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TEACHING MODERN MACROECONOMICS IN THE MUNDELL-FLEMING LANGUAGE: THE IS-MPR-UIP-AD-AS MODEL

Waldo Mendoza Bellido

DEPARTAMENTO DE ECONOMÍA
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Teléfono: (51-1) 626-2000 anexos 4950 - 4951
econo@pucp.edu.pe
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jorge.rojas@pucp.edu.pe
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Resumen

El modelo tradicional de demanda y oferta agregada respaldado por el modelo de Mundell-Fleming y la curva de oferta que relaciona el nivel de precios con la brecha del producto, deberían ser abandonados de la enseñanza de Macroeconomía de pregrado. Primero, porque las economías no regresan automáticamente al equilibrio; en segundo lugar, los bancos centrales modernos controlan la tasa de interés, no la cantidad de dinero; y tercero, la principal variable de interés es la inflación, no el nivel de precios.

Los nuevos modelos keynesianos que se enseñan en la macroeconomía intermedia han planteado estas preguntas, y se esperaba que reemplazaran al modelo tradicional. Sin embargo, carecen de su atractivo y simplicidad. En la actualidad, el modelo Mundell-Fleming, a punto de cumplir 60 años, sigue siendo una parte fundamental de los libros de texto de macroeconomía a nivel de pregrado.

En este artículo presentamos una alternativa, el IS-MPR-UIP-DA-OA, un nuevo modelo keynesiano simple, una suerte de Mundell-Fleming con metas de inflación, que determinan los valores de equilibrio de la producción, la inflación y el tipo de cambio real. El modelo es tan simple como el tradicional, ya que reproduce el esquema de equilibrio general, contiene una dosis razonable de matemáticas y tratamiento gráfico, y tiene una conexión simple entre predicciones y hechos; pero también es útil para analizar las principales cuestiones de interés. Además, y lo que es más importante, el dispositivo es tan flexible como el tradicional, por lo que puede extenderse para tratar asuntos más complejos.

El objetivo es que este modelo sustituya al tradicional Mundell-Fleming en la enseñanza de Macroeconomía a nivel de pregrado.

Código JEL: E32, E52 y E58
Palabras clave: Enseñanza de la Macroeconomía, modelo Mundell-Fleming, modelo newkeynesiano de economía abierta, regla de política monetaria, esquema de metas de inflación.

Abstract

The traditional open aggregate demand and aggregate supply model backed by the Mundell-Fleming model, together with the supply curve that relates the price level to the output gap, should be abandoned in undergraduate Macroeconomics teaching. First, because economies do not return automatically to equilibrium; second, modern central banks set the interest rate, not the amount of money; and third, the main variable of interest is inflation, not price level.

The New Keynesian models taught in intermediate macroeconomics have raised these questions, and had been expected to replace the traditional model. However, they lack its appeal and simplicity. At present, the Mundell-Fleming model, on the verge of turning 60, remains a fundamental part of undergraduate-level macroeconomics textbooks.

In this article we present an alternative, the IS-MPR-UIP-AD-AS, a simple New Keynesian model and a form of the Mundell-Fleming with inflation targeting that determines the equilibrium values of production, inflation, the real interest rate, and the real exchange rate. The model is as simple as the traditional one in that it replicates the general equilibrium scheme, it contains a reasonable measure of mathematics and graphical treatment, and it has a simple connection between predictions and facts; but it is also useful in analyzing the main questions of interest. In addition, and more importantly, the device is as flexible as the traditional one, so it can be extended to deal with more complex matters.

The main objective is that this model replace the traditional Mundell-Fleming in the teaching of macroeconomics at the undergraduate level.

JEL Code: E32, E52 and E58
Keywords: Teaching macroeconomics, Mundell-Fleming model, open-economy New Keynesian model, monetary policy rule, inflation-targeting scheme.

TEACHING MODERN MACROECONOMICS IN THE MUNDELL-FLEMING LANGUAGE:
THE IS-MPR-UIP-AD-AS MODEL

Waldo Mendoza Bellido[1]

1. INTRODUCTION

In the opinion of Blanchard (2017), the traditional aggregate demand and aggregate supply model supported by the IS-LM model or its extensions, along with the supply curve that relates the price level with the output gap, should be excluded from undergraduate-level macroeconomics teaching.

The main reasons behind this proposal are threefold. First, because economies do not return automatically to equilibrium after a shock distances them from it. Second, because central banks do not operate by controlling monetary aggregates but by administering a short-term interest rate, as Taylor (1993) showed us so long ago. Third, because the most visible variable —and the one that we focus on here— is inflation, not price level.

Numerous studies in the field of New Keynesian macroeconomics have raised these three issues: Taylor (2000), Romer (2000), Walsh (2002), Carlin and Soskice (2005), Sorensen and Whitta-Jacobsen (2009, Chapter 6), Sorensen and Whitta-Jacobsen (2009, Chapter 12), Romer (2013), and Carlin and Soskice (2015) for open economies.

In these studies, because central banks operate with inflation targets rather than price-level targets; because low and stable inflation is not achieved automatically but through a central bank mechanism; and because monetary supply is not exogenous but endogenous, the traditional LM has given way to a monetary policy rule (MPR) and the old supply and demand curves that formerly manifested themselves in terms of production and price level now do so in terms of production and inflation.

The new models, however, lack the appeal and simplicity of their traditional counterparts. This is the likely reason why efforts to displace the IS-LM-AD-AS model in the field of closed economies, and the Mundell-Fleming model in the field of open economies, have failed.

[1] Professor of the Department of Economics, Pontificia Universidad Católica del Perú (PUCP). The author is grateful for the assistance of Erika Collantes and Yuliño Anastacio. The author also appreciates the important comments of Paul Castillo.

At present, the IS-LM, which is now more than 80 years old, or the Mundell-Fleming, on the brink of turning 60, are still at the heart of most undergraduate macroecononics textbooks.

In this article we offer an alternative in the field of open economies, the IS-MPR-UIP-AD-AS, a simple New Keynesian model and a form of the Mundell-Fleming with inflation targeting that allows the equilibrium values of production, inflation, the real interest rate, and the real exchange rate to be determined[2].

The model is as simple as the traditional one in that it replicates the general equilibrium scheme, it contains a reasonable measure of mathematics and graphical treatment, and it has a simple connection between predictions and facts; but it is also useful in analyzing the main issues of interest. In addition, and most importantly, the device is as flexible as the traditional one, so it can be extended to deal with more complex matters such as the short term, stationary equilibrium, the stationary equilibrium transition dynamics, and rational expectations.

The aim is for the model to replace the traditional Mundell-Fleming in the teaching of macroeconomics at undergraduate level.

This article is organized as follows. The next section presents the general model. Section 3, based on the general model, presents the subsystems corresponding to the short-term, stationary equilibrium, the stationary equilibrium transition dynamics, and rational expectations. Then, we simulate the effects that an expansive monetary and fiscal policy, as well of an increase in the international interest rate have on the different subsystems. Finally, Section 5 sets out the conclusions.

[2] Similar options for closed economies are presented in Mendoza (2017 and 2017a).

2. THE GENERAL MODEL

In this section we present the general structure of a New Keynesian model for an open economy, which is an extension of Mendoza's (2017)[3] model of the closed economy. It is presented in a similar language to that of the well-known Mundell-Fleming model but applied to the case whereby the central bank follows an inflation targeting scheme, which is only compatible with a floating exchange rate regime, while considering aggregate supply, which is omitted in the traditional model.

The model contains aggregate demand, which is derived from equilibrium in the goods market, the well-known IS, uncovered interest rate parity (UIP), and the monetary policy rule (MR), which is a variety of the Taylor rule. Aggregate supply is obtained from a Phillips curve. The interaction between aggregate demand, aggregate supply, the MR, and UIP allows the equilibrium values of production, inflation, the interest rate, and the real exchange rate to be determined.

2.1. Aggregate demand

The aggregate demand equation, which connects the level of economic activity with inflation, proceeds from the interaction between goods market equilibrium, uncovered interest rate parity, and the monetary policy rule.

The goods market

The goods market is Keynesian, in the sense that production adapts to the level of demand. Production[4] is a direct function of public spending, the real exchange rate, the international GDP, and the state of business confidence, reflected in the parameter a_4, and an inverse function of the real interest rate.

$$y - \bar{y} = a_0(g - \bar{g}) - a_1(r - \bar{r}) + a_2(e - \bar{e}) + a_3(y^* - \bar{y}^*) + a_4 \qquad (1)$$

[3] This, in turn, is based on Chapter 6 of Sorensen and Whitta-Jacobsen (2009).

[4] All variables are expressed in gaps in relation to their trend value.

Interest rate parity[5]

When there is free movement of capital and the local asset is a perfect substitute for the foreign asset, the nominal local interest rate (i) is equaled by the nominal international interest rate (i^*), adjusted for the expected depreciation of the local currency ($E^e - E_0$)[6]. E^e Is the expected exchange rate and E is the nominal exchange rate.

$$i = i^* + E^e - E \qquad (2)$$

This equation of nominal interest rate parity can be transformed, through a series of simple manipulations, into real interest rate parity. By adding and subtracting the expected international inflation (π^{*e}) and the expected local inflation (π^e) in Equation (2), the following is obtained,

$$i - \pi^e = i^* - \pi^{*e} + E^e + \pi^{*e} - E - \pi^e$$

Given that expected international inflation is equal to the difference between the expected international price and the actual international price (in logarithms), $\pi^{*e} = P^{*e} - P^*$, and expected local inflation is the same as the expected local price less the actual local price, $\pi^e = P^e - P$, therefore, Equation (2), of nominal interest rate parity, can be transformed into the following equation of real interest rate parity.

$$r = r^* + e^e - e \qquad (3)$$

Where $r = i - \pi^e;\ r^* = i^* - \pi^{*e};\ e^e = E^e + P^{*e} - P^e; e = E + P^* - P$

According to this equation, the real local interest rate (r) is equal to the real international interest rate (r^*), adjusted for the expected depreciation of the real exchange rate $(e^e - e)$, where e^e is the expected real exchange rate and e is the actual real exchange rate.

Equation (3) can be expressed in terms of the interest rate and the real exchange rate as the UIP line, in Figure 1. The inverse relationship between both variables is shown therein.

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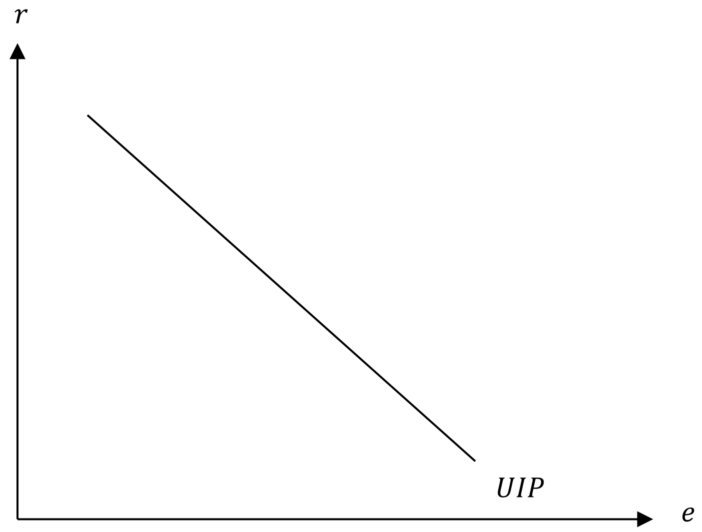
5 We focus on the case of uncovered interest rate parity. That is, investors (investment banks, pension fund managers, the banks) are not "covered" against exchange risk: the risk of changes occurring in the price of a currency or in a financial instrument other than that which the investor uses in their routine operations. For more details, see Mendoza (2015, Chapter 11).

6 Strictly speaking, the expected rate of depreciation is given by $\frac{E^e - E}{E}$. In order for the model to retain its linear character, the expected depreciation is approximated by $E^e - E$.

Figure 1

UIP



The model assumes a floating exchange rate regime, which is the regime that is compatible with an inflation targeting scheme. In consequence, Equation (3) can also be rewritten to obtain the determinants of the real exchange rate in this world of free movement of capital and of local and foreign assets, which are perfect substitutes.

$$e = e^e + r^* - r \tag{4}$$

According to this equation, the real exchange rate is a direct function of the expected real exchange rate and the real international exchange rate, and an inverse function of the real local interest rate.

The trend, natural, or stationary equilibrium interest rate ($\bar{r}$) can also be obtained from Equation (3). In the stationary equilibrium, as we will see in more detail later, the expected variables must be equal to their actual values. In consequence, in Equation (3), since the expected real exchange rate must be equal to its actual value ($e^e = e$), the trend or stationary equilibrium interest rate is equal to the real international interest rate.

$$\bar{r} = r^* \tag{5}$$

The goods market and interest rate parity: IS and UIP

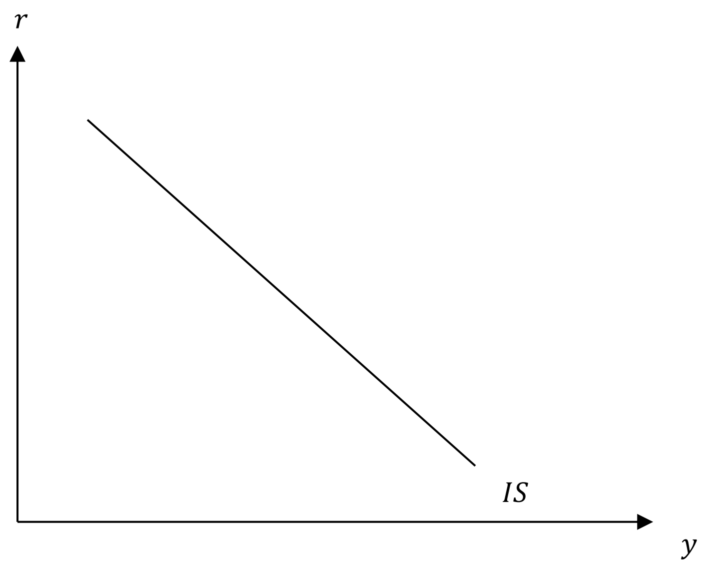
For the graphical treatment of the model, it is important to consider the goods market, real interest rate parity, and the natural exchange rate together. By combining equations (1), (3) and (5) and expressing them to be plotted in terms of the interest rate and production, we obtain the IS line, which considers goods market equilibrium, achievement of real interest rate parity, and the definition of the stationary equilibrium real interest rate.

$$r = r^{*} + \frac{a_5 + a_2(e^e - \bar{e}) + \bar{y}}{a_1 + a_2} - \frac{y}{a_1 + a_2} \qquad (6)$$

Where, $a_5 = a_0(g - \bar{g}) + a_3(y^{*} - \bar{y}^{*}) + a_4$

Figure 2

IS



The IS line has a negative slope given by,

$$\left.\frac{dr}{dy}\right|_{IS} = -\frac{1}{a_1 + a_2} < 0$$

The monetary policy rule

The monetary policy rule is a Taylor-rule policy[7]. According to this rule, the nominal interest rate is a direct function of the natural nominal interest rate, the gap between actual inflation and the inflation target, and the GDP gap. We define the natural nominal interest rate as the sum of the natural real interest rate and the expected inflation[8]. The natural real interest rate is the prevailing rate in the stationary equilibrium and is equal to the real international exchange rate, as in Equation (5). In this way, the monetary policy rule is given by,

$$i = r^* + \pi^e + b_0(\pi - \bar{\pi}) + b_1(y - \bar{y}) \quad (7)$$

This rule can also be expressed in terms of the real interest rate, the nominal rate less expected inflation, $r = i - \pi^e$, as in Equation (8).

$$r = r^* + b_0(\pi - \bar{\pi}) - b_1\bar{y} + b_1 y \quad (8)$$

According to this rule, the local interest rate is immediately adjusted to achieve the monetary policy objectives, which are to keep inflation at its target level and production at the level of full employment.

However, according to Clarida, Galí and Gertler (1999), and Woodford (1999), in practice, central banks adjust the interest rate more cautiously than a rule such as that of Equation (8) would predict. Central banks tend to adjust their interest rates gradually until the level set as the target is reached. For this reason, the monetary policy rules that reproduce the behavior of most central banks incorporate the lagged interest rate as one of the interest rate determinants.

7 In some studies (Walsh 2002; Bofinger, Mayer and Wollmershaeuser 2009; and Carlin and Soskice 2015) the monetary policy rule is obtained from the optimizing behavior of the central bank. Here, we tend towards the options proposed by Taylor (2000) or Sorensen and Whitta-Jacobsen (2009), which are based on the rules that central banks use in practice.

8 Strictly speaking, the natural nominal interest rate is defined as $\bar{r} + \bar{\pi}$, and not as $\bar{r} + \pi^e$, as it features here. The modification helps to arrive at a simple expression for the aggregate demand equation.

There are a number of explanations as to why central banks smooth interest rate movements[9].

First, since production and prices depend not on the short term interest rate but on the long-term one, which is associated with expectations regarding the short-term rates, a simple way of affecting long-term rates is to establish the reputation of keeping the short-term rate high once it has been raised, or of keeping it consistently low once it has been lowered. Second, uncertainty is always present when making monetary policy decisions, which necessitates cautious interest rate management. Third, the linear monetary policy rule can bring about large interest rate fluctuations, which goes against the non-negativity restriction of the short-term nominal interest rate. Four, large interest rate movements can have destabilizing effects on the financial markets. Finally, as Woodford (2002, 2003), points out, central banks can have a further objective function: to smooth interest rate movements such that the presence of the lagged interest rate in the monetary policy rule is removed from a central bank's optimizing behavior.

At any rate, as pointed out by Clarida, Galí and Gertler (1999), understanding why central banks move the interest rate less than the theory predicts is an important issue that remains unresolved.

Because of these considerations, in Equation (9) we express a rule that better reflects the behavior of central banks and leads to improved predictions[10]. According to this rule, the real interest rate has a strong inertial component and depends on all factors established in Equation (8). The rule is represented in Figure 3.

$$r = \alpha[r_{t-1}] + (1-\alpha)[r^* + b_o(\pi - \bar{\pi}) + b_1(y - \bar{y})]; 0 < \alpha < 1. \qquad (9)$$

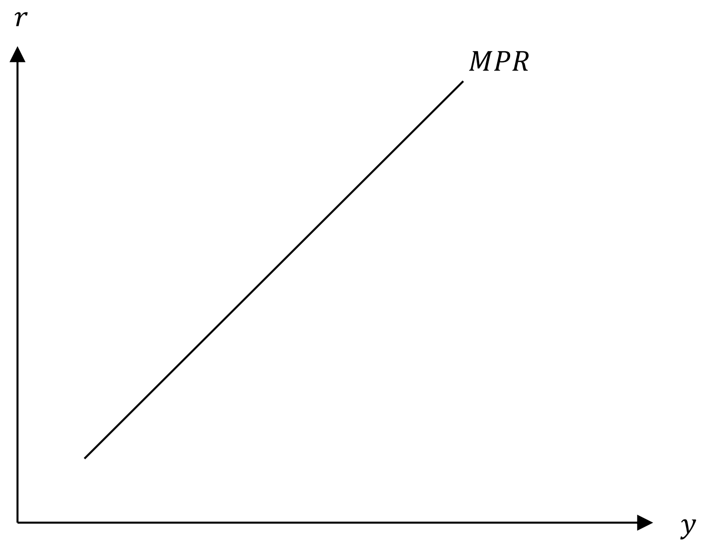
[9] For a detailed explanation of these arguments, see Woodford (2003, Chapter 6), and Levin, Wieland and Williams (1999). A summary of these arguments can be found in Mendoza (2011).

[10] For example, with a rule such as that of Equation (8), a rise in the international interest rate only affects the local interest rate and has no effect on production, inflation, or the real exchange rate.

Several objectives are met through this rule. First, the changes in the interest rate determinants affect it less forcefully than in the previous rule, as they are preceded by a lower parameter than the unit. Second, the interest rate now has inertia: the rise (fall) in the interest rate is the first of successive rises (falls) until the sought-after level is achieved. This equation better reflects the current behavior of central banks.

Figure 3

MPR



The MPR line has a negative slope given by,

$$\left.\frac{dr}{dy}\right|_{MR} = (1-\alpha)b_1 > 0$$

Aggregate demand

To obtain the equation with the determinants of the level of economic activity, we combine goods market equilibrium, real interest rate parity, and the monetary policy rule. By combining Equation (6) of the IS —which already factors in goods market equilibrium and the rates parity equation— with the monetary policy rule, Equation (9), we arrive at the desired equation.

$$y = \bar{y} + \frac{(a_1+a_2)\alpha(r^*-r_{t-1})+a_5+a_2(e^e-\bar{e})-(a_1+a_2)(1-\alpha)b_0(\pi-\bar{\pi})}{1+(a_1+a_2)(1-\alpha)b_1} \tag{10}$$

As in typical Mundell-Fleming models, production depends positively on the expected real exchange rate, the international interest rate, and the international GDP, among other determinants. Rearranging this equation, to plot it in terms of inflation and production, we obtain the following linear equation, which represents the aggregate demand equation of this open economy.

$$\pi = \bar{\pi} + d_0 + d_1(e^e - \bar{e}) + d_2(r^* - r_{t-1}) + d_3\bar{y} - d_3 y \tag{11}$$

Where,

$$d_0 = \frac{a_5}{(a_1+a_2)(1-\alpha)b_0}$$

$$d_1 = \frac{a_2}{(a_1+a_2)(1-\alpha)b_0}$$

$$d_2 = \frac{\alpha}{(1-\alpha)b_0}$$

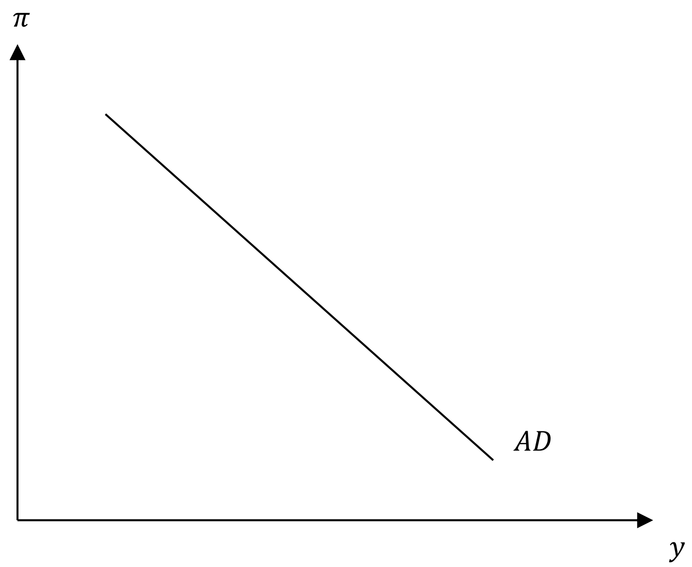
$$d_3 = \frac{1+(a_1+a_2)(1-\alpha)b_1}{(1-\alpha)(a_1+a_2)b_0}$$

The aggregate demand slope is negative. It represents the fact that when inflation goes up, the central bank raises the interest rate, which causes private spending and production to fall.

$$\left.\frac{d\pi}{dy}\right|_{AD} = -d_3 < 0$$

Figure 4

Aggregate demand



2.2. Aggregate supply

Aggregate supply is a variant of the Phillips curve, as in Equation (12). Inflation is a direct function of expected inflation, the output gap, and a disruption of supply expressed in the parameter c_1. A major output gap causes pressure in the labor market; this hastens the nominal wage growth rate, which affects inflation.

This supply curve, despite the fact we are representing an open economy, contains neither the exchange rate nor international prices when unemployment benefits are indexed to wages, as demonstrated by Sorensen and Whitta-Jacobsen (2009, Chapter 10). This is what we assume in this model.[11]

$$\pi = \pi^e + c_0(y - \bar{y}) + c_1 \tag{12}$$

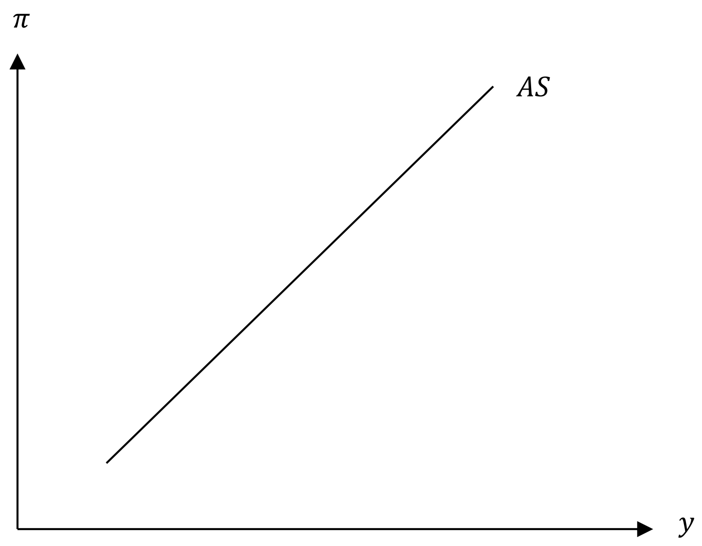
The aggregate supply curve, represented in Figure 5, is positive.

$$\left.\frac{d\pi}{dy}\right|_{AS} = c_0 > 0$$

[11] The purpose of this assumption is essentially to simplify. It is always a problem to work with an aggregate supply equation that contains the exchange rate, which is an endogenous variable in this model with a floating exchange rate.

Figure 5

Aggregate supply

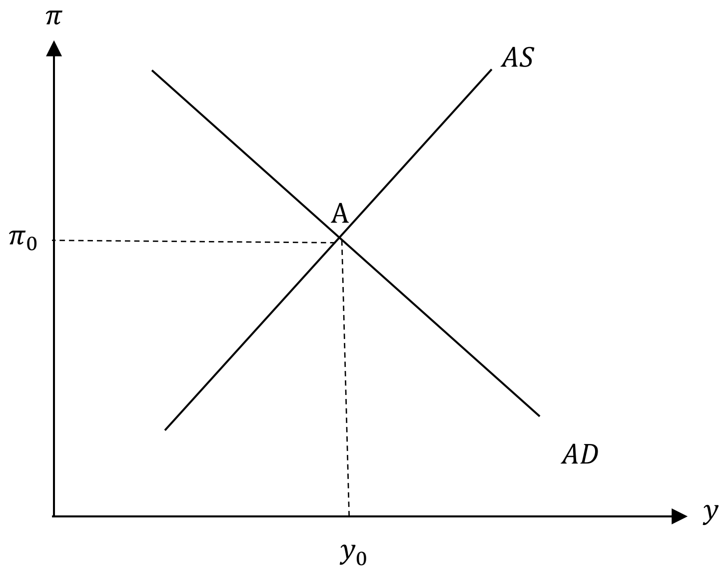


2.3. Aggregate supply and demand

The interaction between aggregate supply and demand allows us to obtain the equilibrium values of inflation and production, as in Figure 6.

Figure 6

Aggregate supply and demand



In summary, the model is made up of the following equations, representing UIP, IS, MPR, AD and AS respectively. The endogenous variables of this model are production, inflation, the real exchange rate, and the interest rate. The monetary policy instrument is the inflation target, and the fiscal policy instrument is public spending.

$$r = r^* + e^e - e \qquad (3)$$

$$r = r^* + \frac{a_5 + a_2(e^e - \bar{e}) + \bar{y}}{a_1 + a_2} - \frac{y}{a_1 + a_2} \qquad (6)$$

$$r = \alpha[r_{t-1}] + (1-\alpha)[r^* + b_o(\pi - \bar{\pi}) + b_1(y - \bar{y})];\, 0 < \alpha < 1. \qquad (9)$$

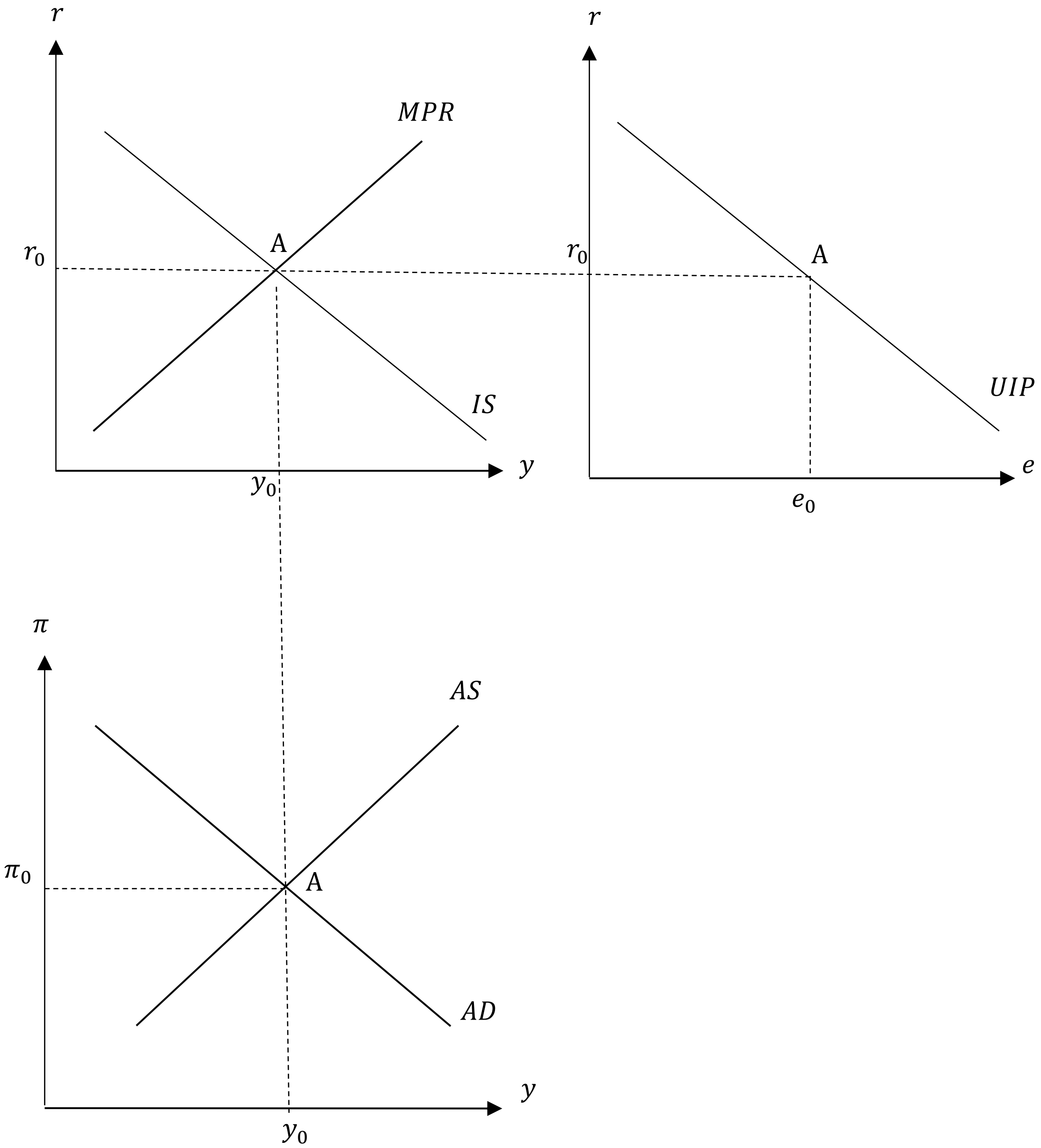
$$\pi = \bar{\pi} + d_0 + d_1(e^e - \bar{e}) + d_2(r^* - r_{t-1}) + d_3\bar{y} - d_3 y \qquad (11)$$

$$\pi = \pi^e + c_0(y - \bar{y}) + c_1 \qquad (12)$$

Figure 7 presents the complete model. The IS-MPR-UIP is represented in the upper part, while the AD-AS system is represented in the lower part.

Figure 7

General equilibrium



3. THE GENERAL MODEL AND THE SUBSYSTEMS

In this section we present the subsystems that arise out of the general model: the short-term, stationary equilibrium, the stationary equilibrium transition dynamics, and rational expectations.

We define the short term as a situation in which the expectations and lagged variables are given. Stationary equilibrium is reached when the expected variables equal those actually observed, when the actual variables reach their trend values, when the current values equal their lagged values, and when there are no supply or demand shocks. Inflation, the expected real exchange rate, and the lagged interest rate remain in motion in the stationary equilibrium transition dynamics. Finally, in the deterministic version of the rational expectations, expected inflation and the expected real exchange rate are equivalent to their expected values in the stationary equilibrium.

3.1 The short-term subsystem

In the short term, the expected inflation and the expected real exchange rate are given and are exogenous ($\pi^e = \pi_0^e$; $e^e = e_0^e$). Moreover, the lagged interest rate is given. In these conditions, based on equations (11) and (12), we obtain the short-run equilibrium values of production and inflation. By replacing the values obtained in Equation (9), we get the short-run equilibrium real interest rate. Finally, when the equilibrium real interest rate is known, the equilibrium value of the real exchange rate is determined in Equation (3). In this way, we arrive at the short-term model in its reduced form, which is given by the system of equations (13)-(16).

$$y^{eq} = \bar{y} + \frac{\bar{\pi} - \pi_0^e + d_0 - c_1 + d_1(e_0^e - \bar{e}) + d_2(r^* - r_{t-1})}{d_3 + c_0} \tag{13}$$

$$\pi^{eq} = \frac{d_3(\pi_0^e + c_1) + c_0(d_0 + \bar{\pi}) + c_0 d_1(e_0^e - \bar{e}) + c_0 d_2(r^* - r_{t-1})}{d_3 + c_0} \tag{14}$$

$$r^{eq} = f_0 r_{t-1} + f_1 r^* + f_2(\pi_0^e - \bar{\pi} + c_1) + f_3(e_0^e - \bar{e}) + f_4 d_0 \tag{15}$$

$$e^{eq} = (1 - f_1) r^* + (1 - f_3) e_0^e - f_0 r_{t-1} - f_2(\pi_0^e - \bar{\pi} + c_1) + f_3 \bar{e} - f_4 d_0 \tag{16}$$

Where:

$$f_0 = \frac{\alpha}{1+(1-\alpha)(a_1+a_2)(b_1+b_0c_0)}; 0 < f_0 < 1.$$

$$f_1 = \frac{(1-\alpha)+(1-\alpha)(a_1+a_2)(b_1+b_0c_0)}{1+(1-\alpha)(a_1+a_2)(b_1+b_0c_0)}; 0 < f_1 < 1.$$

$$f_2 = \frac{(1-\alpha)b_0}{1+(1-\alpha)(a_1+a_2)(b_1+b_0c_0)} > 0.$$

$$f_3 = \frac{(1-\alpha)a_2(b_1+b_0c_0)}{1+(a_1+a_2)(1-\alpha)(b_1+b_0c_0)}; 0 < f_3 < 1.$$

$$f_4 = \frac{(1-\alpha)b_0[(1-\alpha)(a_1+a_2)(b_1+b_0c_0)]}{1+(a_1+a_2)(1-\alpha)(b_1+b_0c_0)} > 0.$$

$$1 - f_1 = \frac{\alpha}{1+(a_1+a_2)(1-\alpha)(b_1+b_0c_0)}; 0 < 1 - f_1 < 1.$$

$$1 - f_4 = \frac{1+(1-\alpha)(b_1+b_0c_0)(a_1+a_2)(1-b_0(1-\alpha))}{1+(a_1+a_2)(1-\alpha)(b_1+b_0c_0)}; 0 < 1 - f_4 < 1.$$

In this short-term subsystem, production is determined in the goods market, the interest rate in the monetary policy rule, inflation in the aggregate supply equation, and the real exchange rate in the arbitration equation.

3.2 The stationary-equilibrium subsystem

Stationary equilibrium is achieved when expected inflation equals actual inflation: when the current interest rate is equal to the lagged one; when the expected real exchange rate is equal to the actual rate; when public spending, the real exchange rate and the international GDP are at their trend levels; and when there is an absence of supply or demand shocks ($\pi^e = \pi; r = r_{t-1};\ e^e = e;\ g = \bar{g};\ e = \bar{e};\ y^* = \bar{y}^*;\ a_4 = c_1 = 0$).

As $\pi = \pi^e$ and $c_1 = 0$, the short-term aggregate supply equation is transformed into the stationary equilibrium aggregate supply equation, Equation (17).

$$y = \bar{y} \tag{17}$$

On the other hand, given Equation (17) and since in the stationary equilibrium $g = \bar{g};\ e = \bar{e};\ y^* = \bar{y}^*\ y\ a_4 = 0$, it is found from Equation (1) that the real interest rate is the same as the natural interest rate, which, in turn, is the same as the real international interest rate, as we saw earlier.

$$r = r^* \tag{18}$$

If we replace equations (17) and (18) in Equation (9), that of the monetary policy rule, and given that the interest rate in the stationary equilibrium is equal to its lagged rate, it can be concluded that in the stationary equilibrium, inflation is equal to the inflation target set by the monetary authority.

$$\pi = \bar{\pi} \tag{19}$$

Finally, given the stationary-equilibrium interest rate and the interest-rate parity equation, it can be concluded that the stationary-equilibrium real exchange rate is equivalent to the expected real exchange rate. And since this, in the stationary equilibrium, is equal to its trend value, the real exchange rate in the stationary equilibrium is therefore equal to its trend value.

$$e = \bar{e} \tag{20}$$

In consequence, the reduced form of this subsystem of stationary equilibrium is given by the set of equations (21) - (24).

$$y^{seq} = \bar{y} \tag{21}$$

$$r^{seq} = r^* \tag{22}$$

$$\pi^{seq} = \bar{\pi} \tag{23}$$

$$e^{seq} = \bar{e} \tag{24}$$

The stationary equilibrium in this model resembles the classical, pre-Keynesian model. As in this model, production is determined in the aggregate supply, the real interest rate is determined in the goods market and in the equilibrium between saving and investment, and inflation is a monetary phenomenon, which in this case is determined by the inflation target set by the central bank.

3.3 The stationary-equilibrium-transition dynamics subsystem

In this section we endogenize the expectations on inflation and the real exchange rate and consider the dynamic generated by the lagged interest rate. It is assumed that the expectations are static; that is, inflation and the expected real exchange rate in this period are equal to the values observed in the preceding period ($\pi^e = \pi_{t-1}; e^e = e_{t-1}$). Thus, in the stationary-equilibrium transition dynamics, inflation, the expected real exchange rate, and the lagged interest rate are in full motion. ($\dot{\pi^e} \neq 0; \dot{e}^e \neq 0;\ \dot{r}_{t-1} \neq 0$).

The new assumptions modify several equations in the short-term model. First, as the expected real exchange rate is now equal to the real exchange rate from the preceding period, the short-term interest rate parity equation, Equation (3), is transformed into Equation (25).

$$r = r^* + e_{t-1} - e \tag{25}$$

As the IS comes from combining the goods market equations and the interest rate parity equation, its expression of the stationary equilibrium transition dynamics is now given by,

$$r = r^* + \frac{a_5 + a_2(e_{t-1} - \bar{e}) + \bar{y}}{a_1 + a_2} - \frac{y}{a_1 + a_2} \tag{26}$$

The aggregate demand equation, which comes from combining Equation (26) and the monetary policy rule equation, (9), which has not been altered, is now expressed by,

$$\pi = \bar{\pi} + d_0 + d_1(e_{t-1} - \bar{e}) + d_2(r^* - r_{t-1}) + d_3\bar{y} - d_3 y \tag{27}$$

Finally, the new hypothesis on expected inflation transforms Equation (12) into the following aggregate supply equation, which is a linear first degree difference equation.

$$\pi = \pi_{t-1} + c_0(y - \bar{y}) + c_1 \tag{28}$$

In this way, the short-term static model is transformed into a dynamic model in discrete time. The stationary equilibrium transition dynamics subsystem is expressed by the following system of linear difference equations.

$$r = r^* + e_{t-1} - e \tag{25}$$

$$r = r^* + \frac{a_5 + a_2(e_{t-1} - \bar{e}) + \bar{y}}{a_1 + a_2} - \frac{y}{a_1 + a_2} \tag{26}$$

$$r = \alpha[r_{t-1}] + (1-\alpha)[r^* + b_o(\pi - \bar{\pi}) + b_1(y - \bar{y})]; 0 < \alpha < 1. \quad (9)$$

$$\pi = \bar{\pi} + d_0 + d_1(e_{t-1} - \bar{e}) + d_2(r^* - r_{t-1}) + d_3\bar{y} - d_3 y \quad (27)$$

$$\pi = \pi_{t-1} + c_0(y - \bar{y}) + c_1 \quad (28)$$

We resolve this series of equations using the same method as that for the short-term subsystem. The only thing to be done is replace the exogenous expectations with static expectations, and in this way we arrive at the following expression of the stationary equilibrium transition dynamics model in its reduced form.

$$y^{eq} = \bar{y} + \frac{\bar{\pi} - \pi_{t-1} + d_0 - c_1 + d_1(e_{t-1} - \bar{e}) + d_2(r^* - r_{t-1})}{d_3 + c_0} \quad (29)$$

$$\pi^{eq} = \frac{d_3(\pi_{t-1} + c_1) + c_0(d_0 + \bar{\pi}) + c_0 d_1(e_{t-1} - \bar{e}) + c_0 d_2(r^* - r_{t-1})}{d_3 + c_0} \quad (30)$$

$$r^{eq} = f_0 r_{t-1} + f_1 r^* + f_2(\pi^e_{t-1} - \bar{\pi} + c_1) + f_3(e_{t-1} - \bar{e}) + f_4 d_0 \quad (31)$$

$$e^{eq} = (1 - f_1)r^* + (1 - f_3)e_{t-1} - f_0 r_{t-1} - f_2(\pi^e_{t-1} - \bar{\pi} + c_1) + f_3\bar{e} - f_4 d_0 \quad (32)$$

In this subsystem, unlike the short-term subsystem in which there are only effects in the period of impact, a movement in an exogenous variable in the first period has effects over time until the economy reaches a new level of stationary equilibrium. The new model is required to be dynamically stable so that a final point of stationary equilibrium can be reached from an initial point of stationary equilibrium[12].

3.4 The subsystem with rational expectations

Another way of endogenizing expectations is the use of the rational expectations hypothesis, in its deterministic version. According to this hypothesis, expected inflation and the real exchange rate must be equal to their expected values in the stationary equilibrium ($\pi^e = \pi^{eseq}$; $e^e = e^{eseq}$). In the stationary equilibrium, inflation is equal to the inflation target and the real exchange rate is equal to the trend exchange rate, as shown in equations (23) and (24). Therefore, the expected real exchange rate is equal to the expected trend exchange rate.

12 For a discussion of the stability conditions of a differences system of this type, see Ferguson and Lim (2003, Chapter 4).

$$e^e = e^{eseq} = \bar{e}^e \tag{33}$$

As a result, the real interest rate parity equation must be altered and, consequently, so too must the IS and AD equations. The monetary policy rule (Equation 9) remains intact.

$$r = r^* + \bar{e}^e - e \tag{34}$$

$$r = r^* + \frac{a_5 + a_2(\bar{e}^e - \bar{e}) + \bar{y}}{a_1 + a_2} - \frac{y}{a_1 + a_2} \tag{35}$$

$$\pi = \bar{\pi} + d_0 + d_1(\bar{e}^e - \bar{e}) + d_2(r^* - r_{t-1}) + d_3\bar{y} - d_3 y \tag{36}$$

On the other hand, the expected stationary equilibrium inflation is equal to the expected inflation target. That is,

$$\pi^e = \pi^{eseq} = \bar{\pi}^e \tag{37}$$

Therefore, the aggregate supply equation with rational expectations is given by,

$$\pi = \bar{\pi}^e + c_0(y - \bar{y}) + c_1 \tag{38}$$

The complete subsystem with rational expectations is, in consequence, expressed by the following system of equations.

$$r = r^* + \bar{e}^e - e \tag{34}$$

$$r = r^* + \frac{a_5 + a_2(\bar{e}^e - \bar{e}) + \bar{y}}{a_1 + a_2} - \frac{y}{a_1 + a_2} \tag{35}$$

$$r = \alpha[r_{t-1}] + (1 - \alpha)[r^* + b_o(\pi - \bar{\pi}) + b_1(y - \bar{y})]; 0 < \alpha < 1. \tag{9}$$

$$\pi = \bar{\pi} + d_0 + d_1(\bar{e}^e - \bar{e}) + d_2(r^* - r_{t-1}) + d_3\bar{y} - d_3 y \tag{36}$$

$$\pi = \bar{\pi}^e + c_0(y - \bar{y}) + c_1 \tag{38}$$

The model in its reduced form is obtained as in the previous system. All that changes is the notion of expectations regarding inflation and the real exchange rate.

$$y^{eq} = \bar{y} + \frac{\bar{\pi} - \bar{\pi}^e + d_0 - c_1 + d_1(\bar{e}^e - \bar{e}) + d_2(r^* - r_{t-1})}{d_3 + c_0} \tag{39}$$

$$\pi^{eq} = \frac{d_3(\bar{\pi}^e + c_1) + c_0(d_0 + \bar{\pi}) + c_0 d_1(\bar{e}^e - \bar{e}) + c_0 d_2(r^* - r_{t-1})}{d_3 + c_0} \tag{40}$$

$$r^{eq} = f_0 r_{t-1} + f_1 r^* + f_2(\bar{\pi} - \bar{\pi}^e - c_1) + f_3(\bar{e}^e - \bar{e}) + f_4 d_0 \tag{41}$$

$$e^{eq} = (1 - f_1)r^* + (1 - f_3)\bar{e}^e - f_0 r_{t-1} - f_2(\bar{\pi} - \bar{\pi}^e - c_1) + f_3\bar{e} - f_4 d_0 \quad (42)$$

In the context of this subsystem with particular rational expectations, in which expected variables and lagged variables coexist, it is necessary to make a distinction between the short term, stationary equilibrium, and the stationary equilibrium transition dynamics[13].

We define the short term as a situation in which the lagged interest rate is given. This short-term model is expressed in the system of equations (39)-(42). In the stationary equilibrium, the expected variables equal those observed, and the current interest rate equals the lagged interest rate. In this case, we arrive at the same stationary equilibrium system as in Section 3.2., expressed in the system of equations (21)-(24). Finally, the stationary equilibrium transition dynamics system of equations is the same as the short-term system, (39)-(42). However, unlike the short-term system in which the lagged interest rate is given, in the stationary equilibrium transition dynamics this rate moves over time until reaching a new level of stationary equilibrium.

In the short-term rational expectations subsystem, only the unexpected shocks have effects on the real variables of production, interest rate, and real exchange rate. An unexpected shock occurs, for example, when the inflation target changes without the public changing their expected inflation target. If the expected inflation target does not change, expected inflation will not change, as a result of which we find ourselves in the world of the short term and of exogenous expected inflation in which monetary policy affects the real variables.

Conversely, when the shocks are anticipated, the inflation target and the expected inflation target move together. In this case, there are no effects on the real variables. We are in the world of monetary policy inefficiency.

We have now completed the presentation of a family of simple New Keynesian aggregate supply and demand models for small and open economies. We will now study the predictions of these models by way of an expansive monetary policy exercise, and another involving a rise in the international interest rate.

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13 If lagged variables did not exist, the model would be static and there would be no scope for making the stated precisions. See, for example, Mendoza (2017).

4. MONETARY POLICY, FISCAL POLICY AND EXTERNAL SHOCK IN THE IS-MPR-UIP-AD-AS

In this section we simulate the effects of an expansive monetary and fiscal policy, as well of an increase in the international interest rate on the model's endogenous variables. In every exercise, the starting point is one of stationary equilibrium. At this starting point, production is at its potential level, inflation is equal to the inflation target, the real interest rate is equal to the lagged interest rate and the international interest rate, and the real exchange rate is equal to its trend value.

4.1 Expansive monetary policy

In the context of this model, the expansive monetary policy consists of an increase in the inflation target ($d\bar{\pi} > 0$). This is a permanent increase in the inflation target: it increases from one level to another and stays at this level forever. We will evaluate its effects on the short term, on the stationary equilibrium transition dynamics, and on stationary equilibrium, as well as in the model with rational expectations in the case that the policy is anticipated.

Short term

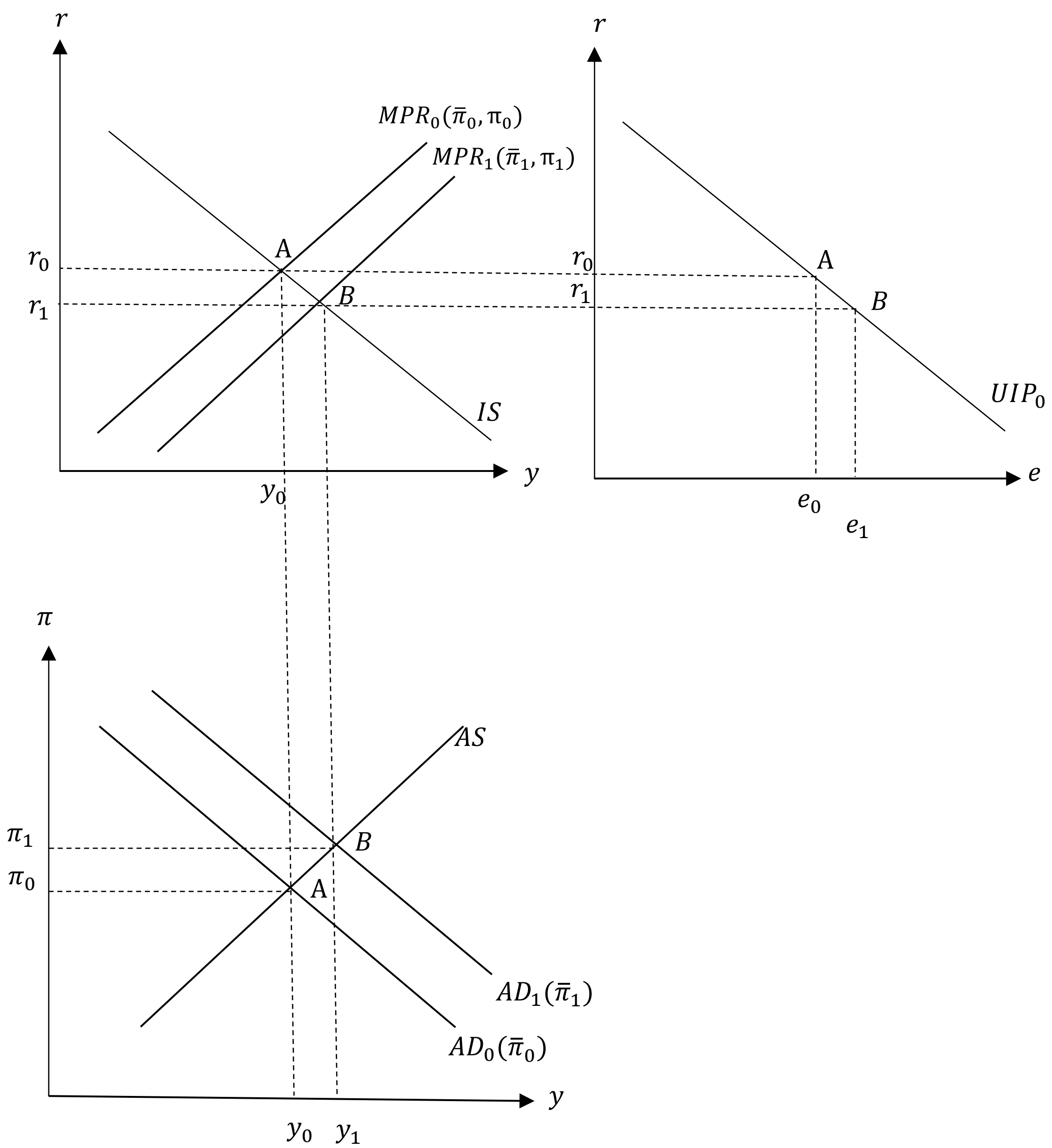
In keeping with the monetary policy rule, in the face of an increase in the inflation target the monetary authority reduces the real interest rate, which increases investment as well as demand in the goods market. The lower real interest rate promotes capital flight, due to which the real exchange rate goes up, thus driving exportation, discouraging importation, and further boosting demand. The rise in demand pushes up production, engendering a positive production gap, which causes inflation to rise. The higher inflation and the greater production gap, through the MR, cause the interest rate to rise, which weakens but does not eliminate the effects of the initial interest rate fall.

In summary, in the short term, the increase in the inflation target reduces the interest rate and increases the real exchange rate, production, and inflation.

In the lower part of Figure 8, the higher inflation target shifts the aggregate demand curve to the right, with which production and inflation rise. In the upper-left part, the MPR shifts to the right as a net effect of the rise in the inflation target (MPR to the right) and the increase in inflation (MPR to the left). The MPR shifts to the right because the increase in inflation, as shown in the mathematical response below, is only a fraction of the rise in the inflation target. In the upper-right part, throughout the UIP, the reduction in the real interest rate leads to an increase in the real exchange rate.

Figure 8

Rise in the inflation target: the short term



The mathematical responses are obtained from equations (13)-(16).

$$dy = \frac{1}{d_3 + c_0} d\bar{\pi} > 0$$

$$d\pi = \frac{c_0}{d_3 + c_0} d\bar{\pi} > 0$$

$$dr = -f_2 d\bar{\pi} < 0$$

$$de = f_2 d\bar{\pi} > 0$$

It should be noted that inflation in the short term only goes up by a fraction of the rise in the inflation target. It will continue to rise in the following periods, until it reaches its new level of stationary equilibrium.

Stationary equilibrium transition dynamics

After the period of impact or the short term, movements in inflation and the expected real exchange rate occur in the second period, as well as in the lagged interest rate, which prompts subsequent changes in the endogenous variables despite the inflation target having already stabilized.

Assuming that the stationary equilibrium transition dynamic is convergent and non-cyclical, after the first period a rise in the real interest rate and a reduction in the real exchange rate will be recorded, the former because in the short term it fell below its level of stationary equilibrium, equivalent to the international interest rate; and the latter because in the short term it was situated above its trend value. The rise in the real interest rate and the fall in the real exchange rate will cause a decrease in production, which in the short term was situated above its potential value. Inflation, which in the short term only increased by a fraction of the rise in the inflation target, will continue going up due to the increase in lagged inflation.

This dynamic of reduction in production and the real exchange rate, and the increase in inflation and the real interest rate, will continue until the economy reaches a new stationary equilibrium in which production, the real interest rate, and the real exchange rate will return to their original levels, and in which inflation will reach its new level of stationary equilibrium, equivalent to the new inflation target.

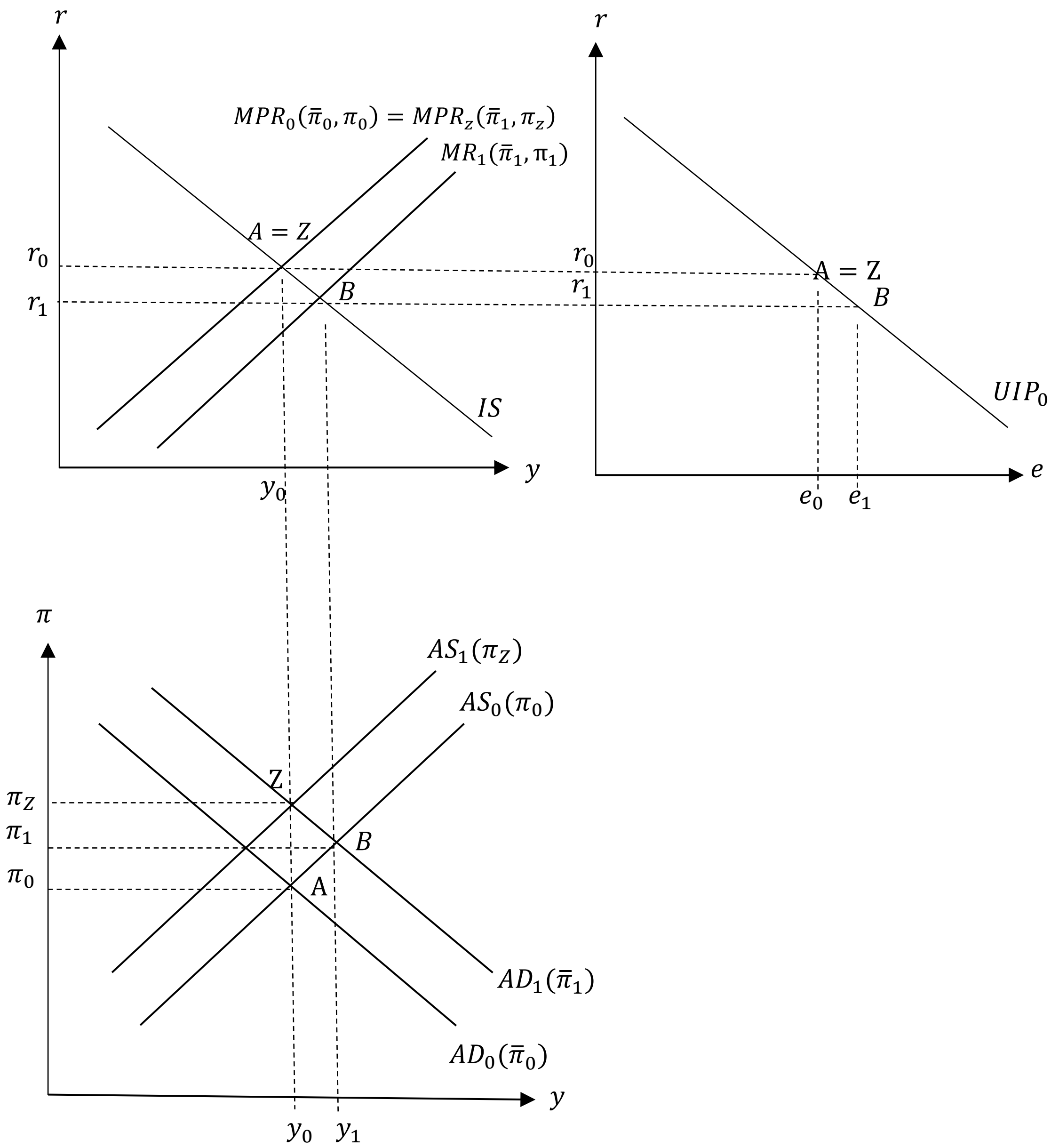
The dynamic that occurs between the short term and the new stationary equilibrium is recorded in Figure 9. In the lower part, the short-term impact of the expansive monetary policy shifts the equilibrium from point A to B. In the following periods, the aggregate supply curve shifts to the left because of the rise in lagged inflation, and the demand curve will move as the interest rate and the lagged real exchange rate move. The exact trajectory between B and Z cannot be traced by any means other than numerical simulation. If the model is stable, we can only ensure that from B we reach Z, which is the new point of stationary equilibrium.

In the upper-left part, the MPR will shift between B and Z due to the movements in inflation and in the lagged exchange rate, while the IS will move based on what occurs with the lagged real exchange rate. As before, the exact trajectory between B and Z is unknown.

Finally, in the upper-right part, again we know that Z is reached from B. The trajectory, however, is not linear because there is a set of shifts from the UIP, as it has the lagged real exchange rate as a parameter.

Figure 9

Increase in the inflation target: they stationary equilibrium transition dynamics



Stationary equilibrium

In the stationary equilibrium, a rise in the inflation target is wholly translated into a rise in inflation, and since production, the real interest rate, and the real exchange rate are independent from inflation, their values remain constant.

The mathematical responses for stationary equilibrium are obtained from equations (23)-(26).

$$dy = 0$$

$$d\pi = d\bar{\pi} > 0$$

$$dr = 0$$

$$de = 0$$

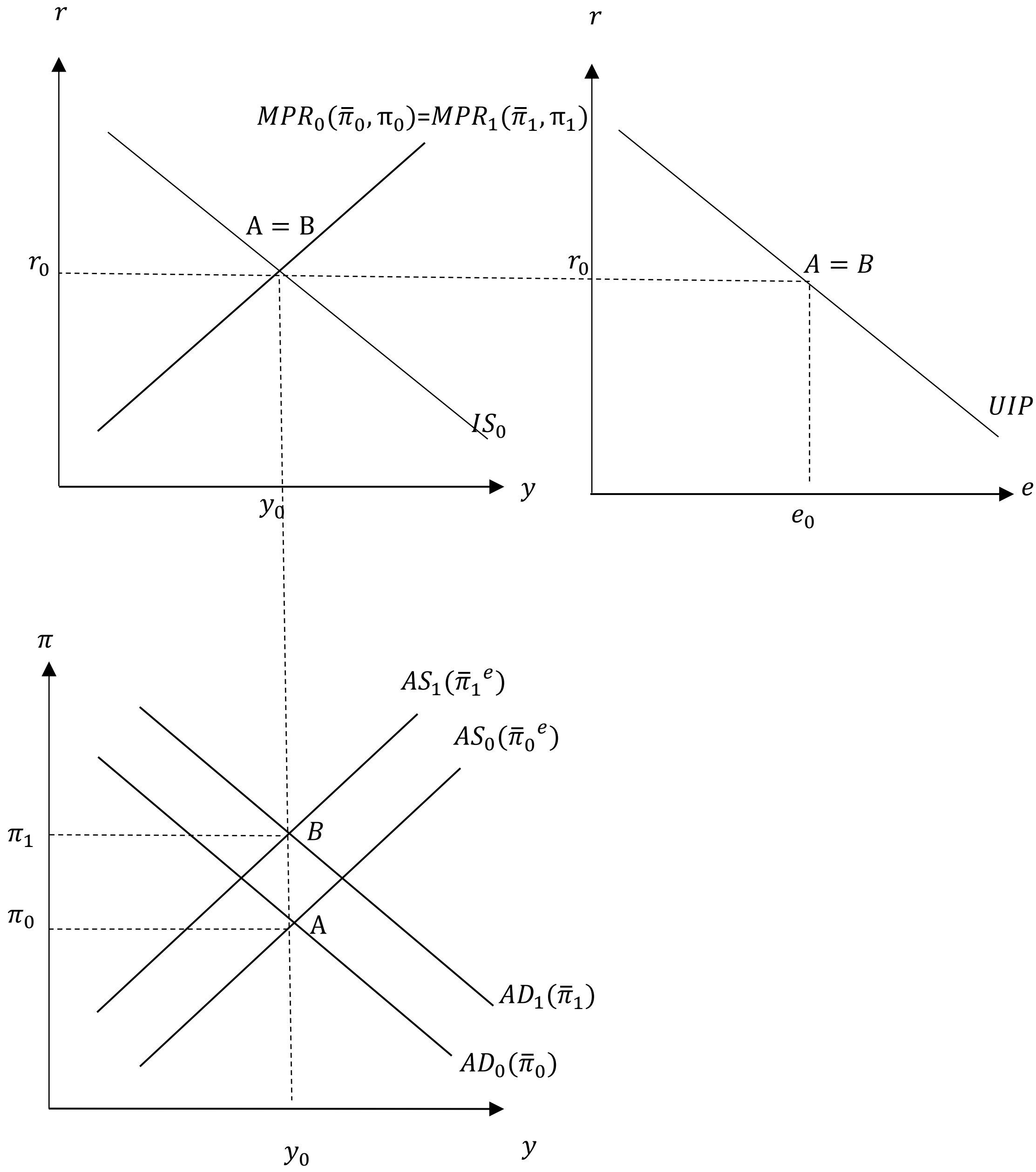
Rational expectations

With rational expectations, in the short term when the expansive monetary policy is anticipated, on the one hand, the rise in the inflation target should signal to the monetary authority that it needs to reduce the real interest rate, according to the monetary policy rule. But on the other hand, the higher expected inflation prompted by the expected hike in the inflation target pushes up inflation, which causes a rise in the interest rate. Because the rise in inflation is equal to the rise in the expected inflation target, and this in turn is equal to the rise in the inflation target, the inflation gap $(\pi - \bar{\pi})$ does not move. In consequence, in the monetary policy rule there is no reason for the monetary authority to change the interest rate. If the interest rate does not change, given the equation of real interest rate parity, nor should the real exchange rate move. If the interest rate and the real exchange rate remain constant, production will also remain constant. The only thing to change is inflation, which goes up.

Figure 10 reproduces this result. In the lower part, the shift to the right in aggregate demand due to the higher inflation target is offset by the shift to the left in the aggregate supply curve due to the higher expected inflation target, such that production remains constant and inflation goes up. In the upper-left part, because the rise in inflation is equal to the rise in the inflation target, the MR does not move, as a result of which the interest rate stays the same. In the upper-right part, it can be seen that if the interest rate does not shift then nor will the real exchange rate.

Figure 10

Rise in the inflation target: rational expectations



The mathematical responses with rational expectations are obtained from equations (39)-(42).

$$dy = 0$$

$$d\pi = d\bar{\pi} > 0$$

$$dr = 0$$

$$de = 0$$

These results are identical to those of stationary equilibrium as seen above. With rational expectations, when the policy is anticipated, the macroeconomic policies have the same effect as in the stationary equilibrium in the model with static expectations, and the monetary-policy-ineffectiveness proposition is fulfilled: the anticipated monetary policy has no effect on the real variables.

On the other hand, because the local interest rate has not been affected in the short term, there is no scope for the stationary equilibrium transition dynamic.

Moreover, the result for the stationary equilibrium of this model with rational expectations is identical to that of the short term: only inflation goes up.

4.2 Expansive fiscal policy

The expansive fiscal policy consists of an increase in public spending$(dg > 0)$. In this case we will address the issue of a *transitory* expansive fiscal policy. That is, public spending rises above its trend in period 1 and returns to its trend, therefore it decreases, in period 2. We will evaluate its effects in the short term, in the transit towards the stationary equilibrium and in the stationary equilibrium, as well as the case with rational expectations.

In the short term

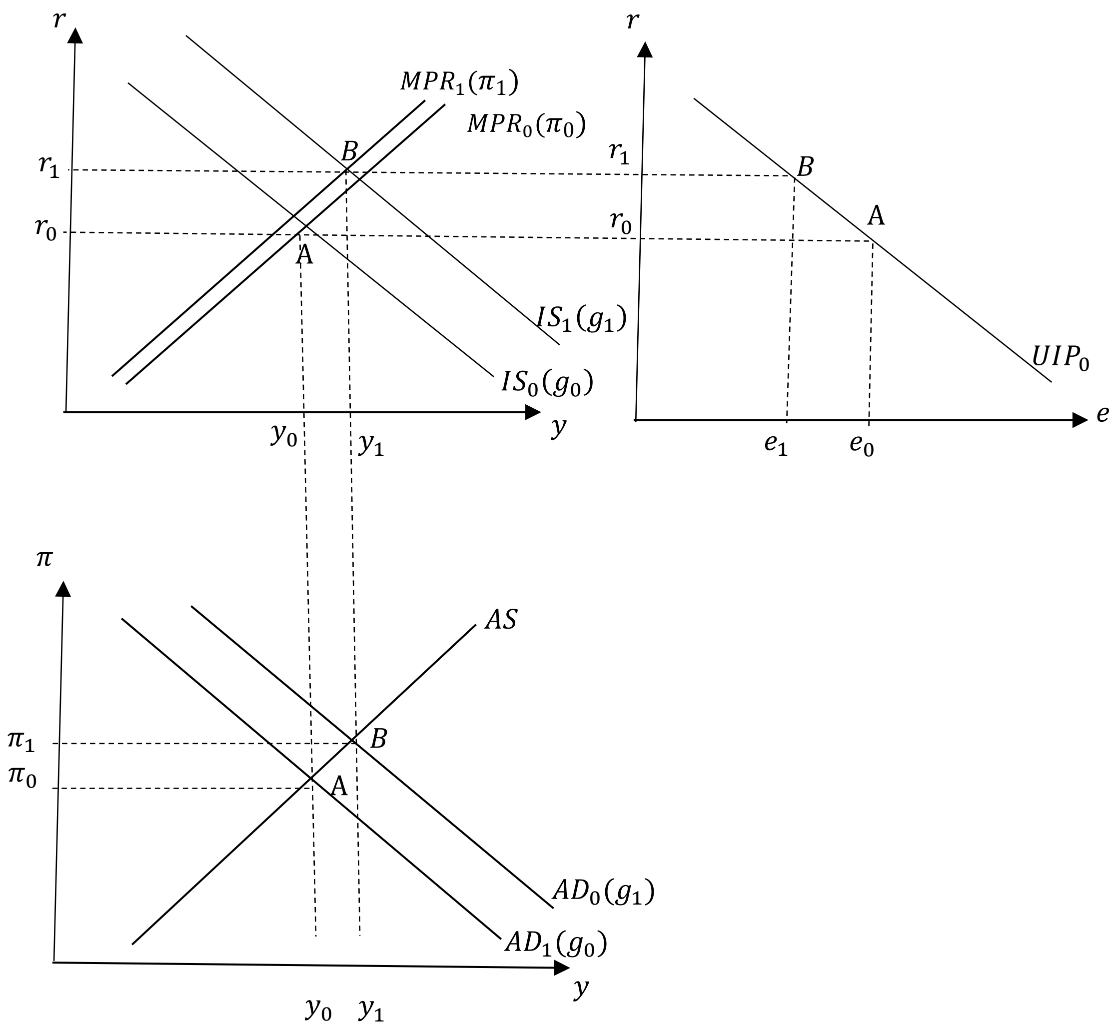
The increase in public spending rises the demand for goods and consequently it also rises production. The greater production generates a positive production gap and therefore increases inflation. The higher inflation, through the MPR, generates the rise of the local interest rate. The rise of the interest rate, attracting financial capital, causes the real exchange rate to fall. The higher interest rate and the lower real exchange rate weaken the reactivating effect of higher public spending, but this effect is not eliminated.

In summary, in the short term, higher public spending rises the interest rate, production, and inflation, but causes the real exchange rate to fall.

In Figure 11, in the lower part, the higher public spending shifts the aggregate demand curve to the right, which increases production and inflation. In the upper left, the MPR shifts to the left as a result of the rise in inflation and shifts the IS to the right, due to the higher public spending. As a result, the interest rate rises. At the top right, the higher interest rate leads to a decline in the real exchange rate. Short-term equilibrium moves from point A to point B.

Figure 11

Increase in public spending in the short term



The formal answers are obtained from equations (15.13)-(15.16).

$$dy = \frac{a_0}{(c_0+d_3)(a_1+a_2)(1-\alpha)b_0} dg > 0$$

$$d\pi = \frac{c_0 a_0}{(c_0+d_3)(a_1+a_2)(1-\alpha)b_0} dg > 0$$

$$dr = f_4 \frac{a_0}{(a_1+a_2)(1-\alpha)b_0} dg > 0$$

$$de = -f_4 \frac{a_0}{(a_1+a_2)(1-\alpha)b_0} dg < 0$$

In the transition to stationary equilibrium

On one hand, in the second period, public spending shrinks, and recovers its trend level, which remains constant. This is an adverse demand shock that reduces output and inflation. On the other hand, the higher inflation of the previous period represents an adverse supply shock that rises inflation and reduces production. As a result, in the second period, since the demand shock is stronger than the supply shock, output and inflation both decrease[14]. The fall in production and inflation, in turn, induce the central bank to reduce the interest rate. The lower local interest rate pushes up the real exchange rate.

In the third period, as in the second, inflation declines, it will continue to do so in the following periods, since there will be no more demand shocks. As it falls to its target level, lower inflation will lead to a lower interest rate and a higher real exchange rate that will increase output until it recovers to its original potential level.

These effects are recorded in Figure 12. At the bottom, the short-run impact of the expansive fiscal policy shifts the demand curve to the right, moving the equilibrium from point A to point B. In the second period, on one hand, the aggregate demand curve returns to its original level, since public expenditure shrunk, and the aggregate supply curve shifts to the left, due to the rise in inflation in the previous period. The equilibrium moves from B to C. In the following periods the aggregate supply curve shifts to the right, period after period, due to the continuous reduction of lagged inflation. This is shown by the arrows between point C and point A, which is the new stationary-state equilibrium point, equivalent to the initial one.

In the upper right section of Figure 12, in the first period, the IS moves to the right due to the higher public spending, and the MPR moves to the left due to the higher inflation. The equilibrium moves from point A to point B. In the second period, the IS contracts, due to the lower public spending, and the MPR moves to the right, because inflation has fallen. The equilibrium moves from point B to point C. Starting from the third period, it is the MPR

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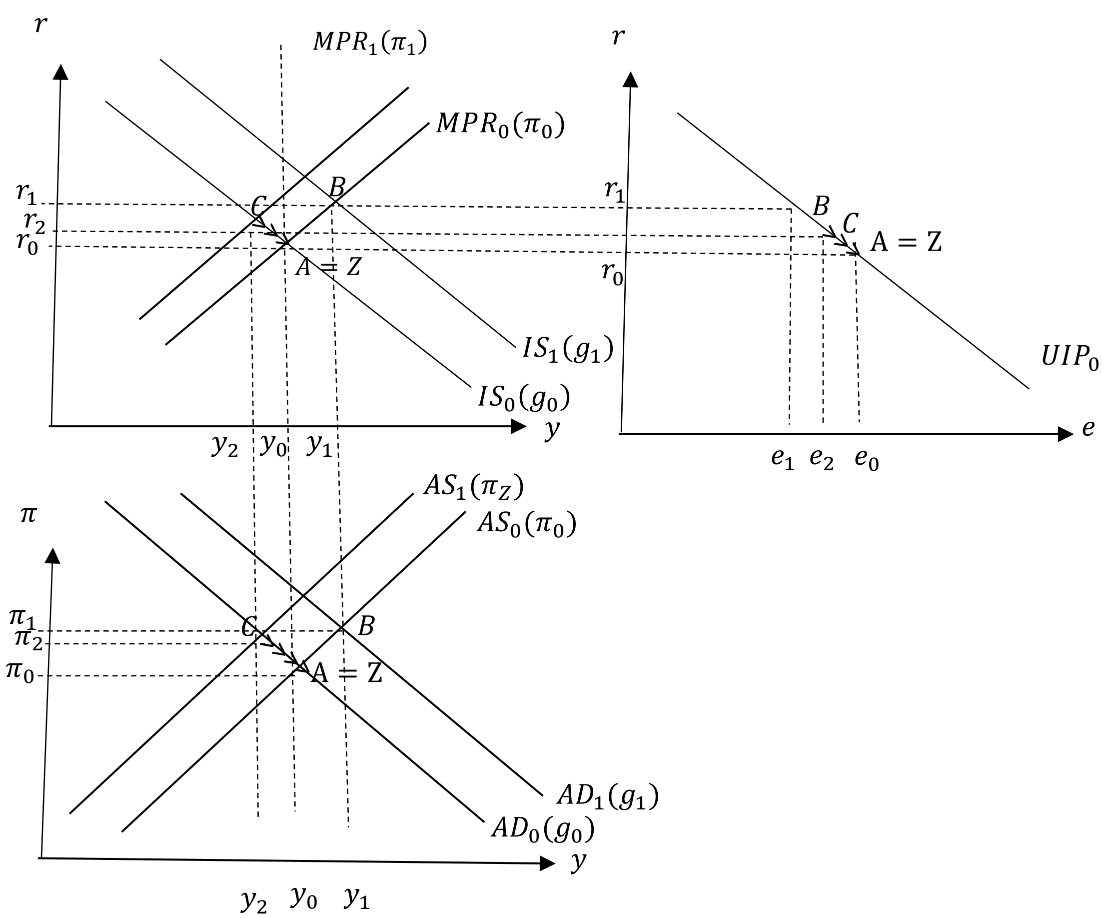
[14] The reduction in public spending is larger in absolute terms than the rise in inflation, as can be seen in the formal result of the short term.

that moves period after period to the right due to the sustained reduction of inflation. The final balance is reached at point A.

In the first period, there is a decrease of the real exchange rate, caused by the rise of the local interest rate. This is portrayed in the upper right section of the graph. In the following periods, as the interest rate decreases, the real exchange rate rises.

Figure 12

Increase in public spending: the transition to stationary equilibrium



The formal answers for the second period are obtained from equations (15.29)-(15.32)[15].

$$dy = -\frac{a_0(1+c_0)}{(c_0+d_3)(a_1+a_2)(1-\alpha)b_0}dg < 0$$

$$d\pi = -\frac{a_0c_0+d_3(c_0a_0)}{(c_0+d_3)(a_1+a_2)(1-\alpha)b_0}dg < 0$$

$$dr = -\frac{f_4a_0+f_2(c_0a_0)}{(c_0+d_3)(a_1+a_2)(1-\alpha)b_0}dg < 0$$

$$de = \frac{f_4a_0+f_2(c_0a_0)}{(c_0+d_3)(a_1+a_2)(1-\alpha)b_0}dg > 0$$

These formal results prove how output rises in the first period and declines strongly in the second period, while inflation and the interest rate rise in the first period and fall in the second. The real exchange rate drops at the beginning and then rises, until it recovers its initial level.

In stationary equilibrium

In the case of temporary shocks, there is no room for a stationary-state equilibrium analysis. In stationary-state equilibrium, temporal shocks have no effect on the endogenous variables.

With rational expectations

In this exercise, the result with rational expectations is the same as the one obtained in the short term. The reason for this is that inflation expectations are tied to target inflation, which is not altered by a rise in public spending.

4.3 Rise in the international interest rate

Short term

In the goods market, a rise in the international interest rate, due to being equal to the trend interest rate, reduces the interest rate gap. In the monetary policy rule, the local interest rate increases by a fraction $(1-\alpha)$ of the rise in the international interest rate, thus increasing the interest rate gap. But because the increase in the local interest rate is

[15] For the formal response of the second period, the variation in expected inflation is equal to the variation in inflation in the previous period, which is the change that occurred with inflation in the short term.

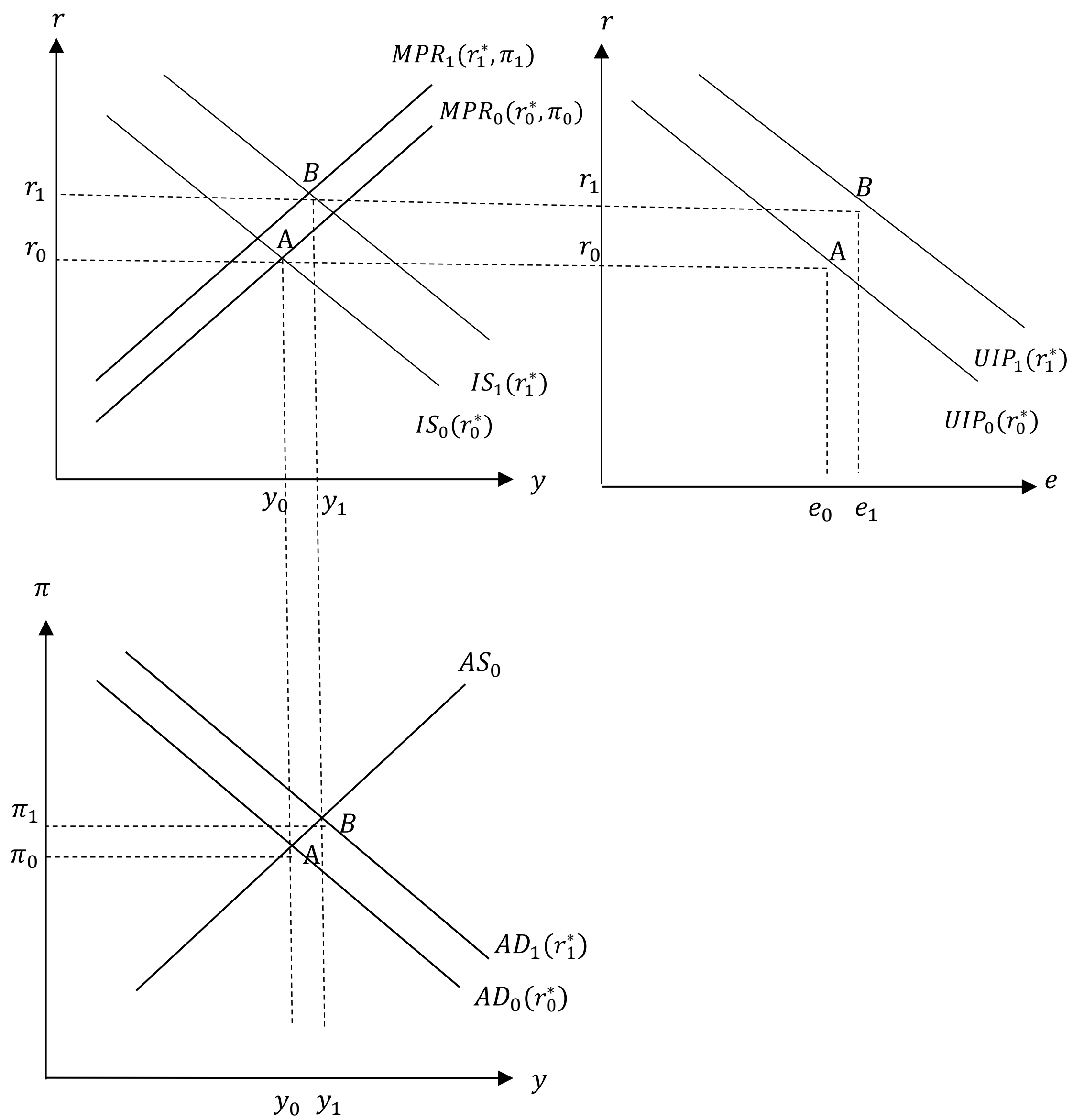
less strong than the increase in the trend interest rate, the interest-rate gap $(r - \bar{r})$ is reduced, which drives up investment. On the other hand, in the interest rate parity equation, because the rise in the international interest rate is greater than the rise in the local interest rate, the real exchange rate goes up. In consequence, the total effect of the increase in the international interest rate on demand for goods is positive, which pushes up production and, hence, inflation. The higher inflation activates the increase in the local interest rate, which weakens but does not eliminate the reactivating effect of the higher international interest rate.

In sum, an increase in the international interest rate reactivates the local economy and increases inflation, the real exchange rate, and the local interest rate.

Figure 13 shows the effects of the increase in the international interest rate. In the lower part, the aggregate demand curve shifts to the right due to the rise in the international interest rate, pushing up production and inflation. In the upper-left part, the IS shifts to the right due to the rise in the international interest rate, while the MPR shifts to the left due to both the increase in the international interest rate and the increase in inflation. In keeping with the analytical response, the shift of the IS is stronger than that of the MPR, such that production and the interest rate go up. In the upper-right part, the higher rate of international interest shifts the UIP to the right, pushing up the real exchange rate.

Figure 13

Rise in the international interest rate: short term



The mathematical responses are obtained from equations (13)-(16).

$$dy = \frac{d_2}{d_3 + c_0} dr^* > 0$$

$$d\pi = \frac{c_0 d_2}{d_3 + c_0} dr^* > 0$$

$$dr = f_1 dr^* > 0$$

$$de = (1 - f_1) dr^* > 0$$

It should be noted that the increase in the local interest rate in the short term is only a fraction of the increase in the international interest rate. This means that it will continue to rise in the following periods, until it reaches its new level of stationary equilibrium.

This prediction by the model —that an increase in the international interest rate expands production— is inconsistent with the Latin American facts. Blanchard et al. (2015) present a model that contradicts this prediction, derived from the Mundell-Fleming models[16].

The reason for this is that the model assumes that the increase in the real exchange rate that occurs as a consequence of the higher international interest rate is expansive. The expansion has to do with the assumption that exports and imports are substitute goods for local goods. If the exchange rate increases, Latin American exports will be rendered cheaper in foreign markets and will displace other exports (substitutes); and in the local market, the higher import prices will cause demand to shift toward the consumption of local goods (import substitutes). This explains how the increase in the real exchange rate increases demand for local goods and revives the economy.

The empirical evidence shows, rather, that in the short term, devaluation is contractionary. In Latin America, the periods of strong rises in the real exchange rate, such as the first half of the 1980s, coincided with reductions in the level of economic activity; while periods of reduction of the real exchange rate, such as the first half of the 1990s, are correlated with the revival of the economies of the region.

Today, Latin America's raw-material-exporting character and dependence on imported inputs are little-changed from what Díaz Alejandro (1966) found 50 years ago, due to which his observation regarding the recessionary nature of devaluation could even be applied to the bulk of the region's economies since the substitute effect of a devaluation is almost null. If we also consider the balance-sheet effect brought about by an increase in the real exchange rate when public or private debt is in foreign currency, the result shown by this model, an extension of the Mundell-Fleming, is even more peculiar.

In the case of the model presented, to incorporate the recessionary character of a devaluation it would be necessary to change the value of the parameter a_2 in the model,

[16] See also Mendoza (2015).

which associates production with the real exchange rate gap and should adopt a negative value.

In the stationary equilibrium transition dynamics

In the period of impact, production, inflation, the interest rate, and the real exchange rate went up.

Since we assume a convergent and non-cyclical stationary equilibrium transition dynamic, from the second period a rise in the real interest rate and a reduction in the real exchange rate will be recorded, the former because in the short term it rose by only a fraction of the international interest rate; and the latter because in the short term it was situated above its trend value. The rise in the real interest rate and the fall in the real exchange rate will cause a decrease in production in the second period, given that in the period of impact it was situated above its potential value. Inflation, which in the short term increased above its stationary equilibrium value, will start to fall.

This dynamic of reduction in production, the real exchange rate, and inflation, and of increase in the real interest rate, will continue until the economy reaches a new stationary equilibrium in which production, inflation, and the real exchange rate will return to their original levels, and in which the interest rate will reach its new level of stationary equilibrium, equivalent to the new international interest rate.

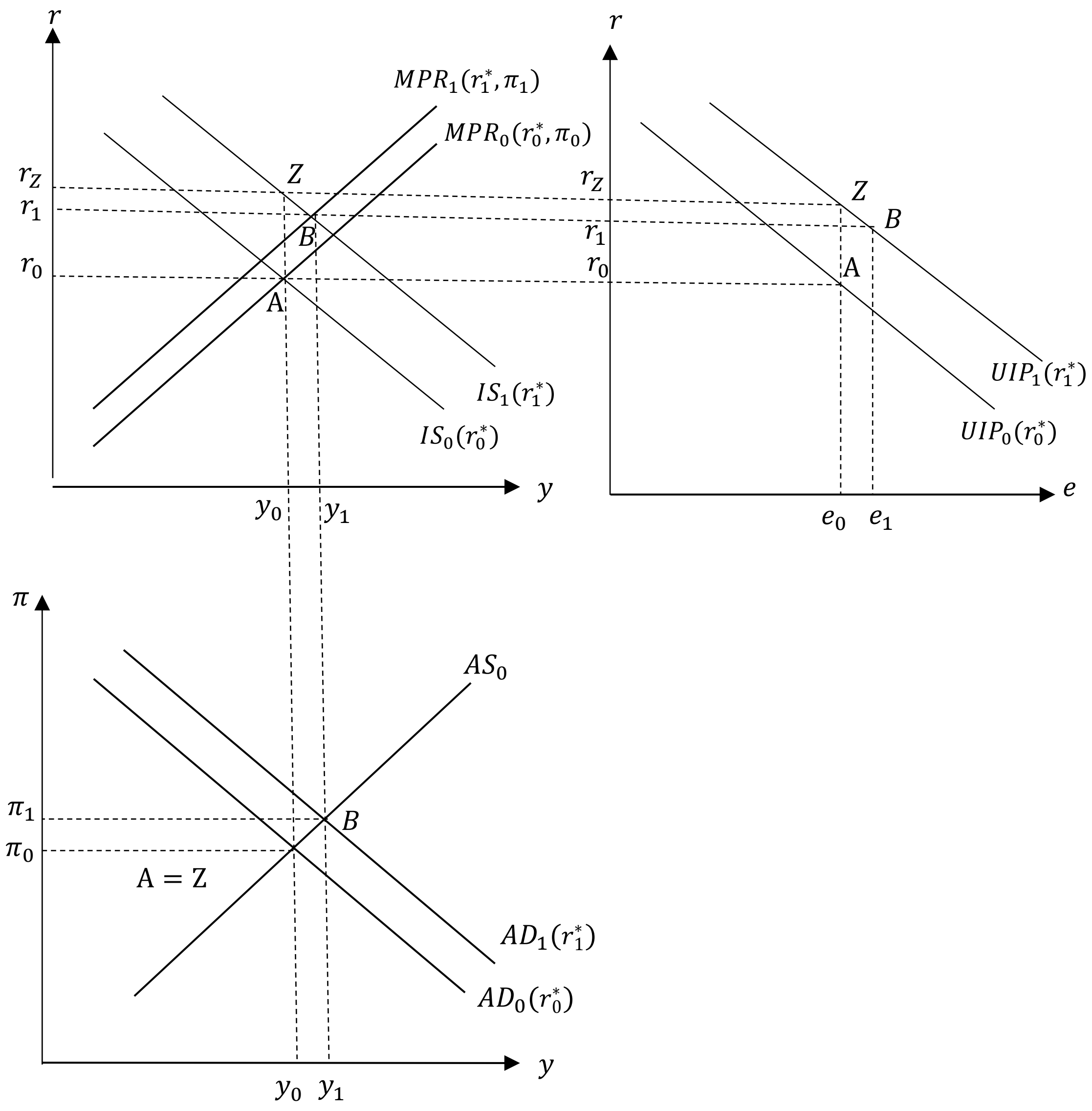
The dynamic that occurs between the short term and the new stationary equilibrium is recorded in Figure 14. In the lower part, the short-term impact of the higher international interest rate shifts the equilibrium from point A to B. In the following periods, the aggregate supply curve will shift based on what occurs with lagged inflation and the demand curve, due to the movements in the interest rate and the lagged real exchange rate. If the model is stable, we are certain that the economy will return to its original point, as inflation and production cannot be affected by the international interest rate in the stationary equilibrium. The exact trajectory between B and Z cannot be traced by any means other than numerical simulation.

In the upper-left part, the MPR will shift between B and Z period after period due to the movements in inflation and in the lagged exchange rate, while the IS will do so because it will have the lagged real exchange rate as a parameter. It is necessary to make numerical simulations to find the trajectory between B and Z.

Finally, in the upper-right part, in the short term the economy will shift from A to B. In the following periods the economy will shift between B and Z with a higher interest rate, equivalent to the new international interest rate and with the same initial exchange rate, equivalent to the trend real interest rate. It is not possible to determine the type of trajectory between B and Z analytically.

Figure 14

Increase in the international interest rate target: the stationary equilibrium transition dynamic



In the stationary equilibrium

In the stationary equilibrium, the rise in the international interest rate has the sole effect of bringing about an equivalent increase in the local interest rate. Because inflation, production, and the real exchange rate have determinants other than the international interest rate, their values remain constant.

The mathematical responses are obtained from equations (20)-(23).

$$dy = 0$$

$$d\pi = 0$$

$$dr = dr^* > 0$$

$$de = 0$$

With rational expectations

In the specific structure of this model, a rise in the international interest rate with rational expectations in the short term has identical effects to those of the standard short-term model. The reason is that in both the short-term model and the rational expectations model, the international interest rate is an exogenous variable and there are no expectations regarding it. As in the case of the short term, an increase in the international interest rate revives the local economy and increases inflation, the real exchange rate, and the interest rate.

In this case, however, a different dynamic to stationary equilibrium is formed because the expectations regarding the exchange rate and inflation, which are rational, do not change; and the lagged interest rate, which is present in the monetary policy rule, only begins to move.

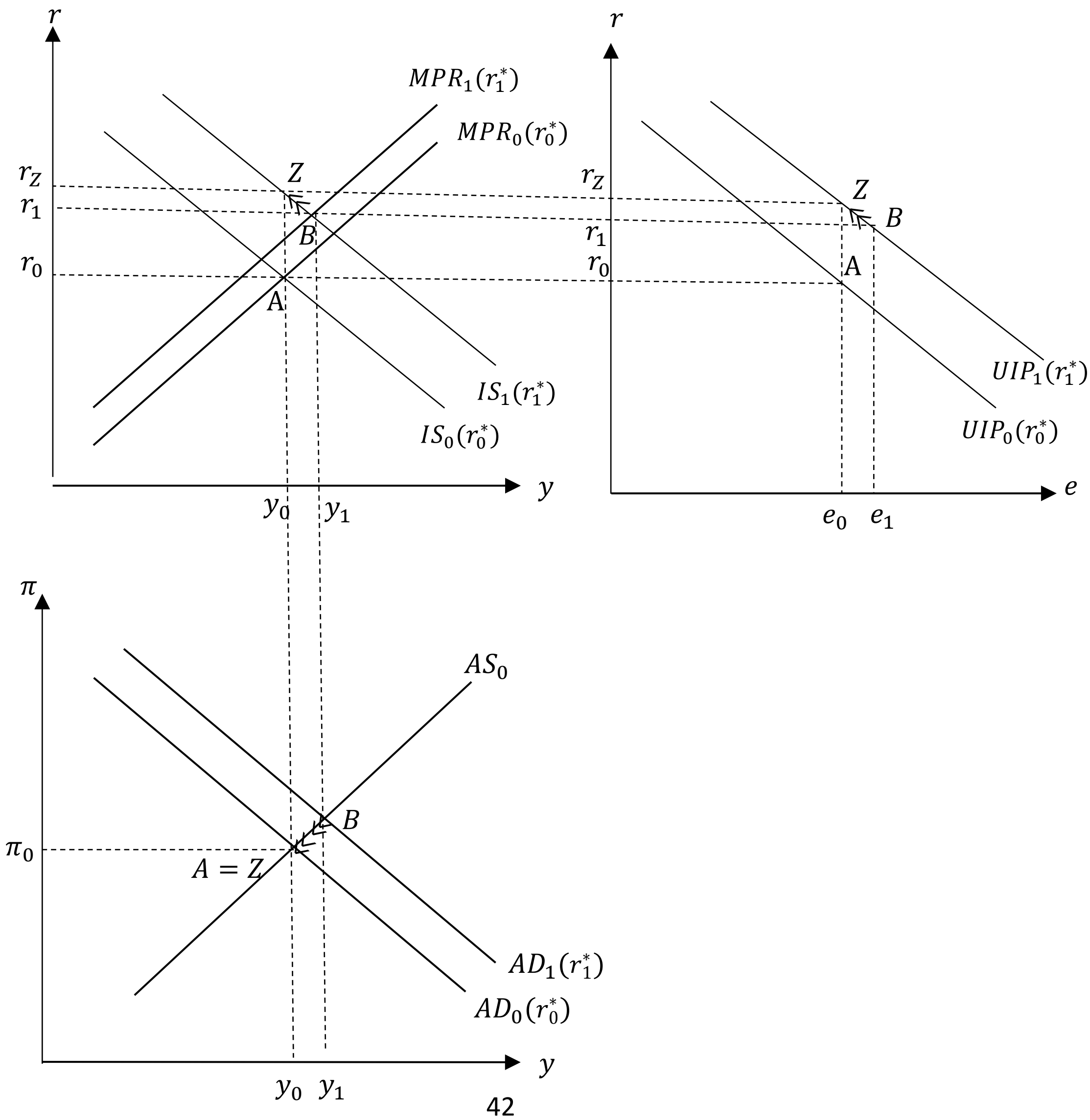
Because the local interest rate increased by only a fraction of the increase in the international interest rate in the short term, in the following periods the lagged exchange rate will continue to rise until the interest rate reaches its new level, equivalent to the new international interest rate. The sustained increase in the interest rate and the consequent fall in the real exchange rate reduce the level of economic activity and inflation. This dynamic of an interest rate on the rise and a real exchange rate and production on the fall will continue until the economy reaches its new level of stationary equilibrium.

This dynamic can be observed in Figure 15. In the lower part of the figure, from point B, short-term equilibrium, the successive rises in the lagged interest rate will shift the aggregate demand curve to its original level. In this case, where the only dynamic equation is that which links the local interest rate with its lag, the dynamic is stable and without oscillations and is signaled with the arrows between B and Z. In the upper-left part, there is also a clear dynamic between B and Z, expressed with arrows, as a result of the shift from the MR due to the sustained rise in the lagged interest rate. Finally, in the upper-right part there is also a clear dynamic between B and Z, a product of the sustained increase in the interest rate which affects the real interest rate contemporaneously.

At the new stationary equilibrium, point Z of the Figure, the interest rate reaches its new level, equivalent to the new international interest rate, while production, inflation, and the real exchange rate recover their original levels.

Figure 15

Increase in the international interest rate target: the stationary equilibrium transition dynamic with rational expectations



5. CONCLUSIONS

In recent years, New Keynesian models have been produced in abundance in the field of intermediate-level macroeconomics of open economies, to explain what occurs with production, inflation, the interest rate, and the exchange rate. These studies, however, lack the appealing simplicity of the more traditional Mundell-Fleming models. As a result, they have failed to make their mark on the undergraduate macroeconomics textbooks.

In this article, we have presented an alternative: a simple New Keynesian model of aggregate supply and demand, a form of the Mundell-Fleming with inflation targets and a floating exchange rate. The virtue of the model is its simplicity as it is presented in a language that resembles the traditional models of macroeconomics textbooks, but it allows somewhat more advanced aspects —such as the short term, stationary-equilibrium transition, and rational expectations— to be tackled.

The model can serve as a perfect substitute for the Mundell-Fleming model in the teaching of the macroeconomics of small open economies at undergraduate level. It can also contribute to the pedagogical function of central banks to disseminate and explain how the inflation-targeting scheme works in the context of small and open economies, such as most of those of Latin America. The essential elements of modern monetary macroeconomics can be explained, but in the user-friendly language of the Mundell-Fleming model.

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Av. Universitaria 1801, Lima 32 – Perú.
Telf. 626-2000 anexos 4950 - 4951
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