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

Part 1

This article attempts to narrow the gap between two macroeconomic paradigms by showing that, in modified form, a graphical tool taken from one of these paradigms can be used to analyze models drawn from the other. The two paradigms are the Keynesian and real-business-cycle approaches to macroeconomics. The graphical tool is the IS–LM diagram.

The IS–LM diagram was originally developed by Hicks (1937) as a graphical representation of ideas put forth by Keynes in his *General Theory*. Not surprisingly, given its origins, the IS–LM diagram has come to be associated with traditional Keynesian macroeconomic analysis—analysis that treats household expectations as either irrelevant or exogenously determined and in which prices fail, in the near term, to clear the markets for goods and for labor. Not all Keynesians are comfortable with the assumption that households are myopic. Nevertheless, the IS–LM diagram remains the graphical framework of choice among those who treat sluggish price adjustment seriously.[1] Expectations have usually been incorporated into textbook IS–LM analysis in only the most rudimentary way.

Given its pedigree, the IS–LM diagram would seem ill-suited to analyzing an economy like that described by Barro (1990), in which prices adjust instantaneously to clear all markets, households are forward-looking, and macroeconomic fluctuations are due solely to shocks to tastes, technology, and government purchases. The point of this article, however, is that household myopia is not an essential component of the IS–LM framework. Once this myopia is eliminated, the IS–LM framework becomes flexible enough to encompass a simple Barro-style real-business-cycle model as a special case. Furthermore, in working through the modified IS–LM model, one gains an appreciation for which of the traditional Keynesian results flow from the assumed myopia of households, as opposed to sluggish price adjustment.

No attempt is made here to pass judgment on the relative merits of alternative models; nor does this article attempt to develop new theoretical insights. The models examined are simple, comparable to those typically included in popular undergraduate textbooks. A more intellectually satisfying reconciliation of the Keynesian and real-business-cycle paradigms would move away from the assumption—maintained throughout this article—that households and firms are price takers. Until research in this direction makes further progress, any device that provides common ground for macroeconomists and policymakers with differing perspectives provides a valuable service.

Overview

The article begins with a review of how a simple market-clearing economy responds to policy and technology shocks. Then, under the assumption that people comprehend the long-run implications of such shocks, the short-run responses of

Stephen P. A. Brown, Zsolt Becsi, and Mark A. Wynne offered valuable comments and suggestions. The views expressed are not necessarily those of the Federal Reserve Bank of Dallas or the Federal Reserve System.

[1] *Examples of intermediate-level texts that rely heavily on the IS–LM model are Mankiw (1992), Hall and Taylor (1988), Dornbusch and Fischer (1987), and Gordon (1987).*

the economy to current and anticipated future changes in the money supply, government purchases, and technology are determined. The short-run analysis has two parts. The first part is a thought experiment in which the dollar price of output is held fixed at an arbitrary level and output and employment are sales-determined. It is in this thought experiment that variants of the traditional IS and LM curves play an important role in determining the level of output. While the LM curve is fairly standard, the IS curve, because it reflects the savings decisions of households, depends heavily on expectations about the future. The final step in the analysis is to determine what, in fact, the short-run equilibrium price level will be. Depending on the speed of price adjustment, results either are identical to those obtained from Barro's real-business-cycle model or are reminiscent of those obtained from Keynesian models.

The essential features of the expectations-augmented IS–LM approach can be presented in a setting that abstracts from capital investment. In models without investment, causality runs entirely from the future to the present: the current actions of private decisionmakers depend on expected future economic conditions, while future economic conditions are independent of people's current actions. This one-way causality considerably simplifies the analysis of policy and technology shocks. Accordingly, I defer discussion of macroeconomic models with investment to Part 2 of the article, which will be published in a subsequent issue of this *Review.*

Long-run equilibrium

In real-business-cycle models, the economy is assumed always to be in a full-information, market-clearing equilibrium. This section reviews how a typical real-business-cycle economy responds to technology and policy shocks. Similar, but more detailed, analyses have been presented by Barro (1990) and Barro and King (1984). Later in the article, we allow for the possibility that sluggish price adjustment or imperfect information may delay the economy's response to current shocks. Accordingly, for our purposes, it is both convenient and accurate to call the full-information, market-clearing equilibrium "long-run equilibrium."

Briefly, the analysis of this section shows that an increase in government purchases raises long-run equilibrium output and employment while reducing long-run equilibrium consumption and the real wage. An adverse technology shock reduces long-run equilibrium output, the long-run equilibrium real wage, and long-run equilibrium consumption. Its effect on long-run equilibrium employment is ambiguous. The real interest rate is determined by the requirement that aggregate saving equal zero. Monetary policy determines the long-run equilibrium price level.

The representative household. The representative household is endowed with a certain quantity of time, L. The household divides this time between market and nonmarket activities (between "labor" and "leisure"). Earnings from market activities are used to purchase output from firms ("consumption"). To maximize its total satisfaction, the household will allocate its time so as to equate the rate at which it is willing to trade leisure for consumption to the rate at which leisure and consumption trade for one another in the marketplace. Thus,

$$MRS_{lc} = w, \tag{1}$$

where MRS_{lc} denotes the household's willingness to exchange leisure for consumption (its marginal rate of substitution between leisure and consumption) and where w denotes the real wage rate. It is usual to assume that both leisure and consumption are "normal" goods, meaning that as the household's wealth increases (holding the real wage constant), the household chooses more of both. In equation 1, assuming normality is equivalent to assuming that the marginal rate of substitution is a decreasing function of leisure and an increasing function of consumption.

Graphically, in a plot with leisure on the horizontal axis and consumption on the vertical axis, the real wage is the negative of the slope of the household's budget line, while the marginal rate of substitution is the negative of the slope of the household's indifference curve map. Equation 1 says that the household selects the point on its budget line that is tangent to one of its indifference curves. See Figure 1.

The representative firm. The representative firm hires labor from the representative household and produces output, which is sold either to households or to the government. The firm finds it profitable

Figure 1
The Representative Household

The representative household chooses l units of leisure and c units of consumption.

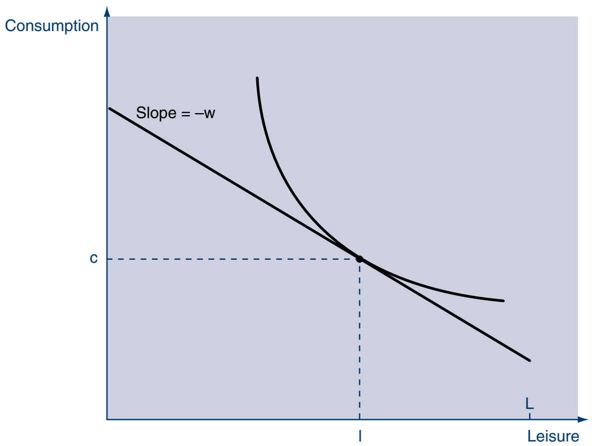
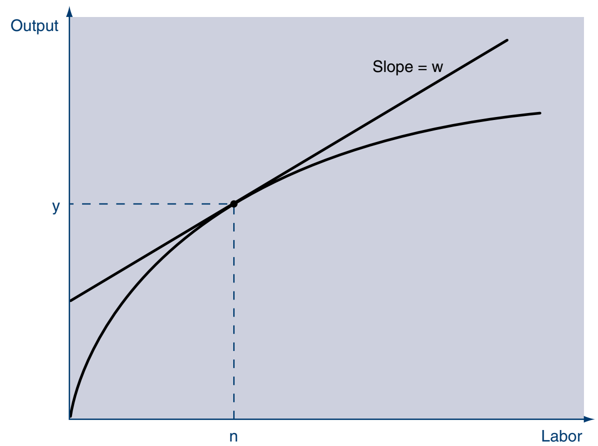


Figure 2
The Representative Firm

The representative firm hires n units of labor and produces y units of output.



to hire labor up to the point where the output produced by an additional unit of labor equals the real wage. Thus,

$$MP_n = w, \tag{2}$$

where MP_n denotes the marginal product of labor. It is usual to assume that labor is subject to the law of diminishing marginal returns: in equation 2, the marginal product of labor is a decreasing function of the hours of work purchased by the firm.

Graphically, equation 2 says that the firm will operate at that point on its production function where the slope of its production function equals the real wage. See Figure 2.[2]

The government. The government purchases output from firms, financing its spending with lump-sum (that is, nondistortionary) taxes. For simplicity, changes in government purchases will be assumed to have no effect on household preferences for private consumption and leisure and to have no effect on the production technology. As a practical matter, these simplifying assumptions mean that fluctuations in government purchases are probably best interpreted as the counterpart to threat-offsetting changes in real-world military spending.

Equilibrium. Figure 1 depicts the optimum of the representative household in a plot of consumption against leisure. Figure 2 depicts the optimum of the representative firm in a plot of output against labor. Leisure and labor are related to one another by the equation

$$n = L - l, \tag{3}$$

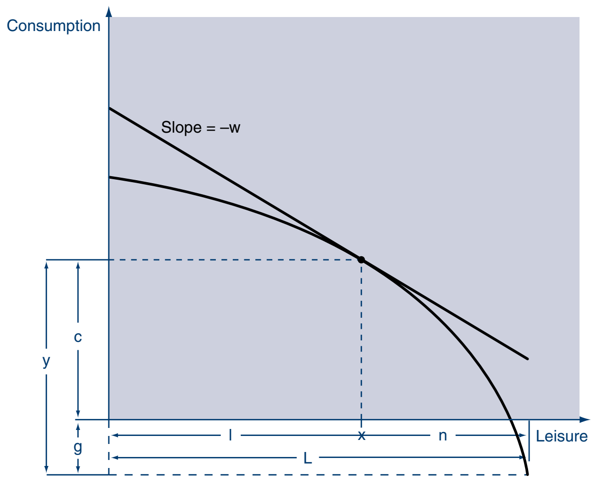
where n and l denote hours of work and of leisure, respectively. Output and consumption are related to one another by the equation

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

where y, c, and g denote output, consumption, and government purchases, respectively. Equations 3 and 4 allow one to transfer Figure 2 into the same space as Figure 1. This transfer is accomplished by taking the mirror image of Figure 2 and shifting the resultant graph downward by the amount g. See Figure 3. Finally, Figure 4 combines Figures 1 and 3 to depict the overall long-run equilibrium of the economy. In the figure, the

[2] *This and all subsequent figures assume that labor is essential to production.*

Figure 3
The Leisure–Consumption Opportunity Set of the Representative Household



equilibrium levels of leisure and consumption are l^e and c^e, respectively, and the equilibrium real wage is w^e.

Comparative statics. An increase in government purchases reduces the amount of output available for consumption at any given quantity of leisure. In Figure 4, the effect of an increase in government purchases is to shift the leisure–consumption opportunity locus downward by the amount of the increase in *g*. Because leisure and consumption are normal goods, the representative household will choose to absorb the impact of the downward shift in its opportunity locus by cutting back on *both* leisure and consumption, rather than on consumption alone. As shown in Figure 5, the new equilibrium of the economy is below and to the left of the original equilibrium. Because the new equilibrium lies to the left of the original equilibrium, it corresponds to a point that is farther out along the production function. Thus, output is higher—and the real wage is lower—than before. The intuition underlying these results is that households, feeling poorer, are more willing to work than before. The resultant rightward shift in the labor supply schedule drives down the equilibrium real wage, making it profitable for firms to increase hours of work and expand production.

An adverse technology shock, which might be due, for example, to a deterioration in the weather, can be modeled as a constant-percentage reduction in the amount of output produced at any given quantity of labor. In Figure 4, the leisure–consumption opportunity locus rotates downward, falling more (in absolute terms) at low levels of leisure than at high levels of leisure. The representative household is unambiguously worse off than before, and the reduction in its wealth tends to induce declines in both leisure and consumption (much as in Figure 5). On the other hand, the new opportunity locus is flatter than the old. The flattening of the opportunity locus reduces the marginal reward for working, so it provides households with an incentive to substitute leisure for consumption. The net effect of these wealth and substitution effects is negative for consumption but ambiguous for leisure. The decline in consumption is accompanied by an equal decline in output. The real wage falls, reflecting both households' increased supply of labor (due to the wealth effect) and firms' increased hesitancy to demand labor (due to labor's lower marginal productivity). See Figure 6.

The interest rate. In a full-information, market-clearing economy without capital investment, the real interest rate plays a largely passive role. As we have seen, the equilibrium levels of consumption, output, and hours can be found, in each period, without bringing the interest rate into the analysis

Figure 4
Long-Run Equilibrium

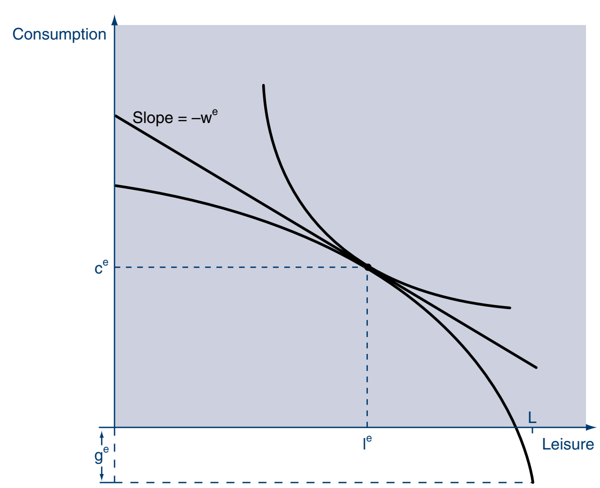


Figure 5
Effects of Increased Government Purchases

An increase in government purchases lowers equilibrium leisure and consumption.

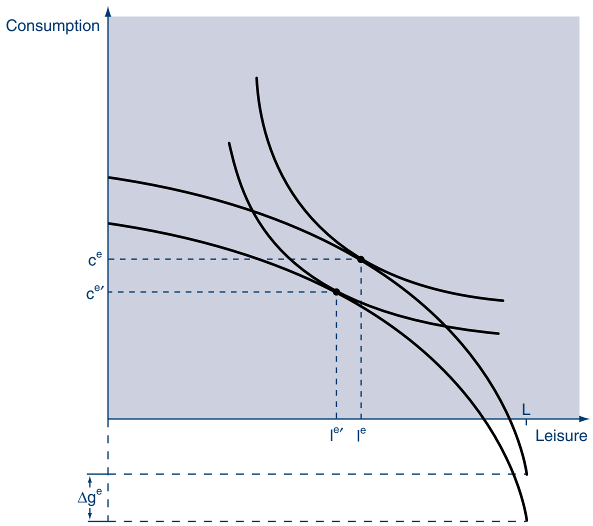
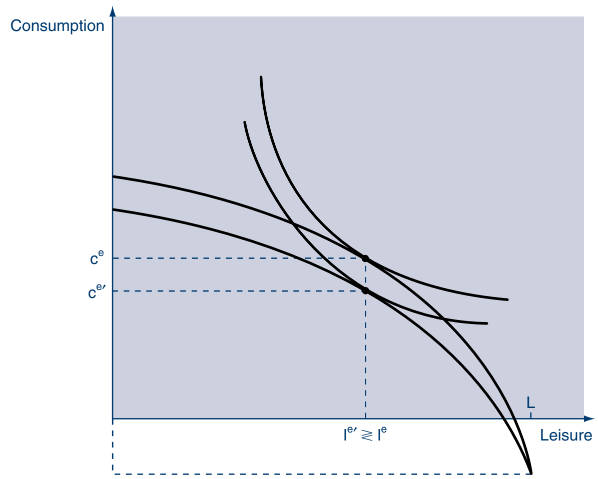


Figure 6
Effects of an Adverse Technology Shock

An adverse technology shock lowers equilibrium consumption and has an ambiguous effect on equilibrium leisure.



at all. It will, nevertheless, be useful later to have an expression for the equilibrium real return on bonds.[3] We can obtain such an expression from the representative household's optimality conditions.

Although aggregate saving must be zero in equilibrium, each individual household feels free to borrow and lend. The representative household will want to adjust its borrowing and lending until the rate at which it is willing to trade current consumption for future consumption matches the rate at which current consumption trades for future consumption in the marketplace. Thus,

$$MRS_{c\bar{c}} = r, \tag{5}$$

where $MRS_{c\bar{c}}$ denotes the amount of future consumption ($\bar{c}$) that the household requires as compensation for a one-unit reduction in current consumption and where r denotes the (gross) rate of return on bonds (equal to 1 plus the real interest rate). Turning equation 5 around and substituting into it equilibrium levels of current consumption and future consumption, each determined as in Figure 4, yields the real return on bonds that is consistent with zero desired aggregate saving.

Because current consumption and future consumption are normal goods, the marginal rate of substitution between current consumption and future consumption is negatively related to current consumption and positively related to expected future consumption. Hence, the equilibrium real rate of return rises in response to shocks that increase expected future consumption relative to current consumption. Intuitively, when they expect the future to be bright in comparison to the present, households are tempted to borrow against their future prosperity. In an economy without investment opportunities, the real interest rate must rise to choke off this incipient borrowing. When they expect the future to be dark in comparison to the present, households are tempted to save for the coming "rainy day." The real interest rate must fall until the desire to save is eliminated.

3 *Note that in an economy with identical households and no capital investment, government bonds are the only securities traded in equilibrium.*

Money and prices. There is no single, generally accepted way of modeling the demand for money.[4] Here, we assume that the representative household makes trade-offs between real money balances and consumption in much the same way it makes trade-offs between leisure and consumption. We assume, in particular, that the demand for real money balances is determined by the equation

$$(6) \qquad MRS_{mc} = (R - 1)/R,$$

where MRS_{mc} denotes the additional current consumption that the household demands in compensation for a one-unit reduction in end-of-current-period real money balances and where R denotes the gross nominal return on bonds. (Thus, R equals 1 plus the nominal interest rate.) Intuitively, MRS_{mc} is the rate at which the household is willing to trade money (m) for consumption, while $(R - 1)/R$ is the opportunity cost of holding money, measured in units of current consumption.[5]

Assuming that consumption and money balances are both normal goods, equation 6 implies that the demand for money is an increasing function of consumption and a decreasing function of the nominal return on bonds.[6]

The nominal rate of return on bonds is related to the real rate of return and inflation by the identity

$$(7) \qquad R = r\pi,$$

where π denotes the ratio of the future price level to the current price level. Hence, equation 6 can be rewritten as

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

where P and $\bar{P}$ denote the current price level and next period's price level, respectively.

Suppose that equation 6′ is satisfied in the current and all future periods. Then a simultaneous doubling of the current and all future nominal money supplies and of the current and all future price levels leaves equation 6′ unaltered. In general, the only effect of a once-and-for-all surprise change in the level of the nominal money supply is to cause a proportionate change in the price level. The equilibrium values of real variables are entirely unaffected.

A short-run thought experiment

There is considerable debate among economists about whether prices actually adjust sufficiently, in the short run, to keep the economy in full-information, market-clearing equilibrium. It is worthwhile, therefore, to adopt an analytical framework that allows price adjustment to be less than immediate. Even if one is personally convinced that market imperfections are of negligible importance, a framework that does not *impose* market clearing has the advantage of keeping channels of communication open to those holding contrary views.

Accordingly, this section attempts to answer a "What if…" question: What would happen to output and interest rates, in response to policy and technology shocks, if the price level were to remain fixed in the short run, with output and employment adjusting to match the level of sales?[7] The twist on traditional IS–LM analysis here is that

[4] *Most undergraduate macro textbooks assume that the demand for money is an ad hoc function of gross income. Real money balances are also sometimes modeled as an argument of the production function, as an argument of the household utility function, or as a constraint on current household spending (the "cash in advance" approach).*

[5] *By transferring \$1 from cash into bonds, the household raises its purchasing power in the next period by \$(R – 1), which has a current purchasing power of \$(R – 1)/R. See Barro (1990, 96–98). The Baumol–Tobin money demand model is obtained in the special case in which the household utility function takes the form* $u(c,m) = \ln(c) + \ln[2m/(2m + \gamma/P)] = \ln(C)$, *where* γ/P *is the real transaction cost associated with each exchange of interest-bearing assets for money and where* $C \equiv c[2m/(2m + \gamma/P)]$ *is consumption net of transaction costs.*

[6] *Both consumption and money balances are assumed to be additively separable from leisure in the household utility function, so that the marginal rate of substitution between real balances and consumption is independent of leisure.*

[7] *By assuming that production adjusts to match changes in sales, I avoid having to deal with the possibility that households might be rationed in the output market. Whether such rationing is of practical significance is controversial. For an attempt to analyze an economy in which such rationing occurs, see Neary and Stiglitz (1983).*

people's expectations of future economic conditions are acknowledged to be an important determinant of their current behavior, and people are assumed to comprehend fully the implications of each shock for the future course of the economy. For example, people recognize that a sustained increase in government purchases will eventually reduce the amount of output available for private consumption. Consequently, the announcement of a defense buildup may have an adverse impact on *current* household demand and, hence, on current output and employment.

We will assume that the short run in our thought experiment—the interval over which the price level is held fixed and output and employment are sales-determined—lasts only one period.[8] Next period, all markets are expected to clear, with equilibrium determined as in Figure 4.

The IS and LM curves. We adopt the standard Keynesian assumption that the markets for money and bonds must continue to clear, even if the markets for output and employment do not. The requirement that the demand for money equal the supply of money yields the LM schedule. The requirement that the supply of bonds equal the demand for bonds—or, equivalently, that investment equal savings—yields the IS schedule.

Here, the demand for money is determined by equation 6′. Because the current price level is held fixed in our thought experiment, the monetary authority controls the short-run *real* money supply through its choice of the short-run *nominal* money supply. Thus, for a given short-run nominal money supply and long-run price level target, equation 6′ defines an upward-sloping LM schedule.[9] The LM schedule shifts to the right in response to increases in the short-run nominal money supply and in response to increases in the monetary authority's perceived long-run price level target. The only unconventional feature of the LM schedule is that it is a relationship between *consumption* and the real rate of return on bonds rather than between *income* and the real rate of return on bonds.

The condition that investment equals savings, in the current model, reduces to the requirement that equation 5 be satisfied. Recall that the marginal rate of substitution between current consumption and future consumption, which appears on the left-hand side of equation 5, is a decreasing function of current consumption and an increasing function of expected future consumption. Consequently, for any given level of expected future consumption, equation 5 defines a negative relationship between current consumption and the real return on bonds. It is this negative relationship that takes the place of the traditional IS curve.[10]

Unlike the traditional IS curve, the IS curve defined by equation 5 depends explicitly on expectations of the future. Intuitively, households want to smooth consumption through time. If expected future consumption rises, households desire more consumption today as well. Thus, with current consumption plotted on the horizontal axis and the real return on bonds on the vertical axis, increases in expected future consumption shift the expectations-augmented IS schedule to the right. Indeed, when $MRS_{c\bar{c}}$ depends only on the ratio of future consumption to current consumption (that is, when household preferences are homothetic), the rightward shift in the augmented IS schedule is exactly proportionate to the increase in expected future consumption. The stronger is the desire to smooth consumption, the steeper is the IS curve.

It is important to note that the optimality conditions from which the expectations-augmented IS and LM curves are derived are not ad hoc additions to the full-information, market-clearing

8 *See Koenig (1987) for an analysis of the case in which the short run lasts several periods.*

9 *I have chosen to assume that the monetary authority targets the long-run price level because critics of Keynesian economic models have often advocated just such a policy. (See, for example, Barro 1986.) One could assume equally well that the monetary authority holds the long-run money supply fixed, that the monetary authority fixes money growth between the two periods, or that the monetary authority targets the rate of inflation between the two periods. Results differ, somewhat, depending on the long-run policy rule adopted (though the basic methodology outlined here carries through).*

10 *As defined here, the expectations-augmented IS curve is a relationship between consumption and the interest rate, rather than between income and the interest rate. Given the manner in which I have chosen to model the demand for money, plotting the expectations-augmented IS and LM curves in consumption × interest rate space seems natural. For further discussion, see the Appendix.*

economy we analyzed earlier. In that economy, equations 5 and 6′ played critical roles in determining the real return on bonds and the equilibrium price path. Now, with the current-period price level held exogenously fixed, these same equations determine the current-period levels of consumption, output, and employment.

Comparative statics. Figure 7 plots the expectations-augmented IS and LM curves defined by equations 5 and 6′ and illustrates the effects of an increase in the current-period money supply. As in traditional IS–LM analysis, consumption (and, so, output) rises and the real interest rate falls, eliminating what would otherwise be an excess supply of money.[11] Similar results are obtained if it becomes known that the monetary authority has adopted a higher long-run price level target.

An increase in current-period government purchases has no impact on either the IS or the LM curve and, hence, has no impact on consumption or interest rates. With consumption unchanged, output must rise by the full amount of the increase in government purchases. These results will seem strange to those used to textbook Keynesian analysis, and they merit explanation.

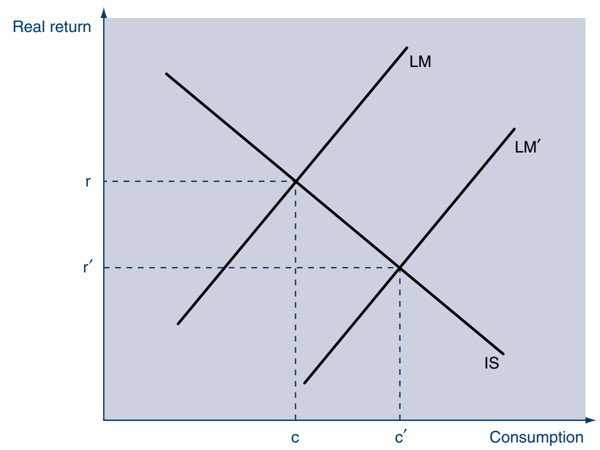
First, given that interest rates fail to rise, why is there no multiplier effect in the model developed here? That is, why does consumption remain constant, rather than increase, as aggregate income expands? In the standard textbook IS–LM model, households are assumed to ignore the future tax liabilities implied by an increase in government purchases. Consistent with most of the real-business-cycle literature, here we have implicitly gone to the opposite extreme and assumed that people are fully cognizant of the tax implications of changes in government spending. The absence of a multiplier effect is exactly what one would expect in a model in which the timing of (lump-sum) taxes is irrelevant, so that any change in government purchases might just as well be financed through an increase in current taxes.[12] After all, when a balanced-budget constraint is imposed on the textbook model, multiplier effects disappear from it too.

Second, interest rates fail to rise in response to increased government purchases because the demand for money is a function of consumption rather than income.[13] If the more conventional textbook specification of money demand were adopted, the current model would yield the standard result that increases in government purchases tend to raise interest rates. (See the Appendix.) Consumption would then tend to fall somewhat (though by less than the increase in government purchases) rather than remain constant.

Summarizing, the response of the current model to monetary policy is entirely conventional. The response of the current model to near-term

Figure 7
Impact of an Increased Money Supply

In the short run, for a given price level, an increase in the money supply raises consumption and lowers the real return on bonds.



[11] *Figure 7 assumes that household utility is additively separable between consumption and money balances. Though not essential to the analysis, this assumption is convenient and will be retained throughout the remainder of the article. For empirical evidence on the separability question, see Koenig (1990). For an analysis of the nonseparable case, see Koenig (1989).*

[12] *That the representative household cares only about the present discounted value of tax payments follows from equation 5.*

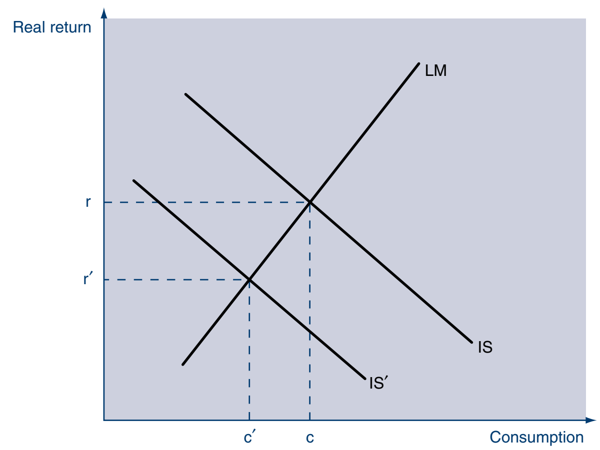
[13] *See Mankiw and Summers (1986) for an analysis of fiscal policy in a model in which the demand for money is a function of consumption, rather than income, but households are myopic.*

changes in fiscal policy would be much like that of a conventional IS–LM model with a balanced-budget constraint, were it not for our assumption that the demand for money depends on consumption rather than on gross income. This assumption is not essential to the expectations-augmented approach to IS–LM analysis.

Expectations-augmented IS–LM analysis, unlike conventional IS–LM analysis, explicitly recognizes that *prospective* fiscal and technology shocks can have every bit as much near-term impact on the economy as realized shocks. The impact of prospective shocks is transmitted to today's economy through changes in expected future consumption, which proxy for changes in permanent income. For example, we saw (in Figure 5) that an increase in long-run government purchases tends to lower long-run consumption. Thus, the prospect of a defense buildup will lower expectations of future consumption and, by equation 5, shift today's IS curve to the left. Today's consumption and today's interest rates, consequently, fall at any given current price level (*Figure 8*). Today's output falls, too, if current government purchases are unchanged. (See the box titled "The Short-Run Impact of a Permanent Defense Cut" for a discussion of what happens if current purchases and expectations of future purchases change simultaneously.) Effects qualitatively similar to those displayed in Figure 8 are also observed in response to a prospective adverse technology shock.

Figure 8
Impact of an Anticipated Increase in Future Government Purchases

In the short run, for a given price level, an anticipated increase in future government purchases lowers consumption and the real return on bonds.



Closing the short-run model

Thus far, our analysis has taken the short-run price level as given. This assumption is unnecessarily restrictive, and we now take steps to relax it. Several alternative models of short-run price determination are considered. At one extreme we have the real-business-cycle model, which assumes that the wage rate and price level adjust instantaneously to clear the labor and output markets. At the other extreme is a model in which output prices are set in contracts before complete information on technology and government policies is available. Between these extremes are models in which the price of output is flexible, but labor contracts prespecify the wage, and models in which firms adjust their output in partial ignorance of the prices prevailing in other markets.

As in the preceding section, we find that the tools of traditional Keynesian analysis can be adapted to analyze models in which people's current behavior depends nontrivially on their expectations of the future course of the economy. In particular, we can derive well-defined counterparts to the traditional Keynesian "aggregate demand" and "aggregate supply" curves. The intersection of these two curves determines the short-run equilibrium price and quantity of output.

The aggregate demand schedule. As a first step in the direction of relaxing the fixed-price assumption, consider what happens to the IS–LM intersection as the current price of output declines. The position of the IS curve depends only on future consumption, which is independent of the current price level. For any given current nominal supply of money, however, a decline in the current price level raises the real money supply, shifting the LM curve to the right, as in Figure 7. Given our assumption that the monetary authority targets the long-run price level, this rightward LM shift is not quite the end of the story. A lower current price level raises expected inflation (or lowers expected deflation) and, hence, lowers the demand for money at any given real rate of return on bonds, shifting the LM curve a bit further to the right (or, more accurately, down).[14] Thus, the level of current consumption determined by the intersection of the IS and LM curves rises as the current price level falls.

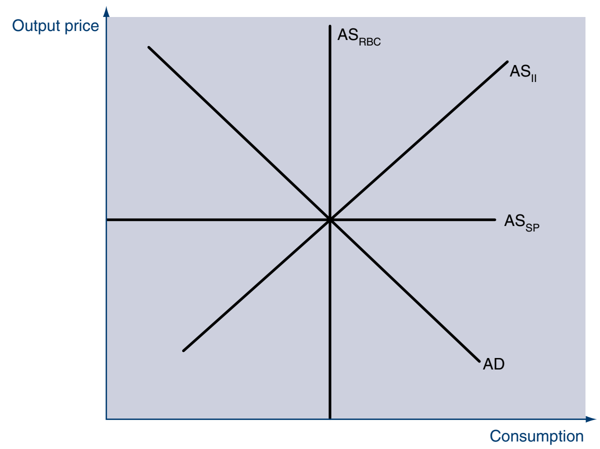
The negative short-run relationship between consumption and the price level is plotted in Figure 9 and labeled "*AD*." Like the so-called aggregate demand curve of traditional Keynesian analysis, the *AD* schedule represents output–price combinations (or, in the present model, consumption–price combinations) in which the demand for money equals the supply of money and, simultaneously, the representative household is content with the intertemporal allocation of output.

Obviously, any disturbance that shifts the IS–LM intersection to the right for a given price level will shift the *AD* schedule to the right by exactly the same amount. Thus, an increase in the current-period nominal money supply, an increase in the monetary authority's long-run price target, a cut in long-run government purchases, and positive long-run technology shocks will tend to move the *AD* schedule to the right. Changes in current technology and current government purchases, on the other hand, have no effect on the *AD* schedule.[15]

The aggregate supply schedule: alternative models

The real-business-cycle model. In the real-business-cycle model, prices adjust instantaneously to clear all markets. In the present context, equations 1 and 2, which define the supply of labor and the demand for labor, must both be satisfied—even

Figure 9
Aggregate Demand Curve with Alternative Aggregate Supply Schedules



in the short run. Thus, short-run equilibrium levels of consumption and leisure are determined as in Figure 4.

In Figure 9, the combinations of price and consumption consistent with the clearing of the labor market are labeled "AS_{RBC}." The curve AS_{RBC} is very much the counterpart of the traditional Keynesian "aggregate supply schedule," except that the curve AS_{RBC} represents the total amount of output available to the *private* sector rather than the total amount of output available to the public and private sectors combined. That the AS_{RBC} schedule is vertical reflects the fact that the indifference curves and production function plotted in Figure 4 are independent of the price of output.

The sticky-price model. The sticky-price model assumes that the price of output is fixed in advance. Usually, this approach also assumes that output adjusts one for one in response to unanticipated changes in sales. (Presumably, either labor contracts give employers discretion in setting hours of work or the wage rate adjusts so that employees are content with whatever hours are required of them.) Equation 2 may be satisfied ex ante but is not, in general, satisfied ex post.

In Figure 9, the assumption that output adjusts one for one in response to changes in sales at a preset price is reflected in a horizontal aggregate supply schedule, AS_{SP}.

[14] Note that this endogenous response of expected inflation to changes in P implies a more elastic aggregate demand curve than does an inflation target.

[15] If the demand for money were assumed to be a function of income rather than consumption, the IS, LM, and AD schedules would be more appropriately plotted with income on the horizontal axis. Increases in current government purchases would shift the IS schedule—and, hence, the AD schedule also—to the right, much as in a traditional Keynesian analysis.

The Short-Run Impact of a Permanent Defense Cut

In traditional textbook Keynesian analysis, no distinction is made between permanent changes and temporary changes in government purchases. Implicitly, the traditional analysis assumes that it is only the contemporaneous change in government purchases that affects the short-run equilibrium of the economy. In expectations-augmented IS–LM analysis, in contrast, whether a change in government purchases is thought to be temporary or thought to be permanent is of considerable importance. An analysis of the impact of a permanent cut in defense spending illustrates the point.

Recall that changes in government purchases that are expected to be transitory have no impact whatsoever on the expectations-augmented IS and LM schedules. In our short-run thought experiment, therefore, consumption and the real return on bonds are not affected by short-term defense cuts. Output falls one for one with government purchases: a $20 billion cut in defense spending results in a $20 billion decline in gross domestic product. A *prospective* change in government purchases, however, shifts the expectations-augmented IS schedule in the same direction as the resultant prospective change in long-run consumption. A prospective cut in the defense budget would, therefore, shift the IS schedule to the right. Assuming that preferences are homothetic in current and future consumption (so that the marginal rate of substitution between current and future consumption depends only on the ratio of current to future consumption) and assuming that current consumption and future consumption are initially equal, the rightward shift in the IS curve will exactly match the increase in future consumption. Because the LM schedule slopes upward, the actual short-run equilibrium level of consumption in our thought experiment rises by *less* than the increase in future consumption, which, in turn, rises by less than the future cut in government spending. If a $20 billion cut in the defense budget raises long-run consumption by $15 billion, then short-run consumption might rise by only $5 billion.

What, then, is the impact of an immediate, permanent cut in the defense budget? Consumption rises in the short run but not as much as it will rise in the long run. The prospect of a rising consumption path puts upward near-term pressure on interest rates. Output falls in the short run, by more than it will fall in the long run. In our numerical example, consumption rises by $5 billion in the short run and by $15 billion in the long run. Output falls by $15 billion in the short run and by $5 billion in the long run.

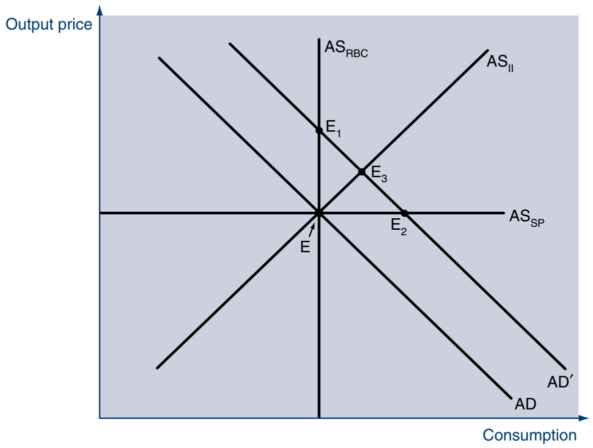
Of course, these results assume that the monetary authority holds both the long-run price level and the current money supply fixed.

The sticky-wage and imperfect-information models. Sticky-wage and imperfect-information models yield an aggregate supply schedule with an elasticity that lies between the elasticities of the real-business-cycle and sticky-price supply schedules. The sticky-wage model assumes that money wages are set in advance. If the price of output rises, unexpectedly, relative to the preset wage, firms find it profitable to expand their production and hiring (Fischer 1977; Taylor 1980). Equation 1 may be satisfied ex ante but is not, in general, satisfied ex post.

In the imperfect-information model, when a firm sees the price of its product rise, the firm is not certain whether this rise reflects an increase in the price of its product relative to the prices of other goods or, instead, an increase in the general level of prices. Because of this confusion, an unexpected increase in the general price level is

Figure 10
Impact of Monetary Stimulus

An increase in the current-period money supply or in the monetary authority's long-run price level target will shift the aggregate demand schedule to the right.



usually accompanied by some increase in each firm's output level. Each firm believes that its behavior is consistent with profit maximization but discovers, after the fact, that it was mistaken.[16]

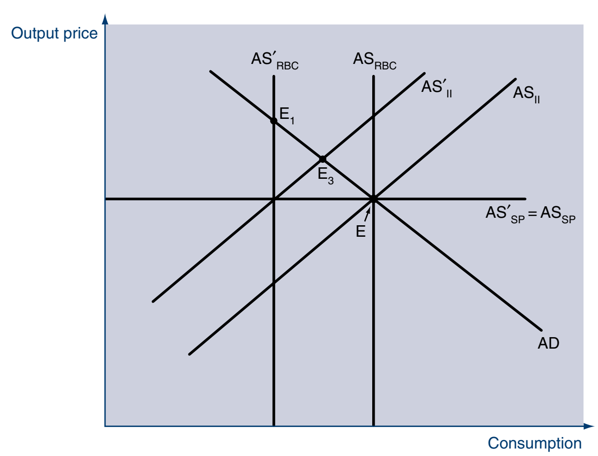
In Figure 9, the sticky-wage and imperfect-information models yield aggregate supply curves like that labeled "AS_{II}."

Comparative statics. Figure 10 illustrates the price and output (consumption) effects of a variety of economic shocks. Much as in the traditional Keynesian model, expansionary monetary policy—as reflected in either an unexpected increase in the current money supply or an upward revision in the monetary authority's perceived long-run price level target—shifts the aggregate demand schedule to the right. In the real-business-cycle model, the only effect of this shift is to cause an increase in the current price level.[17] (The economy moves from point E to point E_1.) In the sticky-price model, it is output, rather than the price level, that increases. (The economy moves from point E to point E_2.) The sticky-wage and imperfect-information models yield increases in both consumption and the price level. (The economy moves from point E to a point like E_3.)

As shown in Figure 11, an unexpected increase in current-period government purchases shifts each aggregate supply curve to the left. (Recall that "aggregate supply" in the current model refers to the amount of output available to the private sector, rather than the amount of output available to the economy as a whole.) In the real-business-cycle, sticky-wage, and imperfect-information versions of the model, consumption falls (but by less than the increase in government spending) and the price level is driven up. The economy moves from E to E_1 in the real-business-cycle model and from E to a point like E_3 in the sticky-wage and imperfect-information models. In the sticky-price model, output rises by the full amount of the increase in government spending, leaving consumption and the price level unchanged. (The economy stays at point E.)

Figure 11
Impact of Increased Government Purchases

An increase in current-period government purchases shifts the aggregate supply curve to the left.



[16] *For additional explanation of the imperfect-information model, see Lucas (1972), Barro (1990, chap. 19), or Mankiw (1992, chap. 11).*

[17] *Recall that, for simplicity, we are assuming that real money balances are additively separable from both consumption and leisure in the household utility function.*

An adverse current-period technology shock has consumption and price effects very like those associated with an increase in current-period government purchases.

Prospective changes in government purchases and technology affect the current-period equilibrium of the economy by altering households' long-run consumption prospects. The announcement of future defense cuts or the future implementation of improved technology will shift the current-period aggregate demand schedule to the right in much the same way as expansionary monetary policy. In Figure 10, the economy will move from E to E_1, E_2, or a point like E_3, depending on whether markets clear instantaneously, the short-run price level is fixed, or firms have difficulty distinguishing general price level movements from relative price level movements.

Concluding remarks

The basic idea underlying IS–LM analysis is that supply and demand in the financial markets determine the economy's short-run equilibrium quantities of labor and output in the event that the wage rate and price level fail to achieve their full-information, market-clearing levels. Traditional Keynesian analysis, in addition, treats household expectations as either exogenous or irrelevant. In this article, we have seen that it is possible to abandon traditional Keynesian myopia without abandoning the basic IS–LM framework.

Admittedly, the thought experiment that underlies IS–LM analysis seems artificial in real-business-cycle models, where prices adjust instantaneously to clear all markets. Even in real-business-cycle models, however, the equilibrium conditions used to derive the expectations-augmented IS and LM curves are indispensable. Thus, the "money demand equals money supply" condition that defines the LM curve determines the equilibrium price path in a real-business-cycle world, while the intertemporal optimality condition that defines the expectations-augmented IS curve determines the real interest rate. In brief, real-business-cycle models *impose* instantaneous market clearing. Expectations-augmented IS–LM analysis is *consistent* with instantaneous market clearing but allows for the possibility that price adjustment in the labor and output markets is less than immediate.

By analyzing a variety of macroeconomic models within a common framework, one obtains insights into how the models relate to one another, facilitating discussion. A particular advantage of the IS–LM approach developed here is that, in using it, one gains some appreciation for which of the traditional Keynesian results flow from the assumed myopia of households and firms, which flow from sluggish wage and price adjustment, and which flow from special assumptions about the determinants of the demand for money.

For example, the impact of monetary policy in the current model is quite traditional, despite forward-looking expectations and despite our use of consumption rather than income as the scale variable in the money demand function. On the other hand, we found that forward-looking expectations eliminate the short-run multiplier effect usually associated with an increase in current government purchases. And whether an increase in current government purchases puts near-term upward pressure on interest rates depends critically on how one models the demand for money.

Finally, the traditional distinction between demand shocks and supply shocks is blurred when household consumption demand is forward-looking, rather than myopic. Thus, the expectation of a future shift in aggregate supply—the result, perhaps, of an anticipated change in technology—affects current aggregate demand.

Postscript. *The analysis presented here is incomplete in that it fails to allow for endogenous changes in capital investment. This omission is potentially serious. Fluctuations in investment were given a prominent place in Keynes' own account of the business cycle. Recently, a study by Fama (1992) has confirmed that fluctuations in investment are an important source of transitory movements in real-world aggregate output. Accordingly, Part 2 of this article, to be published in a future issue of the* Economic Review, *extends the expectations-augmented IS–LM framework developed here to an economy in which investment is endogenous.*

Appendix

Derivation of the Comparative Statics Results

This Appendix formally derives many of the comparative statics results presented in the main text, and it clarifies the relationship between the model developed in this article and standard textbook Keynesian models.

The basic model

Suppose, for analytical convenience, that the representative household's willingness to trade current consumption for future consumption and its willingness to trade consumption for money balances depend only on the ratios of the quantities of the goods in question, so that, for example, the marginal rate of substitution between current consumption and future consumption depends only on the ratio of current consumption to future consumption.[1] Equations 5 and 6′ then imply

$$\text{(A.1)} \qquad c = \bar{c}\phi(r)$$

and

$$\text{(A.2)} \qquad m = c\kappa(r\bar{P}/P),$$

respectively, where both $\phi(\bullet)$ and $\kappa(\bullet)$ are strictly decreasing.

Equation A.1 defines an IS schedule, and equation A.2 defines an LM schedule. Differentiating logarithmically,

$$\text{(A.1′)} \qquad d\ln(c) = d\ln(\bar{c}) - \epsilon_\phi d\ln(r)$$

and

$$\text{(A.2′)} \qquad d\ln(c) = d\ln(M) - d\ln(P) + \epsilon_\kappa[d\ln(r) + d\ln(\bar{P}) - d\ln(P)],$$

where $\epsilon_\phi \equiv -r\phi'/\phi > 0$ and $\epsilon_\kappa \equiv -R\kappa'/\kappa > 0$ equal, in absolute value, the rate-of-return elasticities of consumption demand and money demand, respectively.

Solving for the percentage change in consumption and the percentage change in the real return on bonds,

$$\text{(A.3)} \qquad d\ln(c) = \{\epsilon_\kappa d\ln(\bar{c}) + \epsilon_\phi[d\ln(M) - d\ln(P)] + \epsilon_\kappa\epsilon_\phi[d\ln(\bar{P}) - d\ln(P)]\} /(\epsilon_\kappa + \epsilon_\phi)$$

and

$$\text{(A.4)} \qquad d\ln(r) = \{d\ln(\bar{c}) - [d\ln(M) - d\ln(P)] - \epsilon_\kappa[d\ln(\bar{P}) - d\ln(P)]\} /(\epsilon_\kappa + \epsilon_\phi).$$

Note that consumption and the real rate of return are increasing in expected future consumption. If households are forward-looking, we know that expected future consumption will be increasing in expected future productivity and decreasing in expected future government purchases: $\bar{c} = \psi(\bar{\theta},\bar{g})$, where $\bar{\theta}$ is a positive technology-shock variable and where $\psi_1 > 0$ and $-1 < \psi_2 < 0$. Increases in both current real money balances and expected inflation have a positive effect on current consumption and a negative effect on the real rate of return. Both consumption and the real rate of return are completely independent of

[1] This condition will be satisfied if the household utility function is additively separable in its arguments and preferences are homothetic. Additional realism can be obtained—at the expense of some additional complexity—by relaxing the separability conditions.

(Continued on the next page)

Appendix

Derivation of the Comparative Statics Results—*Continued*

current government purchases.

Thus far, we have treated the current price level, P, as fixed. If, at the opposite extreme, the wage rate and price level adjust instantaneously to clear the labor and output markets, current consumption is determined as in Figure 4—that is, $c = \psi(\theta, g)$. Given c and $\bar{c}$, equation A.1′ determines the real rate of return on bonds. Equation A.2′ determines the current price level. In general, one might expect the aggregate supply schedule to be neither horizontal nor vertical, so that the changes in consumption predicted by equation A.3 will be only partially offset by changes in P.

Encompassing traditional IS–LM analysis

By generalizing equations A.1 and A.2, we can formulate a model that includes traditional Keynesian IS–LM analysis as a special case. Suppose, in particular, that

$$\text{(A.5)} \qquad c = [\bar{c}\,\phi(r)]^{1-\lambda} y^{\lambda}$$

and

$$\text{(A.6)} \qquad m = c^{1-\gamma} y^{\gamma} \kappa(r\bar{P}/P),$$

where 0 $\lambda < 1$ and 0 γ 1. The parameter λ measures the "excess sensitivity" of consumption to current income.[2] The parameter γ will be positive to the extent that the demand for money depends on components of income other than consumption (Mankiw and Summers 1986). Standard textbook Keynesian analysis assumes that λ is close to 1 and that γ is equal to 1. Furthermore, expected future consumption ($\bar{c}$) is held fixed.[3]

Logarithmic differentiation of A.5 and A.6 yields IS and LM curves:

$$\text{(A.5′)} \qquad d\ln(c) = [(1-\lambda)d\ln(\bar{c}) - (1-\lambda)\epsilon_{\phi} d\ln(r) + \lambda\alpha_g d\ln(g)]/(1-\lambda\alpha_c).$$

$$\text{(A.6′)} \quad d\ln(c) = \{d\ln(M) - d\ln(P) - \gamma\alpha_g d\ln(g) + \epsilon_{\kappa}[d\ln(r) + d\ln(\bar{P}) - d\ln(P)]\} /(1-\gamma+\gamma\alpha_c).$$

In deriving these expressions, use has been made of the fact that $d\ln(y) = \alpha_c d\ln(c) + \alpha_g d\ln(g)$, where α_c and α_g are the respective shares of consumption and government purchases in national income. Alternatively, one can write

$$\text{(A.5″)} \qquad d\ln(y) = [\alpha_c(1-\lambda)d\ln(\bar{c}) - \alpha_c(1-\lambda)\epsilon_{\phi} d\ln(r) + \alpha_g d\ln(g)]/(1-\lambda\alpha_c)$$

and

$$\text{(A.6″)} \qquad d\ln(y) = \{\alpha_c[d\ln(M) - d\ln(P)] + (1-\gamma)\alpha_g d\ln(g) + \alpha_c\epsilon_{\kappa}[d\ln(r) + d\ln(\bar{P}) - d\ln(P)]\}/(1-\gamma+\gamma\alpha_c).$$

[2] Campbell and Mankiw (1989) put λ at 0.5, but most empirical studies suggest that a value like 0.1 is closer to the mark. Koenig (1990) tests the Campbell–Mankiw specification and finds it inferior to an alternative model in which all households are forward-looking but utility is not separable between consumption and money balances.

[3] An alternative interpretation of the standard Keynesian model is that λ is equal to zero, but households base their expectations of future consumption solely on their current incomes.

(Continued on the next page)

Appendix

Derivation of the Comparative Statics Results—*Continued*

In the special case in which γ equals 1, so that the demand for money depends on income rather than consumption, the LM equation simplifies to

$$d\ln(y) = d\ln(M) - d\ln(P) + \epsilon_\kappa[d\ln(r) + d\ln(\bar{P}) - d\ln(P)].$$

The importance of excess sensitivity in determining the strength of the "multiplier effect" is clear from equations A.5′ and A.5″. In equation A.5′, increases in government purchases have a positive impact on consumption demand (for a given rate of return on bonds) only insofar as λ, which measures the excess sensitivity of consumption to current income, is greater than zero. Similarly, it follows from equation A.5″ that $dy/dg = 1/(1 - \lambda\alpha_c)$. Thus, changes in government purchases have a larger than one-for-one impact on the demand for output only to the extent that λ is greater than zero.

The IS and LM equations can be solved for percentage changes in income, consumption, and the real rate of return. The general solutions follow:

$$\text{(A.7)}\quad d\ln(y) = \{\alpha_c(1-\lambda)\epsilon_\phi[d\ln(M) - d\ln(P)] + \alpha_c(1-\lambda)\epsilon_\phi\epsilon_\kappa[d\ln(\bar{P}) - d\ln(P)] + \alpha_g[(1-\gamma)(1-\lambda)\epsilon_\phi + \epsilon_\kappa]d\ln(g) + \alpha_c(1-\lambda)\epsilon_\kappa d\ln(\bar{c})\}/\Delta,$$

$$\text{(A.8)}\quad d\ln(c) = \{(1-\lambda)\epsilon_\phi[d\ln(M) - d\ln(P)] + (1-\lambda)\epsilon_\phi\epsilon_\kappa[d\ln(\bar{P}) - d\ln(P)] - \alpha_g[\gamma(1-\lambda)\epsilon_\phi - \lambda\epsilon_\kappa]d\ln(g) + (1-\lambda)\epsilon_\kappa d\ln(\bar{c})\}/\Delta,$$

and

$$\text{(A.9)}\quad d\ln(r) = \{-(1-\lambda\alpha_c)[d\ln(M) - d\ln(P)] - (1-\lambda\alpha_c)\epsilon_\kappa[d\ln(\bar{P}) - d\ln(P)] + \alpha_g[1-(1-\gamma)(1-\lambda)]d\ln(g) + (1-\gamma+\gamma\alpha_c)(1-\lambda)d\ln(\bar{c})\}/\Delta,$$

where

$$\Delta \equiv (1-\lambda\alpha_c)\epsilon_\kappa + (1-\gamma+\gamma\alpha_c)(1-\lambda)\epsilon_\phi > 0.$$

Standard textbook results are obtained in the special case where $\gamma = 1$, $\lambda > 0$, and $\bar{c}$ is held fixed (so that $d\ln(\bar{c}) = 0$).

Equations A.7 and A.8 imply that $dy/dg = [(1-\gamma)(1-\lambda)\epsilon_\phi + \epsilon_\kappa]/\Delta$ and $dc/dg = -\alpha_c[\gamma(1-\lambda)\epsilon_\phi - \lambda\epsilon_\kappa]/\Delta$, respectively. The importance of γ in determining the extent to which crowding out reduces the stimulatory effects of increased government purchases can be seen by differentiating these multipliers with respect to γ. One obtains

$$\text{(A.10)}\quad \partial(dy/dg)/\partial\gamma = \partial(dc/dg)/\partial\gamma = -\alpha_c\epsilon_\phi(\epsilon_\kappa + \epsilon_\phi)(1-\lambda)^2/\Delta^2 < 0.$$

Not surprisingly, the more sensitive is the demand for money to changes in government purchases (the larger is γ), the more increases in such purchases tend to crowd out private spending.

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