COMMENTS ON THE CURRENT STATE OF THE THEORY OF AGGREGATE INVESTMENT BEHAVIOR

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What is an "empirical investment equation?" Ten or even five years ago, most would agree with this definition: It is a function that specifies the dependency of current investment upon current and past values of other variables and upon past values of investment. The successful equation was the one incorporated into the Keynesian macroeconometric models. The view was that as better equations were incorporated, the econometric models would better forecast economic activity conditioned upon policy and other exogenous variables.

Lucas (1976) in his already classic critique argued that there was a fundamental conflict between this highly respected econometric tradition and the equally respected theoretical tradition. He contended that it was the econometric tradition that was in need of major revisions if theory and econometrics were to be complementary, as they should be. Commenting on Abel’s paper presents an excellent opportunity to assess whether the profession is heeding Lucas’s advice. It also provides an opportunity to evaluate the current state of our theories of investment behavior. My conclusion is that the current theory based on adjustment costs is inadequate because it implies that short- and long-run elasticities of supply are equal. This is inconsistent with a wealth of micro and macro data.

Abel, using the adjustment cost theory, estimates a relationship obtained by equating the marginal cost of investment with the shadow price of capital. Much attention is properly given to the treatment of taxes. This is necessary, because taxes affect the price of new capital and the after tax present value of future rentals. His derived relationship can be integrated to obtain the production function in much the same way that a demand function can be integrated to obtain a utility function, at least under reasonably general conditions. Because the parameters being estimated by Abel are functions of parameters of technology only, and not of parameters of the processes governing policy and other exogenous variables, they are policy rules invariant. One would not expect a change in policy to induce a change in Abel’s function.

Does this resolve the conflict between the econometric and theoretical traditions without subjecting the econometric approach to major revision? I think the answer is "no." Abel is not operating within the Keynesian macro-
econometric model framework. His equation can not be introduced into a macro model, which can then be used to predict the consequences of alternative policy actions. It cannot be so used because current investment depends through the shadow price of capital upon the infinite future. Knowledge of the future is required to predict what will happen today, and the future state of the economy depends upon today's decisions. This is contrary to the assumptions upon which Keynesian macro models are predicated.

This is not to say that Abel's investment theory is without policy implications. With an estimated technology and preference structure, which unlike behavioral equations are policy invariant, the operating characteristics of the economy can be predicted conditional upon the policy rule regime. Because of the time inconsistency of optimal plans (Kydland and Prescott, 1976), control theory is not the appropriate tool. Rules, however, can be ordered on the basis of the induced average performance of the economy. Quantitative policy evaluation is possible, but it is rules that must be evaluated.

Adjustment Cost Investment Theory

Abel's empirical investment equation is based upon the adjustment cost theory of investment. The relationships he estimates are homogeneous of degree one jointly in current investment and in current and future outputs and capital stocks. Because this cannot quite be justified using Abel's assumed technology, it is necessary to employ the constant returns to scale adjustment cost model of Lucas (1967). Besides justifying the equations estimated, this model is consistent with the observed variability of firm size and the approximate independence of growth rates and firm size.

The constant returns to scale adjustment cost model assumes that there is a relationship between the outputs of the consumption good C and the investment good I and the inputs labor L and capital K:

\[ C = F(I,K,L), \]

where \[ \dot{K} = I - \delta K \]

Here \( \delta \) is the depreciation rate. Besides being concave, the function \( F \) is decreasing in \( I \) and increasing in both its inputs. The difference between this technology and the one employed by Sargent (1980) is that \( F \) is strictly rather than weakly concave with respect to \( I \). The strict concavity gives rise to increasing costs of rapid adjustment; i.e., if inputs are held constant, the cost of the investment good in terms of the foregone consumption good increases as the rate of investment increases. For the Sargent technology, this production
possibility frontier is linear, rather than convex to the origin, and \( q \) can differ from one only if investment is zero.

In the investment literature, a distinction is sometimes made between external and internal costs of adjustment (cf. Musa, 1977). For aggregate competitive analyses, such distinctions are unimportant. Labor services are required to install capital, whether the equipment is installed by acquiring the capital good or the firm producing it. This well-known result of general equilibrium analysis assumes that all important externalities have been internalized within the firm.

Letting the price of the consumption goods be one, the price of capital be \( q_t \), and the wage rate be \( w_t \), the firm’s problem is simply to maximize real profits

\[
\Pi_t = C_t + q_t I_t - w_t L_t - q_t \delta K_t,
\]

subject to

\[
C_t < F(I_t, K_t, L_t).
\]

Assuming an interior solution and exploiting the constant returns to scale assumption, the solution has the form

\[
\frac{I_t}{K_t} = h(q_t, w_t).
\]

If the real wage is constant, and there is no technological change, or if the two effects offset each other, the function simplifies to

\[
\frac{I_t}{K_t} = g(q_t).
\]

This is the basic relationship considered by Abel.

The price \( q_t \) is a shadow price and is not observed. Abel uses the instrument

\[
q_t = \sum_{s=t}^{\infty} \frac{y_s}{(1+r+\delta)^{t-s}},
\]

where \( y_t \) is the marginal product of capital, and \( r \) is the real interest rate. He also corrects the price of new capital facing the firm for the investment tax credit and the present value of reduced future tax liabilities resulting from depreciation claims. Except in a world with a zero inflation rate, the same interest rate
should not be used to calculate the present value for both after tax marginal product and reductions in future tax liabilities resulting from depreciation allowances. The former is real, and the real interest rate should be used; however, the latter is nominal, at least for the United States, and the nominal interest rate should be used. This is a nontrivial correction. (See Kydland and Prescott, 1978). Another possible problem is the assumption that r is constant over time even though the marginal product varies significantly. Whether this is quantitatively important or not can only be assessed within a general equilibrium framework.

I have characterized the problem of determining a theory of investment as one of determining the transformation between aggregate inputs and outputs; i.e., the problem of empirically determining a good approximation to the technology. In determining the production possibilities, there is no conflict between the econometric and theory traditions. The ad hoc introduction of capital utilization to obtain static production is under attack on both sides (cf. McCarthy, 1979). Therefore, I find it puzzling that Abel estimates a relationship which appears inconsistent with the adjustment cost theory employed in his analysis.

Because Abel is estimating a supply relationship, there is a potential problem of simultaneous equation bias. I thought that there was a need to justify the crucial assumption that the error term was uncorrelated with the instrument used for q. A correlation is not implausible, because the instrument is a function of future capital stocks, and future capital stocks are a function of current investment and, therefore, of the current error term. Possibly, this feedback is so small that only a trivial bias is introduced; however, establishing this seems appropriate.

Inadequacy of Current Theory of Investment Behavior

Dwelling upon econometric details is not warranted unless a theory is consistent with the accepted facts. The implication that the short- and long-run elasticity of the relative output of the investment good with respect to its relative price leads me to reject the single capital good adjustment theory of investment. This implication is inconsistent with the observations that the investment-consumption good production mix varies considerably among regions within a country and among nations. Adjustment costs are probably important, but the single capital good costly adjustment theory is not adequate.

A New Direction for Investment Theory

A problem for the student of investment behavior is to construct a tractable abstraction which is consistent with steady-state or average q being
the same in both a high investment and a low investment economy and with $q$ varying considerably in the short run. One approach is to emphasize the non-reversibility of investment (e.g., Arrow, 1968). When investment is zero, $q$ can differ from one, as shown in Sargent (1980). For some industries, corners are crucial. For example, most of the time oil tankers rent at variable cost, and there is idle capacity. In the remainder of the time, virtually all ships are in use, and rental prices can be several times variable costs. Here, abstracting from corners is not possible, but I don’t think this is the case for aggregate investment. At least, I hope it isn’t, for corners present so many analytic and econometric difficulties.

Another avenue is the one suggested by the Austrian and Norwegian capital theory schools. Capital is not built instantaneously; a long period is required for building a new capital good. Sometimes, a year or more elapses between the beginning and completion of the construction of a ship or factory. Only on completion, does it become part of the productive capital stock. Our national income accounts treat resources allocated to construction activities such as these as investment in plant and equipment. Half-finished ships and factories are considered part of the stock of plant and equipment, rather than goods in process.

A model in which more than a single period is required to build a capital good is considerably more complicated than the adjustment cost model, because there are multiple capital goods. There is the stock of capital that is productive, another stock which requires some additional resource allocation for a single period before it can become part of the productive capital stock, a stock which requires two periods to be so transformed, etc. Although dealing with multiple capital goods is difficult, it is possible for at least some interesting technologies. Kydland and Prescott (1978) who have explored one such technology, found that in equilibrium, $q$ varied considerably in the short run, yet its average value was independent of the demand side of the model. Further, there was considerable positive serial correlation in both investment expenditures and, of course, $q$ as well. Econometrically implementing this approach is an open problem, though there are some closely related econometric analyses—namely, Taylor’s (1979) study with staggered contracts and Huntzinger’s (1979) empirical analysis of the broiler industry.

Parenthetically, time to build capital is not the delivery lag problem facing the firm. As emphasized previously, for aggregate competitive analysis, only the aggregate production possibility set matters. For the integrated firm, if time is required to build new capital, unanticipated changes in demand will result in delays in receiving desired capital goods or in capital goods being held in inventory while awaiting use. The decision of how many new investments

97
projects to initiate depends, among other things, upon how many capital goods there are at various stages of completion.

Summary

I have argued that the search for an aggregate theory of investment is a search for a technology specifying the relationships between aggregate inputs and outputs. I interpreted Abel's study as such a search but concluded that the single capital good adjustment cost model upon which his analysis is based is inadequate. It implies that short- and long-run elasticity of relative investment output with respect to its relative price $q$ are equal. I have suggested that a successful theory will not assume that capital goods are built instantaneously, but rather, require multiple periods to construct. Only upon completion, does the capital good become part of the productive capital stock. The stabilization policy implications, I suspect, are very different for such an investment theory than for the adjustment cost model.
1. The adjustment cost model has a long history. The earliest example of the variational problem being formally presented that I found was Eisner and Strotz (1963).
Abel, A.B.  

Arrow, K.J.  

Eisner, R. and Strotz, R.H.  

Hall, R.E. and Jorgensen, D.W.  

Huntzinger, L.  

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Lucas, R.E. Jr.  

References
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Mussa, M.  

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Taylor, J.B.  