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ARE THE PERMANENT-INCOME MODEL OF CONSUMPTION AND THE ACCELERATOR MODEL OF INVESTMENT COMPATIBLE?

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Abstract

The permanent-income model implies that consumption will be rising when the real interest rate is high. The accelerator model implies that investment will be greater, the greater is the rate of increase of sales. In combination, the permanent-income and accelerator models imply that a money-induced rise in interest rates is expansionary--a prediction at variance with the relationship between monetary policy and economic activity that we observe in the real world.

I. Introduction

Empirical evidence indicates that investment is related more closely to changes in sales than to changes in the cost of capital.[1] A possible explanation is that--as in Grossman (1972) and Precious (1987)--new investment projects become productive while output is sales-constrained, so that changes in the capital stock are driven by an income-investment accelerator.[2]

The accelerator model of investment has been around for a long time. It is usually discussed in a partial-equilibrium setting: the analyst traces the response of investment to exogenously given changes in sales and factor prices. In the few instances when an attempt has been made to examine the interactions between investment and the rest of the economy, consumption demand has been assumed to be a simple function of lagged income (Samuelson 1939) or accumulated wealth (Blanchard 1983). In contrast, according to the modern, permanent-income theory of consumption, households are forward-looking: they base their consumption decisions on the expected stream of their future earnings and the expected time path of the real interest rate.

In this paper I examine the interaction between the accelerator model of investment and the permanent-income model of consumption. The examination is conducted within the context of a simple, stylized model of the economy. In this model, wages and prices fail to respond immediately to new information about the future course of monetary policy. In the interval during which the wage rate and price level fail to adjust, sales determine output, and investment is governed by the accelerator mechanism.

The results obtained in the paper are strikingly different from those obtained in traditional IS-LM analysis and, also, are at variance with what we observe in the real world. In particular, I find that when the monetary authority drives up interest rates, output and employment expand. Intuitively, a high interest rate induces households to delay consumption. Household demand, then, must be rising in the interval during which the monetary authority keeps the interest rate elevated. Even if the level of consumption demand should fall initially, the prospect of rising sales provides sufficient stimulus to investment that output and employment increase.

Following Sidrauski (1967) and Feenstra (1986), I begin by assuming that real money balances enter the household utility function. The demand for money, then, is a function of consumption expenditures rather than income--an implication consistent with empirical results obtained by Mankiw and Summers (1986). Later, I discuss how the analysis must be modified if a more conventional money demand specification is adopted. None of the principal results of the paper are affected by the choice of the scale variable in the money demand equation.

II. The Model

The representative household chooses time paths for its real balances (m), real wealth (a), and--if the labor market clears--hours of employment (n) so as to maximize

$$\int_0^\infty [u(c(t)) + z(m(t)) - v(n(t))]e^{-\beta t}\, dt$$

subject to

$$(1) \qquad \int_t^\infty [c(s) + m(s)i(s) + \theta(s)]\exp[-\int_t^s r(v)dv]ds$$

$$= a(t) + \int_t^\infty w(s)n(s)\exp[-\int_t^s r(v)dv]ds,$$

for all $t \geq 0$. Here, i and r are the nominal and real rates of interest, w is the real wage, and c and θ denote real consumption and net lump-sum taxes, respectively.[3] The household takes as given its initial wealth (a(0)) and the time paths of interest rates, the wage rate, and taxes. It is required that $u(\cdot)$ and $z(\cdot)$ be increasing in their arguments and strictly concave, with $u'(0) = z'(0) = \infty$ and $u'(\infty) = z'(\infty) = 0$. The function $v(\cdot)$ must be increasing and strictly convex. Additive separability between leisure and the other arguments of the utility function is consistent with the empirical findings of Campbell and Mankiw (1987) and Koenig (1987). Additive separability between consumption and real balances is contrary to available empirical evidence (Koenig 1987), but simplifies the analysis. Results derived below are altered little when the separability assumption is relaxed, provided consumption and real balances are normal goods.

The representative firm employs one household. Taking the time paths of the real wage and the real interest rate as given, the firm chooses hours of employment and the time path of the capital stock (k) so as to maximize the present discounted value of profit. The production function, f(k,n), is assumed to be increasing in capital and labor, concave, and homogeneous of degree one, with $f_k(0,n) = f_n(k,0) = \infty$. Capital depreciates at rate δ. Capital adjustment and installation costs will be ignored.

In the long run, when the wage rate and price level are able to adjust, the optimality conditions associated with the household and firm maximization problems are standard:

$$(2) \qquad \dot{u'}(c)/u'(c) = \beta - r,$$

(3) $$z'(m)/u'(c) = i,$$

(4) $$v'(n)/u'(c) = w,$$

(5) $$f_n(k,n) = w,$$

and

(6) $$f_k(k,n) = r + \delta.$$

One must also have

(7) $$f(k,n) = c + \dot{k} - \delta k.$$

Equation 2 is the continuous-time counterpart of the requirement that the marginal rate of substitution between current and future consumption be equated to unity plus the real rate of interest. Equations 3 and 4, similarly, require that the marginal rates of substitution between real balances and consumption and between leisure and consumption equal the nominal interest rate and the real wage, respectively. Equations 5 and 6 state that the representative firm will equate the marginal products of labor and capital to the corresponding factor costs. Equation 7, finally, is a market-clearing condition.

During the "short run," while the wage rate and price level are fixed, firms take their output as given, and equations 5 and 6 are replaced by the requirement that the marginal rate of technical substitution equal the ratio of factor prices:[4]

(8) $$f_k(k,n)/f_n(k,n) = (r + \delta)/w.$$

Also, the labor market may not clear, invalidating equation 4.

In the following analysis, the wage rate and price level are assumed to be completely fixed during the interval from $t = 0$ to $t = T$ (the short run) and completely flexible from $t = T$ on (the long run). It is easiest to think of the monetary authority as choosing the time path of the nominal interest rate. If wages and prices are free to adjust, any given time path of the interest rate is consistent with an infinite number of paths of the money supply and of prices. This indeterminacy can be eliminated by assuming that the monetary authority also targets the initial long-run price level, $p(T)$. (In traditional IS-LM analysis, similarly, expectations of inflation are usually treated as exogenous.)

III. Dynamics

A. The Long Run: Flexible Wage and Price

Together, equations 4 and 5 determine the market-clearing level of employment, n^e, as a function of the capital stock and the rate of consumption: $n^e = n(k,c)$. An increase in the capital stock shifts the labor demand schedule to the right, raising equilibrium employment ($n_k > 0$). An increase in consumption, on the other hand, signals that households feel wealthier. As wealth increases, the labor supply schedule shifts to the left, reducing employment ($n_c < 0$).

Equation (7) implies that the capital stock will be increasing through time if, and only if, c is less than $f(k,n^e) - \delta k$. Equations 2 and 6 imply that consumption will be increasing through time if, and only if, $f_k(k,n^e)$ is greater than $\beta + \delta$--that is, if, and only if, the marginal product of capital, net of depreciation, exceeds households' rate of time preference.

These results yield the phase diagram depicted in Figure 1. Note that there is a unique "knife's edge" path along which the economy will move toward its steady state, (k^*,c^*). If the capital stock at time T exceeds k^*, consumption will exceed c^*, and both the capital stock and consumption will decline monotonically through time. If the capital stock at time T is below k^*, both the capital stock and consumption will <u>rise</u> monotonically through time. The real wage moves with, and the real interest rate moves counter to, the capital stock. What happens to hours of employment as the economy moves along the knife's edge depends on the relative strength of wealth and substitution effects. Additive separability between consumption and real balances in the household utility function guarantees that the long-run dynamics of consumption and the capital stock are completely independent of monetary policy.[5]

B. The Short Run: Fixed Wage and Price

With a fixed price level, the government, through its choice of a nominal interest rate, has direct control of the <u>real</u> rate of interest. According to equation 2, households will defer consumption ($\dot{c}$ will be positive) if, and only if, the government chooses a real interest rate that is greater than the rate of time preference.

Equation 8 implies that the ratio of labor to capital is increasing in the ratio of the rental cost of capital to the real wage: $n/k = \nu((r+\delta)/w)$, with $\nu' > 0$. Substituting into equation 6, one has $\dot{k} > 0$ if and only if $c < k \times (f(1,\nu) - \delta)$. In the $k \times c$ plane, there is thus a ray out of the origin above which the capital stock is declining and below which the capital stock is increasing. The slope of this ray, $f(1,\nu) - \delta$, is higher, the greater is the interest rate.

IV. Policy Shocks

I will assume that the economy is initially, at $t = 0$, in a steady state in which all markets clear. A change in policy is then announced. As is standard in such analyses, the announcement is assumed to be completely unexpected, yet completely credible. The dollar wage and dollar price of output are unable to respond to the policy change until $t = T \geq 0$. From that point on, the wage rate and price level adjust to clear the labor and output markets. Two policy shocks are considered: an increase in expected inflation and an increase in the nominal interest rate.

A. An Increase in Expected Inflation

It is important to note that any anticipated increase in the initial long-run price level, $p(T)$, must be accompanied by a downward jump in consumption at time T. More precisely, the marginal utility derived from spending a dollar, $u'(c)/p$, must be continuous at time T if households are utility maximizers: facing a discontinuous fall in $u'(c)/p$ at time T, a household could always make itself better off by spending now (before T) a little of the money it had been planning to spend later (after T).[6]

Figure 2 illustrates the effects of an increase in $p(T)$ announced at $t = 0$. Not surprisingly, households try to make their purchases before the price increase takes effect. Consumption rises discontinuously at time zero and remains high until time T, absorbing output that would otherwise have been channeled into investment. With no change in relative factor prices, as the capital stock declines, so does employment and, hence, so does output. At time

T, as the price level jumps upward, consumption falls discontinuously. The economy then begins to move gradually up the knife's edge path toward the flexible-price steady state.

Equation 3 implies that to prevent the nominal interest rate from rising, the government must increase the money supply at time zero and keep it high throughout the interval during which consumption remains elevated.

B. An Increase in the Nominal Interest Rate

Suppose that at $t = 0$ the monetary authority unexpectedly drives up the nominal interest rate while holding the initial long-run price level fixed. The higher interest rate is to prevail until $t = T$ (or beyond), when the wage rate and price level become flexible. With $p(T)$ held constant, consumption may jump at time zero, when the higher interest rate is announced, but thereafter its time path must be continuous. According to equation 2, consumption will be rising between time zero and time T.

As discussed in Section IIIB, a higher interest rate drives up the cost-minimizing labor-capital ratio, steepening the short-run $\dot{k} = 0$ locus so that it passes above the economy's long-run steady state.

Depending on the specific parameterization of the model, the economy may follow any one of four qualitatively different routes through the phase diagram. See Figure 3. In every case the capital stock rises, on average, from $t = 0$ until $t = T$.[7] Consumption may jump downward at $t = 0$, but is always higher at $t = T$ than it was in the initial steady state.[8] Employment and output shoot upward at time zero, move with the capital stock during the interval from $t = 0$ to $t = T$, and fall sharply at time T, when the wage rate and price level first have a chance to adjust. By raising the nominal interest rate, the monetary authority thus triggers a short-run boom--a boom in which increased investment spending plays a critical role.

To obtain a higher interest rate, the monetary authority may, at first, have to cut the level of the money supply. (This will certainly be the case if consumption jumps downward at $t = 0$.) Between $t = 0$ and $t = T$, as consumption grows, the money supply will have to be increased gradually (compare eq. 3). Thus, a high interest rate policy is not the same thing as a tight money policy: if the monetary authority wishes to sustain a high rate of interest in the interval during which the wage rate and price level are fixed, it must <u>increase</u> the rate of growth of the money supply--albeit after, perhaps, an initial drop in the level of the money supply.

V. Income as the Scale Variable in the Money Demand Function

Suppose that equation 3 is replaced with a more conventional money demand equation, one in which the demand for real money balances is taken to be an increasing function of real current income, rather than consumption, and a decreasing function of the nominal interest rate. How does this change affect the preceding analysis? The answer, briefly, is "very little." It is the real interest rate that governs the desired labor-capital ratio and rate of growth of consumption. It is the nominal interest rate that, over the short run (while the price level is fixed), determines the real interest rate. The form of the money demand function is important only to the extent that it influences the pattern of money growth required to achieve a given nominal interest rate. If consumption serves as the scale variable in the money demand function, then movements in the supply of money will have to parallel movements in consumption if money demand is to be kept equal to money supply. If income serves as the scale variable, then movements in the supply of money will have to parallel movements in output.

Consider, for example, the analysis of Section IVA, where the monetary authority was assumed to hold interest rates constant, over the short run, while increasing $p(T)$. With the demand for money a function of consumption and the nominal interest rate, the policy analyzed in Section IVA requires that the money supply be increased sharply at $t = 0$, and kept at a high level until $t = T$. If, instead, the demand for money is a function of <u>income</u> and the nominal interest rate, a gradual <u>decrease</u> in the money supply is required in order to hold the interest rate steady.[9]

VI. Discussion

Here, as in the standard IS-LM model, there is an interval during which nominal wages and prices fail to adjust and during which output and employment are demand-determined. In contrast to the standard model, however, households' consumption decisions are forward-looking, and some adjustment of the aggregate capital stock is possible within the interval of wage-price rigidity. With forward-looking households, the real interest rate is high if, and only if, households are deferring consumption. Because new capital becomes productive while output is still sales-constrained, investment is affected by changes in sales, not just factor prices. Hence, the rising consumption occasioned by a high interest rate tends to stimulate investment. Even if interest rates are held constant, anticipated changes in the future price of output--through their effect on current sales--can spur or retard investment spending.

In the real world, the Federal Reserve, when it wishes to stimulate the economy, does not suddenly drive up short-term interest rates. Indeed, an inverted yield curve is regarded as one of the more reliable advance indicators of recession. What, then, is one to make of a model predicting that a money-induced rise in interest rates is expansionary? Some analysts may find it tempting to reject the hypothesis that households are forward-looking in their consumption behavior. Theoretical and empirical results obtained by myself (Koenig 1987, 1988) and others (Poterba and Rotemberg 1987; Nelson 1987), however, lead me to suspect that the difficulty lies, instead, with the accelerator model of investment. In any event, it is clear that the permanent-income model of consumption and the accelerator model of investment are incompatible with one another: in combination, they yield predictions that are contrary to experience.

Appendix

A Linearized Version of the Model

Flexible Wage and Price

Equations 4 and 5 imply

$$(A.1) \qquad N = \alpha K + (1 - \alpha)[\epsilon(u',c)/\epsilon(v',n)]^{*}C,$$

where $\alpha \equiv -\epsilon(f_n,n)^{*}/[\epsilon(v',n) - \epsilon(f_n,n)]^{*} > 0$, and where for any variables x and y, X is the deviation of the logarithm of x from its initial steady-state value, $\epsilon(y,x)$ is the elasticity of y with respect to x, and an asterisk indicates that a variable or expression is evaluated at steady state. In deriving this equation, I have used the fact that since $f(\cdot,\cdot)$ is homogeneous of degree one, $\epsilon(f_n,k) = -\epsilon(f_n,n)$ and $\epsilon(f_k,n) = -\epsilon(f_k,k)$. Note that the elasticity of employment with respect to changes in the capital stock is less than unity.

Use (A.1) to eliminate hours of employment from equation 6, and use the resultant expression to eliminate the real interest rate from equation 2. This yields

$$(A.2) \qquad \dot{C} = a_{cc}C + a_{ck}K,$$

where

$$a_{cc} \equiv (\beta + \delta)(1 - \alpha)[\epsilon(f_k,k)/\epsilon(v',n)]^{*} < 0,$$

and

$$a_{ck} \equiv -(\beta + \delta)(1 - \alpha)[\epsilon(f_k,k)/\epsilon(u',c)]^* < 0.$$

Similarly, by differentiating equation 7 logarithmically and using (A.1) to eliminate N, one obtains

$$\dot{K} = a_{kk}K + a_{kc}C, \tag{A.3}$$

where

$$a_{kk} \equiv \beta + \alpha(\sigma - \beta) > 0,$$

$$a_{kc} \equiv -\sigma + (1 - \alpha)[\epsilon(u',c)/\epsilon(v',n)]^*(\sigma - \beta) < 0,$$

and $\sigma \equiv (c/k)^* = (\beta k + wn)^*/k^* > \beta$.

For any given initial capital stock, K(T), equations A.2 and A.3 have a unique convergent solution:

$$C(t) = \Sigma K(T)\exp[\mu(t - T)] \tag{A.4}$$

$$K(t) = K(T)\exp[\mu(t - T)] \tag{A.5}$$

for $t \geq T$. Here

$$\mu \equiv (1/2)\{(a_{cc} + a_{kk}) - [(a_{cc} + a_{kk})^2 - 4(a_{cc}a_{kk} - a_{ck}a_{kc})]^{1/2}\} < 0,$$

and $\Sigma \equiv a_{ck}/(\mu - a_{cc}) > 0$ is the slope (in K x C space) of the knife's edge path through long-run steady state. It is readily verified that $\Sigma \to \infty$ as $-\epsilon(u',c) \to 0$, while $\Sigma \to 0$ as $-\epsilon(u',c) \to \infty$.

Fixed Wage and Price: Exogenous Interest Rate

In the interval during which the price level is fixed, the government, through its choice of the nominal interest rate, controls $\dot{C}$. That is, $\dot{C}$ may be thought of as an exogenous variable. To find a formula for $\dot{K}$, first note that from equations 2 and 8,

$$\text{(A.6)} \qquad N = K + [A/(\sigma - \beta)]\dot{C},$$

where $A \equiv -(\sigma - \beta)[\epsilon(u',c)/(\beta + \delta)]^*/[\epsilon(f_k,n) - \epsilon(f_n,n)]^* > 0$. Now use (A.6) to eliminate employment from equation 7:

$$\text{(A.7)} \qquad \dot{K} = \sigma(K - C) + A\dot{C}.$$

It follows immediately that the slope of the short-run $\dot{K} = 0$ locus (in a phase-diagram plot in K x C space) is unity.

When $\dot{C}$ is held constant, solutions for capital and consumption are readily obtained:

$$\text{(A.8)} \qquad C(t) = C(0+) + \dot{C}t$$

and

$$\text{(A.9)} \qquad K(t) = (1/\sigma)[A\dot{C} - \sigma C(0+)](e^{\sigma t} - 1) - (\dot{C}/\sigma)[e^{\sigma t} - (1 + \sigma t)],$$

for $0 \leq t < T$, where C(0+) is the post-announcement rate of consumption at t = 0. (Recall that the time path of consumption may be discontinuous at time zero.)

Linking the Short-Run and Long-Run Solutions

The constants, K(T) and C(0+), which appear in equations A.4, A.5, A.8 and A.9 are determined by the requirement that the time-paths of the capital stock and of the marginal utility of spending money be continuous at t=T. Consider, for example, the policy shock depicted in Figure 3: an increase in the nominal interest rate, with no change in the initial long-run price level, p(T). With no jump in p(T), consumption must be continuous at T, so one must have $C(0+) + \gamma T = \Sigma K(T)$, where $\gamma > 0$ is the time rate of increase of consumption implied by the new, higher interest rate. Similarly, for the capital stock to be continuous at time T, one must have

$$K(T) = (1/\sigma)[A\gamma - \sigma C(0+)](e^{\sigma T} - 1) - (\gamma/\sigma)[e^{\sigma T} - (1 + \sigma T)].$$

It follows that

$$\text{(A.10)} \qquad C(0+) = \gamma[(\Sigma/\sigma)(A - 1 + \sigma T)(e^{\sigma T} - 1) - T]/(1 + \Sigma),$$

and

$$\text{(A.11)} \qquad K(T) = (\gamma/\sigma)[(1 - e^{\sigma T} + \sigma T e^{\sigma T}) + A(e^{\sigma T} - 1)]/(1 + \Sigma).$$

With $\sigma > 0$, it is readily verified that $(1 - e^{\sigma T} + \sigma T e^{\sigma T})$ is positive and increasing in T. With γ, A, and Σ positive, one therefore has $K(T) > 0$, and $dK(T)/dT > 0$. Both $C(0+)$ and $dC(0+)/dT$ are ambiguous in sign, but for large T, both are greater than zero.

Figure 3 suggests that the capital stock may sometimes peak before time T. To determine the circumstances under which this occurs, substitute from (A.10) into (A.9), then differentiate with respect to time. By evaluating the resultant expression at $t = T$, one obtains a formula for $\dot{K}(T)$:

$$\text{(A.12)} \qquad \dot{K}(T) = \sigma^2\gamma[Ae^{\sigma T} + (1 - \Sigma)(1 - e^{\sigma T} + \sigma Te^{\sigma T})].$$

Recall that A, σ, γ, and Σ are all positive. The first term in the square brackets on the right-hand side of (A.12) is therefore unambiguously positive, while the second is positive if and only if Σ is less than unity--that is, if, and only if, the long-run knife's edge is flatter than the short-run $\dot{K} = 0$ locus. It follows that if $-1/\epsilon(u',c)$ (the elasticity of intertemporal substitution) is sufficiently small, and hence the long-run knife's edge is sufficiently flat, the capital stock will certainly be increasing during the entire interval of wage-price rigidity. Since $e^{\sigma T}$ approaches unity as $T \to 0$ while $(1 - e^{\sigma T} + \sigma Te^{\sigma T})$ has a limiting value of zero, even if the long-run knife's edge is <u>not</u> flat, a sufficiently short interval of rigidity will guarantee that the capital stock will be rising from $t = 0$ to $t = T$. As $T \to \infty$, on the other hand, the second term on the right-hand side of (A.12) dominates the first; so $\dot{K}(T)$ will be negative when the long-run knife's edge is steeper than the short-run $\dot{K} = 0$ schedule, provided T is sufficiently large.

Notes

1. See, for example, Abel and Blanchard (1983) and Shapiro (1986).

2. An alternative explanation, consistent with neoclassical theory, is that there are exogenous shifts in the production function, shifts reflected simultaneously in output and the marginal product of capital. See Shapiro (1986) and Sargent (1986). Still another possibility is that capital markets are imperfect, so that firms concentrate their investment in periods during which sales, hence profits, are high.

3. Money is withdrawn from (introduced into) the economy via lump-sum taxes (transfers).

4. When there is excess supply in the output market, it may be inappropriate to assume that firms feel free to sell off their excess capital. By imposing equation 8, therefore, I am implicitly limiting my analysis to shocks that are small enough that firms do not wish to liquidate capital at a rate greater the rate at which it depreciates. (In several of the more interesting scenarios presented below, the capital stock is predicted to increase over the entire interval during which the price of output is fixed, so any constraint on disinvestment is irrelevant.)

5. For an analysis of the general case, in which there are nonseparabilities, see Koenig (1989).

6. Alternatively, equations 2 and 3 imply $(\dot{u'/p})/(u'/p) = \beta - i = \beta - z'(m)/u'(c)$ which is finite. For a more general proof, see Theorem 2 in Kemp and Long (1977).

7. Figure 3 depicts the case in which the knife's edge is steeper than the short-run $\dot{k} = 0$ schedule. If the knife's edge is, instead, <u>flatter</u> than this schedule, the capital stock must rise during the entire interval from $t = 0$ to $t = T$. It can be shown that the knife's edge tends to be flat when the elasticity of intertemporal substitution is small. Even if the knife's edge is <u>not</u> flat, a sufficiently short interval of wage-price rigidity will guarantee that the capital stock rises from $t = 0$ to $t = T$. Conversely, a sufficiently long interval of wage-price rigidity implies that the capital stock begins declining before time T. Nevertheless, the larger is T, the larger is K(T). See the Appendix.

8. A downward jump in consumption can be ruled out if the interval of wage-price rigidity is sufficiently long. See the Appendix.

9. Output and, hence, money demand decline with the capital stock in response to the policy analyzed in Section IVA.

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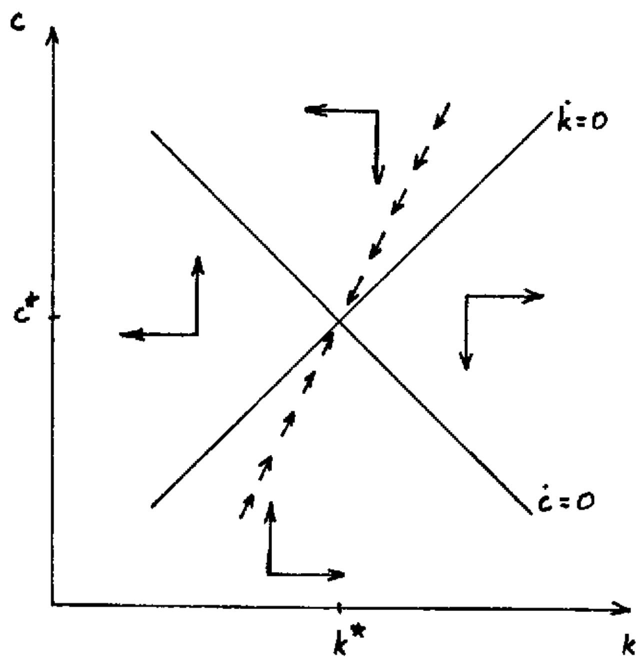

FIGURE 1. LONG-RUN DYNAMICS.

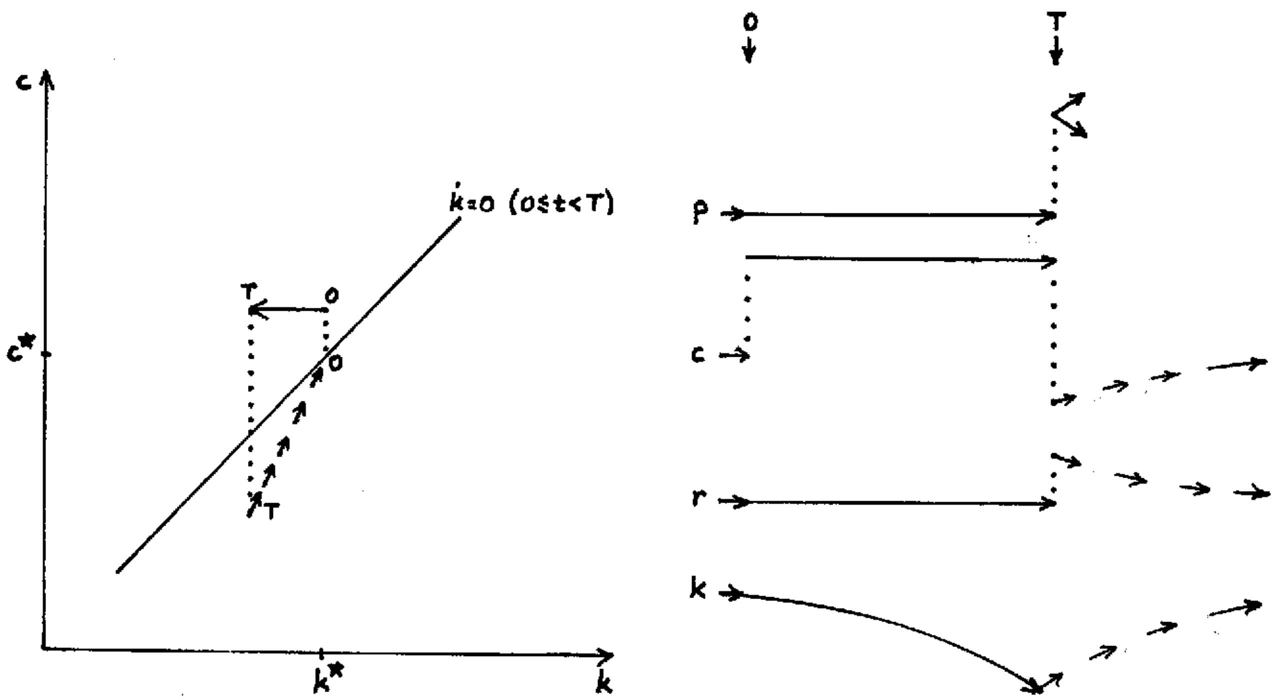

FIGURE 2. RESPONSE OF THE ECONOMY TO A PRE-ANNOUNCED INCREASE IN THE INITIAL LONG-RUN PRICE LEVEL, $p(T)$.

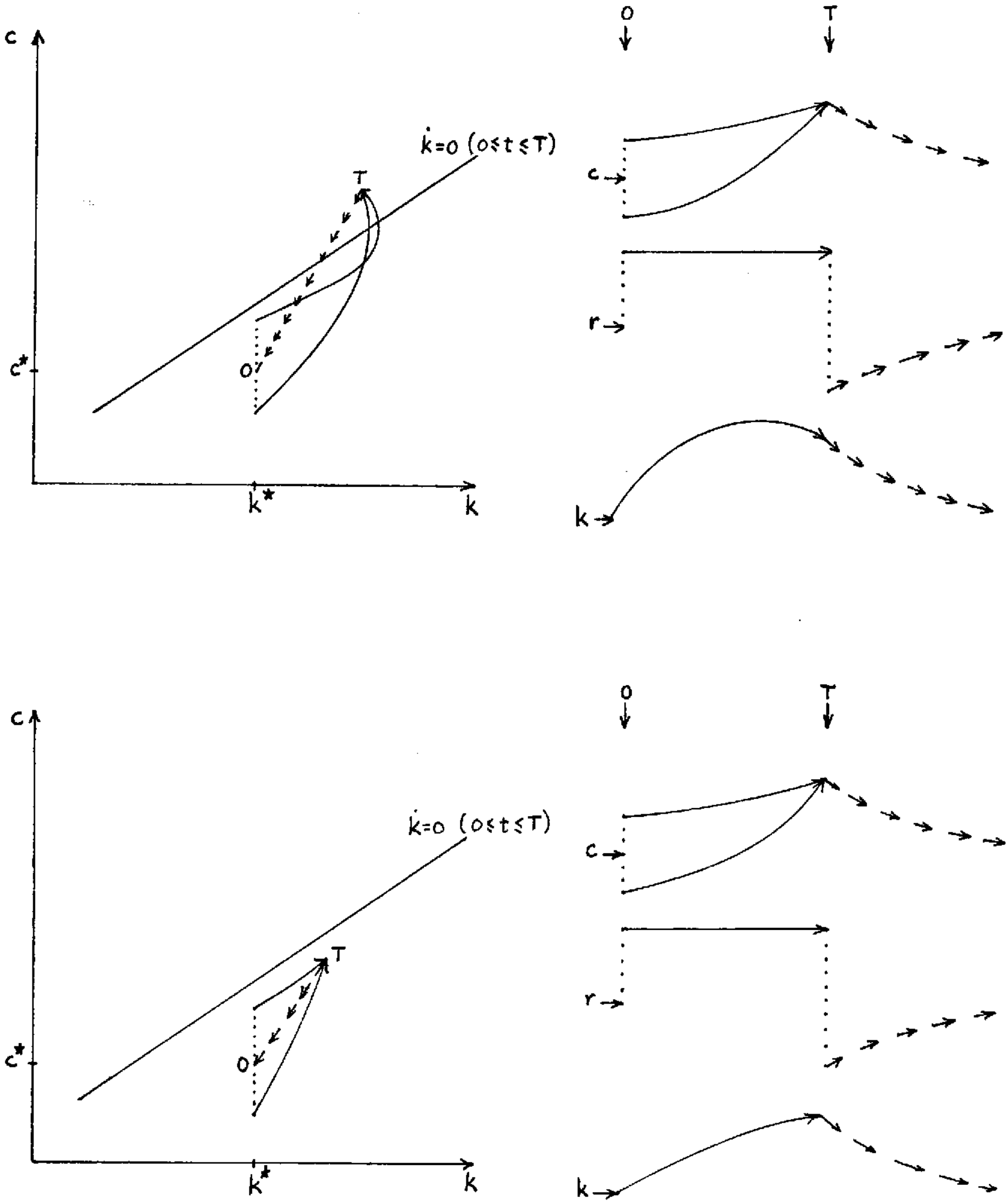

FIGURE 3. ALTERNATIVE RESPONSES TO AN UNEXPECTED INCREASE IN THE NOMINAL INTEREST RATE.

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