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Rethinking the IS in IS–LM: Adapting Keynesian Tools to Non-Keynesian Economies

Part 2

Once the generally accepted framework within which to discuss macroeconomic policy and the centerpiece of every intermediate macro textbook, IS–LM analysis has become a source of controversy within the economics profession. Critics point to its *ad hoc* behavioral assumptions—especially its neglect of expectations—as reasons for abandoning the IS–LM framework altogether (King 1993). Simple real-business-cycle models, such as that popularized by Barro (1990), are seen as better approximations to reality. On the other hand, supporters of the IS–LM analysis stress the importance of working within a framework that does not impose continuous market clearing *a priori* (Tobin 1993).

This article shows how forward-looking expectations can be incorporated into IS–LM analysis. Thus, the article provides a compromise alternative to existing models for those who are uncomfortable with the myopia of traditional Keynesian analysis but hesitate to impose the continuous market clearing of real-business-cycle theory. Of course, not everyone believes that forward-looking behavior is realistic. For such people, this article offers insight into which of the traditional Keynesian results flow directly from sluggish price adjustment and which involve myopia in an essential way. Similarly, for economists to whom sluggish price adjustment is anathema, this article provides a means for communicating with those who hold contrary views.

This article does not pass judgment on existing macroeconomic models nor break new theoretical ground. Instead, the article tries to narrow the gap between the two macroeconomic paradigms that dominate both today's textbooks and today's policy debates by showing that a graphical framework taken from one of these paradigms is consistent with models drawn from the other.

Overview

Part 1 of this article shows how forward-looking expectations can be incorporated into IS–LM analysis of an economy without capital investment.[1] Practically speaking, forward-looking expectations imply that current consumption demand is a function of expected future consumption, as a proxy for permanent income, rather than a function of current income. Part 2 extends the analysis to the case in which current savings decisions have a nontrivial effect on future consumption opportunities. This extension introduces a new simultaneity into the analysis: current consumption depends on expected future consumption, which depends on current saving (the difference between current income and current consumption). The real interest rate adjusts to ensure that, in the aggregate, households' savings decisions are consistent with their consumption expectations. Our goal here

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[1] *See "Rethinking the IS in IS–LM: Adapting Keynesian Tools to Non-Keynesian Economies," pt. 1, Federal Reserve Bank of Dallas* Economic Review, *Third Quarter 1993.*

is to capture, in a simple set of graphs, the forces that determine consumption and interest rates.

The analysis begins with a discussion of consumption and interest rate determination in a simple, Barro-style market-clearing economy. Because investment demand is interest-sensitive, the level of consumption that is consistent with the clearing of labor and output markets is not independent of the real return on bonds. Even in a market-clearing economy, consequently, the IS schedule—which represents combinations of output and the real rate of return that clear the credit market—plays an essential role in determining the equilibrium level of consumption. Because the position of the IS schedule depends on household expectations, so too does equilibrium consumption.

The article demonstrates how, in a market-clearing economy, capital investment allows households as a group to smooth consumption through time. No longer is the impact of a temporary increase in government spending entirely absorbed through reductions in contemporaneous leisure and contemporaneous consumption. Instead, the impact of temporarily increased government purchases is absorbed partly through reductions in *future* leisure and *future* consumption and—insofar as the increased government spending is anticipated—partly through reductions in *past* leisure and *past* consumption. That is, investment in the periods preceding the heightened government spending is increased, and investment in the periods of the heightened government spending is reduced.

Next, the possibility that price adjustment is less than immediate is considered. As in Part 1 of the article, we assume that prices take (at most) one period to respond to economic shocks. Thus, regardless of whether or not prices adjust fully in the current period, people expect all markets to clear next period, absent new disturbances. The optimality conditions that determine the levels of output and interest rates in the period during which price adjustment is incomplete are a subset of the conditions that determine equilibrium in a market-clearing economy. They can be summarized, graphically, as IS and LM schedules. We find that the chief effect of introducing capital investment is a flattening of the IS schedule, so that changes in monetary policy have a larger impact on current output and consumption than before while anticipated future supply shocks have a smaller impact than before. It remains the case that current supply shocks—including shocks to current government purchases—have no effects at all on current consumption, current investment, or the real interest rate.

Possible modifications and extensions of the analysis are discussed in the final section of the article.

Investment in a market-clearing economy

Before analyzing a simple two-period model with investment, we review equilibrium consumption and interest rate determination in an economy with a fixed capital stock. In an economy with a fixed capital stock, the level of consumption that is consistent with clearing of the labor and output markets is completely independent of the real interest rate. This independence breaks down once capital investment is introduced into the economy. Intuitively, an increase in the real interest rate reduces investment demand, raising the amount of output available to consumers at any given quantity of leisure.

A review of the no-investment case. The market-clearing model developed in Part 1 of this article is characterized by four optimality conditions and three identities:

(1) $$MRS_{lc} = w;$$

(2) $$MP_n = w;$$

(3) $$n = L - l;$$

(4) $$y = c + g;$$

(5) $$MRS_{c\bar{c}} = r;$$

(6) $$MRS_{mc} = (R - 1)/R;$$

(7) $$R = r\bar{P}/P.$$

Equation 1 is the optimality condition that determines the supply of labor. It says that in equilibrium the marginal rate of substitution between leisure and consumption (MRS_{lc}, where l and c denote leisure and consumption, respectively) equals the real wage rate (w). *Equation 2* is the optimality condition that determines the demand for labor. It says that in equilibrium the marginal product of labor (MP_n, where n denotes hours of labor) equals the real wage. *Equation 3* says that hours worked by the representative household equal total hours (L) less hours of leisure. *Equation 4* says that output (y) is divided between consumption and government purchases (g). Government purchases, financed with lump-sum (nondistortionary) taxes, are assumed to have no direct effect on household preferences for consumption, leisure, or real money balances and, also, to have no direct effect on the production technology. *Equation 5* is an intertemporal optimality condition. It says that in equilibrium the marginal rate of substitution between current consumption and future consumption ($MRS_{c\bar{c}}$, where $\bar{c}$ denotes future consumption) equals the gross real rate of return on bonds (r). *Equation 6* is the optimality condition that determines the demand for money. It says that in equilibrium the marginal rate of substitution between real money balances and consumption (MRS_{mc}, where m denotes real money balances) equals the real opportunity cost of holding money, which is the nominal interest rate ($R - 1$) divided by the gross nominal rate of return on bonds (R). *Equation 7* is the identity that relates the nominal return on bonds to the real rate of return, next period's price level ($\bar{P}$), and the current price level (P).

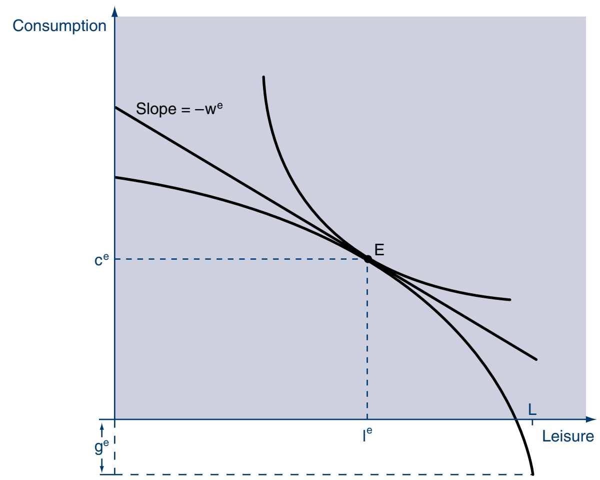
In addition, in Part 1 of this article, we assume that output and employment are related to one another by a production function of the form

$$y = \theta f(n), \tag{8}$$

where θ is a multiplicative technology shock.

Equations 1, 2, 3, 4, and 8 are, by themselves, sufficient to determine the equilibrium levels of output, consumption, employment, leisure, and the real wage, given current government purchases and the current value of the technology parameter, θ. A graphical representation of the economy's equilibrium is given in Figure 4 of Part 1 of this article and is reproduced as Figure 1 here. The convex curve in the middle of the figure is an indifference curve of the representative household, while the concave curve in the lower left corner of the figure is obtained by substituting

Figure 1
Market-Clearing Equilibrium in an Economy Without Capital Investment



from equations 3 and 4 into equation 8, yielding a leisure–consumption opportunity locus that has equation $c = \theta f(L - l) - g$. Equilibrium occurs at the point where the indifference curve is tangent to the opportunity locus.

Note that none of the equations that determine the equilibrium level of consumption depend on the real rate of return on bonds in any way.[2]

Making investment endogenous. How is the analysis above affected by the introduction of capital investment? First, equation 4 is replaced by

$$y = c + i + g, \tag{4'}$$

where i is the amount of investment undertaken in the current period. Second, equation 8 is replaced by

$$y = \theta f(n) + \sigma h(k), \tag{8'}$$

[2] *The implicit assumption here is that the marginal rate of substitution between leisure and consumption is independent of both real money balances and future consumption.*

where k is the current-period capital stock and where changes in σ represent shocks to the productivity of capital.[3] We also have

$$\bar{k} = (1 - \delta)k + i, \tag{9}$$

where $\bar{k}$ denotes the amount of capital that will be available next period and where δ denotes the rate at which capital depreciates.

The representative firm will find it profitable to invest as long as the rate of return available on investment projects exceeds the cost of financing the projects. Formally, the profit-maximizing condition is

$$MP_{\bar{k}} + 1 - \delta = r, \tag{10}$$

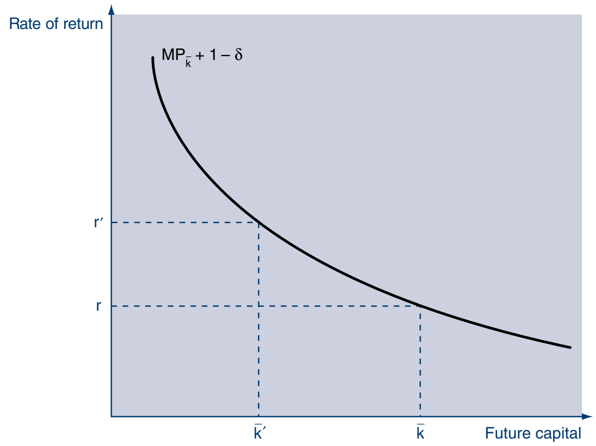
where $MP_{\bar{k}}$ denotes the marginal product of next period's capital stock. Intuitively, the marginal unit of capital investment is expected to produce $MP_{\bar{k}}$ units of additional output next period and has a scrap value equal to $1 - \delta$. Thus, the left-hand side of equation 10 represents the expected marginal return to new capital investment. The right-hand side of the equation represents the return that firms must offer households to attract financing for capital investment.

Assuming that the marginal product of capital is decreasing in the quantity of capital, equation 10 implies that the quantity of capital demanded is decreasing in the real rate of return on bonds. In Figure 2, an increase in the real rate of return from r to r' causes the quantity of capital to fall from $\bar{k}$ to $\bar{k}'$.

Of course, the lower is the amount of capital demanded, the lower is current investment for any given current stock of capital (equation 9). A decline in current investment affects the current-period leisure–consumption opportunity locus of the representative household in exactly the same way as a decline in government purchases: it shifts the opportunity locus upward, over its entire length, by a constant amount.[4] Provided leisure and consumption are normal goods, the representative household will want more of both. In Figure 3, a decline in investment from i to i' moves the economy from E to E′, raising both equilibrium consumption and equilibrium leisure. Because the representative household is less willing to work than before, the real wage must rise. Because hours of work decline, so does output: consumption rises by less than investment falls.

Figure 2
The Demand for Capital

The demand for capital is decreasing in the real rate of return on bonds.



In summary, an increase in the real rate of return on bonds tends to reduce investment, freeing resources for current use. The representative household responds by increasing consumption. This positive relationship between the real rate of return on bonds and current consumption is plotted in Figure 4 and labeled "CS." The less sensitive is investment demand to changes in the real rate of return on bonds, the steeper is the CS schedule. In the absence of capital investment, the CS schedule is vertical.

Increases in the current productivity of labor and capital (increases in θ and σ) tend to raise the amount of consumption consistent with the clear-

[3] *The function h(•) is assumed to have a positive first derivative and a nonpositive second derivative. The assumption that the production function is additively separable between labor and capital, while not essential, substantially simplifies graphical analysis of the economy.*

[4] *Formally, the equation of the leisure–consumption opportunity locus is now* $c = \theta f(L - l) + \sigma h(k) - i - g$.

ing of the labor and output markets, shifting the CS schedule to the right. A decrease in current government purchases also results in a rightward shift in the CS schedule.[5] On the other hand, an anticipated increase in the *future* productivity of capital (an increase in $\bar{\sigma}$) will tend to raise current investment, reducing the amount of consumption consistent with the clearing of the labor and output markets and shifting the CS schedule to the left.[6] Changes in future government purchases and in the future productivity of labor have no effect on the CS schedule.

In summary, we have seen that the quantity of goods available to households for current consumption is an increasing function of the real rate of return on bonds, the current productivity of labor, and the current productivity of capital. It is a decreasing function of current government purchases and the expected future productivity of capital. Formally,

$$c = \underset{+\;\;+\;\;+\;\;-\;\;-}{c^S(r,\ \theta,\ \sigma,\ g,\ \bar{\sigma})}. \tag{11}$$

Deriving the IS curve. We have seen that an increase in the real return on bonds, because it induces a decline in investment, tends to free resources for current consumption while reducing the amount of output available for consumption in the future. At the same time, according to equation 5, an increase in the real return on bonds tends to raise households' incentive to save—that is, to *defer* consumption. Full market-clearing equilibrium requires that the real return on bonds adjust until these two opposing tendencies balance. The tendency for current consumption to rise with increases in r we have captured in the CS schedule. The tendency for current consumption to fall with increases in r can be captured in a schedule that is the natural counterpart, in an economy with forward-looking households, to the Keynesian IS

Figure 3
Effects of Decreased Investment

Leisure and consumption both increase in response to a decline in current investment.

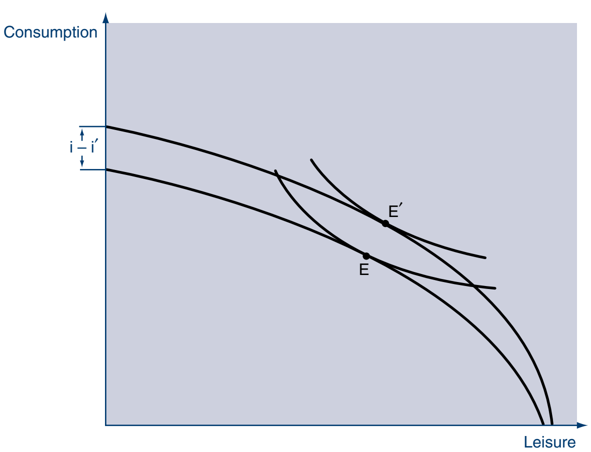
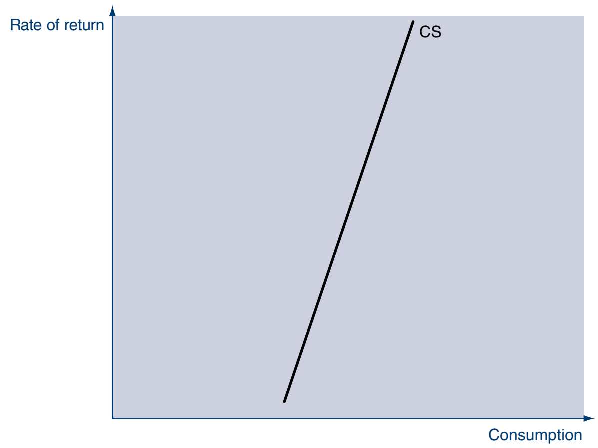


Figure 4
The CS Schedule

In a market-clearing economy, the amount of output available to consumers is increasing in the real rate of return.



[5] *Because a decrease in government purchases will also lead to an increase in leisure (leisure being a normal good), the rightward shift in the CS schedule must be smaller than the decrease in g.*

[6] *Because the impact of the higher investment will be absorbed partly through a decrease in leisure, the leftward shift in the CS schedule will be smaller than the increase in i.*

curve. Figure 5 illustrates the construction of this expectations-augmented IS curve in an economy with capital investment.

The upper left quadrant of Figure 5 displays three $MRS_{c\bar{c}}$ schedules, each corresponding to a different level of future consumption. (For convenience, the diagram assumes that the marginal rate of substitution depends only on the ratio of future consumption to current consumption. When current consumption and future consumption are equal, the marginal rate of substitution is ρ.) In an economy without capital investment, it is a marginal-rate-of-substitution schedule like one of those displayed in this quadrant that serves as the IS curve. With capital investment, however, the level of consumption next period is not independent of the real rate of return on bonds, complicating the construction of the IS curve. The three remaining quadrants of Figure 5 capture the links between future consumption and the real rate of return.

The upper right quadrant of Figure 5, replicating Figure 2, contains a plot of the marginal return on capital, net of depreciation, as a function of next period's capital stock. From equation 10, we know that for any given real rate of return on bonds, the schedule for the net marginal product of capital gives the optimal level of capital. The real return r_0 corresponds to a capital stock of $\bar{k}_0$, the real return r_1 corresponds to a capital stock of $\bar{k}_1$, and so on.

For each future capital stock, the lower right quadrant of Figure 5 gives the corresponding level of future consumption. From the perspective of next period, an increase in $\bar{k}$ represents an unambiguous increase in household wealth.[7] As such, a higher $\bar{k}$ tends to raise the level of consumption next period, $\bar{c}$. We will call the plot of this positive relationship the KC schedule.

Finally, the lower left quadrant of Figure 5 contains a 45-degree line.

According to Figure 5, at real rate of return r_0 ($< \rho$), firms desire capital stock $\bar{k}_0$, which is associated with future consumption $\bar{c}_0$. But if consumption next period is expected to be $\bar{c}_0$ and the real rate of return on bonds is r_0, then households will demand c_0 ($> \bar{c}_0$) units of consumption today. Similarly, at real rate of return r_1 ($= \rho$), consumption next period will be $\bar{c}_1$, and households will demand c_1 ($= \bar{c}_1$) units of consumption today. At rate of return r_2 ($> \rho$), consumption next period will be $\bar{c}_2$, and households will demand c_2 ($< \bar{c}_2$) units of consumption today. In general, corresponding to each real rate of return is a unique level of current consumption that is consistent with the optimal intertemporal allocation of output. As the real rate of return rises, the optimal level of current consumption falls. The locus of all these points constitutes the IS curve. That the IS curve is now flatter than any of the $MRS_{c\bar{c}}$ schedules reflects that in an economy with capital investment, future consumption falls as the real rate of return on bonds rises.

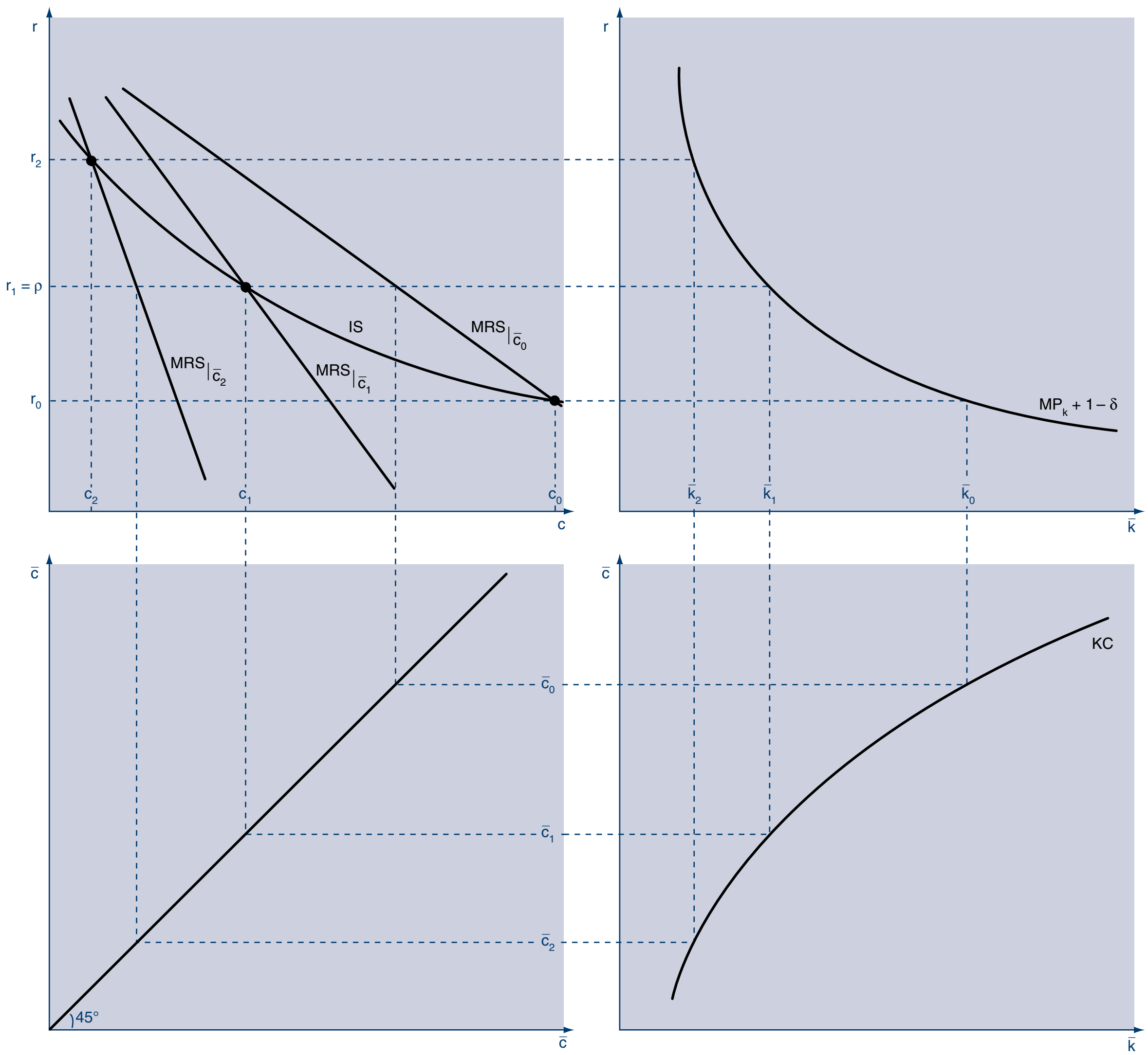
That the introduction of investment into an economy tends to flatten the IS schedule is a standard result in Keynesian macroeconomic theory. The usual story is that a given reduction in the real return on bonds now stimulates both an increase in consumption demand and an increase in investment demand, rather than an increase in consumption demand alone. However, the IS curve in Figure 5 is a plot in $c \times r$ space, not $y \times r$ space; so, finding that the IS schedule in this figure is flatter than before means that introducing investment has increased not just the interest sensitivity of the demand for *output* but also the interest sensitivity of the demand for *consumption*.[8]

Changes in current-period government purchases have no effect whatever on the schedules plotted in Figure 5. Consequently, these changes have no effect on the IS schedule. On the other hand, an anticipated decline in next period's government purchases will raise the amount of consumption available next period at each level of $\bar{k}$. In Figure 5, the KC schedule plotted in the lower right quadrant will shift upward, forcing the IS schedule to shift to the right. See Figure 6.

[7] *A one-unit increase in $\bar{k}$ shifts next period's leisure–consumption opportunity locus upward, along its entire length, by the amount $MP_{\bar{k}} + 1 - \delta$.*

[8] *Some empirical estimates suggest that the timing of consumption (as measured by the ratio of future consumption to current consumption) is largely insensitive to changes in the real interest rate (Hall 1988). However, to the extent that* investment *responds to interest rate changes, the analysis here demonstrates that current consumption demand may, nevertheless, have a significant interest elasticity.*

Figure 5
Construction of the IS Curve in an Economy with Capital Investment

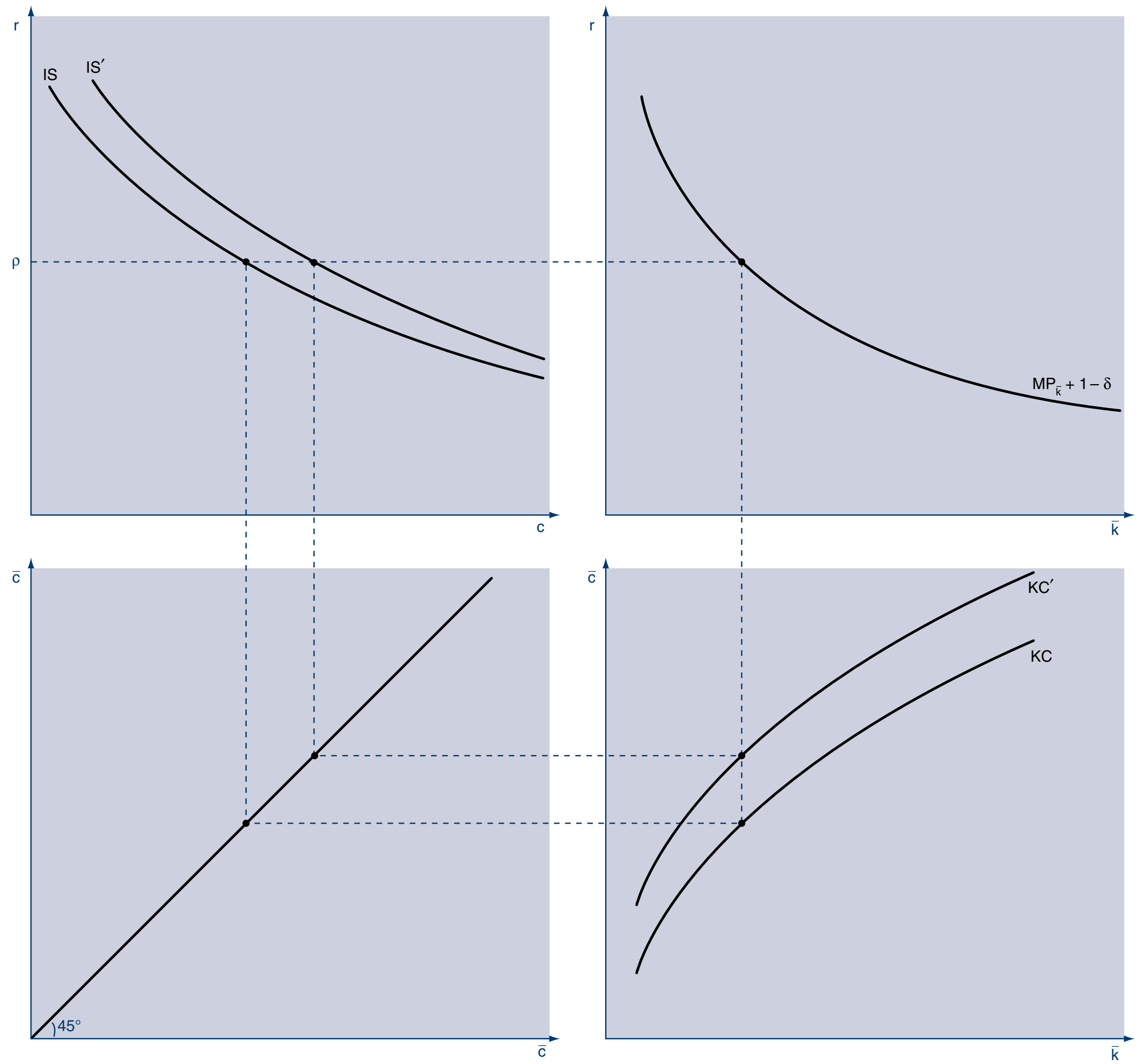


Because the effect next period of the lower government spending will be absorbed partly through an increase in leisure (much as, in Figure 3, the impact of reduced current investment is absorbed partly through an increase in current leisure), $\bar{c}$ rises less than one for one in response to the decrease in $\bar{g}$. It follows that the IS schedule shifts to the right by an amount that is smaller than the decrease in $\bar{g}$.

Like changes in current government purchases, current-period technology shocks have absolutely no effect on Figure 5 and, hence, no effect on the position of the IS curve. Anticipated changes in future technology are a different matter altogether. Anticipated increases in the future productivity of labor (anticipated increases in $\bar{\theta}$) raise the level of future consumption available at each level of $\bar{k}$ and, so, shift the IS schedule to the right. (Again, see Figure 6.) In the case of a positive shock to the future productivity of capital (an increase in $\bar{\sigma}$), the rightward shift in the IS schedule is reinforced by an upward shift in the marginal-productivity-of-investment schedule (*Figure 7*).

Figure 6
Anticipated Future Supply Shocks and the IS Schedule

A decline in future government purchases or an increase in the future productivity of labor shifts the IS schedule to the right.



In summary, the quantity of goods that households wish to purchase today is a decreasing function of the real rate of return on bonds and of expected future government purchases and is an increasing function of the expected future productivities of labor and capital. Formally,

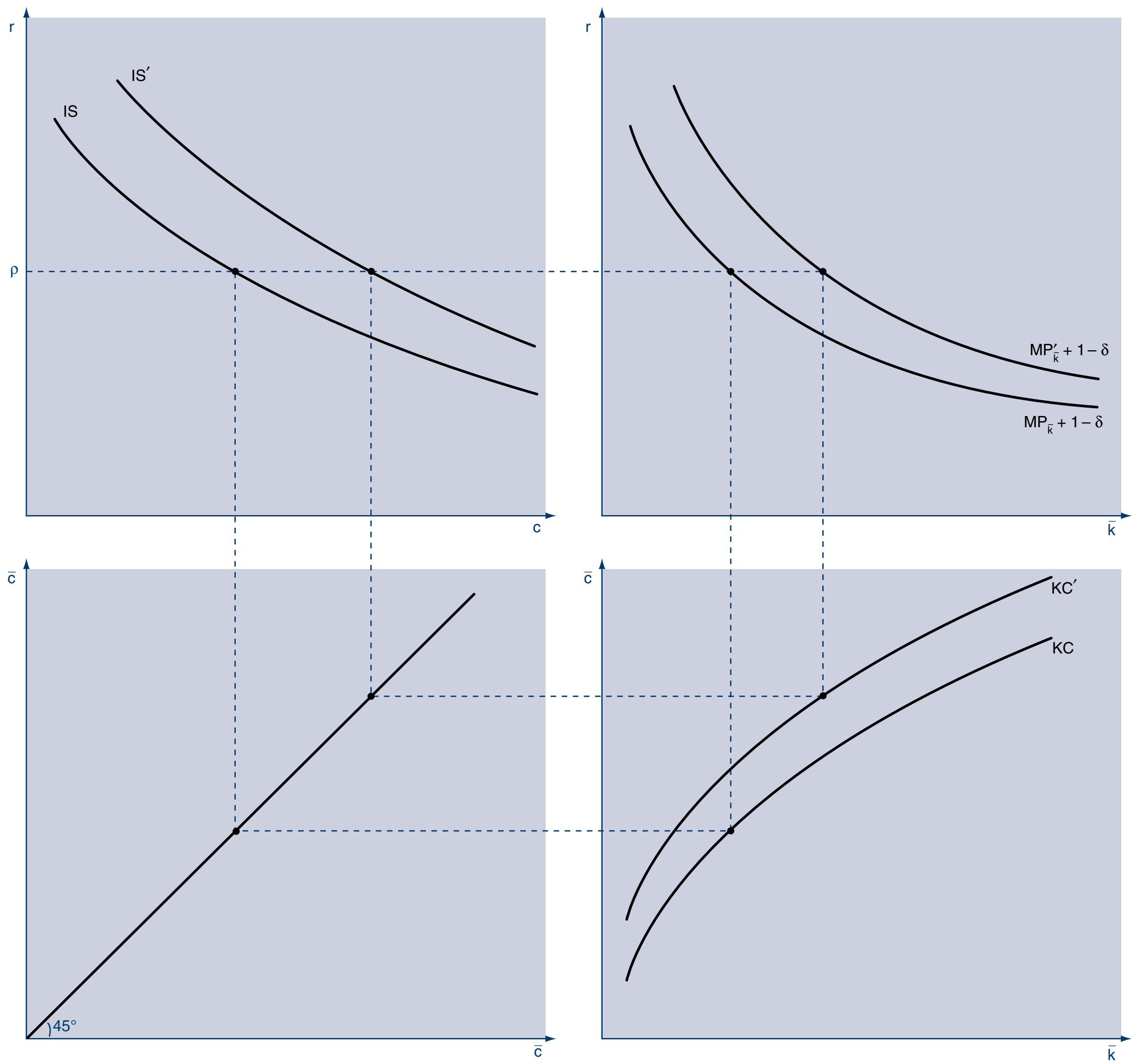
(12) $$c = c^D(\underset{-}{r}, \underset{-}{\bar{g}}, \underset{+}{\bar{\theta}}, \underset{+}{\bar{\sigma}}).$$

Comparative statics. Equilibrium is achieved where the IS and CS curves intersect (point E in Figure 8). It is at this point—and only at this point—that the labor, output, and bond markets simultaneously clear.

Shocks to the economy fall into three broad categories: monetary shocks, current supply shocks, and anticipated future supply shocks. Monetary shocks include changes in the current money

Figure 7
Anticipated Future Capital-Productivity Shocks and the IS Schedule

An increase in the future productivity of capital shifts the IS schedule to the right.

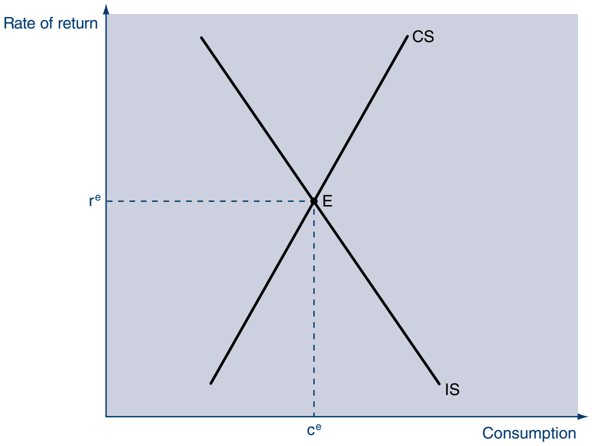


supply (M) and changes in the future price level ($\bar{P}$).[9] Current supply shocks include current-period shifts in the productivity of capital and labor (changes in σ and θ). From the perspective of households, changes in current government purchases (g) are supply shocks too: an increase in government purchases shifts the leisure–consumption opportunity set of the representative household downward by the amount of the increase in g.[10] Anticipated

[9] *Here, as in Part 1, the long-run price level is treated as a policy variable selected by the monetary authority.*

[10] *See Abel and Blanchard (1983) for further discussion of the equivalence between fiscal-policy shocks and supply-side shocks.*

Figure 8
Market-Clearing Equilibrium in an Economy with Capital Investment



future supply shocks include anticipated changes in the future productivity of labor (changes in $\bar{\theta}$) and anticipated changes in future government spending ($\bar{g}$). Anticipated changes in the productivity of capital (changes in $\bar{\sigma}$) act as both current *and* future supply shocks. A rise in the future productivity of capital increases the amount of output available for consumption next period but also tends to stimulate current investment, reducing the amount of output available for consumption today.

Monetary shocks have no effect on the CS and IS schedules and, hence, no effect on the equilibrium levels of consumption, the real rate of return on bonds, output, hours of work, or the real wage. By equations 6 and 7, monetary shocks affect only the nominal rate of return on bonds and the current price level.

Current supply shocks affect the CS schedule but not the IS schedule. Positive shocks to the current productivity of capital and labor and declines in current government purchases all tend to raise the amount of output available for current consumption, shifting the CS schedule to the right. Consequently, the real rate of return on bonds falls, and consumption rises. (In Figure 9, the equilibrium moves from point E to point E′.) The decline in the real return on bonds leads to an increase in investment. Thus, society transfers some of the increase in its current-period real opportunities into the future.

Anticipated future supply shocks affect the IS schedule but not the CS schedule. Anticipated positive shocks to the future productivity of labor and anticipated declines in future government purchases tend to increase future consumption at every given future capital stock, shifting the IS schedule to the right. The resultant increase in the real rate of return on bonds lowers current investment, freeing output for current consumption. (In Figure 10, the equilibrium moves from point E to point E′.) Thus, society transfers some of the increase in its future real opportunities into the present. Because current leisure is a normal good, it responds positively to the increase in household wealth. Consequently, current output must fall.

Like any other future supply shock, an anticipated increase in the future productivity of capital shifts the IS schedule to the right. Unlike other future supply shocks, an anticipated increase in the future productivity of capital has a direct positive impact on current investment demand and, so, has a direct negative impact on the amount of

Figure 9
Effects of a Positive Current Supply Shock in a Market-Clearing Economy

Positive current supply shocks shift the CS curve to the right, increasing equilibrium consumption and lowering the equilibrium real rate of return.

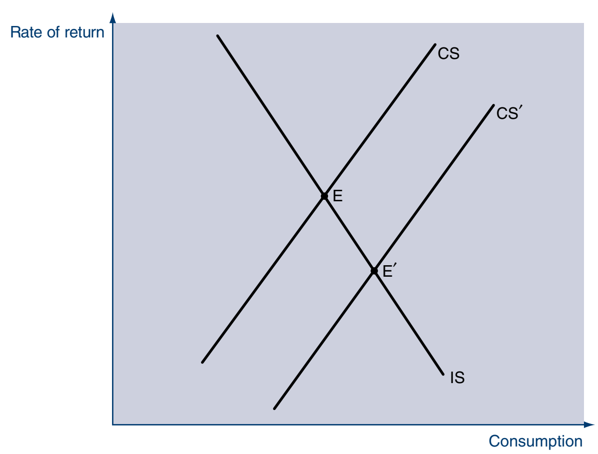
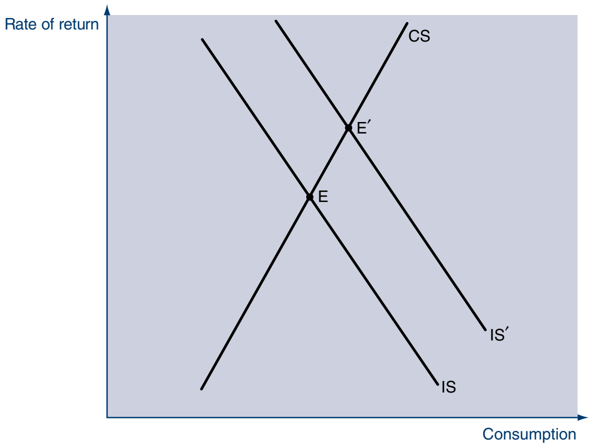


Figure 10
Effects of a Positive Anticipated Future Supply Shock in a Market-Clearing Economy

A decline in future government purchases or an increase in the future productivity of labor raises equilibrium consumption and the real rate of return.



current output available to consumers. In this respect, an anticipated increase in the future productivity of capital acts like an adverse current supply shock, shifting the CS schedule to the left. The leftward shift in the CS schedule combines with the rightward shift in the IS schedule to drive the real return on bonds sharply higher. (See Figure 11.) The net impact on current consumption—and, hence, current investment as well—is ambiguous. Current consumption tends to rise because the increase in the real return on bonds moves firms back along their investment demand schedules, putting downward pressure on current investment. Current consumption tends to fall because firms' investment demand schedules shift upward in direct response to the productivity shock, tending to stimulate current investment. Current leisure moves in the same direction as current consumption. Current output moves opposite to current leisure.

Investment and expectations-augmented IS–LM analysis

We turn now to a thought experiment in which the price level responds to new information with a one-period lag. As is traditional in Keynesian analysis, we assume that output is demand-determined over the interval during which the output market fails to clear. The interest rate adjusts instantaneously to maintain equilibrium in the markets for credit and money. Graphically, equilibrium is achieved at the intersection of the IS and LM curves.

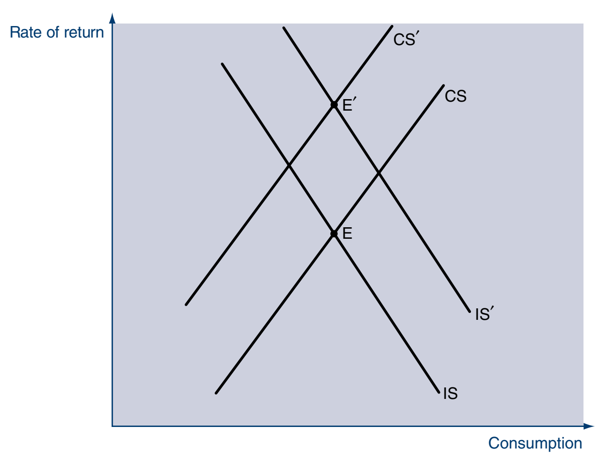
Results are little different from those obtained for an economy without investment. An exception is that positive anticipated future supply shocks may easily have a contractionary short-run effect in an economy with investment. Also, the fact that the IS curve is more elastic in an economy with investment than in an economy without investment means that monetary shocks have a larger short-run impact on consumption than before, while anticipated future supply shocks have a smaller short-run impact on consumption than before.

The LM curve. As in Part 1 of this article, the LM curve is obtained by combining equations 6 and 7 to obtain

$$(6') \qquad MRS_{mc} = 1 - P/(r\overline{P}).$$

Figure 11
Effects of an Anticipated Rise in the Productivity of Capital in a Market-Clearing Economy

An increase in the future productivity of capital raises the equilibrium real rate of return and has an ambiguous effect on consumption.



Because the marginal rate of substitution between real money balances and consumption is decreasing in real balances and increasing in consumption, equation 6′ implies that there is a positive relationship between consumption and the real return on bonds for given values of the current money supply, the current price level, and the monetary authority's long-run price level target. This positive relationship is the LM schedule.

Comparative statics. Much as in an economy without investment, increases in the current money supply or in the monetary authority's long-run price level target shift the LM curve to the right, driving down the real rate of return on bonds and stimulating consumer demand. However, consumption now rises not only because the fall in the real rate of return induces households to increase current consumption relative to future consumption but also because a lower real rate of return on bonds leads to higher investment and, hence, higher future consumption.

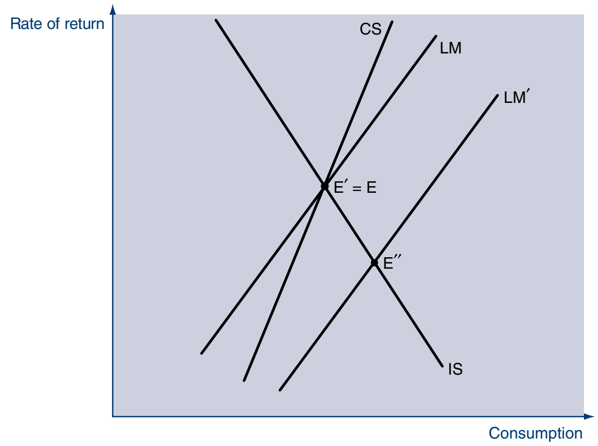
Figure 12 compares the impact of expansionary monetary policy on an economy with lagged price adjustment with the impact of expansionary monetary policy on an otherwise identical economy in which price adjustment is instantaneous. In the latter economy, the current price level rises—instantaneously—by enough to keep the LM curve in its original position, so that the IS–LM and IS–CS intersections remain coincident at point E. In the former economy, equilibrium moves from E to E″ in response to the policy shift. The real rate of return falls, and consumption rises. Thus, to the extent that short-run price adjustment is incomplete, the economy is overly responsive to changes in monetary policy.

In contrast, an economy with incomplete short-run price adjustment is *insufficiently* responsive to current-period supply shocks. In Figure 13, when the price level is fixed, neither the IS curve nor the LM curve moves in response to a cut in current-period government spending, an increase in the current-period productivity of capital, or an increase in the current-period productivity of labor. Thus, the economy remains at its initial equilibrium, point E, after any of these shocks. The market-clearing equilibrium shifts to E′, however, at the intersection of the IS schedule and the new CS schedule. At E′, consumption is higher than originally, and the return on bonds is lower than originally. To eliminate what would otherwise be an excess demand for real money balances, the price level will fall (instantaneously), shifting the LM curve to the right until it intersects the IS curve at E′.[11]

Whether an economy with incomplete short-run price adjustment is overly sensitive or insufficiently sensitive to anticipated future shocks to the productivity of labor and anticipated future changes in government purchases depends on whether the LM curve is flatter or steeper than the CS curve. Whether the LM curve is flatter or steeper than the CS curve depends, in turn, on the relative interest sensitivities of the demand for money and the demand for capital. Both an anticipated cut in future government purchases and an anticipated increase in the future productivity of labor shift

Figure 12
Comparative Effects of Expansionary Monetary Policy

If the price level fails to adjust fully, expansionary monetary policy will increase consumption relative to its market-clearing level and will lower the real rate of return relative to its market-clearing level.



[11] *To avoid undue complexity, this shift in the LM schedule is not illustrated in Figure 13.*

the IS schedule to the right, without affecting the LM and CS schedules. If the LM and CS schedules happen to have the same slope, no price adjustment is required for the economy to remain in full market-clearing equilibrium. The new market-clearing equilibrium, point E′, and the new sticky-price equilibrium, point E″, coincide. On the other hand, if the LM schedule is flatter than the CS schedule—as will certainly be the case in an economy without investment—then some increase in the price level is required if consumption is not to overshoot its market-clearing equilibrium level. Figure 14 illustrates both the case in which the LM schedule is flatter than the CS schedule and the case in which the LM schedule is steeper than the CS schedule.

Two additional observations are appropriate before we consider the impact of prospective shocks to the productivity of capital. First, recall that the IS schedule is flatter in an economy with investment than in an economy without investment. It follows that anticipated changes in the future productivity of labor and in the future level of government purchases will have a smaller effect on equilibrium consumption in a sticky-price economy with investment than in a sticky-price economy without investment.

Second, note that in a sticky-price economy with investment, unlike in one without investment, there is the possibility that a prospective positive supply shock will actually be contractionary in the short run. Although current-period consumption unambiguously rises in response to a prospective positive supply shock, so too does the real return on bonds. If the LM curve is sufficiently steep, the increase in the real return on bonds may have such a large negative impact on investment that the overall demand for output declines. Thus, an announcement of, say, military spending cuts may have an adverse impact on today's economy, even if the cuts are not scheduled to occur for some time.

Consider, finally, the effects of an anticipated future increase in the productivity of capital. In a market-clearing economy, we know that the IS curve shifts to the right, but the CS curve shifts

Figure 14
Comparative Effects of a Positive Anticipated Future Supply Shock

Depending on the steepness of the LM curve relative to the CS curve, consumption and the real rate of return may be insufficiently responsive to future supply shocks or overly sensitive to future supply shocks when the price level is sticky.

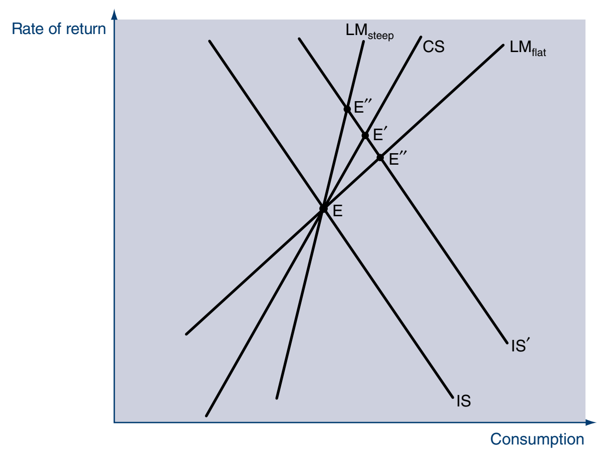
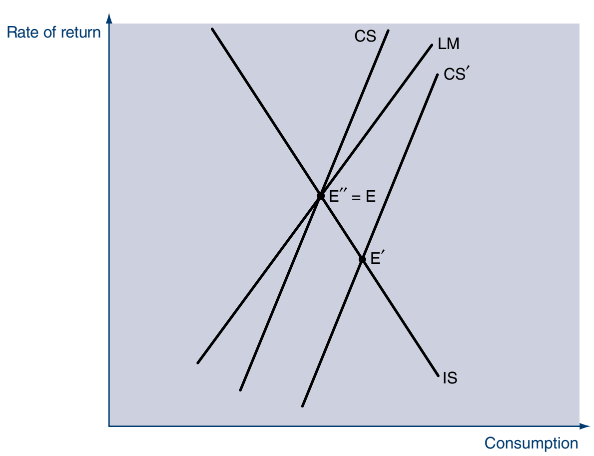


Figure 13
Comparative Effects of a Positive Current Supply Shock

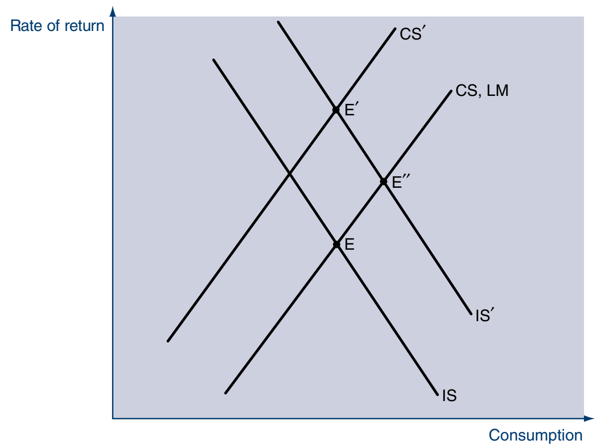
If the price level fails to adjust fully, a positive current-period supply shock will leave consumption below its new market-clearing level and will leave the real rate of return above its new market-clearing level.



to the left (*Figure 11*). If the price of output fails to adjust in the short run, the same rightward shift takes place in the IS schedule, but the LM curve remains fixed. One cannot say, in general, whether the new equilibrium level of consumption in the sticky-price economy will be above or below the equilibrium level of consumption in the market-clearing economy. Clearly, though, consumption in the sticky-price economy is more likely to be overly sensitive to an anticipated future increase in the productivity of capital than to anticipated future shocks to government purchases or the productivity of labor. Figure 15 illustrates the special case in which the LM and CS schedules have the same slope. Equilibrium moves from E to E′ in the market-clearing economy and from E to E″ in the sticky-price economy.

Figure 15
Comparative Effects of an Anticipated Rise in the Productivity of Capital

Unless the LM curve is steeper than the CS curve, an increase in the future productivity of capital will have too large an effect on consumption and too small an effect on the real rate of return when the price level is sticky.



Summary and conclusion

There is nothing in IS–LM analysis that an individual enamored of real-business-cycle theory ought to find objectionable *in principle*. The IS curve is simply the locus of points where the credit market clears. The LM curve is the locus of points where the demand for money equals the supply of money. As long as the credit and money markets clear, therefore, the equilibrium of the economy must correspond to an IS–LM intersection. Real-business-cycle models require, additionally, that the wage rate and price level adjust instantaneously to clear the markets for labor and output. (Graphically, the price level adjusts to ensure that the LM schedule crosses the IS schedule at the point where the IS and CS schedules intersect.) Thus, the real-business-cycle model can be thought of as a special case of the IS–LM model, obtained by imposing additional restrictions.

If there is a problem with IS–LM analysis from a real-business-cycle perspective, it is the way in which IS–LM analysis has traditionally been implemented. Thus, in deriving the IS curve, macroeconomic textbooks have typically assumed that household consumption decisions are made according to myopic rules of thumb. In addition, in deriving the economy's "long-run aggregate supply schedule," traditional Keynesian analyses have ignored the effects of changes in wealth on the supply of labor. Both Part 1 and Part 2 of this article have worked through a version of IS–LM analysis in which the determinants of consumption and the supply of labor are consistent with real-business-cycle theory. The more fully prices adjust in this version of IS–LM analysis, the more closely its predictions conform to those of a standard real-business-cycle model.

Even if prices adjust instantaneously to clear all markets, the optimality conditions that define the IS and LM schedules are no mere sideshow. This statement applies especially to an economy with capital investment, for in such an economy, the equilibrium level of output cannot be determined independently of the IS equation. Even in an economy without investment, the LM equation is needed to determine the price level, and the IS equation is needed to determine the real return on bonds.

In comparing the predictions of our expectations-augmented IS–LM analysis with those of traditional IS–LM analysis, several broad similarities are evident. For example, both models yield substantially similar predictions regarding the impact of an increase in the money supply: insofar as prices fail to rise, interest rates will fall, stimulating consumption and investment. Both models also yield substantially similar predictions regarding the impact of current-period supply shocks: such shocks have no impact on real variables except to the extent that the shocks are accompanied by changes in the price of output.

The traditional and expectations-augmented IS–LM analyses differ most substantially in their predictions regarding the impact of anticipated *future* supply shocks. Traditional analysis pays scant attention to such shocks, except future shocks to the marginal product of capital. In the traditional analysis, a positive shock to the marginal product of capital stimulates investment, drives output above its market-clearing level, and has an ambiguous effect on current consumption. According to the expectations-augmented IS–LM model developed here, on the other hand, it is the response of *investment* to a capital productivity shock that is ambiguous, and it is the response of *consumption* that is clearly positive. Furthermore, output need not be driven above its market-clearing level. More generally, any shock that tends to increase expected future consumption also has a positive impact on current consumption in the expectations-augmented IS–LM model.

The simple version of the consumption-based capital asset pricing model (CCAPM) that is the basis for the IS curve in expectations-augmented IS–LM analysis is rejected in most empirical tests. However, relatively minor modifications to the CCAPM are sufficient to achieve congruence with the data. One approach is to relax the assumption that consumption and real money balances are additively separable in the household utility function (Koenig 1990b). Another approach is to assume that some fraction, λ, of households consume myopically (Campbell and Mankiw 1989). The larger is this fraction, the more the economy behaves as predicted by the traditional IS–LM model. (See the Appendix to Part 1 of this article.) Most empirical estimates indicate that a substantial fraction of households are forward-looking (Hall and Mishkin 1982; Jappelli 1990).

An interesting extension of the current model is a version in which price adjustment occurs gradually, over several periods, rather than all at once. If, in an otherwise conventional IS–LM model, households have forward-looking inflation expectations, increased price flexibility is potentially destabilizing (De Long and Summers 1986)—a result that is very much in the Keynesian tradition (Tobin 1993). However, Koenig (1990a) has shown that the potentially destabilizing effects of price flexibility are unlikely to be a concern if households are forward-looking when making their consumption decisions.

Another interesting extension of the current model would allow capital investment to become productive before the price of output has a chance to adjust fully to its market-clearing level. In such a model, the demand for capital is driven, partly, by expectations of future sales. This "accelerator" model of investment can have bizarre implications if combined with forward-looking consumption behavior (Koenig 1989; King 1993).

To say that the expectations-augmented IS–LM model includes a standard real-business-cycle model as a special case is certainly not to claim that the augmented IS–LM model encompasses all—or even the most promising—alternatives to Keynesian orthodoxy.[12] Nevertheless, insofar as expectations-augmented IS–LM analysis helps close the gap that currently separates the Keynesian and real-business-cycle paradigms, it provides a valuable service.

[12] *For an overview of some of the new alternatives to the Keynesian and real-business-cycle paradigms, see Romer (1993).*

Appendix

Derivation of the Comparative Statics Results for a Market-Clearing Economy

Exogenous investment

Suppose that the household utility function is additively separable across time and, also, between real money balances and other household utility arguments. Then equations 1, 2, 3, 4′, and 8′ can be solved for the market-clearing level of consumption (as well as the market-clearing levels of output, employment, leisure, and the real wage) as a function of government purchases, investment, the initial capital stock, and the technology-shift parameters, θ and σ.

We begin with the labor market. Combine equations 1 and 3, then differentiate, to obtain a linearized labor supply schedule:

(A.1) $$dw = \mu_c dc - \mu_l dn,$$

where $\mu_c \equiv \partial MRS_{lc}/\partial c > 0$ and $\mu_l \equiv \partial MRS_{lc}/\partial l < 0$. Similarly, equations 2 and 8′ yield a labor demand schedule:

(A.2) $$dw = f'd\theta + \theta f''dn,$$

where $f' > 0$ and $f'' < 0$. Solving A.1 and A.2 for equilibrium hours of work, we obtain

(A.3) $$dn = (f'd\theta - \mu_c dc)/(-\theta f'' - \mu_l).$$

In words, equilibrium hours of work are increasing in the labor-productivity-shift parameter, θ, and decreasing in equilibrium consumption, which proxies for wealth.

Next, we differentiate equations 4′ and 8′:

(A.4) $$dy = dc + d(g + i)$$

and

(A.5) $$dy = fd\theta + hd\sigma + \theta f'dn + \sigma h'dk.$$

Finally, substitute from A.3 into A.5, and then solve A.4 and A.5 for equilibrium consumption:

(A.6) $$dc = \left[\frac{\theta(f')^2 - f(\theta f'' + \mu_l)}{D}\right]d\theta - \left(\frac{\theta f'' + \mu_l}{D}\right)[hd\sigma + \sigma h'dk - d(g + i)],$$

where $D \equiv \theta f'\mu_c - (\theta f'' + \mu_l) > 0$. Thus,

(A.7) $$c = \psi(\theta, \sigma, k, g + i),$$

where $\psi_\theta > 0$, $\psi_\sigma > 0$, $\psi_k > 0$, and $-1 < \psi_{g+i} < 0$. Similarly,

(A.7′) $$\bar{c} = \psi(\bar{\theta}, \bar{\sigma}, \bar{k}, \bar{g} + \bar{i}),$$

where a bar over a variable indicates that it is evaluated in period 2. In Part 1 of this article, we assume that $d\sigma = dk = di = d\bar{\sigma} = d\bar{k} = d\bar{i} = 0$.

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Appendix

Derivation of the Comparative Statics Results for a Market-Clearing Economy—*Continued*

Endogenous investment: the CS and IS schedules

By using equations 8′, 9, and 10, the demand for capital and the demand for investment can be written as decreasing functions of the productivity-adjusted cost of capital:

$$\text{(A.8)} \qquad \bar{k} = \xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right)$$

and

$$\text{(A.9)} \qquad i = \xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right) - (1-\delta)k,$$

where $\xi(\bullet)$ is the inverse of $h'(\bullet)$, so that $\xi'(\bullet) < 0$. The CS schedule is obtained by substituting from A.9 into A.7:

$$\text{(A.10)} \quad c = \psi\left[\theta, \sigma, k, g + \xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right) - (1-\delta)k\right].$$

It follows that the CS schedule is upward sloping when plotted in $c \times r$ space. The schedule shifts to the right in response to increases in θ, σ, and k, and it shifts to the left in response to increases in $\bar{\sigma}$ and g.

In a two-period economy, $\bar{i} = -(1-\delta)\bar{k}$. More generally, $\bar{i} = \iota(\bar{k})$, with $\iota'(\bullet) < 0$. Hence, $\bar{c} = \psi[\bar{\theta}, \bar{\sigma}, \bar{k}, \bar{g} + \iota(\bar{k})]$ or, using A.8 to eliminate $\bar{k}$,

$$\text{(A.11)} \qquad \bar{c} = \psi\left\{\bar{\theta}, \bar{\sigma}, \xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right), \bar{g} + \iota\left[\xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right)\right]\right\}.$$

It follows that $\bar{c}$ is decreasing in the real rate of return on bonds, r.

If household preferences are homothetic in current and future consumption, equation 5 can be written in the form $c = \bar{c}\phi(r)$, where $\phi'(\bullet) < 0$. Then, by using A.11 to eliminate $\bar{c}$, the equation of the IS curve is

$$\text{(A.12)} \qquad c = \phi(r)\psi\left\{\bar{\theta}, \bar{\sigma}, \xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right), \bar{g} + \iota\left[\xi\left(\frac{r+\delta-1}{\bar{\sigma}}\right)\right]\right\}.$$

The demand for current consumption is decreasing in the real rate of return, not only because an increase in the rate of return induces substitution away from current consumption toward future consumption but also because an increase in the rate of return depresses capital accumulation, leading to a decline in future consumption. The IS schedule shifts to the right in response to increases

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Appendix

Derivation of the Comparative Statics Results for a Market-Clearing Economy—*Continued*

in $\bar{\theta}$ and $\bar{\sigma}$ and to the left in response to increases in $\bar{g}$.

Comparative statics

The horizontal shift in the CS schedule, which will be denoted ΔCS, is found by differentiating equation A.10:

$$\text{(A.13)} \quad \Delta CS = \psi_\theta d\theta + \psi_\sigma d\sigma + [\psi_k - (1-\delta)\psi_{g+i}]dk + \psi_{g+i}dg - \psi_{g+i}\left(\frac{r+\delta-1}{\bar{\sigma}}\right)\left(\frac{\xi'}{\bar{\sigma}}\right)d\bar{\sigma}.$$

This shift can be interpreted as a current-period supply shock. Even changes in $\bar{\sigma}$ shift the CS schedule only insofar as they affect the quantity of output drawn away from consumption into investment.

The horizontal shift in the IS schedule, which will be denoted ΔIS, is found by differentiating equation A.12:

$$\text{(A.14)} \quad \Delta IS = \left(\frac{c}{\bar{c}}\right)\left(\bar{\psi}_\theta d\bar{\theta} + \bar{\psi}_{g+i} d\bar{g}\right) + \left(\frac{c}{\bar{c}}\right)\left\{\bar{\psi}_\sigma - \left(\frac{\xi'}{\bar{\sigma}}\right)\left[\psi_k + \iota'\bar{\psi}_{g+i}\right]\left(\frac{r+\delta-1}{\bar{\sigma}}\right)\right\}d\bar{\sigma}.$$

This shift can be interpreted as the change in household demand for current consumption in response to anticipated future supply shocks. The IS schedule shifts only insofar as households expect a change in future consumption.

Finally, equilibrium consumption and the equilibrium real rate of return are found by equating A.10 and A.12. This calculation yields

$$\text{(A.15)} \quad dr = (\Delta IS - \Delta CS)/(\Sigma_{CS} - \Sigma_{IS})$$

and

$$\text{(A.16)} \quad dc = (\Sigma_{CS}\Delta IS - \Sigma_{IS}\Delta CS)/(\Sigma_{CS} - \Sigma_{IS}),$$

where

$$\text{(A.17)} \quad \Sigma_{CS} = \psi_{g+i}\xi'/\bar{\sigma} > 0$$

and

$$\text{(A.18)} \quad \Sigma_{IS} = \bar{c}\phi' + \left(\frac{c}{\bar{c}}\right)\left(\frac{\xi'}{\bar{\sigma}}\right)\left(\bar{\psi}_k + \iota'\bar{\psi}_{g+i}\right) < 0$$

are the slopes of the CS schedule and IS schedule, respectively. In particular,

$$\text{(A.19)} \quad \frac{dr}{d\bar{\sigma}} = \left\{\left(\frac{r+\delta-1}{\bar{\sigma}}\right)\left[\left(\frac{\xi'}{\bar{\sigma}}\right)\psi_{g+i} - \left(\frac{\xi'}{\bar{\sigma}}\right)\left(\frac{c}{\bar{c}}\right)\left(\bar{\psi}_k + \iota'\bar{\psi}_{g+i}\right)\right] + \left(\frac{c}{\bar{c}}\right)\bar{\psi}_\sigma\right\}\left(\frac{1}{\Sigma_{CS} - \Sigma_{IS}}\right) > 0,$$

and

$$\text{(A.20)} \quad \frac{dc}{d\bar{\sigma}} = \left(\frac{1}{\Sigma_{CS} - \Sigma_{IS}}\right)\left(\frac{\xi'}{\bar{\sigma}}\right)\left[\left(\frac{c}{\bar{c}}\right)\bar{\psi}_\sigma + \phi'\bar{c}\left(\frac{r+\delta-1}{\bar{\sigma}}\right)\right]\psi_{g+i}.$$

The latter expression is of ambiguous sign.

References

Abel, Andrew B., and Olivier J. Blanchard (1983), "An Intertemporal Model of Saving and Investment," *Econometrica* 51 (May): 675–92.

Barro, Robert J. (1990), *Macroeconomics*, 3d ed. (New York: John Wiley and Sons).

Campbell, John Y., and N. Gregory Mankiw (1989), "Consumption, Income, and Interest Rates: Reinterpreting the Time Series Evidence," in *NBER Macroeconomics Annual 1989*, ed. Olivier Jean Blanchard and Stanley Fischer (Cambridge, Mass.: MIT Press), 185–216.

De Long, J. Bradford, and Lawrence H. Summers (1986), "Is Increased Price Flexibility Stabilizing?" *American Economic Review* 76 (December): 1031–44.

Hall, Robert E. (1988), "Intertemporal Substitution in Consumption," *Journal of Political Economy* 96 (April): 339–57.

———, and Frederic S. Mishkin (1982), "The Sensitivity of Consumption to Transitory Income: Estimates from Panel Data on Households," *Econometrica* 50 (March): 461–81.

Jappelli, Tullio (1990), "Who Is Credit Constrained in the U.S. Economy?" *Quarterly Journal of Economics* 105 (February): 219–34.

King, Robert G. (1993), "Will the New Keynesian Macroeconomics Resurrect the IS–LM Model?" *Journal of Economic Perspectives* 7 (Winter): 67–82.

Koenig, Evan F. (1993), "Rethinking the IS in IS–LM: Adapting Keynesian Tools to Non-Keynesian Economies," pt. 1, Federal Reserve Bank of Dallas *Economic Review*, Third Quarter, 33–49.

——— (1990a), "Is Increased Price Flexibility Stabilizing? The Role of the Permanent Income Hypothesis," Federal Reserve Bank of Dallas Research Paper no. 9011 (Dallas, November).

——— (1990b), "Real Money Balances and the Timing of Consumption: An Empirical Investigation," *Quarterly Journal of Economics* 105 (May): 399–425.

——— (1989), "Are the Permanent-Income Model of Consumption and the Accelerator Model of Investment Compatible?" Federal Reserve Bank of Dallas Research Paper no. 8915 (Dallas, December).

Romer, David (1993), "The New Keynesian Synthesis," *Journal of Economic Perspectives* 7 (Winter): 5–22.

Tobin, James (1993), "Price Flexibility and Output Stability: An Old Keynesian View," *Journal of Economic Perspectives* 7 (Winter): 45–65.