OPEN ECONOMY KEYNESIAN MACROECONOMICS WITHOUT THE LM CURVE

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ABSTRACT

When teaching intermediate Macroeconomics, the integration of recent developments in the field of macroeconomic modelling and practice is not common. Some novelties such as the use of a monetary policy rule instead of the traditional LM function, an aggregate supply function based on the Phillips curve, and the extension of the open economies models to describe a monetary union have not been yet incorporated into most available manuals on the subject. There have been several attempts proposing to replace traditional assumptions. But most of them have focused just in one aspect and have been disseminated through academic papers or, in the best cases, incorporated as isolated case studies or discussions in a few textbooks.

In this paper, we present a novel framework for macroeconomic analysis, which tries to incorporate recent theoretical developments into an integrated model describing an open economy. The model includes a monetary policy rule instead of the LM function together with an aggregate supply function derived from the Phillips curve, and the model of the open economy is later extended to describe the case of a monetary union. This new approach should be useful for teaching purposes.

In our model, monetary policy is assumed to follow a rule, or MR function. According to this rule, the interest rate will be changed by the central bank as a function of the deviation of the current inflation rate from the target set by the monetary authority, and of the evolution of the level of output. Therefore, the MR function together with the traditional IS function, make the IS-MR model, alternative to the IS-LM model, from which we obtain the aggregate demand function, AD. Regarding aggregate supply, we include imperfect competition assumptions to stress the role of institutional aspects on economic evolution. Finally, from the Phillips curve so obtained, we derive the aggregate supply function, AS, and complete the AS-AD model, which now relates the level of output and the rate of inflation, instead of the price level.

Under this approach, a special attention is given to the open economy. When modelling the open economy we include two novelties: first, the real exchange rate is incorporated into the aggregate supply function; and, second, the IS-MR and AS-AD models are adapted to the case of a monetary union. In the model of the monetary union, her member countries are assumed to be identical, and each variable of the union is a weighted average of the corresponding variables of the union's member countries. The MR function will be the same for the whole union, which implies that, even though the nominal interest rate is common for the member countries of the union, the real interest rates will be different across them as long as the inflation rates are different too. Therefore, in our model, the open economies analysis is presented for the cases of flexible exchange rate and monetary union, instead of the standard cases of flexible and fixed exchange rate.

INTRODUCTION

Recent developments in the field of Macroeconomics have not been fully incorporated into the available textbooks. Certainly, the "canonical" New Keynesian model (see, e.g., Galí, 2008), currently representing the prevailing orthodoxy in academic circles, includes, together with an IS function, a monetary policy rule and an aggregate supply function based on the Phillips curve. However, the use with didactic purposes of a model of this kind when teaching intermediate Macroeconomics is not common.

In a paper published some years ago, David Romer proposed to replace "the LM curve, along with its assumption that the central bank targets the money supply, with an assumption that the central bank follows a real interest rate rule" (Romer, 2000, p. 150). Assuming the real interest rate is an increasing function of the inflation rate, he obtained an MP (for monetary policy) function, horizontal in the real interest rate-output space that, when coupled with a traditional IS function, led to a decreasing aggregate demand (AD) function in the inflation rate (instead of price level)-output space. The model was completed with the assumption that inflation rises when output is above its natural rate and falls when output is below its natural rate, which gave a horizontal inflation adjustment (IA) line in the inflation-output space. Put together, the IA-AD functions provided an alternative to the AS-AD model, in terms of the inflation rate instead of the price level. Finally, some extensions were also discussed; in particular, the analysis of the open economy was referred to a companion paper available online at the author's web page, where he presents a model with a monetary rule for both the closed and the open economy, but considering only the aggregate demand side for the latter. The first version of that paper, designed to accompany Mankiw's (2012) textbook (first edition published in 1992), dates from August 1999, and the most recent one from January 2012 (Romer, 2012). Similar points were also made by Taylor (2000) and Walsh (2002), but they did not deal with the case of the open economy.

Since then, some (but very few, and mostly European) Macroeconomics textbooks have incorporated a monetary policy rule instead of the LM function, together with an aggregate supply function derived from the Phillips curve; which implies that the AS-AD model is defined as a relationship between the level of output and the rate of inflation, instead of the price level. While this has resulted in a more realistic approach, the analysis has been mostly applied to the closed economy. And, when the open economy was introduced, its treatment has not been substantially different from the closed economy case, in particular regarding aggregate supply.

In this paper, we present a proposal of analysis of the open economy within a framework that incorporates a monetary policy rule instead of the LM function, extended to describe the case of a monetary union. The model comes from a recently published textbook (Bajo-Rubio and Díaz-Roldán, 2011b), aimed to teach Macroeconomics at an intermediate level. We begin by examining how the available Macroeconomics textbooks have dealt with the depiction of monetary policy from the determination of the interest rate through a rule followed by the central bank. Then, we turn to present in greater detail the main features of the approach followed along the book, in order to extend to an open economy framework the model with a monetary policy rule.

MONETARY POLICY RULES IN MACROECONOMICS TEXTBOOKS

As far as we know, the first textbook to introduce a macroeconomic model including a monetary policy rule instead of an LM function is Sørensen and Whitta-Jacobsen (2010) (first edition published in 2005). In general, their approach is similar to ours, with the supply side based on imperfect competition features, where workers set wages and firms set prices; and the model is developed for the open economy. Unlike us, however, the real exchange rate is not included in the aggregate supply, which implies that the aggregate supply function will be the same in the open economy and in the closed economy, except for the assumption that the expected value for the rate of inflation is the rate of inflation of the rest of the world; which, on the other hand, also equals the target inflation in the monetary rule.

In their ambitious textbook, Carlin and Soskice (2006) develop with a great detail a model with a monetary rule, but only for the case of a closed economy. However, the model for the open economy (Part Three, chapters 9 to 12) does not incorporate a monetary rule based on the control of inflation, simply assuming that the real interest rate equals that of the rest of the world. The model with a monetary rule for the closed economy of Part One is later developed for the open economy case in Carlin and Soskice (2010). The real exchange rate is included into the IS function, and a function for the real exchange rate similar to ours is obtained; however, the real exchange rate does not appear in the aggregate supply, which will be identical therefore to that of the closed economy. As an important difference of Carlin and Soskice's models with ours (see below), their monetary rule is obtained from the minimization by the central bank of a loss function that depends on the deviations of the level of output with respect to potential, and of the rate of inflation with respect to target. This assumption implies that, in the medium-run equilibrium, the inflation rate will always equal the target value set by the central bank.

In any event, notice that the textbooks by Sørensen and Whitta-Jacobsen and Carlin and Soskice are both of an advanced level and their coverage of topics is much wider than in our book, which is intended to provide a more compact and self-contained approach, and is aimed at an intermediate level of complexity.

Leaving aside Romer's (2012) above mentioned paper, the first textbook on intermediate Macroeconomics that incorporates a monetary policy rule instead of the LM function is Jones (2011) (first edition published in 2008). The style of this book is quite didactic, but the level is sometimes rather elementary for a textbook on intermediate Macroeconomics. For instance, the monetary rule does not depend on the level of output, but only on the difference between the current inflation rate and the target set by the central bank. On the other hand, although the foreign sector appears in the book's core devoted to the short run (Part 3, chapters 9 to 14), it is introduced in fact as an exogenous variable, so its role is indistinguishable from that of fiscal policy or the autonomous components of consumption and investment. The foreign sector as a separate component of aggregate demand (that is, with net exports as a function of the real exchange rate) is not truly introduced until chapter 19, at the end of the book; and the discussion is rather brief. Lastly, the real exchange rate does not appear in the aggregate supply, so that the aggregate supply function is the same for both the open and the closed economy.

Finally, we will mention the recently published sixth edition of Burda and Wyplosz (2013). Unlike previous editions of this textbook, the authors replace from the beginning the

LM curve with a Taylor rule (from Taylor, 1993), termed TR. While their IS-TR model in Chapter 10 is roughly similar to our IS-MR model (see below), the AS-AD model presented in Chapter 13, designed directly for the open economy, is not fully worked out. In particular, the exchange rate is not incorporated into the aggregate supply, and the analysis of supply shocks is simply sketched.

MAIN FEATURES OF OUR APPROACH

As mentioned above, the analysis of monetary policy in our book makes use of a monetary policy rule that replaces the traditional LM function. As is well known, the outbreak of financial innovation, through the development of many new financial assets with a high degree of liquidity but offering a return to their owners, means that the demand for money, and hence the LM function, become extremely unstable. Then, as already shown by Poole (1970), in such circumstances the desirable intermediate target for monetary policy should be the interest rate rather than money supply. On the other hand, although the interest rate controlled by the central bank is the nominal interest rate, it is the real interest rate who affects the goods market; but, assuming the expected inflation rate is given in the short run, the real interest rate will be controlled indirectly by the central bank.

Hence, monetary policy will be assumed to follow a rule, so that the interest rate will be changed by the central bank as a function of the difference between the current inflation rate and a target set by the monetary authority (i.e., following the so called inflation targeting), and of the evolution of the level of output. This implies that the function of the monetary rule (or MR function) describes an increasing relationship between the interest rate and the level of output, as the traditional LM function. Accordingly, the MR function, together with the traditional IS function, makes the IS-MR model, alternative to the IS-LM model.

Notice, on the other hand, that, unlike the approach of Carlin and Soskice (2006), our monetary rule does not derive from the optimization of the target function of the central bank, given the macroeconomic model describing the economy. We follow in turn the pragmatic proposal of McCallum (1988) of using a “robust” rule in the sense of providing reasonable results for a wide variety of models; in particular, our rule is derived from that suggested by Taylor (1993). This choice will imply that, as a result of any shock that is not transitory, the inflation rate will deviate from the target set by the central bank, assuming that in the starting situation both were equal.

Our analysis of the aggregate supply is based on imperfect competition assumptions, where wages are set through a bargaining process between workers and firms, and prices are then set by firms. Such a modeling of aggregate supply, widely used in the analysis of unemployment in the European economies, follows Layard, Nickell and Jackman (2005) (first edition published in 1991). That framework allows one to stress the role of institutional aspects in economic evolution, as well as to account for the presence of involuntary unemployment. In this way, from the wage and price equations, a Phillips curve is obtained; which, combined with a simple assumption of proportionality between the levels of output and employment (together with the definition of the unemployment rate), leads to the aggregate supply function. Then, joining this aggregate supply function with the aggregate demand function obtained from the IS and MR functions, we have the AS-AD model that now relates the level of output and the rate of inflation, instead of the price level. According to this approach, potential output

is obtained in the medium run, once prices have fully adjusted and the inflation rate does not change as compared to the previous period; and the associated unemployment rate will be the NAIRU or non-accelerating inflation rate of unemployment.

Finally, our analysis of the open economy incorporates two main novelties. First, we start from the assumption that, in an open economy, workers are not concerned with the real wage in terms of domestic prices, but with the real wage in terms of the consumption price index, i.e., that including the prices of imported goods. And this in turn implies that the aggregate supply function depends on the real exchange rate, in line with Sachs's (1980) pioneering contribution. As a consequence, in the medium run, neither potential output nor the NAIRU will be unique, but they will depend on the real exchange rate. Hence, and unlike the closed economy, the level of potential output could be changed due not only to supply shocks, but also in the presence of shocks to the domestic demand of goods, and external shocks; the only shocks unable to change the level of potential output are monetary shocks.

Second, when analyzing the open economy, we consider, together with the case of flexible exchange rate, a monetary union as an alternative to the case of fixed exchange rates. As is well known, in last years fixed exchange rate systems have revealed as extremely fragile and difficult to maintain. The ultimate reason would be the huge growth of international capital markets, which has resulted in a great vulnerability of the fixed exchange rate systems faced to speculative attacks in a massive scale. This problem is related with the "impossible trilogy" principle, that is, the impossibility of keeping simultaneously free capital movements, a fixed exchange rate, and an independent monetary policy. So, in a world characterized by an enormous international capital mobility, where many countries are reluctant to adopt a flexible exchange rate system (Calvo and Reinhart, 2002), the only alternative for a country would seem to be the formation of a monetary union, namely, the adoption of a common currency with other countries with which she has some special links.

Notice that a monetary union is somewhat of a particular case of a fixed exchange rate, since when a country joins a monetary union her national currency disappears, setting an irrevocable fixed exchange rate with regard to the new currency. In turn, the latter can be either a completely new currency (such as the euro), or other country's currency (such as the US dollar in some Latin American countries, or the euro in some Eastern European countries). Hence, in a world in which maintaining a fixed exchange rate system becomes increasingly difficult, the traditional alternative regarding the choice of the exchange rate system, between flexible exchange rates and fixed exchange rates, is more and more a choice between flexible exchange rates and a monetary union (Obstfeld and Rogoff, 1995).

In this way, we adapt the IS-MR and AS-AD models to the case of a monetary union, following the general framework proposed in Bajo-Rubio and Díaz-Roldán (2011a). We assume a monetary union made up of two identical countries, where each variable of the union is a weighted average of the corresponding variables of the member countries. A particular feature of these models is that, as long as monetary policy is performed by a central bank that is common to the two countries, such central bank is going to control the nominal interest rate common to both economies; however, the real interest rates will be different across countries, as long as inflation rates are different too. In addition, we will differentiate between common shocks, which occur simultaneously in the two countries belonging to the union, and country-specific shocks, which occur in just one of them. This differentiation is important since, in some particular circumstances, a country-specific shock will provoke opposite-sign effects in

each country of the union; in other words, it will work as an asymmetric shock, namely, that requiring a different optimal policy response in every country that suffers the shock. The existence of asymmetric shocks has been pointed out as a potential impediment for the successful working of a monetary union, since the pioneering contribution of Mundell (1961).

In the next section, we sketch the AS-AD model for the open economy, for the case of a flexible exchange rate. The model for the monetary union will be presented in the following section.

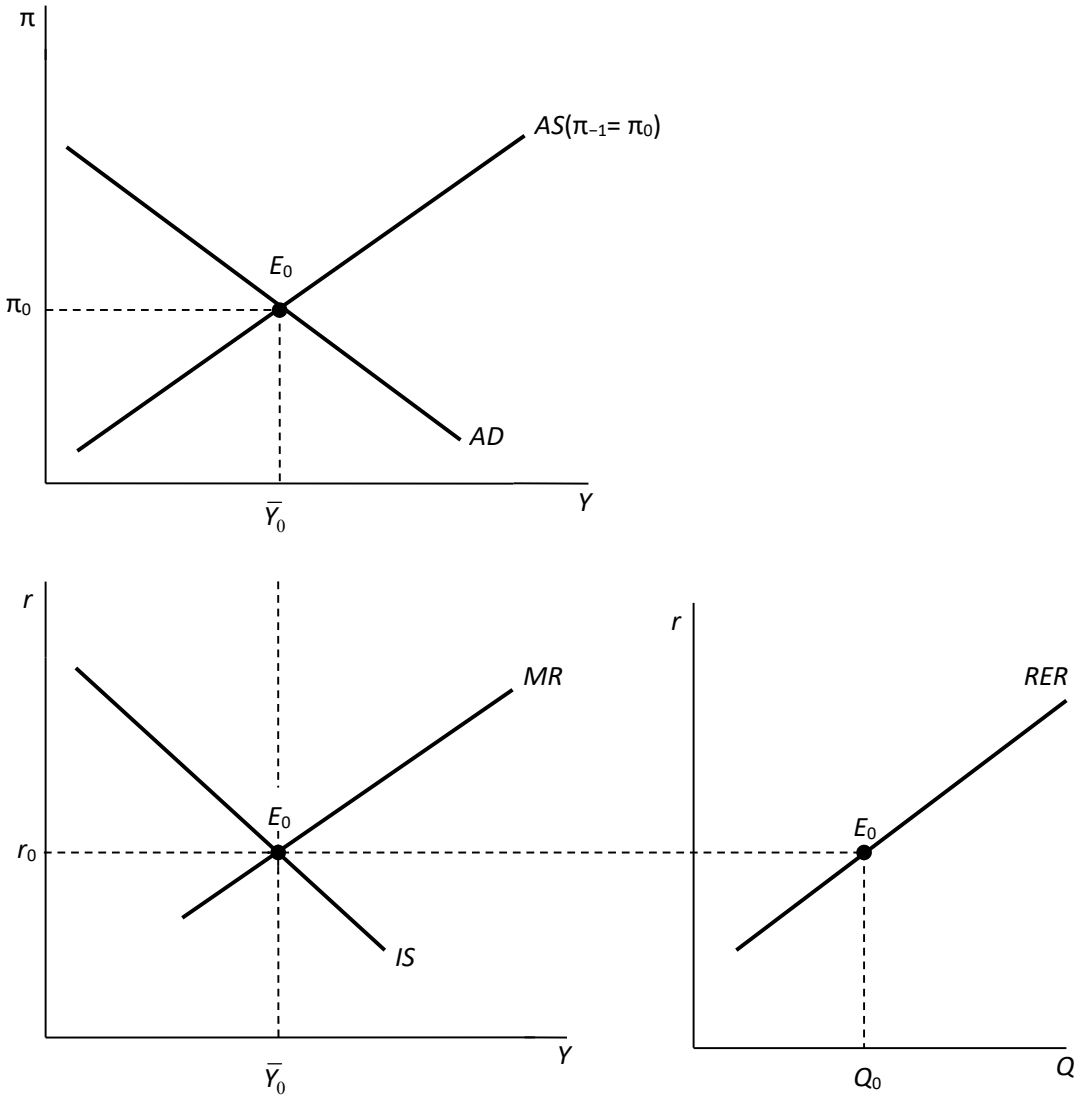
AN AS-AD MODEL FOR THE OPEN ECONOMY

We assume a standard IS function including net exports, which depend negatively on the real exchange rate. The real exchange rate is defined as the price of domestic goods in terms of foreign goods, so that an increase (decrease) means an appreciation (depreciation). In addition, the real exchange rate is assumed to depend positively on the differential between the domestic and foreign real interest rates, which gives an increasing relationship between the real interest rate and the real exchange rate, termed the RER schedule. We also have an MR function, where the real interest rate depends positively both on the difference between the inflation rate and the target set by the central bank, and on the level of output. And from the IS and MR functions, we get an AD function decreasing in the inflation-output space.

Regarding aggregate supply, we have a Phillips curve-type AS function that positively relates output and inflation, where inflation expectations are proxied by the inflation rate at the beginning of the period of analysis. In the specific case of the open economy, it is assumed that the wage set in the bargaining process does not depend on the domestic price level, but depends on the consumption price index, i.e., a weighted average of the prices of domestic and import goods; in other words, the real wage target is now defined in terms of the consumption price index instead of the domestic price level. Accordingly, the AS function will shift upwards (downwards) following a one-period lagged depreciation (appreciation) of the real exchange rate.

The AS-AD model for the open economy, with a flexible exchange rate, is shown in Figure 1. Here, r, Y, Q, and π denote the real interest rate, output, real exchange rate, and inflation rate, respectively. The medium-run equilibrium occurs at points E_0, where inflation is constant (i.e., $\pi_0 = \pi_{-1}$), so that output equals its potential level, denoted by $\bar{Y}$ (and the unemployment rate equals the NAIRU).

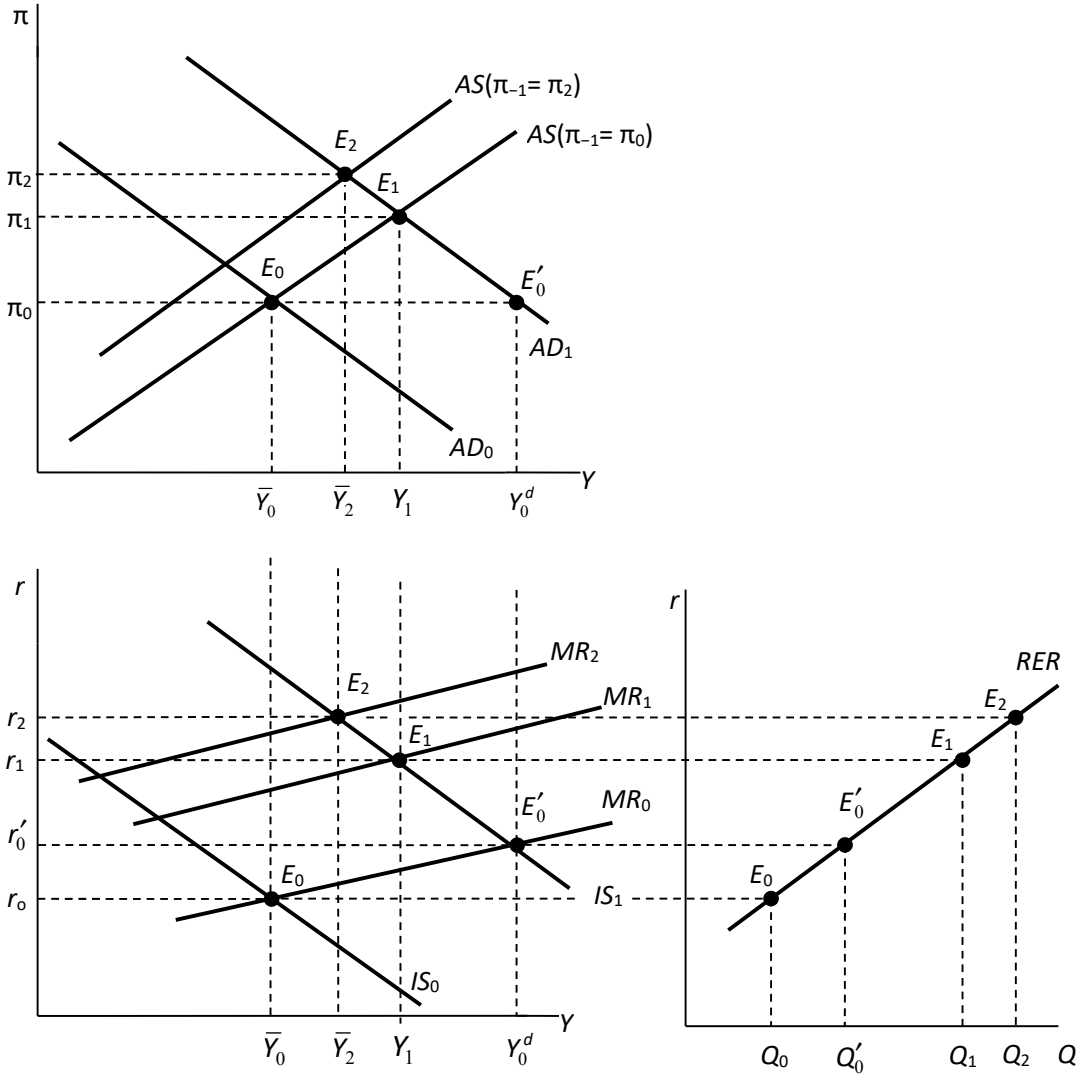
Figure 1
THE AS-AD MODEL FOR THE OPEN ECONOMY



The effects of an increase in government spending (or, in general, an increase in the domestic demand of goods, say, an increase in autonomous consumption or investment, or a tax cut) are shown in Figure 2. Starting from the medium-run equilibrium at points E_0, aggregate demand initially raises up to Y_0^d at points E_0' due to the higher government spending, amplified by the multiplier effect on consumption, and lowered by a decrease in investment (via a higher real interest rate through the monetary policy rule) and a worsening of the trade balance (via the multiplier effect on imports and an appreciation of the real exchange rate). Output increases following the rise in aggregate demand, which raises the inflation rate (via

higher wage claims), and this in turn leads to a fall in aggregate demand at points E_1, due to a new increase in the real interest rate through the monetary rule, and an additional real exchange rate appreciation. In the next period, the increase in domestic inflation would lead to higher wage claims, but the real exchange rate appreciation (by lowering import prices) would work in the opposite sense; we have assumed in Figure 2 that the first effect dominates so the AS function shifts upwards, leading to an additional increase in inflation. In the end, in the new medium-run equilibrium at points E_2 the level of potential output has risen, as well as the real interest rate and the domestic inflation rate, although the effect on the latter variable would be strictly ambiguous. Therefore, unlike the closed economy, in the new medium-run equilibrium potential output would be higher (and the NAIRU lower), since the real exchange rate appreciation tends to offset the effects on wage claims of the higher domestic inflation.

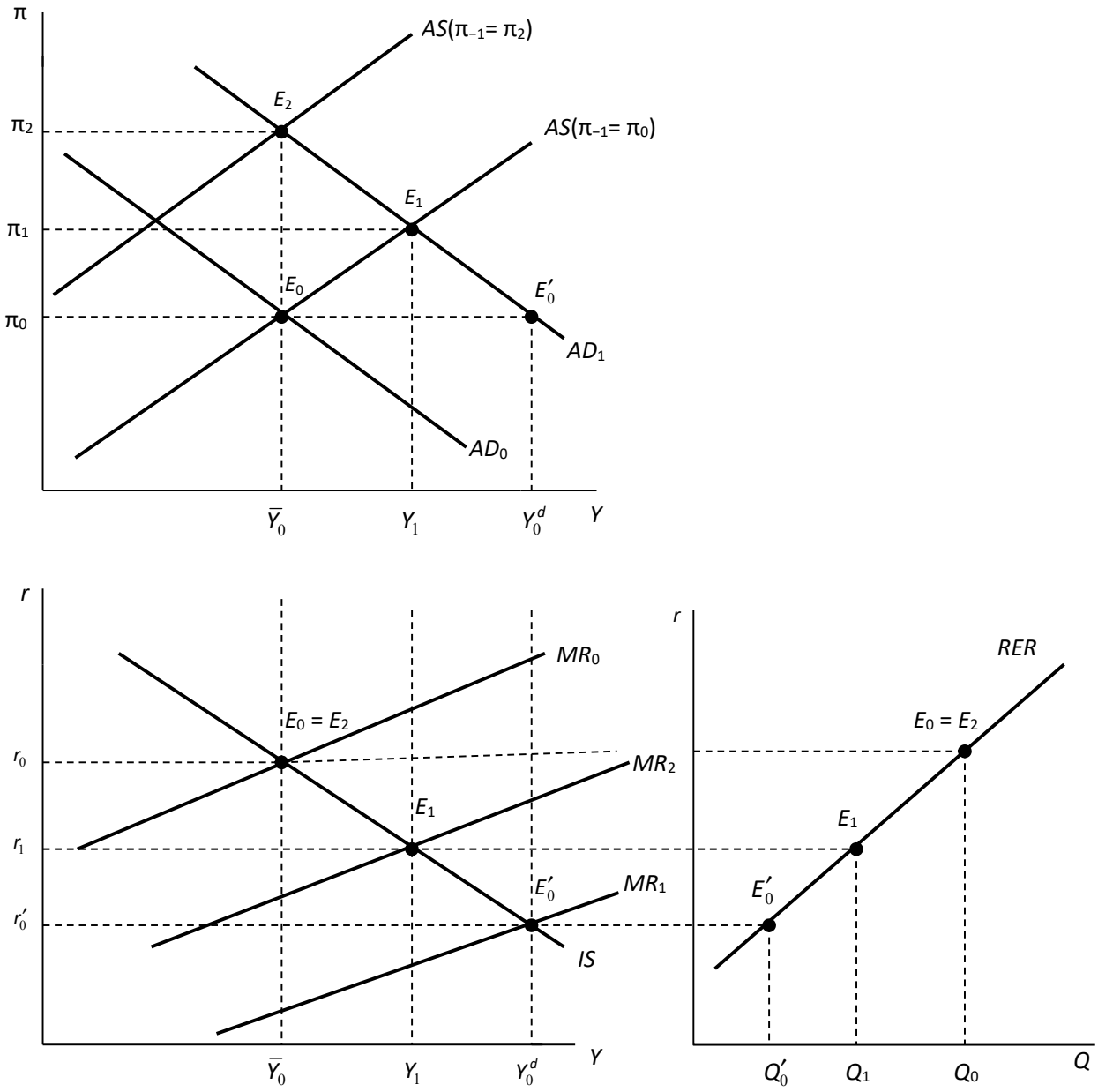
Figure 2
AN INCREASE IN GOVERNMENT SPENDING IN THE AS-AD MODEL FOR THE OPEN ECONOMY



The case of an expansionary monetary policy, through an increase in the inflation target set by the central bank, is depicted in Figure 3. Starting again from the medium-run equilibrium at points E_0, the real interest rate falls; and this raises aggregate demand up to Y_0^d at points E_0', due to an increased investment and an improved trade balance in response to the depreciation

of the real exchange rate. As in Figure 2, output increases, raising the inflation rate (via higher wage claims), which decreases aggregate demand due to the increase in the real interest rate through the monetary rule, and a partial real exchange rate appreciation, reaching points E_1. Next, in the following period both the increase in domestic inflation and the real exchange rate depreciation (by raising import prices) would lead to higher wage claims, so that the domestic inflation rate increases even more, the central bank raises again the real interest rate, and the real exchange rates appreciates. Therefore, in the final medium-run equilibrium at points E_2 potential output (and the NAIRU), the real interest rate and the inflation rate return to their initial levels, and the domestic inflation rate increases in the same proportion than the central bank's inflation target. That is, unlike the fiscal policy case shown in Figure 2, the final new medium-run equilibrium does not change as compared to the closed economy case; and the ultimate reason is that the real exchange rate is kept unchanged since the nominal exchange rate depreciates in the same proportion than the increase in domestic prices.

Figure 3
AN INCREASE IN THE INFLATION TARGET IN THE AS-AD MODEL FOR THE OPEN ECONOMY



The above model can be used to show the effects of other shocks, such as external shocks (either to the trade balance, or the foreign interest rate) or supply shocks. In particular, for the latter case, it can be shown that a positive supply shock (i.e., one reducing the inflation

rate at the initial level of output) raises potential output (and reduces the NAIRU) in the medium run, which is accompanied with a lower domestic inflation and real interest rate, together with a real exchange rate depreciation; see Bajo-Rubio and Díaz-Roldán (2011b).

THE MODEL FOR A MONETARY UNION

The AS-AD model for the open economy with flexible exchange rates assumed that the economy analyzed was small, which implied that the variables from the rest of the world were exogenous. Now we will assume, on the contrary, that the two countries in our simplified world (i.e., the country under study and the rest of the world) make a monetary union, which means that the two countries decide to abolish their national currencies and adopt a currency common to both of them. The two countries are assumed to be identical, and each variable of the union is a weighted average, being the weights equal to $\frac{1}{2}$, of the corresponding variables of the two countries. Accordingly, the variables from the rest of the world will be now endogenous and, on the other hand, the assumption of a two-country world will imply that the monetary union as a whole is a closed economy.

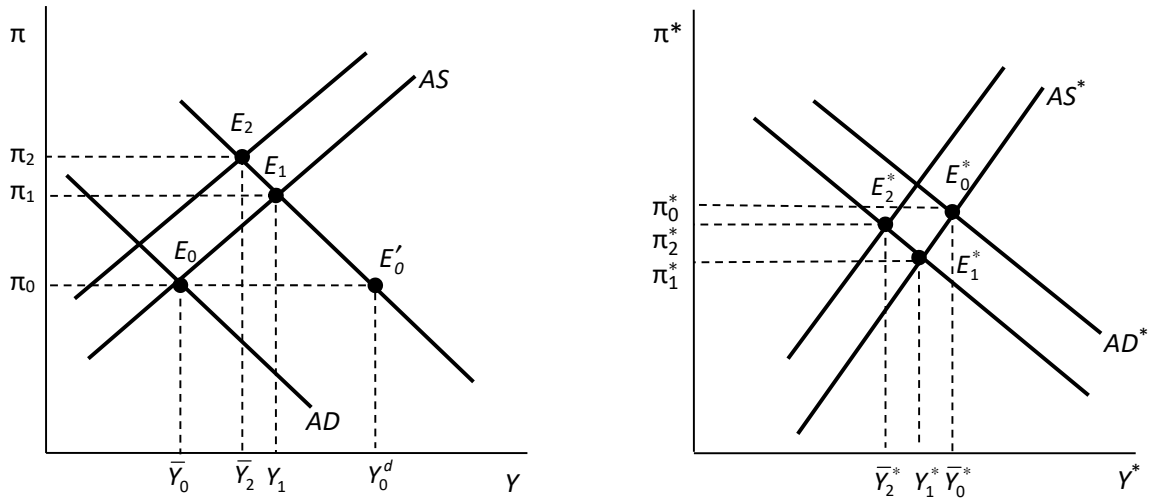
In this way, each country will have an IS and an MR function, which make up the IS-MR model for the monetary union; notice here that, although the nominal interest rate is common for the two economies, the real interest rates will be different across them as long as the inflation rates are different too. As before, from the IS and MR functions we get the AD function for each country that, coupled with the corresponding AS functions, make up the AS-AD model for the monetary union. Again, and for the sake of comparison with the previous section, we will also focus on this AS-AD model.

Regarding the occurrence of shocks, our framework allows to differentiate between common shocks, which occur simultaneously in the two countries belonging to the union, and country-specific shocks, which occur in just one of them. Given our assumption of a monetary union made up of two identical countries, with weights equal to $\frac{1}{2}$, the effects of a common shock will be the same in each member country and in the whole union; and these effects, in turn, will equal those resulting in the closed economy case. As for the effects of a country-specific shock, they will be the same for the union as a whole as in the model of the closed economy; and will equal the weighted sum, with weights equal to $\frac{1}{2}$, of the effects on each member country. The distribution of these effects across the two countries will not be uniform, however. So, for the country of origin of the shock the sign of the effects will be the same than in the union as a whole, but this will not be necessarily true for the other member country to which the shock is transmitted. Indeed, the effects of a country-specific shock will be quantitatively greater, in absolute terms, for the country of origin of the shock, both regarding the other country and the union as a whole.

Since the effects of a common shock, on each country and the whole union, are standard, and equal to those occurring in the closed economy, in the rest of this section we will only analyze the effects of country-specific shocks. In particular, we will examine the case of two country-specific shocks: on the domestic demand of goods, and on the aggregate supply; notice that in this framework monetary shocks are always common.

The effects of a country-specific increase in government spending in the AS-AD model for a monetary union, are depicted in Figure 4. The figure shows the AS and AD functions for the two member countries of the monetary union, and we assume that the shock occurs in the first country (the results would be symmetrical if the increase in government spending would had happened in the other country); the variables of the second country are denoted by a star. Starting from a medium-run equilibrium at points E_0 and E_0^* for each country, aggregate demand initially increases in the first country up to Y_0^d at point E_0' due to the higher government spending, amplified by the multiplier effect on consumption, and lowered by a decrease in investment (via a higher real interest rate through the monetary policy rule). Following the rise in aggregate demand, output increases and so the inflation rate (via higher wage claims), which leads to a fall in aggregate demand due to the increase in the real interest rate through the monetary rule; so, output reaches Y_1, above potential, at point E_1.

Figure 4
A COUNTRY-SPECIFIC INCREASE IN GOVERNMENT SPENDING IN THE AS-AD MODEL FOR A MONETARY UNION



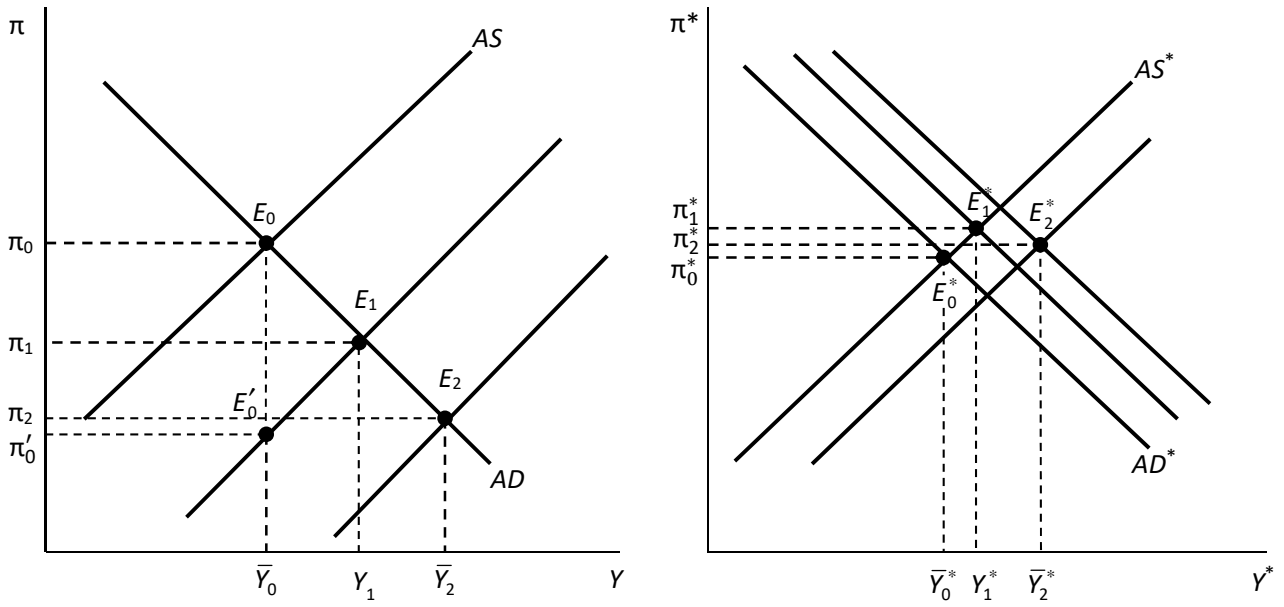
As for the second country, the higher level of output in the first country leads to two opposite effects: (i) a contractionary effect due to the increase in the interest rate by the central bank of the union; and (ii) an expansionary effect due to the higher income level in the first country that raises the second country's exports. The net effect is therefore ambiguous; we have assumed in Figure 4 that the first one prevails so the level of output in the second country falls up to Y_1^*, below potential, at point E_1^*.

Notice that the union's inflation rate will be higher, since the increase in the first country is greater than the fall in the second. Accordingly, via higher wage claims, inflation rate in both countries will tend to rise as the AS and AS* functions shift upwards. In the end, compared with the initial equilibrium, in the new medium-run equilibrium at points E_2 and E_2^* potential output is higher in the first country and lower in the second; and inflation rates increase and decrease (although in the latter case, the sign of the effect would be generally ambiguous), respectively.

Notice, however, that the rise in potential output in the first country from $\overline{Y}_0$ to $\overline{Y}_2$ in the first country, and the fall in the second from $\overline{Y}_0^*$ to $\overline{Y}_2^*$, offset exactly, so that potential output in the union as a whole will be unchanged.

Finally, we show in Figure 5 the effects of a country-specific aggregate supply shock that lowers the inflation rate at the initial level of potential output, in the AS-AD model for a monetary union, where we assume again that the shock occurs in the first country. Starting from a medium-run equilibrium at points E_0 and E_0^* for each country, the inflation rate falls in the first country up to π_0' at point E_0', which leads to a higher level of output (via a lower real interest rate through the monetary policy rule) at point E_1. In the second country, the lower real interest rate has an expansionary effect on output, and the same happens with the higher output level in the first country, even though the latter effect would lead the central bank to raise the real interest rate. Assuming that the expansionary effect prevails, the AD^* function shifts rightwards and output rises in the second country too, at point E_1^*. The overall effect on the union, on the other hand, would be a higher output and a lower inflation rate.

Figure 5
A COUNTRY-SPECIFIC AGGREGATE SUPPLY SHOCK THAT LOWERS THE INFLATION RATE IN THE AS-AD MODEL FOR A MONETARY UNION



In the following period, the lower inflation rate in the first country leads the AS and AS^* functions to shift downwards, via lower wage claims; and the central bank will reduce again the real interest rate in response to the lower inflation, which raises aggregate demand and output. In the new medium-run equilibrium at points E_2 and E_2^* potential output is higher in both countries; and the inflation rate is lower and slightly higher, respectively, although the sign of the effect on inflation for the second country would be generally ambiguous. Again, in the final equilibrium potential output rises and inflation falls in the union as a whole.

CONCLUDING REMARKS

In this paper, we have presented a novel framework for macroeconomic analysis, which tries to incorporate recent theoretical developments into a model describing an open economy, and should be useful for teaching purposes. The main features of our approach are as follows:

1. First, monetary policy is assumed to follow a rule, so that the interest rate is set by the central bank as a function of the difference between the current inflation rate and a target set by the monetary authority, and of the evolution of the level of output. This implies that the function of the monetary rule (or MR function) describes an increasing relationship between the interest rate and the level of output, as the traditional LM function. Accordingly, the MR function, together with the traditional IS function, makes the IS-MR model, alternative to the IS-LM model.
2. Second, our analysis of the aggregate supply is based on imperfect competition assumptions, where wages are set through a bargaining process between workers and firms, and prices are then set by firms. In this way, from the wage and price equations, a Phillips curve is obtained; which leads to the aggregate supply function. Then, joining this aggregate supply function with the aggregate demand function obtained from the IS and MR functions, we have the AS-AD model that now relates the level of output and the rate of inflation, instead of the price level.
3. Third, regarding the case of the open economy, we assume that workers are not concerned with the real wage in terms of domestic prices, but with the real wage in terms of the consumption price index, i.e., that including the prices of imported goods. This in turn implies that the aggregate supply function depends on the real exchange rate. Hence, and unlike the closed economy, the level of potential output could be changed due not only to supply shocks, but also in the presence of shocks to the domestic demand of goods, and external shocks; with monetary shocks being the only ones unable to change potential output.
4. Finally, and as a novelty compared with the available textbooks, we adapt the IS-MR and AS-AD models to the case of a monetary union. Notice that a monetary union can be considered as a particular case of a fixed exchange rate, and an alternative to the latter in a world characterized by a huge degree of international capital mobility. Accordingly, when analyzing the open economy we consider, together with the case of flexible exchange rates, the case of a monetary union instead of fixed exchange rates.

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