefficients.[27] These values are 0.0266, 0.0056, and 0.0013, respectively. When $g = 0.00075$, which is about a 40 percent reduction in the strength of the system, the values are 0.0108, 0.0023, and 0.0008. The value of these coefficients at $g = 0$ characterizes how procyclical investment might have been if the investment funds system were not in operation.

These coefficients are somewhat smaller than might have been suspected. Their sum, 0.034, is at most one-half of the sum of the unconstrained accelerator coefficients estimated for the United States and for the period in Sweden during which the system was not in effect. Thus, according to this structural interpretation, one should not attribute the small accelerator parameters in the reduced form models entirely to the

26. The choice of zero for the β coefficients can be considered as a smoothness constraint that is statistically consistent with the data. A better approach, which is unfortunately not an option here, would be to use technological data on the v's that would put implicit constraints on the lag distribution of the β's. Zero was chosen rather than the estimated coefficients because of the high standard error associated with these coefficients. Minor changes in the β coefficients can change the structural parameters in major ways and can lead to implausible values for these parameters. For example, some of the actual estimated coefficients in table 2 lead to negative values for v_2. A slight change in the sample period for the unconstrained estimates generated plausible values for the v's even though there was little perceptible differences in the β's. It is not surprising that the unconstrained β values have high standard errors given the multicollinearity problems.

27. To summarize, the parameter values are as follows: value-put-in-place weights for each type of capital, $w_{11} = 1.00$, $w_{21} = 0.82$, $w_{22} = 0.18$, $w_{31} = 0.49$, $w_{32} = 0.37$, $w_{33} = 0.14$; depreciation rate, $h = 0.026$; autoregressive parameter, $a = 0.44$; investment funds policy rule parameter, $g = 0.00125$; discount rate, $b = 0.94$; capital-output ratio for each type of capital, $v_1 = 0.03$, $v_2 = 0.06$, $v_3 = 0.11$; and curvature of U-shaped cost function, $d = 0.07$.

investment funds system. Another reason for these low coefficients is the small persistence parameter, *a*. According to the model, low values of *a* indicate that cyclical fluctuations in demand are rather transient and would not therefore stimulate much new investment. Higher values for *a* would raise the accelerator coefficients significantly, as is clearly seen in the expressions following equation 24. It should be noted that the value for *a* estimated over the 1966–78 sample period was 0.77, considerably higher than the 0.44 value estimated over the earlier period and used in this structural analysis. This higher persistence could in itself raise the accelerator coefficient as observed (in table 2) for Sweden. According to these estimates, the standard deviation of the fluctuations in manufacturing structures investment from trend would have been about 0.12 billion kronor higher in 1975 prices if the investment funds system had been in operation. This compares with a standard deviation for the change in real GDP about trend of 4.5 billion kronor as calculated from the estimated autoregressive model.

Concluding Remarks

The main empirical findings of this study indicate that the Swedish investment funds system reduced the cyclical fluctuations in investment during the late 1950s and 1960s. The system had a major impact on the effective price that firms paid for investment goods, and in general this impact was countercyclical with the price being relatively low during recessions and high during booms. Such countercyclical price effects would be expected to shift firms' investment plans in a countercyclical direction. In fact, the procyclical variability of investment in manufacturing structures—as measured by an accelerator formulation—was shown to be negligible while the system was in operation in Sweden, a result that contrasts with similar investment series in the United States. The model of investment behavior used here suggests that some of these differences were due to the investment funds system, but that relatively low business cycle persistence during the period was also a factor. Although the analysis indicates that such a scheme could in principle destabilize investment for certain forecasting procedures used by firms, no evidence of such destabilizing effects was found in the empirical analysis.

The analysis reveals less about the welfare implications of such a

system or about how it should be considered as part of an overall system of fiscal and monetary policy rules. It seems clear that any reduction in business cycle fluctuations that does not also make aggregate prices less stable is a gain in economic welfare. By reducing the size of the cyclical swings in investment, a policy rule like the investment funds system could have such an effect. Viewed in the context of an overall mix of monetary and fiscal policy rules, such a system could have an important role as a complement to other automatic stabilizers. Many of the current automatic stabilizers are oriented toward consumption and thereby shift the composition of output away from investment during recessions. A countercyclical investment rule could offset this bias. The role of such a rule could be especially important if monetary policy is not used for countercyclical purposes, but instead is geared entirely toward a steady growth rule designed to promote long-run stability of prices.

APPENDIX A

Derivation of the Starts Equation

AFTER substituting for I_t in equation 1 using equations 2 and 3, one obtains

$$(A\text{-}1) \qquad \sum_{t=1}^{\infty} b^t \left[\frac{d}{2} (vY_t - K_t)^2 + c_t(K_{t+1} - (1 - h)K_t) \right],$$

the expected value of which must be minimized with respect to the sequence $K_2, K_3, \ldots$. Note two special features of this problem: first, although this is a dynamic stochastic control problem (because Y_t and c_t are random), it is of the linear quadratic form and therefore satisfies the certainty equivalence assumptions; that is, one can replace the random variables by their expectations, $\hat{Y}_t$ and $\hat{c}_t$, and solve the problem as if it were deterministic.

Second, each period's decision determines only one future period of capital stock. In the case in which capital construction takes one single period, the period 1 decision determines K_2, but K_3 is not determined until period 2. (However, the initial conditions for the period 2 problem are altered by the decision taken in period 1.)

These two characteristics of the problem mean that one can obtain an

analytic solution by differentiating with respect to each of the decision variables, K_2, K_3 . . ., and setting the derivatives to zero. The differentiation with respect to a given K_t takes the expectation $\hat{Y}_t$ and $\hat{c}_t$ conditional on information available in period t − 1, when K_t must be determined. For example, the terms in A-1 that involve K_2 are

$$
(A\text{-}2) \qquad b\left[\frac{d}{2}(vY_1 - K_1)^2 + c_1(K_2 - (1 - h)K_1)\right]
$$

$$
+ b^2\left[\frac{d}{2}(v\hat{Y}_2 - K_2)^2 + \hat{c}_2(K_3 - (1 - h)K_2)\right],
$$

where the hats represent expectations at time 1. Hence the derivative of A-1 with respect to K_2 is

$$
(A\text{-}3) \qquad bc_1 - b^2 d(v\hat{Y}_2 - K_2) - b^2\hat{c}_2(1 - h) = 0,
$$

or

$$
(A\text{-}4) \qquad K_2 = v\hat{Y}_2 - \frac{1}{bd}(c_1 - b(1 - h)\hat{c}_2).
$$

But 2 shows that $K_2 = K_1 + S_1 - hK_1$, which results in

$$
(A\text{-}5) \qquad S_1 = v\hat{Y}_2 - \frac{1}{bd}(c_1 - b(1 - h)\hat{c}_2) - (1 - h)K_1.
$$

The same argument holds for the determination of S_2 in period 2 and in general for all S_t; this is the derivation of equation 4 in the text. For the case of longer gestation periods the calculations are similar except that there will be more terms involving K_2 in equation A-2.

This method for solving stochastic control problems is explained in more detail in Thomas J. Sargent, *Macroeconomic Theory* (Academic Press, 1979). A multivariable generalization (useful, for example, for the full multivariate investment problem but with cross terms) is found in Lars Peter Hansen and Thomas J. Sargent, "Linear Rational Expectations Models for Dynamically Interrelated Variables," in Robert E. Lucas, Jr., and Thomas J. Sargent, eds., *Rational Expectations and Econometric Practice,* vol. 1 (The University of Minnesota Press, 1981), pp. 127–56. The dynamic stochastic programming approach to these problems is found in G. C. Chow, "Estimation of Rational Expectations Models," *Journal of Economic Dynamics and Control,* vol. 2 (August 1980), pp. 241–55.

APPENDIX B

THIS appendix presents the data on investment, manufacturing output, and real GDP for Sweden and the United States that were used in the tables, figures, and regressions in the text.

Table B-1. Investment in Manufacturing Structures, Output in Manufacturing, and Real GDP in Sweden and the United States, 1958–78

Year	Sweden (billions of 1975 kronor)			United States (billions of 1972 dollars)		
	Investment in manu- facturing structures	*Manu- facturing output*	*Real GDP*	*Investment in manu- facturing structures*[a]	*Manu- facturing output*	*Real GDP*
1958	1.99	31.7	150.4	3.92	153.3	676.3
1959	2.21	33.5	158.8	3.50	171.2	716.9
1960	2.60	36.7	164.2	4.74	171.8	732.0
1961	3.19	39.2	173.4	4.64	172.0	751.0
1962	2.99	42.3	180.8	4.69	186.7	793.8
1963	2.92	44.8	189.7	4.71	202.2	825.6
1964	2.31	50.2	204.5	5.67	216.7	868.9
1965	2.35	54.0	213.2	8.77	236.7	921.4
1966	3.02	56.7	219.3	10.83	254.9	977.5
1967	3.16	57.7	225.4	9.43	254.3	1,003.9
1968	2.70	61.4	234.1	8.14	268.2	1,050.0
1969	2.90	66.3	248.2	8.41	277.2	1,079.7
1970	2.99	70.7	261.4	7.44	261.2	1,077.6
1971	2.93	72.0	260.9	5.74	266.8	1,112.8
1972	2.87	73.3	265.2	4.68	292.5	1,175.0
1973	2.94	78.3	274.1	5.77	325.3	1,239.8
1974	3.64	82.0	285.6	6.18	311.7	1,230.8
1975	4.02	80.1	287.9	5.74	289.6	1,220.0
1976	3.71	79.2	291.6	5.16	317.4	1,284.8
1977	3.07	74.3	283.8	5.23	338.7	1,354.7
1978	2.26	74.6	291.6	6.71	356.9	1,416.8

Sources: Investment data on Sweden are from unpublished series of the Swedish Central Bureau of Statistics; output data on Sweden are from United Nations, *Yearbook of National Account Statistics,* various issues. Data on the United States are from the national income and product accounts.

a. This series is the "industrial buildings" component of nonresidential fixed investment in the national income and product accounts. Industrial buildings include manufacturing plants and warehouses and other buildings on manufacturing plant sites. Some structures owned by manufacturing companies but not on plant sites (such as center city office buildings) are not included in this series.

Comments
and Discussion

Martin Neil Baily: John Taylor has presented a clearly written and skillful analysis of the Swedish experiment with countercyclical investment incentives. As a good econometrician, he has emphasized those parts of the problem that were of particular importance given the data set he is working with. There are, however, some additional questions that would arise should such a policy regime be suggested as a major component of U.S. stabilization policy.

It was not an easy task to distill from the intricate rules of the Swedish system what its central features were. I am not familiar with the details of the program, but Taylor gives me considerable confidence that he has in fact researched the details thoroughly and been able to summarize the economic impact of the program. It substantially reduced the cost of structures investment for business during recession years. Taylor goes on to give careful consideration to the complexity introduced because investment projects have different gestation periods. Quite appropriately, he recycles some of the methodology he learned in analyzing wage contracts of one, two, and three years for investment projects with gestation periods of one, two, and three years.

By using information from U.S. data, Taylor imposes some of the parameters of the lag structure on his investment function for Sweden. He assumes that there is fixed time-dimension of construction technology, one that is the same for Sweden and the United States. A business decides to build a new plant and an order is placed that specifies a price and a completion schedule. On the whole I prefer this assumption to most cost-of-adjustment models, but it may be a bit too rigid. A business could ask for more rapid completion at a higher price. This would require a procedure called "fast-tracking," in which the project is speeded up.

100

In Taylor's model, firms would have a considerable incentive to speed up projects if the net cost (after allowing for incentive payments) is thereby reduced. This speeding-up effect may be more important than the possibility he considers whereby firms switch between short- and long-term projects.

The U.S. parameters on gestation lags are combined with a Swedish capital-output ratio to provide the information Taylor needs to identify the effect of the investment stimulus program. I admired how neatly this was done, and the final answer may well be exactly correct. But the basic result is governed by the fact that the unconstrained accelerator coefficients are very small during the period when the stabilization program was in effect. Since the capital-output ratio suggests substantial coefficients, this means that the program must be working. However, there are other reasons why the estimated coefficients might be low. For example, in a small, open economy there may not be much relation between current and lagged GDP changes and the demand for manufacturing structures. To support his findings, Taylor looks at another period in Sweden when it did not have the same tax system and at a similar regression for the United States. These results do show larger unconstrained accelerator coefficients and therefore strengthen his case. The only reservations are that none of the coefficients is estimated very precisely, and the equations do not explain a large fraction of the variance of structures investment.

I turn now to two small points about his procedures. First, some people have found liquidity or interest rate effects on structures investment to be important. This form of investment is usually highly leveraged. Taylor has the basis for calculating a Jorgenson-style cost of capital series, so why not use it? Second, there is a relation between equipment investment and structures investment. Businesses do not build new structures to leave them empty. The investment funds, according to Taylor, can reduce the cost of a structure by 30 percent, but the percentage reduction in the cost of a whole project (including equipment) might be much smaller.

The final point may be more serious. Arthur Okun criticized countercyclical investment tax credits in 1972 on the grounds that they could be destabilizing because of anticipatory effects. This line of criticism has become much in vogue as part of the general Lucas critique of policy evaluation. Okun describes the problem as follows: ''[Countercyclical

variations in the investment tax credit] are appealing because of their presumably enlarged multiplier impact, with substitution effects reinforcing the normal income effects of a tax rate change; the required dollar change in the instrument settings for any given stimulus or restraint is thereby made smaller. But the anticipatory effects of such practices are destabilizing—for example, a slowdown in investment outlays is exacerbated if a weakening of the economy makes a temporary rise in the tax credit seem likely. A commitment to retroactivity can ameliorate the problem for tax reduction, but, for a tax rise, retroactivity is universally rejected as inequitable."[1]

This problem cannot enter Taylor's model because fluctuations in investment are assumed to have no impact on GDP. The model of the business cycle he uses is really very simple and rational expectations consistency is easy to obtain. There is no interaction in which private decisions are affected by the policy rule but also affect the GDP outcome and hence the policy choice in the next period. Taylor does show that assuming a second-order process for GDP does not change his conclusion that the Swedish system is always stabilizing, provided the second-order process itself is stable. But that misses the point, because the question is whether a Swedish-style program applied to all forms of investment could cause instability in a model in which volatility of investment is a major cause of cyclical movements in GDP. There is the fear that if businesses anticipate a recession they will cut back investment and fulfill their own prophecy. By strengthening this tendency, an investment stabilization program could conceivably backfire.

The data Taylor presents seem to say, however, that Okun was worrying unnecessarily. No unstable movements are apparent in the annual data and, in any case, the amount of manufacturing structures investment simply is not enough to feed back into GDP in an important way. For the econometric purpose at hand, Taylor was probably correct to treat GDP as exogenous. This was a sound analysis of what looks like a sound policy regime.

Stanley Fischer: John Taylor's paper is a pleasure to read; it is clear, brief, and neat. And it reaches a surprising conclusion: somewhere, sometime, a government policy worked in a way it was intended to.

1. Arthur M. Okun, "Fiscal-Monetary Activism: Some Analytical Issues," *BPEA*, *1:1972*, pp. 132–33.

Let me start by describing what the paper does not do, then discuss what it does. One way to proceed might have been to look at figure 1, which shows the cost of investment goods moving countercyclically, and to try to develop measures of the cost of capital, and then the effects of the scheme. Taylor does not choose this route, thereby avoiding having to estimate the effects of the cost of capital on investment and the embarrassment of explaining the major role of expectations of future demand in investment equations. Rather, he proceeds directly to an accelerator-type model of investment, in which the effects of changes in the cost of capital are implicit in changes in the dynamics of investment. This has the benefit of permitting the funds release scheme to have worked through availability rather than explicit price.

The paper focuses mostly on stabilization of *investment* rather than stabilization of GNP. If GNP fluctuations are mainly the results of investment fluctuations, this comes to much the same thing. But since GNP is modeled as a first-order autoregressive process, and investment as potentially second order, it is possible that the rest of GNP also contributes independent dynamics to the economy. In that case it would have been preferable to use a simple model of noninvestment aggregate demand rather than GNP to study the effects of the funds release scheme on economic activity.

Let me briefly reinforce the message contained in the last part of the paper. This paper does not attempt standard microeconomic welfare evaluation of the investment funds scheme. There is indeed some tension between the type of macro stabilization analysis of this paper and that approach to stabilization. There one would have started by asking why there was any need to interfere in the first place. Answering this question takes one into the details of the Swedish capital market at the time, a market that by all accounts used credit rationing as its major allocative mechanism.

In this paper Taylor's concern is not so much the desirability of the scheme, but its effects. He is faced with the problem raised in the classic policy evaluation critique of Kareken and Solow.[1] They pointed out that a series that has been successfully stabilized will look random and not bear any econometrically detectable relation to the variable used to

1. See Robert M. Solow and John Kareken, "Lags in Monetary Policy," part 1 of "Lags in Fiscal and Monetary Policy," by Albert Ando and others, in the Commission on Money and Credit, *Stabilization Policies* (Prentice-Hall, 1963), pp. 14–96.

stabilize it. To detect the effects of the policy instrument, one has to go beyond reduced forms. Taylor does that by building a structural investment model. I want to raise a few questions about the model.

The first is whether the potential destabilizing effects of the funds scheme have been assumed away. The concern about potential destabilization is a real one, which has been raised in the United States in connection with the proposal that the investment tax credit be used as an automatic stabilizer. There are several features that might make the funds release scheme destabilizing in practice, though not in the model.

In the paper Taylor shows how the scheme could be destabilizing if output followed something other than a first-order autoregressive process. Under the assumed process, it is never possible to forecast that the scheme will be implemented next period if it is not already in effect. There is thus never any danger that firms hold off investment this period in anticipation of the scheme coming into effect next period. Once the process is made second order, that possibility arises, as Taylor shows. Of course, well designed policy can prevent the destabilization.

The use of annual data may be partly responsible for the data showing only first-order autoregression. If the process is of second or higher order, two more features not treated in the model create further destabilization potential. First, the scheme is modeled as continuous, though it was in fact on and off. Taylor's suggestion, that uncertainty about the implementation of the scheme makes it appropriate to use the continuous model, is appealing, but he also gives indications that there was about a six-month warning of the change on occasion. Second, the model treats investment and disinvestment symmetrically. Investment can as easily be negative as positive in the model of this paper. Given that, there is less worry about committing oneself too soon. If disinvestment is difficult, the firm is more anxious to choose exactly the right moment to invest. This introduces another potentially destabilizing element.

These considerations suggest caution in interpreting the apparent success of the Swedish scheme as carrying over directly to similar success for the implementation of countercyclical operation of the investment tax credit.

A second general modeling question concerns the distribution of the investment projects by maturity. As the model is set up, firms undertake the three different types of investment project (one-, two-, and three-years) in isolation. There is no possibility of switching the *type* of

investment undertaken. For instance, one- and two-year investment projects may be substitutes in building a given type of capital. Then a temporary funds release would lead the firm to switch to one-year projects. Such a mechanism is not present in the paper. If it were, the effects of the scheme would be stronger.

The switch in maturity structure described above is not the same as the shift toward shorter-term projects in recessions described in the paper. That switch occurs because the response of one-year projects to the funds release is larger than the response of two-year projects. The mechanism described in the previous paragraph would strengthen the tendency to switch to shorter-term projects in recessions.

General Discussion

Several discussants wondered whether the noncyclical performance of Swedish investment might be attributable to factors other than the investment funds system. Martin Baily suggested that Swedish investment in manufacturing structures might be aimed at production for foreign markets. Consequently, even in the absence of the funds system, such investment might not be sensitive to cyclical fluctuations in the Swedish economy. However, William Nordhaus cited OECD studies of European investment behavior that show European investment typically is sensitive to domestic fluctuations, not to international fluctuations. Nordhaus pointed out that one could test whether the funds system had worked by observing whether structures investment was damped relative to investment in equipment.

Lawrence Summers asked whether the end of the countercyclical investment funds policy coincided with a return to procyclical fluctuations in manufacturing investment. Taylor reported that it did, though he noted that the variability of investment also increased. Christopher Sims, while generally concurring with the paper's main finding, offered a qualification. The assumption that the discount factor is constant is not innocuous; it implies that real interest rates are treated as fixed, whereas they are probably cyclical. Furthermore, interest rates would behave differently in the absence of a funds policy. Thus the net impact of the policy is probably smaller than that suggested by the paper.

Some discussion was devoted to the incentives the funds policy created for intertemporal substitution of investment by firms. Summers

noted that the costs of capital discussed in this paper are different from Jorgensonian user costs that economists conventionally think about. Those conventional user costs reflect the expected change in effective capital goods prices, which would be affected by countercyclical operation of the funds system. At the point at which the countercyclical policy becomes operative, firms face drastically lower costs of capital. Consequently, the user cost of capital just before the funds are made available reflects the anticipated future reduction in the cost of capital and becomes quite high. Summers observed that Taylor's results do not show particularly large responsiveness to the cost of capital; they show responses because there are unusually large *changes* in the cost of capital. Finally, he noted a similarity between the Swedish countercyclical funds policy and U.S. policies that provided accelerated federal funding for state and local public works projects during a recession. Since the funds were provided on a matching grant basis in the United States, local governments had an incentive to delay public works projects when a recession was anticipated in order to qualify for the expected federal subsidy. From a macroeconomic perspective, this incentive could have occurred at the wrong time and thus could have exacerbated the recession.