

1974

# Imperfect Stock Adjustment and the Relative Efficacy of Monetary and Fiscal Policy

Gerard O. Gaudet

Follow this and additional works at: <https://ir.lib.uwo.ca/economicsresrpt>

 Part of the [Economics Commons](#)

---

## Citation of this paper:

Gaudet, Gerard O.. "Imperfect Stock Adjustment and the Relative Efficacy of Monetary and Fiscal Policy." Department of Economics Research Reports, 7405. London, ON: Department of Economics, University of Western Ontario (1974).

20261

Research Report 7405  
IMPERFECT STOCK ADJUSTMENT  
AND THE RELATIVE EFFICACY OF MONETARY  
AND FISCAL POLICY

Gérard O. Gaudet

ECONOMICS LIBRARY  
APR 01 1974

March 1974

IMPERFECT STOCK ADJUSTMENT AND THE RELATIVE  
EFFICACY OF MONETARY AND FISCAL POLICY\*

Gérard O. Gaudet  
Department of Economics  
University of Western Ontario  
London Canada  
March 1974

\* The author wishes to thank Albert Ando, Dale Henderson, Stephen Salant, and members of the Money Workshop at the University of Western Ontario, in particular Joel Fried and Russell Boyer, for helpful comments on earlier drafts of this paper.

## I

Many economists have recognized that the pure neoclassical theory of the firm, with a perfect market in capital goods, does not lead to a smooth investment demand function, relating the rate of investment at a point in time to the rate of interest.<sup>1</sup> In other words the Keynesian marginal efficiency schedule cannot be deduced directly from the neoclassical theory of the firm in such a context. With a perfect market in capital goods, existing capital goods can be bought and sold at the prevailing market price for new capital.<sup>2</sup> Thus the firm can purchase capital services just like it purchases labor. What the theory of the firm leads to under these circumstances is a demand function for capital services (and thus a stock of capital, assuming that services are proportional to the stock). Such a firm has no investment demand schedule, relating the rate of investment to the rate of interest. All values of the rate of interest at a point in time, except the one which equates the rental price of capital to the marginal productivity of the existing stock of capital, involve a jump in the optimal stock of capital.<sup>3</sup> At the rate of interest which is consistent with the existing stock of capital there is no room in this model for any non-zero rate of accumulation, whereas at any other rate of interest one has to conclude that the rate of change of capital stock must be either plus or minus infinity.<sup>4</sup>

At the other extreme, one could assume that there is no market at all for existing capital goods. In such circumstances, a rate of interest different from the one consistent with the existing stock of capital could result in a finite rate of investment in new capital goods. This is the route followed, for example, in Sargent and Wallace [18] in justifying the Keynesian investment demand function. They make the rate of investment a function of the gap between the marginal productivity of the existing stock of capital and its

rental price. There is however a missing link in this rationale for a Keynesian investment demand function. It is one thing to say that the rate of investment will be positive (negative) if the marginal productivity of capital is greater (smaller) than the rental price of capital, but quite another thing to say that it is an increasing function of this gap. Sargent and Wallace fail to rationalize this second step explicitly in terms of the optimal behavior of the firm, and without this second step the rate of investment remains indeterminate.<sup>5</sup>

In this paper, we present an attempt to construct a macroeconomic model which would represent the situation lying in between those two extremes of a perfect market for capital goods and no market at all. In other words we propose a model where there exists a market for capital goods which is, however, marred by certain kinds of frictions and imperfections. Or, we should say, we reinterpret the standard Keynesian model as being representative of such a situation.

Since the work of Eisner-Strotz [5], quite a bit of attention has been paid in the literature to the introduction of adjustment cost in dynamic models of the firm (see, for example, Lucas [12], [13]; Treadway [21], [22], [23]; Gould [7]; Nerlove [15]). To a large extent, this literature came about from the recognition that adjustments in the stock of capital do not in reality take place instantaneously, as the neoclassical theory of the firm with a perfect market for capital goods would assume. These adjustment costs make instantaneous adjustments prohibitively costly, and as such provide a rationale for a smooth investment demand function. Much of the literature on the subject centers around the analysis of the specific dynamic behavior of the model or on the properties of the linear approximation to the investment path, which can be shown to yield a flexible accelerator type of investment function.

What we propose here is to introduce the investment demand function which results from the adjustment cost model of the firm directly into a simple one-sector macroeconomic model. This gives us our imperfect adjustment model. We take the liberty of calling this the imperfect capital goods market model, as opposed to the perfect capital goods market case described above, where a zero bid-ask price spread prevails. We are quite aware that many of the factors which give rise to adjustment costs are purely technological in nature and have nothing to do with the market side of the transaction. On the other hand, the adjustment costs formulation can also account for many types of frictions and peculiarities in the market itself, which also give rise to a spread between reproduction cost and replacement cost.<sup>6</sup>

We then show that the corresponding model with a perfect capital goods market can be considered as a special limiting case of the more general imperfect capital goods market model,<sup>7</sup> and that whether one assumes a perfect or an imperfect market for capital goods has implications for the relative efficacy of various short-run stabilization policies. In particular we will show that in the perfect market model monetary policy is very potent in affecting the level of output, whereas fiscal policy would appear to be quite ineffective as a short-run stabilization tool. In the imperfect market model fiscal policy becomes effective, and monetary policy has relatively less of an impact than with a perfect market for capital goods, its impact becoming less the more "important" is the degree of imperfection (as measured by our adjustment costs function). In this sense the imperfect market model might be considered as being more "Keynesian" in its policy implications.

II

Consider a firm which produces a gross output of  $Y(t)$  selling at a price  $p(t)$  in period  $t$ , using labor  $L(t)$  and capital  $K(t)$ . The firm owns its capital which can be reproduced at the price  $q(t)$ . We assume that  $p(t)$  and  $q(t)$ , and the wage rate  $w(t)$ , are given to the firm. We assume however that an expansion of its stock of capital at the gross rate  $I(t)$  costs the firm not only the amount  $q(t) I(t)$ , but that in addition it has to incur an adjustment cost of  $A(I)$ , where we measure  $A(I)$  in terms of the resources lost to the production of its output. In other words a given rate of gross investment cannot be attained without the firm having to devote some of its resources to this activity because search, dismantling, installation, and transactions in general, are costly. Since these resources could otherwise be devoted to the production of its output, we value these adjustment costs at  $p(t)$ , the price of its output. The total expenditures necessary to attain a gross rate of expansion of  $I(t)$  are then  $q(t) I(t) + p(t) A(I)$ .

The variable  $Y(t)$ , which we have called "gross" output is in effect then an abstraction as far as the firm itself is concerned. For its real net output, meaning by this the output which results in its sales to the market, is

$$Q(t) = F(K(t), L(t)) - A(I) \quad (1)$$

where  $F(K(t), L(t)) = Y(t)$  is its production function. We note however that if the activity of "adjusting" is to be considered as a "productive" activity, which generates income, then from the point of view of the economy as a whole the output of that firm is  $Y(t)$ .<sup>8</sup>

We make adjustment costs a function of gross rather than net investment. The net investment specification of the adjustment cost function explicitly excludes

the types of costs that arise whether the capital good is bought for expansion or replacement purposes. These costs are then to be interpreted as purely internal to the firm: expansion of the scale of operation can require re-organization of the production lines, retraining of workers, temporary slow-downs in the production process, etc. A gross investment specification, on the other hand, also admits costs which are due to peculiarities in the market for capital goods itself, and are therefore external to the firm. These recognize that transactions are not, as a rule, costless. For example, information flows are not perfect and instantaneous so that resources must be spent in searching the market, so to speak. Increasing the rate of investment may also at times require shortening, at a cost, unexpected lags between orders and deliveries. There are lags between acquisition and installation which by themselves may lead to a trade-off between output and investment of the form implied by the adjustment cost formulation. The purchase of an investment good often involves dismantling and installation charges. Increasing the rate of investment may also require overtime charges to speed-up installation or construction. All of these introduce in effect a wedge between acquisition cost of an investment good and its reproduction cost, some of which would be ignored by an internal cost only specification. It is not clear either that internal adjustment costs are completely independent of the level of replacement investment: consider for example the replacement of an important piece of equipment by a newer and different model.

We assume the usual shape for the adjustment cost function.<sup>9</sup>

- (i)  $A(I) \geq 0$  ,  $A(0) = 0$
- (ii)  $A'(I) \geq 0$  as  $I \geq 0$
- (iii)  $A''(I) > 0$  .

$$A(I) = I + bI^2 \quad (2)$$



The assumption that  $A''(I) > 0$  means of course that the cost per unit of  $I$  is higher the higher  $I$ . To use a discrete time analogy, what this says is that if an addition of say  $X$  to the stock of capital is desired in order to attain the optimal stock, then it will be more costly to attempt to acquire  $X$  in a period of time  $(\Delta t)_2$  if  $(\Delta t)_1 < (\Delta t)_2$ . The latter implies a lower rate of investment.

We drastically simplify the problem by assuming stationary expectations for all prices, so that the firm expects that the prices holding at  $t=0$  will obtain forever. We further specify the firm to be financed totally through equities, and we assume that the only alternatives to holding money in the economy are equities and government bonds, and that these two are perfect substitutes.<sup>10</sup> Under these assumptions, the net cash flow of the firm at time  $t$  is

$$R(t) = pY(t) - wL(t) - qI(t) - pA(I(t))$$

and the present value of the firm at time zero is

$$V(0) = \int_0^{\infty} e^{-rt} R(t) dt \quad (3)$$

where  $r$  is the continuous market rate of interest. The firm acts to maximize  $V(0)$  subject to

$$Y(t) = F(K(t), L(t)), \quad K(t), L(t) \geq 0 \quad (4)$$

$$\dot{K}(t) = I(t) - \delta K(t), \quad \delta \geq 0 \quad (5)$$

and

$$K(0) = K_0 \quad (6)$$

where  $\delta$  is the constant rate of physical depreciation. We will assume the production function,  $F(K,L)$ , to be homogeneous of degree one, and  $F_K, F_L > 0$ ,  $F_{KK}, F_{LL} < 0, F_{KL} > 0$ .

control variable  $u = (I, L)$   
state variable  $x = K$   
multiplier is  $y = e^{-rt} \lambda(t)$ .

Forming the Hamiltonian

$$H = e^{-rt} \{ pF(K, L) - wL - qI - pA(I) + \lambda(I - \delta K) \} \quad (7)$$

where we drop the explicit time notation, the optimality conditions are given by (see Pontryagin [16]):

$$\begin{aligned}
 \text{(i)} \quad & \dot{K} = I - \delta K, \quad K(0) = K_0, \quad \frac{\partial H}{\partial y} = \dot{K}_0. \\
 \text{(ii)} \quad & \dot{\lambda} = (r + \delta)\lambda - pF_K, \quad \frac{d}{dt}(e^{rt}\lambda(t)) = -\frac{\partial H}{\partial K} \\
 \text{(iii)} \quad & \lambda = q + pA'(I) \\
 \text{(iv)} \quad & F_L = \frac{w}{p} \\
 \text{(v)} \quad & \lim_{t \rightarrow \infty} e^{-rt} \lambda(t) \geq 0, \quad \lim_{t \rightarrow \infty} e^{-rt} \lambda(t) K(t) = 0
 \end{aligned} \quad (8)$$

Given  $L, H$  in (7) can be interpreted as the value of investment at time  $t$  discounted to  $t=0$ . Labor,  $L$ , and the rate of investment,  $I$ , are then chosen to maximize  $H$  every period. For labor, this gives us condition (8-iv), which is the familiar marginal productivity condition. Condition (8-iii) tells us that in order to maximize  $H$ ,  $I$  must be chosen so as to make the marginal cost of investment,  $q + pA'(I)$ , equal to the shadow price of capital.

We also need an equation to determine  $\lambda(t)$ . The maximum principle gives us such a relation in condition (8-ii). This is a first-order constant coefficient differential equation in  $\lambda$  with forcing function  $-pF_K$ . It has as solution

$$\lambda(t) = \int_t^{\infty} pF_K(K(s), L(s)) e^{-(r+\delta)(s-t)} ds$$

where the transversality condition has been used to eliminate the complementary solution to the homogeneous equation. Therefore  $\lambda$  is the present-value at  $t$  of the future expected marginal returns of capital, which is steadily depreciating at the rate  $\delta$ . Condition (8-iii) therefore says that  $I$  be determined to make the marginal cost of investment equal to the present value of an additional unit of capital.

The transversality condition can be interpreted as saying that the present value of a stock of capital accruing at a date  $t$  tends to negligibility as the date of accrual becomes very far in the future. This in effect implies that the very distant future be negligible. Condition (8-i) is just a repetition of the feasibility constraint.

It is convenient for our purposes to reformulate the conditions in a slightly different way. Differentiating (8-iii) with respect to time and substituting in (8-ii) we can reduce system (8) to

$$\begin{aligned}
 \text{(i)} \quad \dot{K} &= I - \delta K \\
 \text{(ii)} \quad \dot{I} &= \frac{(r+\delta)[q/p + A'(I)] - F_K(K,L)}{A''(I)} \\
 \text{(iii)} \quad F_L(K,L) &= w/p .
 \end{aligned} \tag{9}$$

System (9) is illustrated in phase-space in the accompanying diagram. Note that because of the homogeneity of degree one of the production function, marginal products depend only on the capital-labor ratio. Solving for this ratio as a function of the real wage from (9-iii) and substituting in (9-ii), we may rewrite system (9) as

$$\begin{aligned}
 \text{(i)} \quad \dot{K} &= I - \delta K \\
 \text{(ii)} \quad \dot{I} &= \frac{(r+\delta)[q/p + A'(I)] - F_K(k(w/p), 1)}{A''(I)} .
 \end{aligned} \tag{10}$$

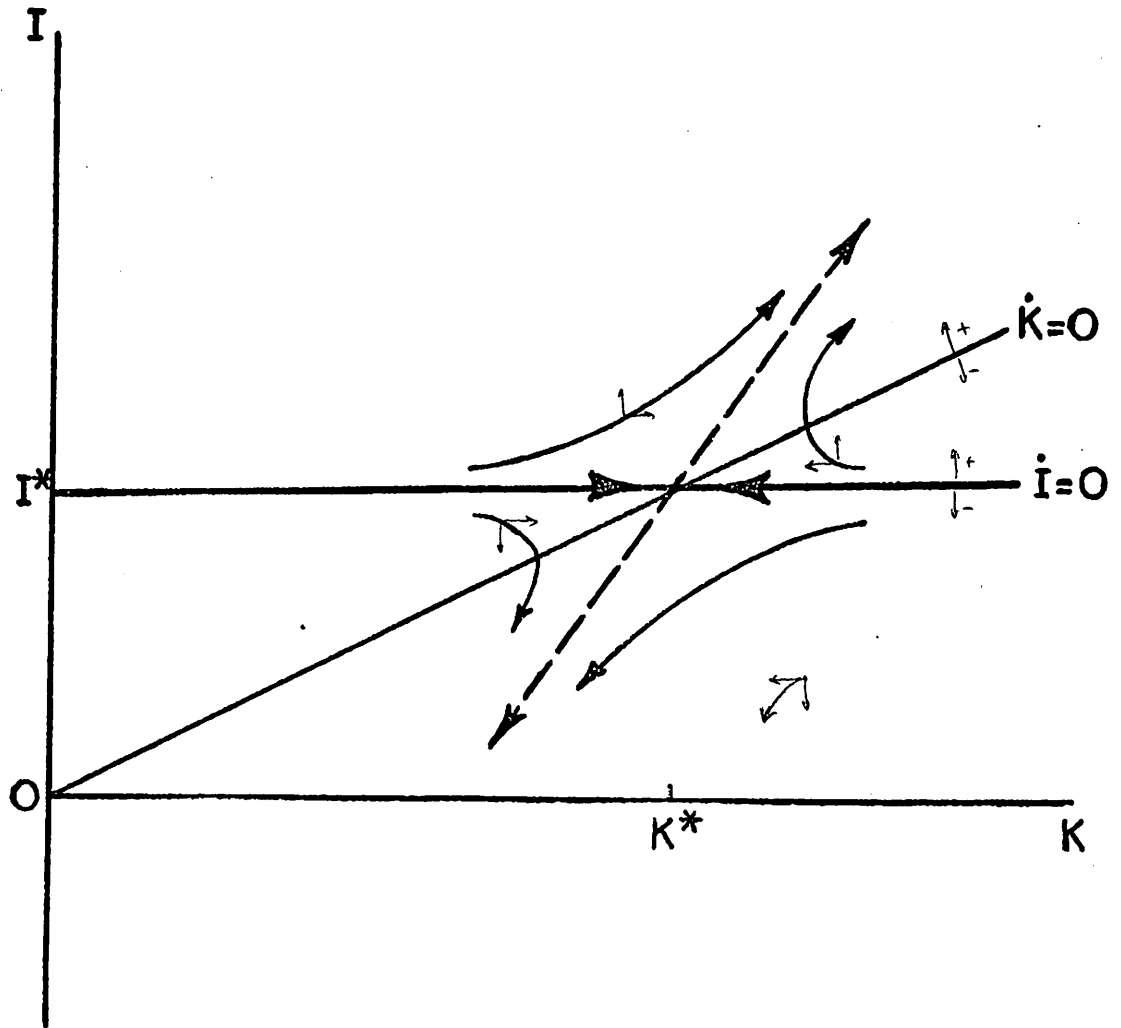
The long-run stock of capital,  $K^*$ , is obtained by solving for  $\dot{K} = \dot{I} = 0$ , and the optimal investment path is given by the  $\dot{I} = 0$  locus, since, given that  $A''(I) > 0$ , the  $\dot{I} = 0$  implies a unique gross investment rate of  $I^*$ . Thus the  $\dot{I} = 0$  locus yields the following implicit relation for the investment demand function:

$$F_K - (r+\delta)[q/p + A'(I)] = 0 . \tag{11}$$

From equation (11) we can verify that

$$\frac{\partial I}{\partial r} = \frac{-F_K}{(r+\delta)^2 A''(I)} < 0 ,$$

or investment demand is inversely related to the rate of interest. <sup>11</sup>



Phase diagram representation of System (9)

III

In our simple macro model, the identical firms are assumed to behave in the fashion just described, and so we simply assume that the optimality conditions hold for the aggregate. Therefore production takes place according to the production function relation

$$Y = F(K,L) \tag{12}$$

and the marginal productivity condition

$$F_L = w/p \tag{13}$$

is assumed to hold.

The investment demand function is given by the  $\dot{i} = 0$  condition of equation (11). Since we assume a one sector model, we have  $q = p$ . The investment demand function is therefore given by

$$F_K = (r + \delta)(1 + A'(I)) \tag{14}$$

It is interesting to note that we can rewrite equation (14) as

$$A'(I) = \frac{F_K}{(r + \delta)} - 1 ,$$

which can be interpreted as saying, since  $A''(I) > 0$ , that the rate of investment is an increasing function of the gap between marginal productivity of the existing stock of capital and the rental price of capital that would prevail if there existed a perfect market for capital goods.

The government liabilities are the stock of money,  $M$ , and the outstanding stock of government bonds. The government undertakes open market operations at a point in time subject to  $dM = -dB$ , where  $B$  is the nominal value of the outstanding government bonds.

The real net worth of households is then given by

$$NW = V + \frac{M+B}{p}$$

where  $pV$  is the value of equities, which equals the discounted value of future dividends from these equities. We have

$$V = (1+a)K$$

where  $a$  is the average long-run adjustment cost. In general  $a = a(r,K)$  because of external adjustment costs, and can easily be calculated from equation (3). We would have  $a = 0$  if there is zero depreciation.

The market for real cash balances is in equilibrium when demand equals supply. This gives us

$$\frac{M}{p} = L(Y,r) \tag{15}$$

where the right-hand side is the demand for real cash balances, with  $L_Y > 0$  and  $L_r < 0$ .

Households consume an amount  $C$  out of real output, and we assume that consumption is a function of  $Y$  and  $r$ , and a scale parameter  $\alpha$ :

$$C = C(Y,r,\alpha) \tag{16}$$

where  $0 < C_Y < 1$ ,  $C_r < 0$  and  $C_\alpha > 0$ .

Finally, for the economy to be in equilibrium requires aggregate supply to equal aggregate demand, or

$$Y = C + I + A(I) \tag{17}$$

Equations (12) to (17) together determine the position of the economy at a point in time. It will be convenient for reference purposes to rewrite the model in a more compact form. These six equations are:

$$\begin{aligned} (i) \quad Y &= F(K,L) \\ (ii) \quad F_L &= \frac{w}{p} ; \quad w = \bar{w} \\ (iii) \quad F_K &= (r + \delta)(1 + A'(I)) & (18) \\ (iv) \quad C &= C(Y,r,\alpha) ; \quad 0 < C_Y < 1, C_r < 0, C_\alpha > 0 \\ (v) \quad Y &= C + I + A(I) \\ (vi) \quad \frac{M}{p} &= L(Y,r) ; \quad L_Y > 0, L_r < 0, M = \bar{M} . \end{aligned}$$

At a point in time, the stock of capital,  $K$ , is given. We also assume that the money wage,  $w$ , is inflexible. Ideally the model might be thought of as being closed on  $w$  by some sort of Phillips curve relation. The other variables which are exogenous to the model are  $\alpha$  and  $M$ .

We can look at the determination mechanism behind the model as follows: given a level of real output  $Y$  to be attained,  $L$  is determined from equation (18-i), and given  $L$ ,  $p$  is determined from equation (18-ii). Given this price level, the rate of interest is then determined in the money market, by equation (18-vi). The rate of investment is then given by equation (18-iii), and consumption,  $C$ , by equation (18-iv). Finally  $Y$  must adjust to satisfy the equilibrium condition (18-v). This equilibrium condition states the familiar equality between investment and savings, only now instead of investment equals savings we should read  $E = Y - C$ , where  $E = I + A(I)$ .

We will use, as a point of comparison, a model where there exists a perfect market for physical capital goods, and call the two models the imperfect market model and the perfect market model, respectively. By the

perfect market model, we understand that equation (18-iii) is replaced by

$$F_K = (r + \delta) \quad (18-iii')$$

and the appropriate changes are made in equations (18-v) for the non-existence of adjustment costs. This model is exactly the short-run version of Tobin's "Dynamic Aggregation Model" [19], where adjustments take place instantaneously to maintain the equality in (18-iii').<sup>12</sup>

Notice that the perfect market model is block recursive. Indeed, equations (18-i, ii, iii' and vi) are sufficient to determine Y, L, r and p. Having determined these variables, C is then determined from equation (18-iv) and I is determined from equation (18-v). Thus investment is determined as a residual in this model, after instantaneous adjustments have taken place in the market for existing capital goods to establish the equality in (18-iii'). Or to put it differently, investment is completely supply determined.

We can reduce the system of equations (18) to a system of two equations in Y and r, one equation giving the combinations of Y and r consistent with portfolio balance and the other giving the set of Y and r consistent with equilibrium in the real sector.

The portfolio balance (PB) curve is obtained by solving for p in terms of Y from equations (18-i) and (18-ii) and substituting into (18-vi). The total differential of the PB curve is given by

$$\frac{dM}{P} + \frac{M}{P} \frac{F_{LL}}{F_L^2} dY = L_Y dY + L_r dr . \quad (19)$$

The PB curve is a variant of the textbook LM curve. It differs from the usual LM curve in that along the PB curve P is not fixed but varies to satisfy equation (18-ii). From (19), the slope of the PB curve, given M, is



$$\left. \frac{dr}{dY} \right|_{PB} = \frac{\frac{M}{P} \frac{F_{LL}}{F_L} - L_Y}{L_r} = \Sigma \quad (20)$$

which we verify to be always positive. Notice that the PB curve is the same in both the imperfect market and perfect market models.

The curve giving the levels of Y and r compatible with equilibrium in the real sector is the IS curve. The IS curve is obtained by substituting from (18-i, iii, and iv) into (18-v). Its total differential is given by

$$(1 - C_Y - \frac{(1+A')}{(r+\delta)A''} \frac{F_{KL}}{F_L}) dY = (C_r - \frac{(1+A')^2}{(r+\delta)A''}) dr + C_\alpha d\alpha \quad (21)$$

and given  $\alpha$ , its slope is

$$\left. \frac{dr}{dY} \right|_{IS} = \frac{1 - C_Y - \frac{(1+A')^2}{(r+\delta)A''} \frac{F_{KL}}{F_L}}{C_r - \frac{(1+A')^2}{(r+\delta)A''}} \quad (22)$$

From (18-iii) it is easily verified that the last term in the numerator is  $\frac{\partial E}{\partial Y}$ , where  $E = I + A(I)$ . Similarly the second term of the denominator is  $\frac{\partial E}{\partial r}$ . The denominator is always negative, but the sign of the numerator is indeterminate, and so the slope of the IS curve is indeterminate. We will have

$$\left. \frac{dr}{dY} \right|_{IS} = \leq 0 \quad \text{as } 1 - C_Y \geq \frac{\partial E}{\partial Y}$$

where  $(1 - C_Y)$  is of course the marginal propensity to save. We will assume that if the IS curve is positively sloped, it is less so than the PB curve. This can be regarded as a stability condition.

Whereas the PB curve is the same in both the imperfect and perfect market cases, this is not true of the IS curve. From equations (18-i) and (18-iii') we get that, in the perfect market model,

$$\left. \frac{dr}{dY} \right|_{IS} = \frac{F_{KL}}{F_L} \quad (23)$$

which is always positive. We continue to call this curve the IS curve, although equations (18-i) and (18-iii') really give us in this perfect market model the combinations of Y and r that clear the market for existing capital goods. However, I being totally supply determined in this case, the equilibrium condition (18-v) can be satisfied no matter what Y and r are. The intersection of this curve with the PB curve is still what determines the equilibrium Y and r.

We can say more about the two IS curves. Denote by  $S^i$  and  $S^p$  the slopes of the IS curves for the imperfect and perfect market cases, respectively. We can show that the following relationship holds:

$$(a) \quad S^i < S^p \text{ always}$$

and

$$(b) \quad \text{the limit of } S^i \text{ as adjustment costs become negligible is } S^p.$$

The perfect market model is then a special extreme case of the general adjustment cost model. Consider first proposition (a). It can be verified from (22) and (23) that the inequality  $S^i < S^p$  holds if

$$1 - C_Y > \left( C_r - \frac{(1+A')A'}{(r+\delta)A''} \right) \frac{F_{KL}}{F_L}.$$

Since  $0 < C_Y < 1$ , the left-hand side of this inequality is always positive. But the right-hand side is always negative, and therefore the inequality holds.

Consider now  $\lim_{\substack{A' \rightarrow 0 \\ A'' \rightarrow 0}} S^i$ . This can be written

$$\begin{aligned}
 \lim_{A' \rightarrow 0} \lim_{A' \rightarrow 0} & \frac{(r + \delta)A'' (1 - C_Y) - (1 + A') \frac{F_{KL}}{F_L}}{(r + \delta)A'' C_r - (1 + A')^2} \\
 &= \lim_{A' \rightarrow 0} \frac{1}{1 + A'} \frac{F_{KL}}{F_L} \\
 &= \frac{F_{KL}}{F_L} \\
 &= S^P .
 \end{aligned}$$

It is clear then that the implications for the relative efficacy of the various short-run stabilization policies is quite different in the two models. The effect of specific policies will be at least quantitatively different and in some cases qualitatively different in the two models.

Consider first the effect of an open-market operation, which changes the stock of money. From (19), (22) and (23) we have that

$$\frac{dY}{dM} = \frac{1}{pL_r (S - \Sigma)} ; \quad S = S^i, S^P,$$

where  $\Sigma$  denotes the slope of the PB curve (equation (20)). Assuming the stability condition  $S < \Sigma$  to hold, we see that  $\frac{dY}{dM}$  is positive in both the imperfect and perfect market models. It is clear however that the fact that  $S^i < S^P$  implies that the effect of a change in the stock of money on  $Y$  is always greater in the perfect market world than in the imperfect market world.

Similarly, the effect of the stock of money on the rate of interest is given by

$$\frac{dr}{dM} = \frac{1}{pL_r (1 - \Sigma/S)} ; \quad S = S^i, S^P$$

and again, since  $S^i < S^P$ , the effect of  $M$  on  $r$  will always be algebraically

greater in the perfect market case. In fact money may have a qualitatively different effect on the rate of interest in the two models. For if the adjustment costs are important  $S^1$  will be negative, and an increase, say, in the stock of money will have the familiar effect, in the imperfect market world, of lowering the rate of interest. In the perfect market model however the final effect of an increase in the stock of money will always be to increase the rate of interest.

The transmission mechanism of changes in the stock of money in the perfect market model can be described in the following way. Consider, for example, an increase in the stock of money. Households will hold more money and less bonds only at a lower rate of interest. The initial effect will then be a decrease in the rate of interest to establish portfolio balance at the higher stock of money. But at a lower rate of interest, the marginal productivity of capital condition (condition (18-iii')) does not hold. Firms will wish to acquire more capital, and, given the existing stock of capital goods, this will drive the price of capital goods up. In this case this will mean an increase in the price level,  $p$ . But a rise in  $p$  reduces the real wage, with the result that employment and output would be induced to rise. However, this in turn will increase the rate of interest at which firms would be satisfied with the existing stock of capital, as well as the rate of interest required for portfolio balance. If stability is assumed, in the sense that the PB curve is steeper than the IS curve, the new equilibrium will be established at a higher level of output and a higher rate of interest. The point to notice is that in that model (the perfect market model) monetary policy has its impact on output solely by impinging on the market for existing physical assets.<sup>13</sup>

This transmission mechanism of monetary policy is quite different from that which exists in the imperfect market model. In this case, although there is still room for some impingement of money through the market for existing physical assets, the more the imperfections in this market are important the more the impact of money on output will be manifested via its effect on the desired flows of consumption and investment. Thus the channels of monetary policy are more in accord in this case with what we find in the so-called Keynesian models. The change in the rate of interest brought about by the portfolio imbalance has an effect on the desired rate of investment, with the subsequent multiplier effect on output. In the perfect market model, on the other hand, the rate of investment is completely supply determined, as we have seen, and the consumption function (and consequently the multiplier) play no role in determining the level of output at a point in time.

Since in the perfect market model equations (18-iv) and (18-v), and thus the multiplier, do not enter into the determination of  $Y$  and  $r$ , it is clear that the shift parameter  $\alpha$  has no impact at all on the level of output at a point in time. In other words, a shift in aggregate demand, brought about by fiscal policy or otherwise, has no effect on the level of output in the short-run. The shift parameter could still have an impact on the rate of growth of the economy, since it is instrumental in determining the desired distribution of output between consumption and investment.

In the imperfect market model, however, the multiplier plays an important part in determining the short-run level of output, and therefore fiscal policy is an effective stabilization tool. Changes in the shift parameter of the consumption function have the usual effect of moving the IS curve and thus varying the equilibrium  $Y$  and  $r$ . It is easily verified that both  $\frac{dY}{d\alpha}$  and  $\frac{dr}{d\alpha}$  are positive.

IV

The conclusion that one has to draw from this analysis is that imperfections in the market for capital goods do have an influence on the relative efficacy of monetary and fiscal policy, and to some extent on the way in which the impact of these policies is transmitted. We have shown that the situation of a perfect market for capital goods can be considered as a special limiting case of a model where there exists a market for capital goods but this market is marred by certain types of frictions and imperfections, as measured by the adjustment cost hypothesis which we have introduced. It would be too much to claim that this representation constitutes an adequate measure of all the forms of imperfections that might arise in such a market. It is our contention, however, that many of the frictions which prevent instantaneous adjustments from taking place can be adequately characterized in this form.

Inasmuch as one accepts this representation of these market imperfections, one cannot escape the conclusion that they will have an effect on the relative efficacy of different stabilization tools. The model also permits us to avoid having to compare simply the two extreme cases of a perfect market versus no market at all for existing capital goods. Rather, it allows us to consider market imperfections as a matter of degree, with a perfect market as a limiting case. And it allows us to show that the difference in impact of various stabilization tools is not only a matter of existence versus non-existence of imperfections in the capital goods market, but also a matter of the degree of imperfection.

On purely theoretical grounds, the imperfect market model that we have proposed here has all the characteristics of the so-called Keynesian model.

This is true both of the policy recommendations that would come out of it, and of the transmission mechanism of the impact of the policy tools. The perfect market model, on the other hand, has much more of a "monetarist" flavor, in the sense that money matters very much and fiscal policy matters not at all in the short run. We would by no means claim that this model represents exactly what the recent vintage of "monetarists" have in mind. What our analysis suggests however is that the assumptions as to the characteristics of the market for physical assets might possibly go some way in explaining some divergences in policy recommendations.

From an empirical point of view, one has to choose between the two representations of the economy: either there are imperfections or there are not. As pointed out in Sargent and Wallace [18], most econometric models include some form of flexible accelerator or distributed lag specification for the demand for physical assets. These specifications are often motivated by the observation of frictions in these markets, and our analysis would suggest that these may in fact capture the essentials of the workings of imperfect physical assets markets. As far as the empirical representation of the economy is concerned, our analysis can therefore only substantiate the use of these types of specifications as a better approximation of the functioning of the economy in a world of imperfect markets for physical assets.

Footnotes

<sup>1</sup> See Lerner [11], pp. 330-338; Haavelmo [8]; Witte [24]; Tobin [20]; Sargent-Wallace [18]. For arguments to the contrary, however, see Jorgenson [10], and more recently Sandmo [17]. The term "perfect market" implies here that the bid-ask price spread (or the spread between reproduction cost and replacement cost) resulting from transactions costs, dismantling and installation costs, search costs, and other types of frictions and "imperfections" in the market is zero. See in particular Sargent-Wallace [18].

<sup>2</sup> This assumes that capital is homogeneous in quality, regardless of vintage or other such considerations.

<sup>3</sup> See Arrow [2], [3] and [4] where the optimal capital adjustment of the firm under such conditions is analyzed in detail.

<sup>4</sup> See Haavelmo [8], pp. 162-165, 170-172, and Tobin [20].

<sup>5</sup> Sargent and Wallace do however allude to this problem and to the approach adopted here. See [18], footnote 11, page 483.

<sup>6</sup> We might add that in a partial equilibrium framework the existence of monopsonistic elements in the capital goods market can also be represented as external adjustment costs.

<sup>7</sup> As could of course the model with no market at all for existing capital goods.

<sup>8</sup> We might also note that we have implicitly assumed, by valuing them at the price  $p(t)$  of the output of the firm, that all these costs are "output-reducing" costs. In other words the firm uses up some of its own resources for the purpose of "adjusting", resources which would otherwise have been used to produce its own output. To the extent that the firm hires outside services for this purpose, this valuation is arbitrary. But to make this distinction explicitly in the valuation of the adjustment costs would only introduce inessential complications in the analysis, and in a one sector aggregate model this distinction would disappear in any case. We might however keep in mind that we do not exclude the possibility of the firm hiring services from outside for this purpose.

<sup>9</sup> We will not dwell further on the justifications and interpretations of the adjustment cost function, which can be found in the literature already cited. We note however that a quadratic, for example, could be made to fit this specification. Holt, et al. [9] have found, in a not unrelated study, that a quadratic provided a good approximation to such costs as hiring and layoff costs, overtime costs, idle time costs, machine set-up costs, etc.

<sup>10</sup> These assumptions are not necessary at this stage: one could clearly do away with them by appealing to the Modigliani-Miller theorem [14]. These assumptions will however be very convenient and will greatly simplify matters when we get to the macro model, and for this reason we prefer introducing them immediately.



<sup>11</sup>The analysis could be extended to the case of non-constant returns to scale, and to variable returns to scale. Treadway [22] shows that with variable returns to scale adjustment costs lead to an investment demand that is inversely related to the rate of interest. The proof is much more involved than the one above since in that case the optimal path does not coincide with the  $\dot{i}=0$  locus, and investment demand will not be independent of the existing stock of capital.

<sup>12</sup>We make liberal use in our interpretation of this model of an excellent analysis of it in an unpublished note by Thomas Sargent entitled "Notes on Tobin's Dynamic Aggregative Model".

<sup>13</sup>It is worth noting the similarity of this description of the channels of monetary policy with that in, for example, Friedman-Meiselman[6], pp. 217-222, where the emphasis is also put on the impingement on markets for physical assets, as the route through which monetary policy has its impact on output. See in particular pp. 218-220.

- [1] Alchian, Armen. "Costs and Output," The Allocation of Economic Resources. Edited by M. Abramovitz, Palo Alto, Calif: Stanford University Press, 1959.
- [2] Arrow, K. J. "Optimal Capital Adjustment," Studies in Applied Probability and Management Science. Edited by K. J. Arrow, S. Karlin and H. Scarfe, Palo Alto, Calif: Stanford University Press, 1962.
- [3] \_\_\_\_\_. "Optimal Capital Policy, The Cost of Capital, and Myopic Decision Rules," Annals of the Institute of Statistical Mathematics (Tokyo), Vol. 16 (1964), 21-29.
- [4] \_\_\_\_\_. "Optimal Capital Policy with Irreversible Investment," Value, Capital and Growth. Edited by J. N. Wolfe, Chicago: Aldine Press, 1968.
- [5] Eisner, R., and Strotz, R. "Determinants of Business Investment," Impacts of Monetary Policy. Commission on Money and Credit. Englewood Cliffs, N.J.: Prentice-Hall, 1963.
- [6] Friedman, M., and Meiselman, D. "The Relative Stability of Monetary Velocity and the Investment Multiplier in the United States, 1897-1958," Stabilization Policies. Commission on Money and Credit. Englewood Cliffs, N.J.: Prentice-Hall, 1963.
- [7] Gould, J. P. "Adjustment Costs in the Theory of Investment of the Firm," Review of Economic Studies, Vol. 35 (1968), 47-56.
- [8] Haavelmo, T. A Study in the Theory of Investment. Chicago: University of Chicago Press, 1960.
- [9] Holt, C., et al. Planning Production Inventories and Work Force. Englewood Cliffs, N.J.: Prentice-Hall, 1960.
- [10] Jorgenson, D. W. "The Theory of Investment Behavior," The Determinants of Investment Behavior. Edited by R. Ferber. New York: National Bureau of Economic Research, 1967.
- [11] Lerner, A. P. The Economics of Control. New York: The Macmillan Company, 1944.
- [12] Lucas, R. E. "Adjustment Costs and the Theory of Supply," Journal of Political Economy, Vol. 75 (1967), 321-34.
- [13] \_\_\_\_\_. "Optimal Investment Policy and the Flexible Accelerator," International Economic Review, Vol. 8 (1967), 78-85.
- [14] Modigliani, Franco, and Miller, M. H. "The Cost of Capital, Corporation Finance, and the Theory of Investment," American Economic Review, Vol. 48 (1958), 261-97.

- [15] Nerlove, M. "On Lags in Economic Behavior," Report No. 7109, Center for Mathematical Studies in Business and Economics, Department of Economics and Graduate School of Business, University of Chicago, February 1971.
- [16] Pontryagin, L. S., et al. The Mathematical Theory of Optimal Processes. New York: Interscience, 1962.
- [17] Sandmo, A. "Investment and the Rate of Interest," Journal of Political Economy, Vol. 79 (1971), 1335-45.
- [18] Sargent, T., and Wallace, W. "Market Transaction Costs, Asset Demand Functions, and the Relative Potency of Monetary and Fiscal Policy," Journal of Money, Credit and Banking, Vol. 3 (1971), 469-505.
- [19] Tobin, J. "A Dynamic Aggregative Model," Journal of Political Economy, Vol. 63 (1955), 103-15.
- [20] \_\_\_\_\_. "Comment on Crockett-Friend and Jorgenson," The Determinants of Investment Behavior. Edited by R. Ferber. New York: National Bureau of Economic Research, 1967.
- [21] Treadway, A. B. "Adjustment Costs and Variable Inputs in the Theory of the Firm," Journal of Economic Theory, Vol. 2 (1970), 329-47.
- [22] \_\_\_\_\_. "Optimal Entrepreneurial Behavior and Distributed Lag Investment Equations," Review of Economic Studies, Vol. 36 (1969), 227-39.
- [23] \_\_\_\_\_. "Rational Entrepreneurial Behavior and the Dynamics of Investment," unpublished Ph.D. Dissertation, University of Chicago, 1967.
- [24] Witte, J. G. "The Microfoundations of the Social Investment Function," Journal of Political Economy, Vol. 71 (1963), 441-56.