ECONOMICS

AN ELEMENTAL MACROECONOMIC MODEL FOR APPLIED ANALYSIS AT UNDERGRADUATE LEVEL

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DISCUSSION PAPER 11.11

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Abstract:

A graphical representation is offered based on a fairly standard formulation of an underlying comparative static model for applied undergraduate analysis. Contrary to standard practice the approach takes Walrasian equilibrium as its starting point and considers market failures that include nominal rigidities as special cases. It therefore builds intuition that centers on price rather than quantity adjustment following shocks. Beyond this, its advantages include that it offers comparative ease of representation of external shocks, which are particularly important in small open economies, it uses intuitive demand-supply market diagrams throughout and it provides the ability to set as clear targets for monetary policy the exchange rate, the CPI and the GDP price. Finally, it allows for forward expectations so that it offers useful insights for students into the economic consequences of financial shocks.

1. Introduction:

Macroeconomics is a very old sub-discipline to which approaches have been many and varied. The challenge is to capture key characteristics of the economy as a whole, which presses toward general equilibrium analysis and economic dynamics in ways that are too technically advanced for the average undergraduate. To avoid disguising fundamental ideas about macroeconomic behavior behind advanced technique, the undergraduate teaching of macroeconomics has tended to emphasize short run comparative statics. Most commonly, the approach uses aggregate demand and aggregate supply, combined with Hicks' (1937, 1980) IS-LM representation.[1] Fixed price levels are commonly assumed in the Keynesian tradition and there is most often a "Keynesian cross" diagram the subterranean message from which is to emphasize that, in determining GDP, failures of labour, product and financial markets are the default case, with output being driven by unintended inventory changes.[2] Awkwardly, this treatment is usually presented to undergraduates immediately following a semester of microeconomics that is dominated by economic stories about optimizing agents and clearing markets.

The approach described here was conceived to offer an alternative, one that avoids the difficult intuition of the equilibrium loci used in AD-AS and IS-LM and the default conception of the economy crippled by nominal rigidities. It was conceived jointly with Ben Smith (2000) originally as a teaching tool to offer an alternative representation to the standard used in principles and intermediate economics courses.[3] It is centered on a flexible price level Mundell (1963) - Fleming (1962) framework with imperfect financial

[1] Recently, as growth and economic dynamics have become more central to the advanced teaching of macroeconomics elements such as comparative steady states and two-period analysis have become more frequently used, as in Williamson (2011). While the associated Walrasian approach is desirable, these dynamic perspectives can come at the cost of much intuition and institutional detail (concerning, for example, the balance sheets and roles of central banks) that is more commonly taught along side the comparative static models.

[2] This is even true of Hall and Taylor (1991) and the very recent otherwise excellent treatment by Feenstra and Taylor (2008: Chapter 7), who use the Keynesian cross diagram to derive the IS curve. An alternative market diagram approach to this derivation is offered in Section 13.

[3] The representation used also derives in part from the graphical model offered intermediate readers in Mankiw (2004). It is also informed by frequent discussions with Graeme Wells, whose text (Wells 1995) offers a comprehensive coverage of advanced undergraduate approaches and supporting evidence emphasizing the Australian case.

capital mobility, in which an open financial capital market experiences inflows and outflows depending on yield differentials and exchange rate expectations but does not achieve uncovered interest parity.

The key advantages it offers are 1) the ease of representation of external shocks, which are particularly important in small open economies, 2) the use of more intuitive demand-supply market diagrams throughout, 3) the endogeneity of the price level, 4) the Walrasian starting point (reference case) with wage stickiness offered as a special case, 5) the ability to set as clear targets for monetary policy the exchange rate, the CPI and the GDP price, an advantage over the AD-AS IS-LM representation in which the money supply must be exogenous, and 6) it incorporates expectational variables that allow the analysis of optimism and pessimism shocks stemming from information failures in financial markets.

The graphical approach has been used in support of wider macroeconomic analysis by Tyers (2001), Roberts and Tyers (2003) and Rees and Tyers (2004). The model generalizes readily into one suitable for applied analysis in more advanced classes and a two period, multi-product version is available for computer simulation using the freeware Rungem, a component of the Australian Gempack modeling package.[4]

The next section summarises the key assumptions, the labour market is presented in Section 3 and consumption and saving are discussed in Section 4. The small open economy financial capital market is presented in Section 5, the Foreign Exchange market in Section 6 and the market for money in Section 7. The complete model is assembled in Section 8 and money neutrality is demonstrated in Section 9. Shocks with nominal wage rigidity are considered in Section 10 and, for illustration, an unexpected bond-financed fiscal expansion is analysed in Section 11 and a financial crisis in Section 12. Links with

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[4] This model and software were routinely used by students at intermediate and advanced levels at the ANU through 2009 and they are in use by a third year macroeconomics class at the UWA Business School. It has also been used for several years in training courses at the Australian Treasury. Applications of the computational model appear in Tyers and Rees (2004). Details are available from the author.

the more standard AD-AS IS-LM representation are formalized in Section 13 and conclusions are offered in Section 14.

1. Key assumptions:

Short run: The relevant length of run is within the gestation period of new investment, so that investment places demands on the capital goods sector but does not add significantly to the productive capital stock in the current period (though it does in future periods, if modelled) so $K = \bar{K}$.

Expectations: Much depends on expectations and these are exogenous in the comparative static graphical representation. Agents form expectations over the GDP price level, P_Y, the exchange rate, E, the level of future private disposable income, Y_F, and the real rate of return on installed capital net of depreciation, r_C. These then become shifters in the graphical representation. If these are left inactive, the model generates changes in price levels, exchange rates and interest rates but they are not anticipated.

No steady state: The real interest rate in the capital market, r, generally differs from the net rate of return on installed capital, r_C:

(1) $$r \neq r_C = \frac{P_Y MP_K}{P_K} - \delta$$

Financial assets are bonds and money: risk considerations are not modeled explicitly, so assets are consolidated into bonds of short maturity (monetary instruments) and of long maturity (the bulk of the collective asset portfolio and the key instruments in saving and investment), the yields on which are separated via the segmentation theory of the yield curve.

No uncovered interest parity: In general, financial capital is imperfectly mobile internationally on the grounds that home long maturity bonds are differentiated from their

foreign counterparts by considerations of risk and transaction cost. Yet responses to shocks to yield differentials and exchange rate expectations do move toward uncovered interest parity.

An initially clearing labour market: The reference case is Walrasian, in which all represented markets clear. The price level is flexible (endogenous) and, at least **i**nitially, the nominal wage is assumed to adjust to clear the labour market. Once changes in the price level are determined, the effects of wage stickiness can then be resolved. So employment is initially constant at $L = \bar{L}$. Initial output in volume units is therefore**:**

$$(2) \qquad\qquad Y = Y\left(A, L, \bar{K}\right) = Y\left(A, \bar{L}, \bar{K}\right)$$

where A is the exogenous total factor productivity coefficient.

2. The labour market:

Labour supply is inelastic on the grounds that empirical studies find its short run elasticity to be small, and because it is intuitive for students to derive the labour supply curve from the trade-off between consumption and leisure with Cobb-Douglas preferences.[5] In this case, income and substitution effects offset one another, leaving the labour supply curve vertical.

Labour demand is driven by production technology with the standard condition equating the money wage, W, in \$/worker year, to the value of the marginal product of labour, or the real wage, w, to the marginal physical product of labour:

$$(3) \qquad \frac{W}{P_Y} = w = MP_L\big|_{L=\bar{L}} = \frac{\partial Y\left(A, L, \bar{K}\right)}{\partial L}\bigg|_{L=\bar{L}}$$

This equilibrium is illustrated in the labour market diagram of Figure 1.

3. Investment depends on the net rate of return on installed capital:

The real gross rate of return on an already installed machine is just the value of its marginal product, $P_Y MP_K$, which is the annual increase to revenue generated by the machine, divided by the market price of the machine, P_K. The net rate of return just subtracts the rate of depreciation, δ. This is what drives investment decisions.

$$(4) \qquad r_c = \frac{P_Y}{P_K} MP_K\bigg|_{K=\bar{K}} - \delta = \frac{P_Y}{P_K} \frac{\partial Y\left(A, \bar{L}, K\right)}{\partial K}\bigg|_{K=\bar{K}} - \delta$$

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[5] The most recent research on the long run elasticity of labour supply (its rate of response to the real wage) is from Ashenfelter, O., K. Doran and B. Schaller (2010), "A shred of credible evidence on the long run elasticity of labour supply", NBER Working Paper 15746, Cambridge MA. Evidence on employment contracts shows supply elasticities around zero, while evidence from taxi drivers who enjoy a fare rate increase suggests a very small negative number – the income effects of the fare increase tended to be very slightly larger than the substitution effects from leisure to consumption.

Figure 1
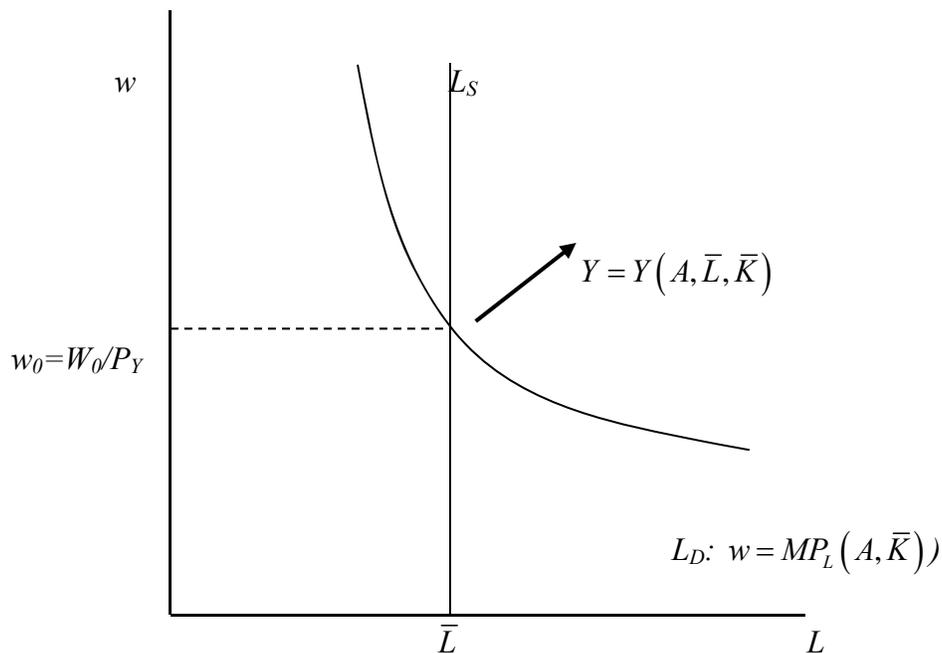
In the short run the capital stock is given, so firms do not necessarily have the optimal quantity. In the long run steady state, however, investment takes place until the real net rate of return on capital falls to the level of the real financing cost or the opportunity cost of invested funds (the real rate of return that can be earned on financial instruments, or that must be paid if bonds are issued to finance the investment, or the market real interest rate), r. The real rate is preferred here to the nominal rate on the assumption that capital gains are expected to accrue when the price of capital goods inflates at the same rate as home goods-services. So in the steady state, but not in general, $r_c = r$.

So, in the length of run to be considered, expected changes in r_C , r_C^e drive investment:

- if $r_C^e > r$ the return will exceed the real financing cost,

- if $r_C^e < r$ the investment will not be made.

This expected future value of this rate of return which is then exogenous.

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4. Consumption and saving:

Here a simple income tax rule is used with a Keynesian consumption equation in present and expected future disposable income, measured in real volume equivalents. All units are product volumes. Government spending, G, is a real exogenous policy variable.

(5) Elemental tax rule: $\qquad\qquad T = t + \tau(Y)$

(6) Real private consumption $C(Y,r) = a_C - b_C r + c_C \left[Y - T(Y)\right] + c_F \left[Y_F^e - T(Y_F^e)\right]$

(7) Real private saving: $\qquad\qquad S(Y,Y_F^e,r) = Y - T(Y) - C(Y,Y_F^e,r)$

(8) Total real domestic saving: $\qquad S_D(Y,Y_F^e,G,r) = S(Y,Y_F^e,r) + T(Y) - G$

To reflect consumption smoothing behaviour, private saving responds positively to current disposable income and negatively to expected future disposable income. The substitution effects are assumed to dominate when changes in bond yields occur, so that private saving also responds positively to the real yield on saving instruments (long maturity bonds), r.

5. The small open economy financial capital market:

This is the market that matches saving to investment. Units are equivalent volumes of goods and services.

(9) Real investment (break-even + net): $\qquad I = I_b + I_N = \delta K + \gamma \left(\dfrac{r_C^e}{r}\right)^\varepsilon$

Here the ratio of the expected net rate of return on installed capital and the current real long bond yield is closely related to Tobin's Q, since the numerator determines the current market value of capital assets and the denominator determines the real cost of

financing their replacement.

(10) Net foreign investment demand: $NFI\left(Y,G,r_c^e,r\right)=I\left(r_c^e,r\right)-S_D\left(Y,Y_F^e,G,r\right)$

(11) Capital account net inflows: $KA\left(r*,\Delta e_R^e,r\right)=S_{NF}\left(r*,\Delta e_R^e,r\right)-\Delta R$

Where KA represents the net provision by foreigners of funds to finance a surplus of imports over exports (current account or CA deficit), S_{NF} is net foreign saving, or the private component of these inflows, dependent on the foreign bond yield, $r*$, the home bond yield, r, and any (exogenous) expectation of a real exchange rate change, Δe_R^e. The real exchange rate here has the financial definition, so it rises with appreciations. The change in the sock of official foreign reserves, ΔR, is an exogenous monetary policy variable and, consistent with the small open economy assumption, the foreign bond yield, $r*$, is also exogenous.

This dependence implies something short of the real version of uncovered interest parity $\left(r=r*-\Delta e_R^e / e_R\right)$. Indeed, S_{NF} is influenced by departures from uncovered interest parity, the latter applying only in a steady state:

(12) $$S_{NF}=a_{SF}+b_{SF}\left(r+\frac{\Delta e_R^e}{e_R}-r*\right).$$

The size of the slope of this curve, b_{SF}, then determines how quickly the solution approaches uncovered interest parity. Small values suggest capital controls and large values suggest high levels of financial capital mobility. Allowing departures from uncovered interest parity admits reality in a way that avoids the application inflexibility of approaches that impose it.[6]

The small open economy financial capital market equilibrium is then obtained by finding the home bond yield, r, that renders:

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[6] The excellent general macroeconomics text by Blanchard and Sheen (2004) is a case in point.

$$(13) \quad NFI\left(Y,Y_F^e,G,r_c^e,r\right) = I\left(r_c^e,r\right) - S_D\left(Y,Y_F^e,G,r\right)$$
$$= KA\left(r^*,\Delta e_R^e,r\right) = S_{NF}\left(r^*,\Delta e_R^e,r\right) - \Delta R$$

Once the supply side equilibrium has been determined, GDP, or *Y*, is known. All the other variables in this equilibrium condition are exogenous, except the home long bond yield, *r*, which is readily solved for. From this, then, the real value of net financial inflows on the capital account, *KA*, also emerges.

Critically, with clearance of the labour market, the capital account balance is seen to depend only on financial variables, not on trade and the current account. The equilibrium in this small open economy financial capital market is illustrated as in Figure 2, with the curves showing only their shifters in parentheses.

Figure 2
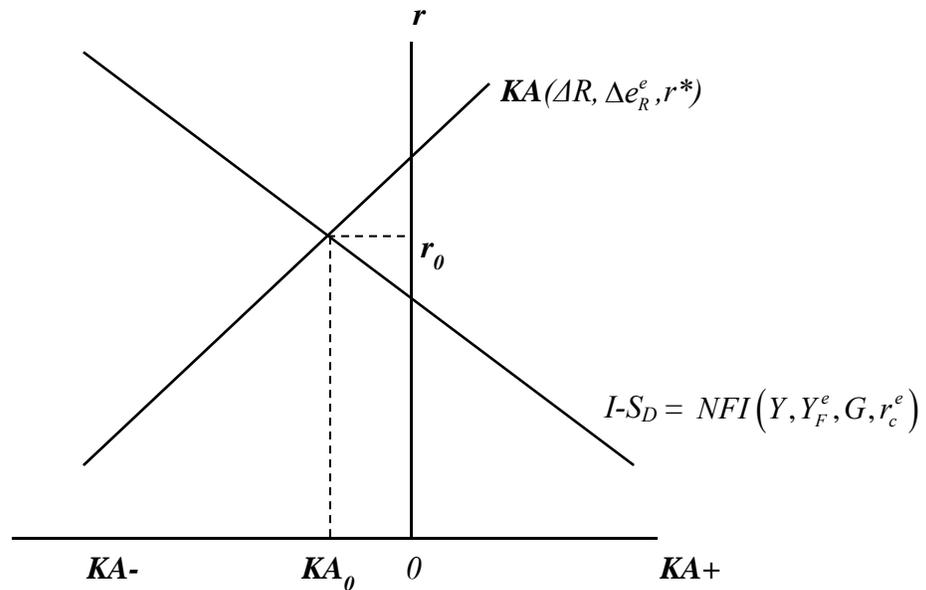
6. The market for foreign exchange:

First define the exchange rates. The real exchange rate is the number of representative foreign product-service bundles that can be acquired in exchange for a single home product-service bundle. It is therefore the common currency ratio of the price of home goods to that of foreign goods, best represented by the respective GDP prices, P_Y and P_Y^*. But P_Y^* is expressed in foreign currency and so requires conversion at the nominal exchange rate, E. Thus, if that is also defined financially (appreciating when it rises) we have that:

$$(14) \qquad e_R = \frac{P_Y}{\left(P_Y^* / E\right)} = E \; \frac{P_Y}{P_Y^*}.$$

Because the capital account[7] must balance the current account and the latter is linked to the values of imports and exports in home \$, the balance of payments in home \$ is:

$$(15) \qquad \begin{aligned} BoP &= KA + CA = 0 \\ -KA &= S_D - I = CA = N + X - M \end{aligned}$$

where N is net factor income from abroad. Imports, M, and exports, X, both depend on the real exchange rate.

Consistent with the practice adopted in representing the financial capital market, this should also be expressed in equivalent real volumes of home product. Since N depends mainly on past investments abroad, consider hereafter that N is an exogenous constant, expressed in real terms and so in units of *foreign* output. Redefining the X and M in home product equivalents, the balance becomes:

$$(16) \qquad -KA = S_D - I = CA = \frac{N}{e_R} + X - M$$

Exports are foreign demands for home goods, which, like any product demand, depend positively on foreign income and negatively on the relative price of home goods or the real exchange rate. Imports are home demand for foreign goods and so will depend

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[7] This is here defined as the complement of the current account. It is therefore the sum of what is commonly referred to as the capital account, the financial account and the balance on reserves.

positively on home income, or GDP, and negatively on for relative price of foreign goods (the inverse of the real exchange rate). For an intuitive diagram, express these in terms of the inverse of the real exchange rate – the relative price of foreign goods. So the current account deficit is:

$$\overset{+ \quad - \qquad \quad + \quad +}{(17) \qquad -CA = N\left(\frac{1}{e_R}\right) + M\left(Y, \frac{1}{e_R}\right) - X\left(Y^*, \frac{1}{e_R}\right)}$$

Net import demand, or excess demand for goods, is therefore unambiguously downward sloping in the relative price of foreign goods or positively dependent on the real exchange rate. Net factor income has the opposite dependence, however, though this is a pure valuation effect, whereas the trade flows combine valuation with volume adjustment effects. We will assume the trade account to dominate, so that the current account deficit can be written:

$$\overset{+ \quad - \quad -}{(18) \qquad -CA = -CA\left(Y, Y^*, \frac{1}{e_R}\right)}$$

The current account measures the net inflow of payments associated with current transactions, here measured as the equivalent volume of home goods. A deficit means a net outflow.

This is the equivalent of a net outflow of foreign exchange, matched by a net inflow of foreign exchange arising out of financial flows in the financial capital market. But we know from that market that the net inflow of foreign exchange associated with asset transactions is KA. And, so long as the labour market clears, the equivalent quantity of home products is already bolted down. So the real exchange rate adjusts to ensure that the balance of payments does actually balance:

$$
\begin{aligned}
BoP &= KA + CA = 0 \\
(19) \\
KA &= -CA\left(Y, Y^*, \frac{1}{e_R}\right)
\end{aligned}
$$

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The only endogenous variables in this relationship are Y and e_R, but Y has already been determined in the labour market. So this relationship reveals the real exchange rate, as shown graphically in Figure 3. Knowing Y and e_R, M and X can be obtained by back solving if needed.

7. Demand side, nominal part:

Since the maturity of financial assets matters, a note on the yield curve is useful at the outset. Financial assets are here generalised as bonds. No risk considerations are explicit in the model, except to the extent to which they differentiate home from foreign bonds and therefore cause the failure of uncovered interest parity, leading to imperfect financial capital mobility even where no capital controls are present. But central banks dominate trade in "money market instruments" of maturity less than a year, while the collective portfolio comprises mainly long term instruments, which might be thought of here as 10 year bonds. The yields on short and long instruments do not move together through time, with short rates being altered by central banks in the management of home business cycles while long rates move more smoothly through time and their markets are more integrated across countries, reflecting their role in equating the global supply of saving to global investment demand.[8]

For these reasons, the home real long bond yield is the equilibrating variable in the financial capital market. And, since long instruments dominate the collective portfolio the nominal long bond yield is the opportunity cost of holding money. The two are related as $r = i_L - \pi^e$, where π^e is the expected rate of inflation.

A conventional cash in advance constraint is assumed to underlie the demand for real money balances, which then depends on GDP, representing transactions demand, and the

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[8] The rates are kept separate by three standard theories of the yield curve, of which the most telling is the segmentation theory. When short rates are low compared with long rates, the gap is sustained by the transaction costs that would be incurred were a sequence of short contracts to replace a single long contract.

nominal long term bond rate.

$$+ \quad - \quad - \quad +$$

(20) $$m_D = m_D\left[Y,(i-\lambda)\right] = m_D\left[Y,(r+\pi^e-\lambda)\right]$$

Figure 3
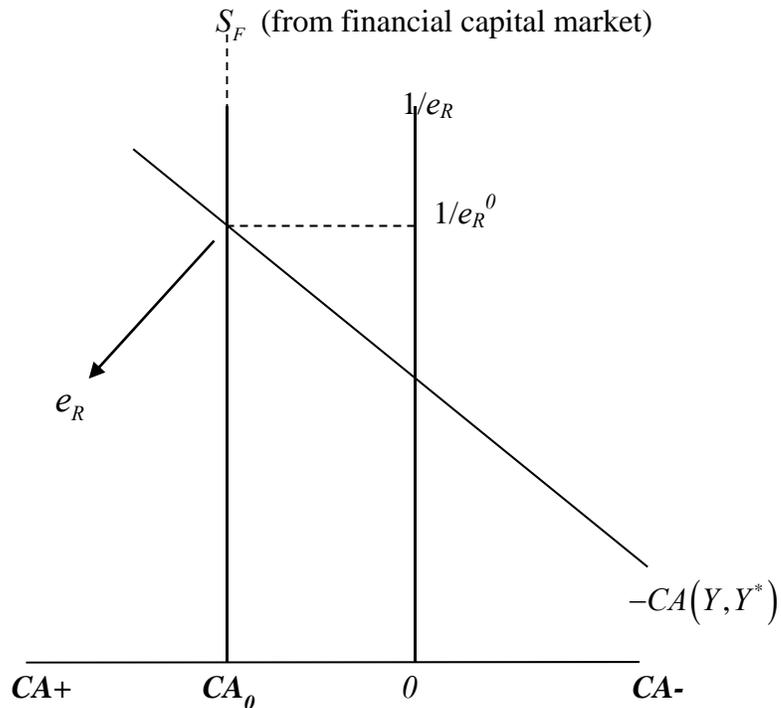
Where λ is an exogenous risk premium that may be shifted upward by pessimism about the performance of financial instruments other than money. Thus, when financial instruments appear riskier, the opportunity cost of holding money may not be as large as the current long term real yield even after adjustment for expected inflation.

The supply of money begins with the monetary base, M_B, which central banks control by committing to trade in short term instruments until excess demand at a designated short yield is reduced to zero. The relationship between short rates and M_B need not be made explicit here, however. The money multiplier then links the monetary base to the

nominal money supply and thence to the supply of real money balances.

$$(21) \qquad \theta = \frac{M_S}{M_B} = \left(\frac{1+c}{c+\rho} \right)$$

Where c is the public's cash to deposit ratio and ρ is the reserve to deposit ratio of banks and other financial institutions. So the supply of real money balances can then be equated with its demand in a clearing money market.

$$(22) \qquad m_D\left(Y, r + \pi^e + \lambda\right) = m_S = \frac{M_S}{P_Y} = \frac{M_B\left(i_S\right)}{P_Y} \theta = \frac{M_B\left(i_S\right)}{P_Y} \left(\frac{1+c}{c+\rho} \right)$$

If the monetary base is considered an exogenous policy instrument, determined by declared levels of i_S in a separate process, the expected inflation rate is exogenous, as are the parameters c, ρ and λ, the only endogenous unknown is the price level, P_Y, or the exchange rate between home money and home goods-services.

The diagram in Figure 4, unconventionally, uses the real interest rate on the vertical but, conventionally, real money balances on the horizontal. GDP, as a proxy for transactions demand, expected inflation, π^e, and the risk factor, λ, are then shifters of the money demand function, with the latter two always exogenous. As above, the money market equilibrium is where:

$$(23) \qquad m_D \overset{+\ -\ +\ -}{\left(Y, \pi^e, \lambda, r\right)} = \frac{M_S}{P_Y}$$

The only variable that remains to be calculated is the nominal exchange rate. If the foreign price level, P_Y^*, is exogenous, consistent with the small country assumption, then the nominal exchange rate, E, can be obtained by transforming the standard expression

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(14) for the now known real exchange rate in terms of the known home price level:

(24)
$$E = e_R \cdot \frac{P_Y^*}{P_Y} \, .$$

Figure 4
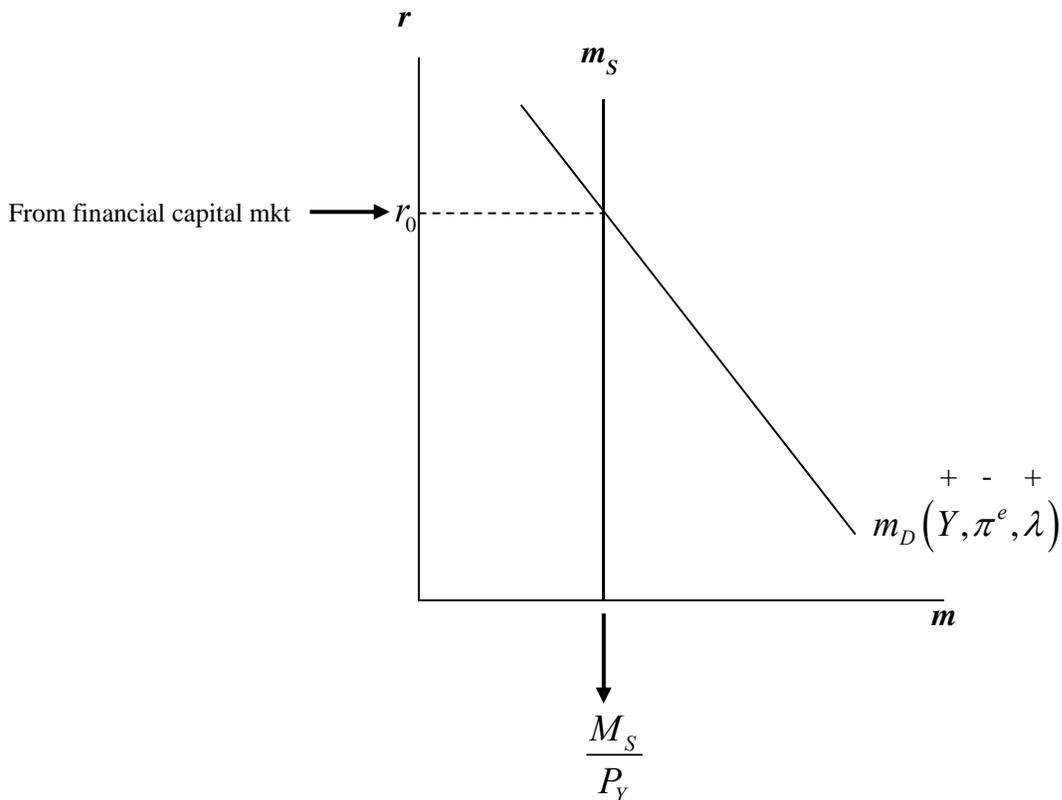
8. The complete model:

The model assembles graphically on a sequence that follows from the default assumption
of Walrasian equilibrium – the simultaneous clearance of all four inter-related markets:
the labour market, the financial capital market and the markets for home and foreign
money. The graphical (and, if needed, the numerical) solutions are recursive,
commencing with the labour market and moving through the other markets, all of which
have quantity axes that are expressed in equivalent volumes of home products.

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1. In the clearing labour market GDP (Y) is determined.

2. Once Y is known, private and government saving is known and so the open economy financial capital market can be drawn. This determines both the home long bond yield and the net inflows on the capital account, KA.

3. The net supply of foreign exchange from the financial capital market is KA and the excess demand for foreign exchange in current international transactions is the current account balance, defined as the deficit $-CA$. For a balance of payments, these must be equated in the foreign exchange market diagram. This yields the real exchange rate.

4. The real long bond rate from the financial capital market, combined with the exogenous expected inflation and risk factor, indicate the quantity of real money balances demanded. To bring supply into equality with this, for a given short bond yield and hence a given monetary base and nominal money supply, the price level must adjust. This is the exchange rate between money and home goods-services in which the demand for real money balances is measured. The equilibrium price level emerges from the money market diagram.

5. The nominal exchange rate then follows from the real exchange rate and the home price level.

In the set of diagrams in Figure 5, the labour market is omitted since Walrasian equilibrium implies clearance and a fixed level of GDP, Y. Only the demand side is represented. Arrows indicate the recursive solution in the Walrasian case.

Figure 5

Upper left quadrant:

r

$KA(\Delta R, \Delta e_R^e, r^*)$

r_0

$I\text{-}S_D =$
$NFI\left(Y, Y_F^e, G, r_c^e\right)$

$KA-$ KA_0 0 $KA+$

Upper right quadrant:

r

m_S

r_0

$m_D\left(Y, \pi^e, \lambda\right)$

m

$\dfrac{M_S}{P_Y}$

Lower left quadrant:

S_F

$1/e_R$

$1/e_R^{\,0}$

$-CA\left(Y, Y^*\right)$

$CA+$ CA_0 0 $CA-$

Lower right:

$e_R = E \cdot \dfrac{P_Y}{P_Y^*}$

17
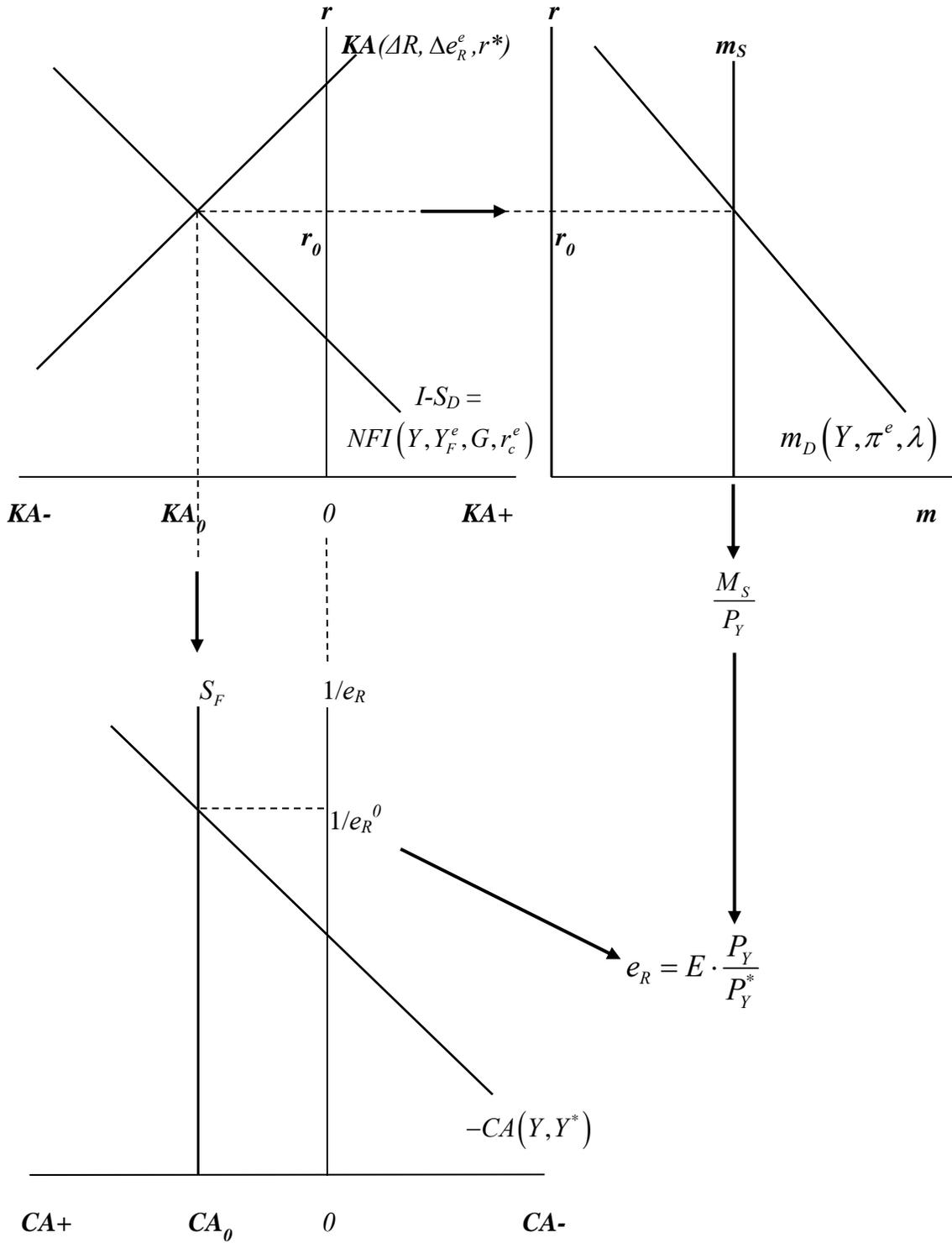
9. Money neutrality:

The neutrality of money when there are no nominal rigidities (all markets clear as in the Walrasian reference case) is an essential test. It is readily seen from the recursive solution, above and the measurement of all the horizontal axes in real home product-service volume equivalents.

The effect of a surprise (unexpected) 10% helicopter expansion in the nominal money supply at each stage is:

1. In the clearing labour market, labour supply depends on consumption-leisure preferences and labour demand depends on the production technology, neither of which bears any direct relationship with the supply of money and so GDP (Y) is unaltered.

2. In the financial capital market, private saving measured as the real volume of consumption denied and this depends only on real variables, including the real interest rate or long bond yield. The same is true for government saving, home investment and for financial investors exchanging assets internationally. There is therefore no change in the financial capital market due to a rise in the supply of money.

3. The net supply of foreign exchange from the financial capital market, KA, and the current account balance, CA, are both here measured in terms of equivalent volumes of home products-services and neither has any direct dependence on the supply of home money. No change therefore occurs in this market either.

4. In the same way, the money market is characterised in terms of real money balances with dependence on the real home long bond yield. There is therefore no change in the real supply of money. Thus:

$$(24) \qquad \overline{m}_S = \frac{M_S \uparrow}{P_Y \uparrow}.$$

So the excess supply of money reduces its value relative to goods-services and so the GDP price rises by 10%.

5. With no change to the real exchange rate the new relative abundance of home money reduces its value relative to foreign money and so the nominal exchange rate depreciates by 10%.

$$(25) \qquad \overline{e}_R = E \downarrow \cdot \frac{P_Y \uparrow}{\overline{P}_Y^*}$$

6. Finally, in the clearing labour market the market-clearing real wage, w, is unchanged, which then requires that the nominal wage rises by 10%.

$$(26) \qquad \overline{w} = \frac{W \uparrow}{P_Y \uparrow}$$

Thus, an unexpected helicopter money expansion has no effect on variables measured in real terms (as equivalent volumes of home goods-services). Only nominal variables (those measured in terms of $) are altered, and in each case they change by the same proportion as for the nominal money supply.

10. Shocks with a rigid nominal wage:

The recommended approach in the use of the graphical version of this model is merely to determine whether any shock, or combination of shocks, is expansionary or contractionary. A graphical solution for the new level of GDP is difficult since iterations are required. This is a disadvantage relative to the standard AD-AS, IS-LM approach, which goes directly to an equilibrium level of GDP with nominal rigidities.

Iterations begin with the application of the shock or shocks to the graphics on the initial assumption that the labour market clears. Consider the simplest case; that of the monetary expansion considered in the previous section. This causes no changes to the demand side diagrams but there is an inflation. The effect of this in a labour market with a fixed nominal wage is then to raise employment above the initial equilibrium level.[9]

Figure 6
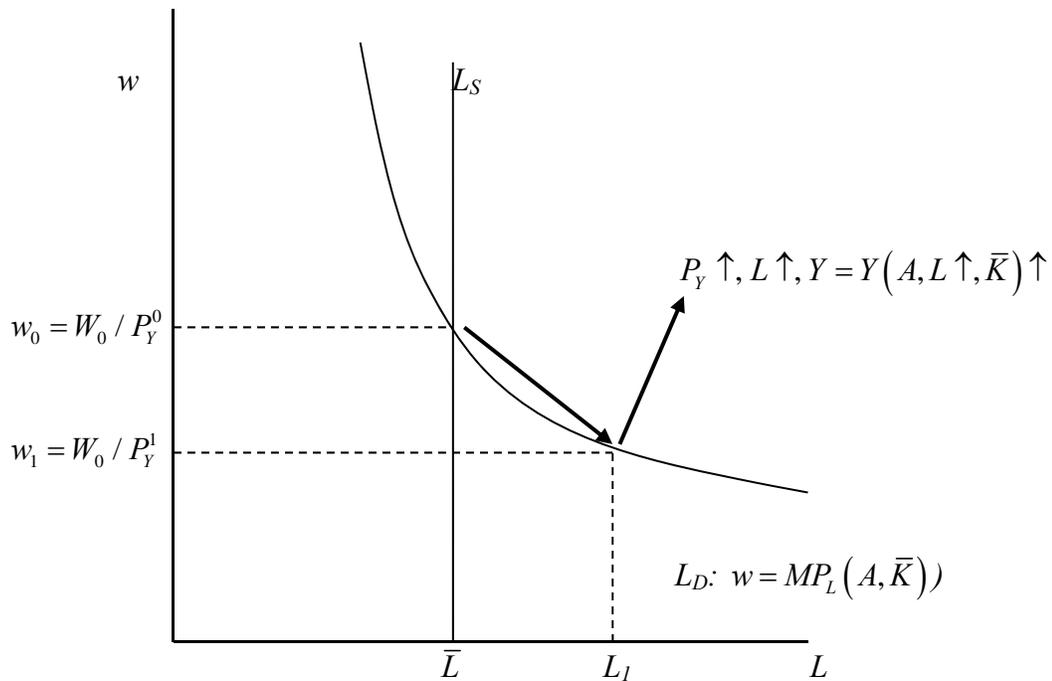
Thus, an unanticipated monetary expansion is expansionary of employment and GDP. To find the new level of GDP, the implications of the labour market result of Figure 6 are assessed using the demand side diagrams of Figure 5. Almost all curves shift with a rise in output and no change in the expectational variables. The consequences are

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[9] If the initial level of unemployment is the minimum feasible, this implies a transition to greater use of overtime contracts and temporary immigration.

1. A reduced long bond yield and an expanded *KA* deficit (or reduced *KA* surplus; expanded *CA* surplus or reduced deficit), as savings rise with expanded GDP.

2. The expanded CA surplus depreciates the real exchange rate, which also follows from the new relative abundance of home products-services compared with foreign products-services.

3. The lower real interest rate reduces the opportunity cost of holding money and so real money balances expand. Because the nominal money supply remains fixed, the scarcity value of money rises relative to home goods-services and so the price level falls.

4. From (24), the effect on the nominal exchange rate is indeterminate, since the real exchange rate depreciates and the price level falls.

In general, this second iteration yields a smaller net inflation from the initial monetary expansion – the sharing of the effects between price and quantity adjustments. Further iterations are then possible, but these are not needed if all that is required is to distinguish expansionary from contractionary effects. Indeed, the key to GDP effects is the change in the GDP price level, P_Y. If an unanticipated inflation results the shock is expansionary, if the result is a deflation, then the effect is contractionary.

11. Bond-financed fiscal expansion:

This exercise illustrates the choice of monetary target. It draws the following conclusions:

1. that unanticipated fiscal expansions do raise output and employment if they are permitted to cause unanticipated inflations but not otherwise, hence the dependence of the result on the target of monetary policy

2. if they cause inflations, the effectiveness of fiscal expansions in raising output and employment is reduced the greater is financial capital mobility.

An unanticipated, debt financed rise in G adds to the supply of bonds seeking purchase by savers. Bond prices fall and yields rise, crowding out some private investment. Net inflows on the capital account rise (or become less negative in the case of a capital account deficit) as financial investors are attracted to home bonds and the real exchange rate appreciates.[10]
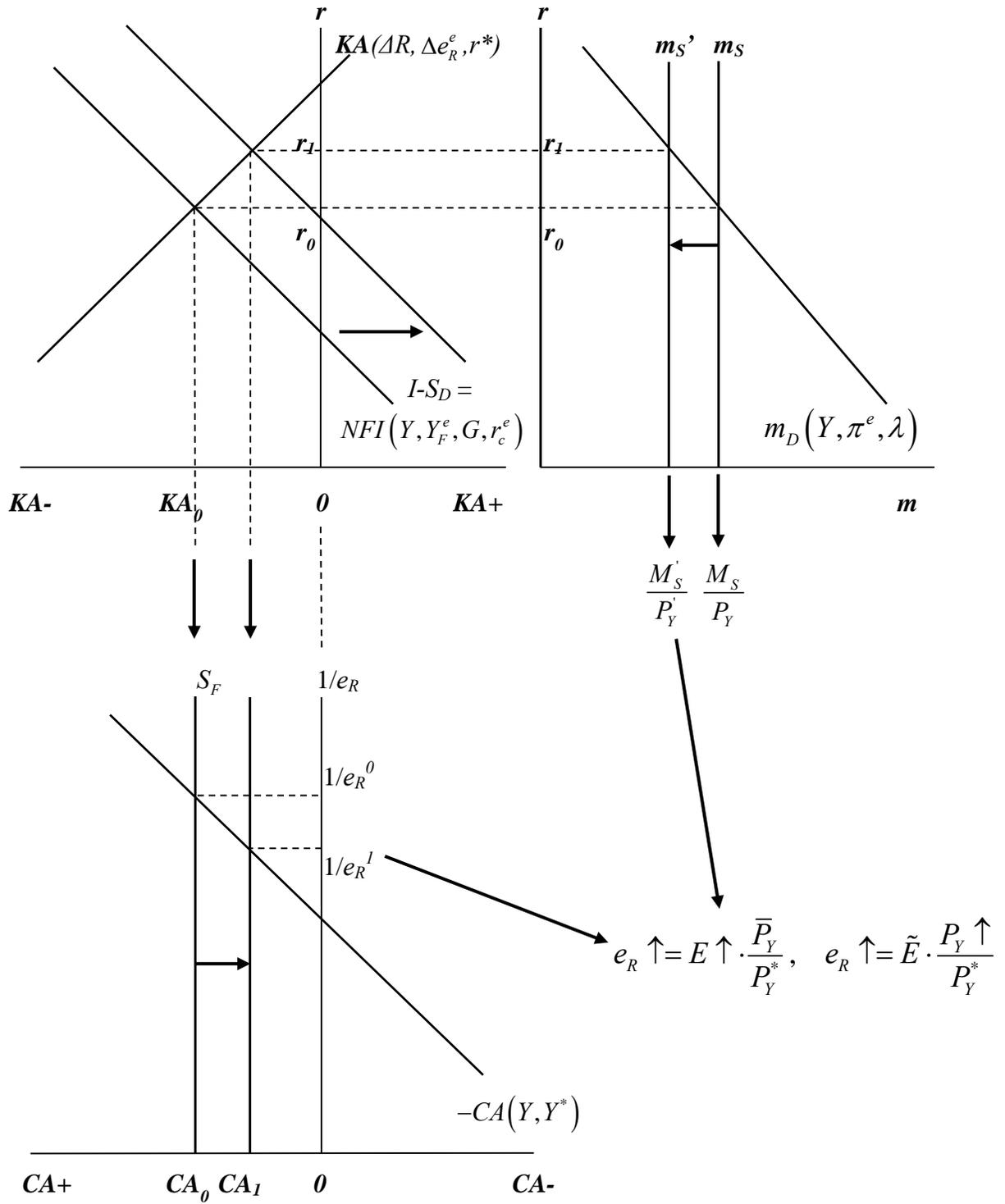
The analysis is illustrated in Figure 7. Commencing with the Walrasian reference case, GDP is initially unaffected and the shock occurs in the financial capital market. The rise in G reduces domestic saving and shifts the I-S_D or NFI curve to the right. The higher real bond yield and the less negative or more positive capital account balance emerge from the financial capital market.

The real appreciation then arises in the foreign exchange market. In the money market the higher bond yield, again assuming no anticipation of any subsequent inflation, raises the opportunity cost of holding money and reduces real money balances. Here is where the target of monetary policy matters.

If the target is the money supply itself, implying that the central bank holds the short rate constant, then there is an excess supply of money so its value falls relative to home goods-services and there is an inflation. Returning to the labour market, this time with a fixed nominal wage, the inflation is seen to cause a rise in employment and therefore in GDP, so the shock is expansionary.

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[10] Of course, if the shock and its immediate effects are anticipated, Ricardian equivalence arises and private saving could rise sufficiently to offset the effects of the expansion. This can be illustrated with the graphical model but what follows focuses on the unanticipated case.

Figure 7

$KA(\varDelta R, \Delta e_R^e, r^*)$

r_1

r_0

$I\text{-}S_D =$
$NFI\left(Y, Y_F^e, G, r_c^e\right)$

$m_S{'}\quad m_S$

r_1

r_0

$m_D\left(Y, \pi^e, \lambda\right)$

KA-   **KA$_0$**   **0**   **KA+**   **m**

$\dfrac{M_S^{'}}{P_Y}\quad \dfrac{M_S}{P_Y}$

S_F $1/e_R$

$1/e_R{}^0$

$1/e_R{}^1$

$e_R \uparrow = E \uparrow \cdot \dfrac{\overline{P}_Y}{P_Y^*}, \quad e_R \uparrow = \tilde{E} \cdot \dfrac{P_Y \uparrow}{P_Y^*}$

$-CA\left(Y, Y^*\right)$

CA+   **CA$_0$ CA$_1$**   **0**   **CA-**

23

If the target of monetary policy is the price level, say P_Y,[11] then a monetary contraction is required. There is no inflation and hence no expansion in employment and GDP. Thus, an independent central bank that targets product price stability completely nullifies the power of fiscal policy.

For the final conclusion, the international mobility of financial capital depends on the slope of the *KA* curve in the financial capital market. The flatter this curve (the more mobile is financial capital or the more substitutable are home with foreign bonds), the smaller the rise in the home bond yield and hence the smaller the contraction in real money balances. This means that, if the target of monetary policy is the money supply itself, then the necessary inflation is smaller and so is the power of the fiscal expansion to raise employment and output.

Of course, there are cases in which fiscal expansions can be expected to be effective even with independent inflation-targeting central banks. An obvious one is the case illustrated most strongly during the GFC in the US, the UK and Japan, where the power of monetary policy was exhausted – the liquidity trap, which fixes the nominal money supply so that fiscal expansions have traction over the price level and so can offset deflationary tendencies. Even if central banks retain traction over the price level, there is also a role for fiscal policy in circumstances illustrated at the outset of the GFC, where pessimism shocks temporarily raise the share of saving that goes to money holdings, thus increasing the money share of the collective portfolio. In this case a rise in the private saving rate does not cause an equivalent spend on new capital goods. If governments can issue bonds to soak up some of that money accumulation and spend the proceeds on home goods-services quickly enough, they can forestall the downturn. This is a tall order for fiscal policy, however, which is notoriously slow acting.

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[11] The target can be the consumer price level, recognizing that $P_C = Av\left(P_Y, P_Y^*/E\right)$. Because the exchange rate would appreciate, holding this constant would lead to a GDP price inflation and so he shock would be expansionary, though by an amount that depends on the share of imports in home consumption.

12. Pessimism shock – the effects of a financial crisis

This is a useful illustration of the application of expectation shocks. Two types of financial crisis might be considered. Financial collapses that are local and isolated precipitate capital flights and runs on the home currency. These are readily modelled as upward shocks to r*, the foreign bond yield, intended to represent rises in the home asset risk premium. The analysis starts in the financial capital market with a shift in the *KA* curve and is, thereafter, quite straightforward. That said, the simplicity of the analysis does depend on the level to which the consequences are anticipated and hence whether the shock is complicated by changes in the expectational variables. It also depends on the complexity of the policy responses. In the case of the Asian financial crisis of 1997-98, the runs on Asian currencies were only arrested once the currencies had been forced to float and by substantial money-financed fiscal expansions. That said, all these shocks are readily represented.

Perhaps the best illustration of the application of expectations shocks, however, is the GFC. It commenced with the realisation across financial markets that US and UK assets were over-valued and hence US households were struck by a substantial wealth cut. This was exacerbated by associated balance sheet problems in key financial institutions, confidence in which was suddenly eroded. While, during the early stages of the GFC there were elements of capital flight, this was not the primary cause of its main economic impact. Representation in the model requires the following exogenous shocks:

$Y_F^e \downarrow$: households expect future disposable income to be lower and therefore increase saving to smooth consumption forward

$r_C^e \downarrow$: investors anticipate lower future real net returns on new capital

$c \uparrow, \lambda \uparrow$: households lose confidence in their financial institutions and seek greater liquidity, as well as a higher cash to deposit ratio

25

$\rho \uparrow$: financial institutions hedge against runs by holding more cash on reserve
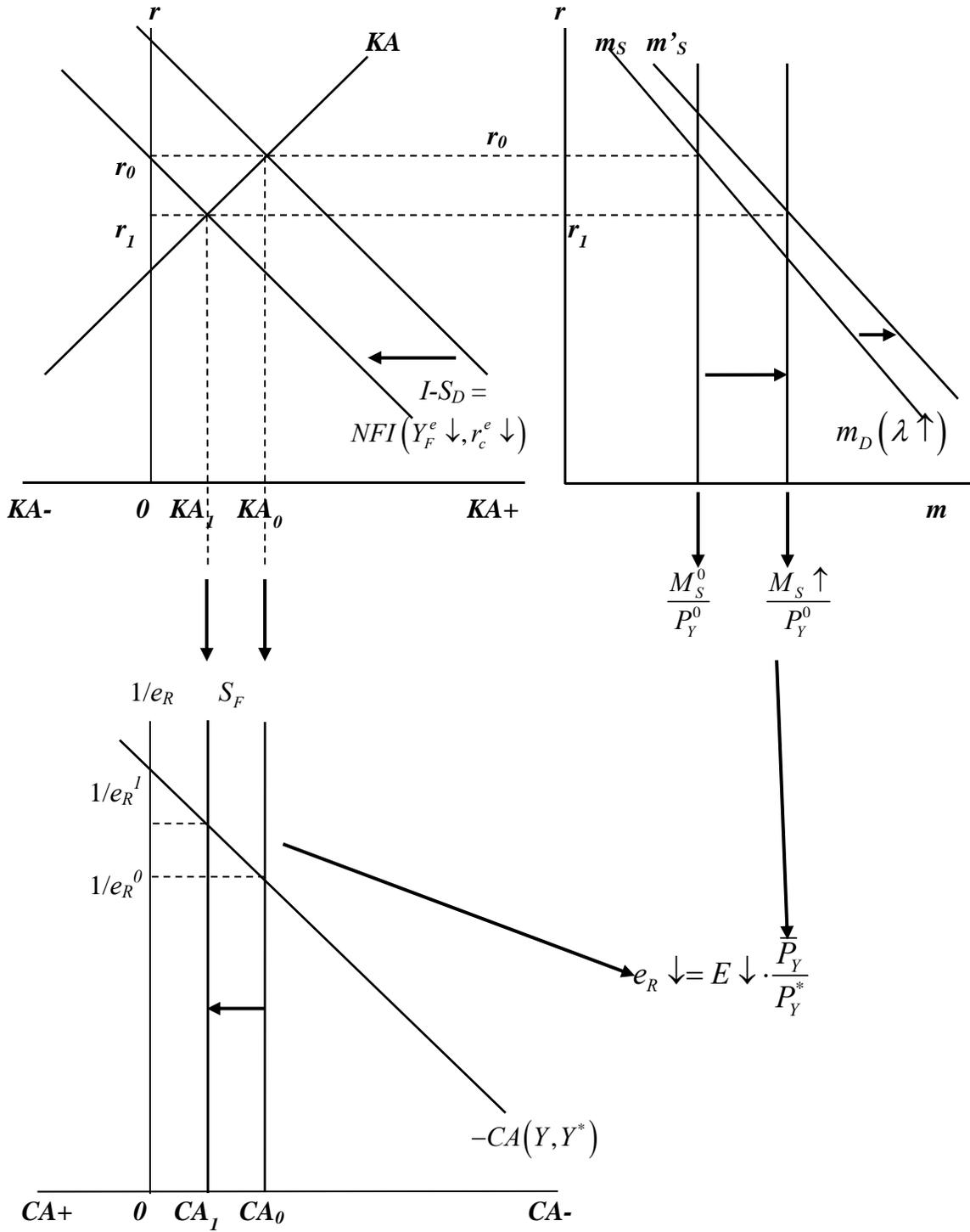
The changes in the cash to deposit ratio and the reserve ratio reduced the money multiplier and were the reason the Fed's attempted monetary expansions seemed like "pushing on a piece of string". Short rates would be lowered and the monetary base expanded but the money supply did not rise. But, before we can see the effect of this we must know what happened to real money balances and for that we need the entire demand side of the model. The shocks are imposed in Figure 8, assuming that the target of monetary policy is the price level and that the central bank is capable of defending it, so $P_Y = P_Y^0$. Note that the diagram is here drawn for a current account deficit, in place of the surpluses represented in Figures 2, 3, 5 and 7.

From Figure 8 it is clear that pessimism on the part of both savers and investors causes the $I - S_D = NFI\left(Y_F^e \downarrow, r_C^e \downarrow\right)$ curve to contract to the left since, at any home bond yield, investors are prepared to supply fewer financing bonds and households restrict their consumption in the current period in order to save for the apparently inferior future. The long bond yield falls, the current account deficit falls and the real exchange rate depreciates. If the central bank is able to defend the domestic price level, this indicates that the nominal exchange rate also falls. In the money market, increased liquidity preference causes the demand curve to shift to the right and so the equilibrium volume of real money balances expands due to the lower opportunity cost of holding money but that expansion is made larger by the increased liquidity preference. The key question now arises: is the central bank capable of defending the price level when a large rise in the money supply is required?

That this could be a tall order is clear from (22), here re-expressed:

$$(27) \quad m_D\left(\lambda \uparrow\right)\uparrow = m_S \uparrow = \frac{M_S \uparrow}{\overline{P}_Y} = \frac{M_B\left(i_S \downarrow\downarrow\right)\uparrow\uparrow}{\overline{P}_Y}\theta \downarrow = \frac{M_B\left(i_S \downarrow\downarrow\right)\uparrow\uparrow}{\overline{P}_Y}\left(\frac{1+c\uparrow}{c\uparrow + \rho\uparrow}\right)\downarrow$$

Figure 8

Not only is the rise in real money balances double barrelled but, because the money multiplier falls, the monetary base must rise by even more and hence the short interest rate must fall considerably. From this it is not surprising that the US and the UK, when subjected to these shocks in 2008, reached liquidity traps so quickly.

The next question is, if a liquidity trap is reached and the monetary base cannot be raised further by conventional means then money is in excess demand and the value of goods-services in terms of money falls – there is a deflation. In Figure 6 a deflationary shock clearly contracts employment and GDP. So, what is to be done? Well, note that the monetary base, and hence the real money supply, are stalled. This is the precise circumstance under which a fiscal expansion was seen in Section 11 to be expansionary. That is, the fiscal expansion in these circumstances offsets the deflation and so contributes to limiting the resulting contraction.

13. Links with the standard AD-AS, IS-LM representation

The algebra that underlies this model is standard and so it is not surprising that loci of equilibrium combinations of P_Y, Y and r, or $i = r + \pi^e$, which is what AD, AS, IS and LM are, follow directly from it. The advantage of the treatment offered here is that the abstraction of equilibrium loci is not required. All diagrams have true demand and supply curves.

13.1 The open economy aggregate demand curve

This is the set of combinations of (P_Y, Y) for which the *demand side* of the economy (the capital, money and foreign exchange markets) is in equilibrium. It is not an ordinary demand curve. Also, because the money supply must be an exogenous shifter of the *AD* curve, it does not represent well the modern role of the central bank. This is because the money supply need not be exogenous, and indeed it is not if the central bank has an alternative target, as in most of the analytical examples of the previous sections.

To derive the AD curve for the case where the central bank targets the money supply, imagine that there is a supply side shock so $Y \nearrow$. The diagrams for the financial capital market and the money market can then be used to calculate the associated change in the price level, as in Figure 9. The initial equilibrium combination is $\left(Y_0, P_Y^0\right)$. A second combination arises when we have the rise in GDP to Y_1. At higher GDP there is more income and more saving so, other things equal, there is less excess demand for foreign funds to finance home investment, or more demand for home bonds, so higher bond prices and lower yields. In the money market, lower opportunity cost, combined with higher transactions demand, necessitates increased real money balances. With the money supply exogenous this creates excess demand for money relative to goods-services and so a lower price level results.

Figure 9

29
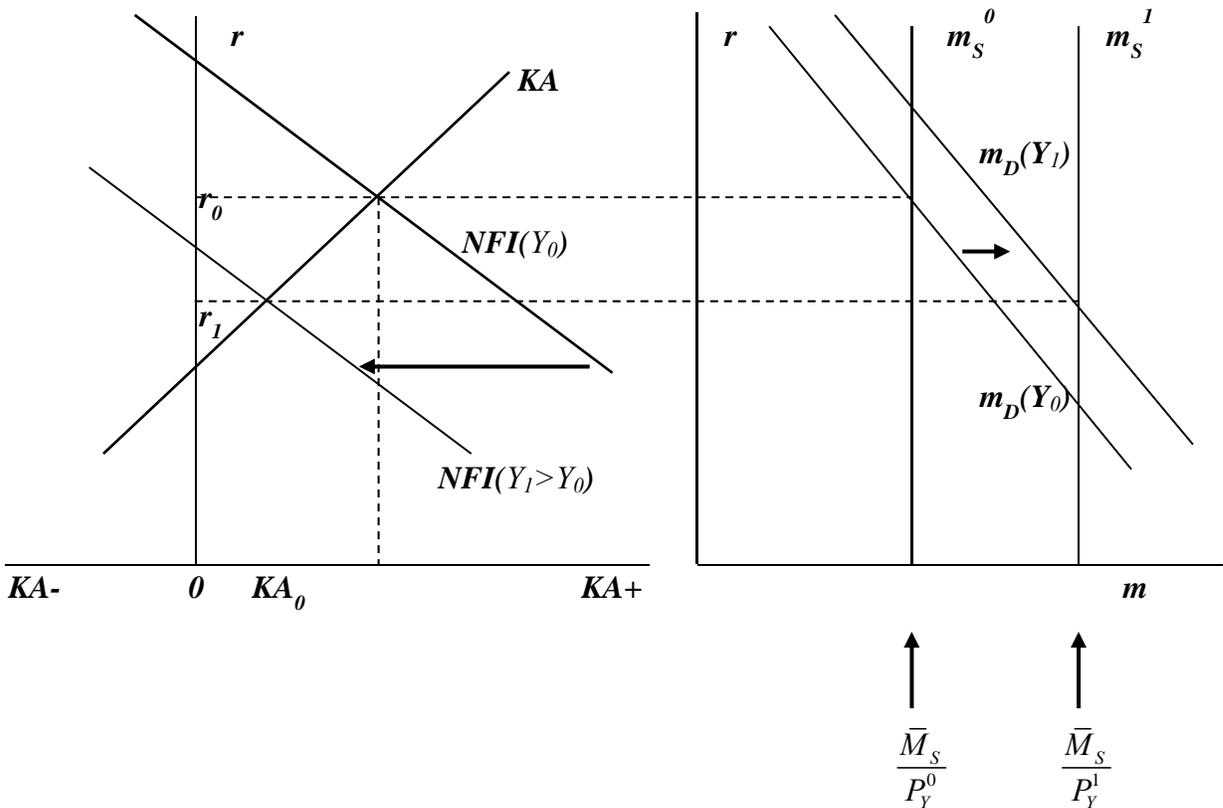
By selecting a range of supply side shocks and calculating the change in the price level for each a downward sloping AD curve is mapped out. The shifters of the curve are shown in Figure 10, where the directional signs indicate the effects of the shifters on the price level for any given quantity, Y.

13.2 Aggregate supply

The Walrasian case, which fixes the levels of employment and GDP in a clearing labour market, yields what is often referred to as the "long run" equilibrium in GDP and the

Figure 10
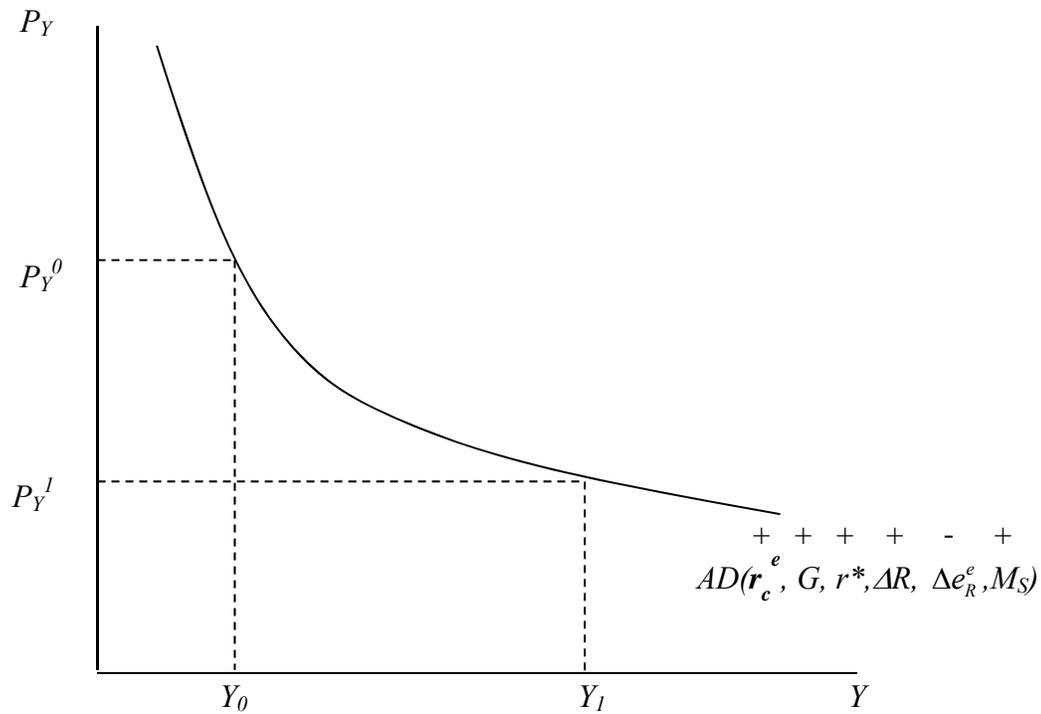
price level, yielding a vertical "long run aggregate supply curve".[12] The commonly drawn short run aggregate supply curve, SAS, is specific to a given fixed nominal wage

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[12] Since the model is constructed to fit the short run interval within the gestation period of investment, the long run offers many differences in addition to the clearing labour market. This title is therefore misleading. It is better thought of as the Walrasian aggregate supply curve.

rate. It is readily derived from the production function, not specified here, from (3), as the relationship between GDP and the price level for a particular fixed nominal wage, W.

$$(28) \quad \frac{W}{P_Y} = w = MP_L\big|_{L=\bar{L}} = \frac{\partial Y(A, L, \bar{K})}{\partial L}\bigg|_{L=\bar{L}} \Rightarrow L = L(\bar{W}, P_Y) \Rightarrow Y = Y\big[L(\bar{W}, P_Y), \bar{K}\big]$$

13.3 The IS curve

This is simply an alternative representation of the financial capital market, of Figure 2, from which it tracks equilibrium combinations of the level of GDP and the interest rate. It is obtained in the same way as for the AD curve, by applying supply side shocks to Y, which shift the $I - S_D = NFI$ curve, and observing changes in the equilibrium yield on long bonds. Increased GDP raises income and saving, and therefore the demand for home bonds, so it reduces their yield, rendering the IS curve downward sloping and shifted by all the exogenous variables that influence the financial capital market.

13.4 The LM curve

This is a representation of the money market, of Figure 4. The quantity of real money balances (M_S/P_Y) is fixed and GDP is shocked. The long bond yield at which that particular quantity of real money balances would be chosen is then solved for. The greater is transactions demand for money, the higher the opportunity cost must be to justify this choice, and so the LM curve is upward sloping in the interest rate. Again, the shifters include all the exogenous parameters in Figure 4.

13.5 The BoP curve

A common addition to the IS-LM approach for open economy macroeconomics is the BoP curve.[13] This is usually added to the IS-LM diagram and, again, it represents combinations (Y, r) at which there is a balance of payments ($KA=-CA$). This curve must

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[13] This curve was originally added by Mundell (1963) and Fleming (1962). It is clearly explained in many texts. Two cogent examples are Levacic and Rebmann (1989) and Wells (1995).

pass through the intersection of the IS and LM curves since there can be no economy wide equilibrium without a balance of payments. To ensure that it does, the exchange rate must be made endogenous. In standard applications, domestic price levels at home and abroad are fixed and hence, when shocks are applied, the upward or downward shifts in BoP as it follows the common equilibrium in the financial and money markets, indicate nominal appreciations or depreciations. This is a clever addition though, in a flex price environment it needs to be formulated in terms of the real exchange rate. Once this is done, however, some external shocks become difficult to implement. For example, a capital flight, stimulated by a rise in the risk premium-adjusted foreign bond yield, r^*, cannot readily be demonstrated since r^* is a shifter in both the IS and BoP curves.

14. Conclusion

Despite the many and various views and analytical approaches to macroeconomic analysis, the most common approach to training undergraduate economics majors is via the AD-AS IS-LM approach with its Keynesian precepts and its reliance on graphical representation of equilibrium loci. Here, a graphical representation is offered based on a standard formulation of an underlying comparative static macroeconomic model. It takes Walrasian equilibrium as its starting point and considers nominal rigidities as special cases. It therefore builds intuition that centers on price rather than quantity adjustment following shocks. In addition, it offers comparative ease of representation of external shocks, which are particularly important in small open economies, it uses intuitive demand-supply market diagrams throughout and it provides the ability to set as clear targets for monetary policy the exchange rate, the CPI and the GDP price. Finally, it allows for forward expectations so that it offers useful insights for students into the economic consequences of financial shocks.

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