Estimates of Investment Functions and Some Implications for Productivity Growth

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My original assignment was first to evaluate Larry Summers' paper as a description of the current state of the art regarding investment behavior and second to determine the adequacy of the investment sector of Michael Evans' econometric model (Evans, 1980) in light of Summers' paper. The late arrival of Larry's paper forced me to alter my strategy, and it is just as well. Summers' investment function is a very long-run relationship that does not purport to explain cyclical movements in business investment outlays, while Evans' relationship is a more traditional analysis of quarterly expenditures.[1] Moreover, Summers is concerned with only corporate investment, while Evans deals with all of domestic fixed investment. My revised strategy was to employ two papers recently presented at Brookings Conferences (Hendershott, 1980, and Hendershott and Hu, 1981) as the standard with which to contrast Evans' work.

The first two sections of the present paper are concerned with nonresidential and residential fixed capital outlays, respectively. In each of these I first summarize my earlier work and then critique Evans' treatment of the same investment component. A general discussion of the relationship between the form of investment and productivity growth is the subject of the third section, and a

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[1]Summers' equations explaining the annual ratio of gross real investment to the beginning period capital stock over the 1932-78 period have $\bar{R}^2$ that range from 0.05 (no autocorrelation correction) to 0.75 (Summers, 1980, Table 2, p. 34). Of course, investment equations must have plausible long-run properties if they are to be useful in examining the long-run impacts of tax changes, but this does not rule out relationships that also explain cyclical behavior.

summary concludes the paper. Summers' imaginative work is referred to periodically when it bears on the issue at hand, but time and space constraints prevent me from discussing his analysis at length.

NONRESIDENTIAL INVESTMENT

GENERAL DETERMINANTS

Investment outlays (or orders) can be thought of as the sum of four components: Those due to normal growth, to disequilibrium, to replacement, and to mandates of governments. The general determinants of each of these parts are the following:[2]

Normal Growth (I_n): Normal growth in the economy requires greater production capacity. How capital intensive this is should depend on the real user cost of capital (c). Thus one can write

$$I_n = I_n(\overset{+}{\dot{y}}, \overset{-}{c}),$$

where ẏ represents any of a variety of variables that proxy for the expected growth rate in real output, and the expected signs of the partial derivatives are indicated above the arguments in the function. I emphasize here that the relationship is between net investment and the rate of change in output, not the level of output. As Summers (1981) and others have noted, the latter is a major misspecification of an investment function and has nonsensical macroeconomic policy implications.

Disequilibrium (I_d): Disequilibrium investment (positive or negative) arises when factor prices or aggregate demand change unexpectedly. Proxies often employed to represent disequilibrium are deviations between current and long run or "normal" values of Tobin's Q (the ratio of the market value of corporate debt and equity to the replacement cost of nonfinancial assets) and capacity utilization (CU). Thus

$$I_d = I_d(\overset{+}{Q\text{-}Q^*}, \overset{+}{CU\text{-}CU^*}),$$

where * denotes normal or long-run values (assumed to be constant).

[2]This analysis assumes a CES production function. The use of a variable elasticity function, such as the translog (see Berndt and Christensen, 1973), requires inclusion of either the user costs or quantities of other factors in the estimation equation.

Replacement (I_r): In a pure putty-putty world where changes in the capital/labor ratio can occur both before and after the installation of capital, replacement investment is reasonably approximated by the product of the depreciation rate and the existing capital stock. But in a putty-clay world, where variable factor portions exist only for net investment and upon replacement of old capital, replacement investment also depends on changes in the real user cost since the capital being replaced was initially installed. More specifically, one can write

$$I_r = K_{-1}\delta \sum_{\tau=0}^{\infty} Y_\tau(c_{-\tau}/c) = K_{-1}\delta^f.$$

where Y_τ equals 1.0 for $\tau = 0$ and 0.0 otherwise, if technology is putty-putty, or equals the fraction of each vintage of capital in the total existing stock, if technology is putty-clay, and the symbol δ^f denotes the optimal feasible replacement investment fraction.[3]

Mandated investment (I_m): This investment is mandated by law and is thus reasonably treated as exogeneous.

Combining the four investment (orders) components into a single function,

$$\text{(1)} \qquad I = \phi(\overset{+}{\dot{y}}, \overset{-}{c}, \overset{+}{Q}, \overset{+}{CU}) + \delta^f K_{-1} + I_m.$$

Our empirical results suggest the following. First, the user cost variable, which affects both ϕ and δ^f, is a fundamental factor affecting investment.[4] Second, the accelerator variable, $\dot{y}$, works as expected. And third, the capacity utilization rate, but not Q, is an important determinant of disequilibrium investment.

REAL USER COST OF CAPITAL

Consider the following assumptions/definitions:

i) all prices are expected to rise at rate π forever,

ii) the productivity of an investment declines at rate δ over an infinite holding period,

[3]Putty-clay technology is a possible source of long lags in investment functions, but it is still difficult to explain Summers' 16 year adjustment period to obtain half of the impact of an inflation shock (1980, Table 4, p. 45).

[4]With $\delta = 0.13$, δ^f varies from a low of 0.115 in 1957:1 to a high of 0.156 in 1971:4. Replacement of δK_{-1} with $\delta^f K_{-1}$ in the estimated equation significantly raised the explanatory power.

iii) the statuatory income tax rate is μ,
iv) the rate of investment tax credit is k,
v) the present value of depreciation allowed for tax purposes on a dollar of capital is z,
vi) pollution control outlays of ψ dollars are required for every dollar of capital investment,
vii) the ratio of inventories based on FIFO accounting to the stock of capital is ν, and
viii) the real after-tax financing rate is r.

With these assumptions, one can derive the real user cost of capital as

$$c = \frac{(1+\psi)q}{(1-\mu)p}[(1-k-\mu z)(r+\delta) + \mu\nu\pi], \tag{2}$$

where $z = \sum_{t=1}^{\infty} \frac{dx_t}{(1+r+\pi)^t}$,

dx_t = the fraction of the capital price allowed to be treated as tax depreciation in period t,

q = the price of capital goods, and

p = the general price of output.

This equation is identical, in appearance, to equation (4.2), p. 4.15 of Evans except for the addition of the inventory term to allow for the taxation of FIFO-based inventory profits. Assuming that a portion α of investment $[(1\text{-}k)q]$ is debt financed, the debt and equity portions are expected to remain constant forever, and debt finance charges are deductible from the income tax base,

$$r = \alpha(1-\mu)i + (1-\alpha)e_a - \pi, \tag{3}$$

where i is the nominal debt yield and e_a is the nominal after-tax cost of equity funds. A plausible proxy for e_a is the sum of the after-tax earnings-price ratio (E/P) and $\pi/(1-\alpha)$. The division by $1-\alpha$ reflects the fact that all inflation gains accrue to shareholders (except those indirectly built into i). Substitution into (3),[5]

$$r = \alpha(1-\mu)i + (1-\alpha)E/P. \tag{3$'$}$$

[5]This equation looks like an analogue to the Modigliani-Cohn stock market error; it appears that a nominal debt yield is being averaged with a real equity yield. In fact, the expression is an average of two real yields $(1-\mu)i-\pi$ and $E/P + [\alpha/(1-\alpha)]\pi$. The π terms cancel when the expression is simplified.

EVANS' ANALYSIS

The aggregate investment equations reported account for the normal growth and disequilibrium investment components in a reasonable fashion. A variety of sectoral income variables drive investment; the user cost variable generally performs as expected (more on this below); and the capacity utilization rate, the unemployment rate and stock prices all appear as disequilibrium proxies. The putty-clay optimal feasible replacement investment fraction does not appear, but the establishment of its relevance is of recent "vintage." However, I cannot even find the lagged capital stock in the equations, although it is referred to in the text. Even more disconcerting is the absence of mandated investment outlays. The importance of these outlays is emphasized by Evans and these outlays are incorporated in the calculation of the user cost, but the actual outlays are ignored in the estimation. To put these outlays in perspective, during the 1972-78 period they were roughly 4 percent of total new orders for equipment and 12 percent of net new orders (roughly two-thirds of orders were for replacement).

One final point on these equations. An undefined index of credit rationing appears in the equipment equation with rationing (supposedly a slowdown in deposit flows) reducing equipment outlays. While outlays on trucks and autos (p. 4.67) may be reduced, as are housing starts (see below), it would seem to me that outlays somewhere in the economy should be stimulated. That is, if accelerated flows into open market paper, defined broadly to include large CDs and money market funds, are detrimental to outlays financed by regular deposits, then these flows ought to be favorable to the outlays financed by open market paper; rationing ought to have an allocative, zero-sum impact rather than a cumulative negative impact. Finally, if rationing matters for business investment, then business cash flows obviously matter to investment, a fact Evans denies on p. 4.10.

Evans spends a great deal of time and effort in the construction of user costs of capital for business investments. For this he is to be commended. Unfortunately, there appears to be a number of errors in the calculations. First, consider the measurement of the real after-tax financing rate. In the aggregate investment equations (pp. 4.70 and 4.76), the yield is

$$r = 0.4\, i + 0.6\, E/P.$$

Note that the interest rate is before-tax when it should be after-tax.[6]

[6] In the industry studies (pp. 4.19 and 4.42), the dividend-price ratio replaces E/P, and the 0.4 and 0.6 weights may have been switched.

Also, there does not appear to have been any attempt to adjust earnings for the overstatement due to historic cost depreciation. Thus the real after-tax financing rate is clearly overstated by a significant amount. Second, depreciation rates of 0.095 (structures) and 0.181 (equipment) have been employed. These, too, are far too high (by about 0.05). Third, the effective (average) rather than statuatory (marginal) corporate tax rate is utilized. To the extent that the vagaries of the tax code are already accounted for—the investment tax credit, tax depreciation, and FIFO accounting—the statuatory rate is clearly the appropriate variable. Just as important, the average tax rate moves cyclically, being high when profits are great and low when profits are small, but the expected tax rate over the life of the investment, the relevant rate in the user cost calculation, is unlikely to move in this manner. This illustrates an important point about the user cost expression (2). All values in it denote expected values over the life of the investment asset. If these values are expected to change in the short run, then such expectations could have a large impact on the *timing* of orders or investments, even if only the long-run expected values affect long-run capital accumulation. To illustrate, a temporary increase in the investment tax credit would have a far larger short-run stimulative impact on investment (Lucas, 1976, pp. 30-35) than would a "permanent" increase.[7] Further, as Summers illustrates (1981) anticipations of tax changes can have major, and even surprising, effects.

In summary, the Evans model has not advanced econometric modeling of nonresidential investment. Replacement and mandated investment are not accounted for, and there are significant errors in the calculation of the important user cost variable. Moreover, the measurement and inclusion of z in the user cost is hardly innovative, as is suggested on p. 4.16. This variable was included in early Jorgensonian formulations and has been part of the data bank for the various versions of the Federal Reserve econometric model for at least a decade.

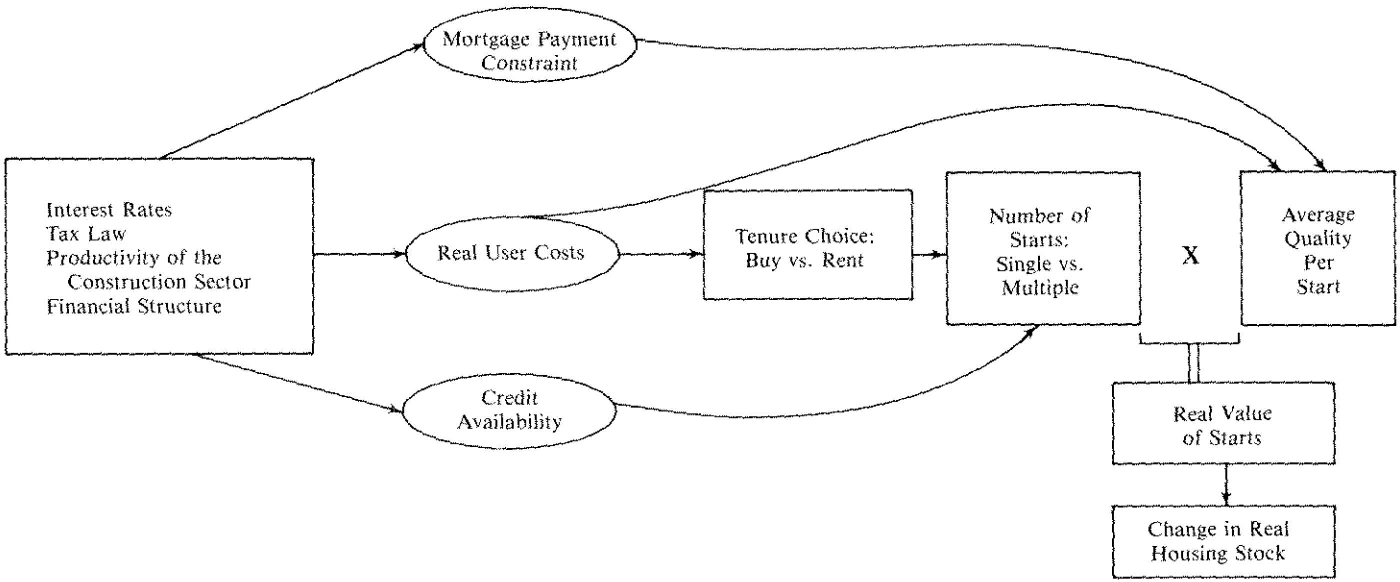
RESIDENTIAL INVESTMENT

AN OVERVIEW OF THE HOUSING MARKET

My view of the determination of increments to the real housing stock is depicted in Figure 1. The major financial variables are circled: the mortgage payment constraint (roughly the product of the *nominal* after-tax mortgage rate and the real price of

[7] Evans states the opposite on p. 4.13.

FIGURE 1
Determination of Changes in the Housing Stock



structures), the user costs of capital for owner-occupied and rental housing (the former is approximately the product of the *real* after-tax mortgage rate and the real price of structures), and credit availability. (An inflation-induced increase in the mortgage payment constraint will limit the size of house purchases if imperfections in the capital market prevent households from borrowing against future housing capital gains.) These variables depend on those in the box on the left: the level of interest rates, tax law, the financial structure, and the relative productivity of the construction sector (which determines the real price of structures). The three double-lined boxes represent the important economic decisions. Tenure choice depends on the rental price (user cost) of housing services generated by an owner-occupied dwelling versus that of services produced by a rental unit. This choice, along with total household formations and credit availability, determines the numbers of single and multifamily starts. The average quality (square feet, number of fireplaces, etc., valued in constant dollars) per start, in turn, is a function of real income per household and "prices," both the real user cost (user cost divided by the price of non-housing goods) and the real mortgage payment constraint. The product of the number of starts and their average quality is the real value of starts, and this is converted to real housing outlays or the change in the real housing stock with a short production lag.

Implicit equations for single (SST) and multifamily (MST) starts and explicit equations for the average real qualities of single (SQ) and multifamily (MQ) starts are

$$\mathrm{SST} = \phi_s(\overset{+}{\Delta \mathrm{HH}}, \overset{-}{\Delta(c/r)}, \overset{+}{\mathrm{AVAIL}})$$

$$\mathrm{MST} = \phi_m(\overset{+}{\Delta \mathrm{HH}}, \overset{+}{\Delta(c/r)}, \overset{+}{\mathrm{AVAIL}})$$

$$\mathrm{SQ} = \psi_s(\overset{+}{y}, \overset{-}{c}, \overset{-}{m})$$

$$\mathrm{MQ} = \psi_m(\overset{+}{y}, \overset{-}{r}),$$

where HH is the number of households, c and r are the real user costs for owning and renting, AVAIL represents credit availability, y is real income per household, m is the mortgage payment variable, and the signs of the partial derivatives are indicated above the variables. Significant lags exist, particularly with regard to the tenure decision.

The above starts equations are consistent with a world in which prices of new housing units are a mark-up on costs and builders determine starts so as to equate the expected future supply and demand for incremental units. An alternative view, which I label the pure supply view, has the price of new units determined by the supply and demand for existing units and has builders responding to profit opportunities, as well as the availability of credit:

$$ST = \phi_p(\overset{+}{Ph/p}, \overset{-}{Cost/p}, \overset{+}{AVAIL}),$$

where Ph/p is the real price of housing and Cost/p is the real cost of production.

THE EVANS MODEL

Starts equations appear in the Evans investment chapter, but average quality equations do not. Multiplication of starts by a housing price translates starts into nominal dollars, and a production lag converts these into nominal outlays on housing. How or whether real outlays are determined is unclear. Thus, my discussion relates only to the behavior of starts.[8]

It is difficult to fit the Evans starts equations into either of the above frameworks. The equations are of the forms

$$SST = \phi_{es}(\overset{+}{y}, \overset{-}{m}, \overset{+}{\pi_h}, \overset{+}{AVAIL})$$

$$MST = \phi_{em}(\overset{+}{y}, \overset{+}{\frac{RENT}{COST}}, \overset{-}{\frac{INT + RENT}{WAGES}}, \overset{+}{AVAIL}, \overset{-}{OVER}),$$

where the signs over the variables are the signs of the estimated coefficients, π_h is the housing inflation rate, RENT/COST is a profitability measure, (INT + RENT)/WAGES is the ratio of NIA interest and rent income to wage income, and OVER is a measure of overbuilding (the cumulated difference since 1970 between 600 thousand and actual annual starts). The first equation has no cost variables and looks more like an average quality rather than number of starts equation. The inflation and mortgage payment

[8] One exception. It is stated that "most recent estimates indicate that the (income) elasticity (of housing) is now closer to 1.5 [than unity]" (p. 4.94). My estimate is 0.68 and those of the micro studies I have seen are only slightly higher. Possibly the studies referred to (not cited) intermingle the income and price effects. The price (user cost) is lower for households with higher incomes (in higher tax brackets). If the income variable captures this price effect, then a higher elasticity would be estimated.

variables could be reflecting tenure choice, and the rise in income over time, too, likely reflects the shift towards home ownership, although there is no reason why higher income *per se* should increase ownership. Unfortunately, this would suggest that income should enter the multifamily equation with a negative sign. The multifamily equation also includes a profit variable, a factor share variable, and a measure of overbuilding consistent with desired starts over time being a constant 600 thousand and thus independent of any economic considerations. That is, the equation appears to include most any variable that "worked."

Because Evans' credit availability index is undefined, discussion of its plausibility is impossible. However, the impact of the change in FHLB advances, another availability proxy employed, is subject to interpretation. This variable reflects what appears to be a common problem with econometric models of housing: availability of funds variables work far *too* well. During the 1976-79 period, only 23 percent of savings and loan loans closed, net of refinancings, were used to finance new construction of dwelling units. Yet the coefficients on the advances variables in the starts equations suggest that a billion dollars of advances would generate $2 billion in new construction.[9] A quite careful specification of starts equations is needed to prevent a vast overstatement of availability effects. My own estimates are that a billion dollars of deposits generates only $0.31 billion of 1-4 family housing, and even this seems to be too large an effect.

Regrettably, the residential investment sector of the Evans model is no improvement on poorly formulated existing models.

Supply-Side Economics and the Productivity of Capital

Supply-side economics is concerned with increasing economic growth and thus the size of the economic pie. This can be achieved by increasing either the level of effort (more manhours worked) or the quality of a given level (more output per manhour). One way of increasing productivity is to increase capital per worker, and this is most directly achieved by raising the saving rate. Thus the most important supply-side economic issues are the sensitivities of labor supply to real after-tax wage rates and of saving to real after-tax interest rates. Because neither of these topics relates to investment, it is fortunate that other means of raising productivity exist. In

[9]Somewhat similarly, Jaffee and Rosen, 1979, and Poterba, 1980, report that an additional billion dollars of thrift deposits would lead to $1.5 billion in construction.

order to focus on such means, I assume in what follows that labor supply and saving, respectively, are independent of wage and interest rates.

Economic policy can affect economic growth in such a world via two routes. First, an increase in government saving that is not accompanied by an equal decrease in government investment or private saving will increase the capital stock. A reduction in government "consumption" outlays would reduce government borrowing and thus real interest rates, thereby stimulating investment. Alternatively, an increase in taxes on private consumption outlays would accomplish the same objective. Second, a reallocation of investment from less to more productive uses will raise the productivity of a given total stock of capital.

There are two general means of channeling investment into more productive uses. There has been a surge in explicitly mandated investments in the last decade, some of which have been of questionable value. The massive retrofitting of transportation networks to allow access of the handicapped comes to mind. Similarly, government regulations implicitly require overinvestment in some areas. For example, our trucking fleet is larger than it need be owing to "gateway" requirements whereby trucks are forced to make empty return trips on suboptimal routes. A reduction in explicit and implicit mandated investments would free resources for more productive uses.

A second means of improving the productivity of capital is to reduce the relative subsidy extended to owner-occupied housing. The user cost of capital for owner occupied housing tends to be low because neither the implicit rents from the unit nor the capital gain earned is taxed. Moreover, this user cost has declined in response to increases in anticipated inflation because real after-tax debt yields have fallen. Estimates of real user costs for owner-occupied housing and corporate structures in 1964 and 1978 are listed in Table 1. The 1964 data illustrate the relationships among user costs in a noninflationary period. The costs for housing are lower because of its preferred tax treatment, and the costs are lowest for those in the highest tax brackets. The 1978 data reflect the decline in real after-tax debt yields; the decline is largest for those in the highest tax brackets. The fall in the user costs for owner-occupied housing would have been greater but for a sharp rise in the real price of structures. Referring back to equation (2), the near doubling of the user cost for corporate structures reflects: 1) a decline in z, the present value of tax depreciation, owing to the use of historic cost

TABLE 1
Real User Costs of Capital, 1964 and 1978
(Percent)

	1964	1978
Owner-Occupied Housing:		
15 Percent Tax Bracket	9	5
30 Percent Tax Bracket	8	2
45 Percent Tax Bracket	7	0
Corporate Structures	15	27

Sources: Owner-occupied Housing, Hendershott and Hu, 1981a. Corporate Structures, Hendershott and Hu, 1981b.

depreciation, 2) an increase in taxes paid on inventory profits, and 3) a rise in the real price of structures (q/p). Also, the real after-tax financing rate for structures has not fallen because the heavily-weighted equity yield component has risen by enough to offset the decline in the real after-tax debt yield. Given this movement in user costs, the surge in the levels of sales and production of single-family housing in the second half of the 1970s and the sluggishness of investment in nonresidential structures are hardly surprising. America is now investing resources in housing that has a net (or depreciation) marginal product of near zero and foregoing the construction of corporate structures that have a net marginal product of over 20 percent.

The relative subsidy for owner-occupied housing and the resultant misallocation of capital can be reduced through a variety of methods. Most obviously, implicit rents and housing capital gains could be taxed. Not only does this appear politically infeasible, but the taxation of largely nominal capital gains has little appeal on equity grounds. Alternatively, a wide range of business tax cuts could be employed to offset the subsidy to owner-occupied housing: these include a switch to replacement cost depreciation, expanded investment tax credits, a reduction in the double taxation of corporate dividends and a general cut in the corporate income tax rate. The investment stimulated by these cuts would drive up real interest rates, thereby rechannelling resources from housing to nonresidential investments.[10] Feldstein, 1980, has generalized this argument by calling for a switch from an easy-money/tight-fiscal

[10]See Hendershott and Hu, 1980, for an analysis of the impact of these tax cuts on the user costs for business investments and owner-occupied housing.

policy mix, in which real after-tax mortgage rates are negative and the taxation of capital income is great, to a tight-monetary/easy-fiscal policy mix, in which the reverse is true.

My own favorite method of reducing overinvestment in owner-occupied housing is a large, say $12,000, exemption of interest and dividends from taxation, subject to the netting of personal (largely mortgage) interest expense. To illustrate, consider two households, each with $12,000 in interest income but one with a mortgage entailing an annual interest expense of $9,000 and the other with no mortgage and thus no interest expense. The former household would pay taxes on $9,000 of interest income (only $3,000 = $12,000 − $9,000 would be exempt), while the latter would pay no tax on interest income. This would reduce both the relative tax advantage to owner-occupied housing and the inequitable current taxation of largely nominal interest income. In effect, a tax break (cessation of taxation of nominal interest) would be extended to those not leveraging investment in owner-occupied housing. Finally, we should discourage any further subsidies to housing such as the use of tax-exempt financing (mortgage revenue bonds).

Summary

It is not clear that the new emphasis on supply-side economics has implications for major revisions in the form of business investment equations. There is, of course, a need to account carefully for the interaction between inflation and taxes and to incorporate mandated investment outlays into the analysis. But existing models either already do this or can be easily adapted. Possibly as a result, the equations in Evans' model do not appear to be particularly innovative. Moreover, there seem to be some errors in the calculation of user costs, and replacement and mandated investment outlays are overlooked.

The residential construction equations in existing models are not in as good shape as the nonresidential investment equations. The major problems are a failure to measure user costs as carefully as is done for the business sector, and a tendency to attribute far greater impact to credit availability than is remotely plausible. Unfortunately, the equations in Evans' model do not appear to address these problems in a useful manner.

While the new supply-side emphasis should not be expected to alter greatly the form of investment equations, hopefully its emphasis on supply constraints will alter the type of policy simulations run with the models. Too often in the past, simulations of policy actions or legislation designed to encourage a specific type of capital outlay have been run in the context of a world with unlimited resources or infinite supplies. The result implied by such simulations is, not surprisingly, an increase in not only the targeted capital good but in all capital and consumption goods. In such a world, *any* capital-specific policy should be pursued. In the real world, resources are limited. Even in the intermediate run, the only policies that should be analyzed are those designed to have zero aggregate demand impact. For example, a specific tax cut should be accompanied by other tax increases, expenditure cuts, or higher real interest rates (a more restrictive monetary policy).[11] Of course, if the policies are well-designed, then productivity and thus the total size of the economic pie, will increase. As Summers emphasizes (1981), however, significant quantities of these aggregate benefits will not be achieved quickly.

[11] For discussion of the issues raised in this paragraph, see Hendershott, 1980.

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