TEACHING MODERN MACROECONOMICS IN THE TRADITIONAL LANGUAGE: THE IS-MR-AD-AS MODEL

Waldo Mendoza

ABSTRACT

During the last two decades we have witnessed the emergence in the field of intermediate macroeconomics of an extensive literature that seeks to dismiss the traditional IS-LM-AD-AS model and replace it with the New Keynesian option. However, the efforts have not been successful, and currently most macroeconomics textbooks still rely on the traditional model, which is more than 80 years old.

In order to help break this inertia, this paper proposes the IS-MR-AD-AS model, a New Keynesian model that allows determining the equilibrium values of production, inflation and the real interest rate.

The model differs from the existing ones in two respects. Firstly, in the description of the model, in the graphic and mathematical treatment, and in the use of comparative static as a method to simulate the effects of the exogenous variables on the endogenous ones, the simplicity and elegance of the traditional IS-LM-AD-AS is replicated. Second, in spite of its simplicity, more complex issues can be dealt with, since the general model gives rise to four subsystems with which short-term equilibrium, steady-state equilibrium, transit toward steady-state equilibrium and rational expectations are addressed one at a time.

JEL Code: E32, E52

Keywords: New Keynesian model, monetary policy, inflation targeting scheme.

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1. INTRODUCTION

The influential publications of Taylor (1993), Clarida, Gali and Gertler (1999) and Woodford (2003) gave rise to numerous papers in the field of neo-Keynesian intermediate macroeconomics that seek to displace the popular and traditional IS-LM-AD-AS model found in macroeconomics textbooks. Taylor (2000), Romer (2000, 2013), Walsh (2002), Carlin and Soskice (2005, 2015), Bofinger, Mayer and Wollmershaeuser (2006) and Sorensen and Whitta-Jacobsen (2009) are examples of such works. Recently, Blanchard (2016 and 2017) has joined this cause.

In these works—since central banks work with inflation targets, not with price level targets; low and stable inflation is not achieved automatically, but through central bank activism; and the money supply is endogenous and not exogenous—the traditional LM has given way to a rule of monetary policy rule (MR) while the old demand and aggregate supply curves that were presented at the level of production and price level, are now presented at the plane of production and inflation.

However, efforts to displace the IS-LM-AD-AS model have not been successful. At present, that model, over 80 years old, remains at the core of most undergraduate macroeconomics textbook.

In order to help break this inertia, this paper proposes the IS-MR-AD-AS model, a New Keynesian one, to determine the equilibrium values of production, inflation and the real interest rate. We believe that this model is a perfect substitute for the traditional model.

The model differs from existing ones in two respects. Firstly, in the description of the model, in the graphic and mathematical treatment, and in the use of comparative static as a method to simulate the effects of the exogenous variables on the endogenous ones, it replicates the simplicity and elegance of traditional IS-LM-AD-AS. Secondly, in spite of its simplicity, it allows

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dealing with more complex issues, as the general model gives rise to four subsystems with which short-term, steady-state equilibrium, steady-state transit and rational expectations are addressed.

In the following section this paper deals with the general model. In Section 3, based on the general model, it presents the subsystems for the short-term, the steady-state equilibrium, the transition toward a steady-state equilibrium, and the rational expectations subsystem. The next section simulates the effects of an expansive monetary policy on the various subsystems. Finally, some conclusions appear in Section 5.

2. THE GENERAL MODEL

The general structure of the model presented here is a development of Sorensen and Whitta-Jacobsen's (2009, chapter 6).

The model includes aggregate demand, derived from the equilibrium in the goods market; the well-known IS, and the monetary policy rule, MR, which is a variation of Taylor's Rule. The aggregate supply is obtained from a Phillips curve. The interaction of demand, aggregate supply and MR allows determining the equilibrium values for output, inflation and the interest rate.

2.1 Aggregate demand

The aggregate demand equation comes from the interaction between the goods market equilibrium, IS, and the monetary policy rule, MR.

The goods market

The goods market is Keynesian in nature, in that output follows the level of demand. Production[2] is a direct function of public expenditure and business confidence, reflected by parameter a_2, and an inverse function of the real interest rate[3].

$$y - \bar{y} = a_0(g - \bar{g}) - a_1(r - \bar{r}) + a_2 \qquad (1)$$

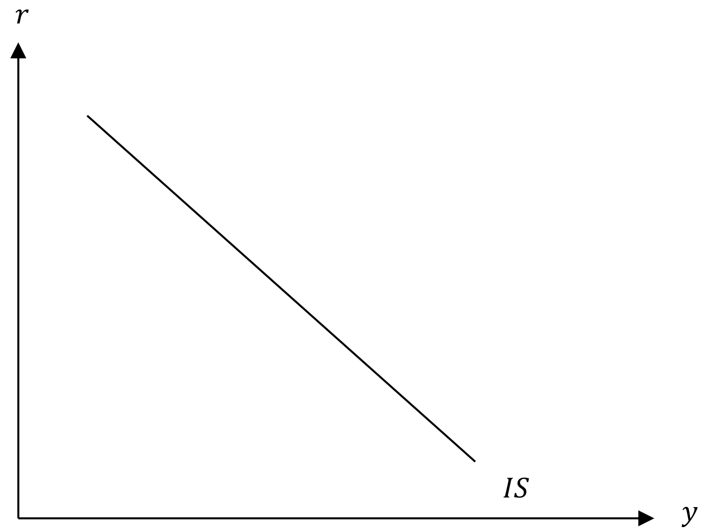
The equilibrium in the goods market can be expressed on the interest rate and production plane as the IS curve.

[2] All variables appear as gaps from their trend value.
[3] This equation results from a conventional IS, as found in Sorensen and Whitta-Jacobsen (2009).

$$r = \bar{r} + \frac{a_0(g-\bar{g})+a_2+\bar{y}}{a_1} - \frac{y}{a_1} \quad (2)$$

Figure 1

IS



The monetary policy rule

The monetary policy rule is a Taylor type rule [4]. The nominal interest rate rises when the natural nominal interest rate rises, when inflation exceeds its target level or when output is above its potential level[5].

$$i = \bar{r} + \pi^e + b_0(\pi - \bar{\pi}) + b_1(y - \bar{y}) \quad (3)$$

[4] Some studies (Walsh 2002 and Carlin and Soskice 2015) derive the monetary policy rule from the central banks' optimizing behavior. Here we rather turn to alternatives put forth by Taylor (2000) or Sorensen and Whitta-Jacobsen (2009), based on actual rules enforced by central banks in practice.

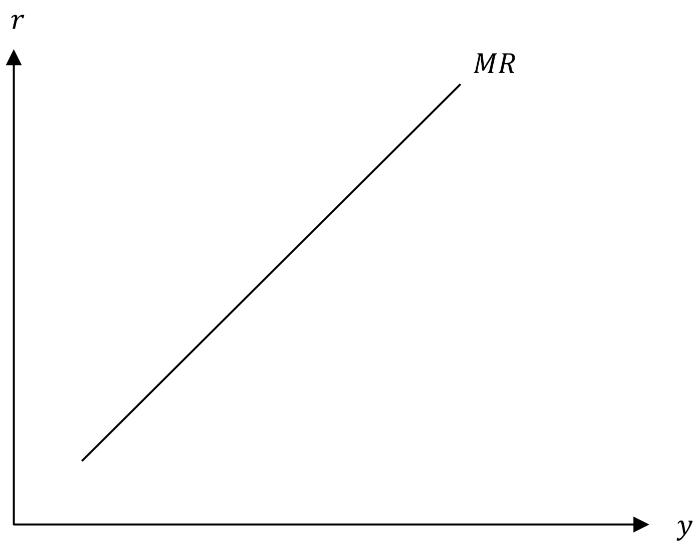
[5] Strictly speaking, the natural nominal interest rate is defined as $\bar{r} + \bar{\pi}$, and not as $\bar{r} + \pi^e$, as shown in Sorensen and Whitta-Jacobsen's MR (2009). This modified version helps in determining a simple expression for the aggregate demand equation.

This rule can also be expressed in terms of the real interest rate, i.e. the nominal rate less the expected inflation, $r = i - \pi^e$, as in equation (4). Figure 2 shows MR, the monetary policy rule.

$$r = \bar{r} + b_0(\pi - \bar{\pi}) - b_1\bar{y} + b_1 y \quad (4)$$

Figure 2

MR



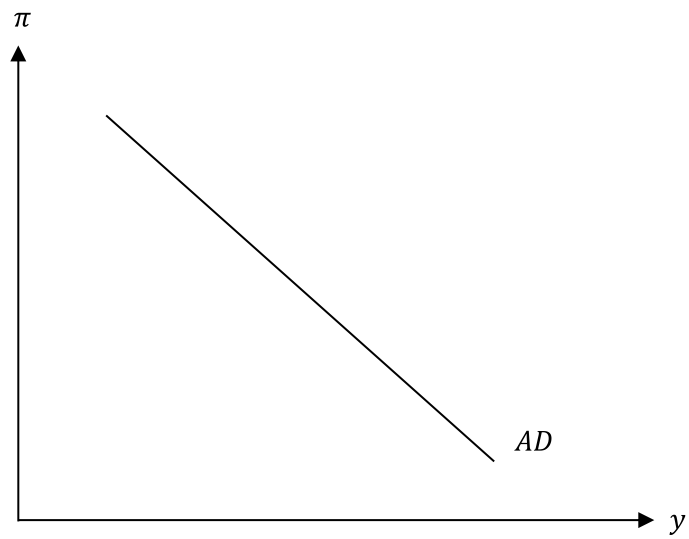
Aggregate demand

By obtaining the real interest rate gap ($r - \bar{r}$) from equation (4), and introducing the resulting expression in equation (1), we obtain the aggregate demand equation for this economy shown as equation (5). The negative relationship between inflation and output can be observed. The reason is that when inflation rises, the central bank raises the interest rate, causing output to fall.

$$\pi = \bar{\pi} + \left[\frac{a_0(g-\bar{g})+a_2+(1+a_1b_1)\bar{y}}{a_1b_0}\right] - \left[\frac{1+a_1b_1}{a_1b_0}\right] y \quad (5)$$

Figure 3

Aggregate demand



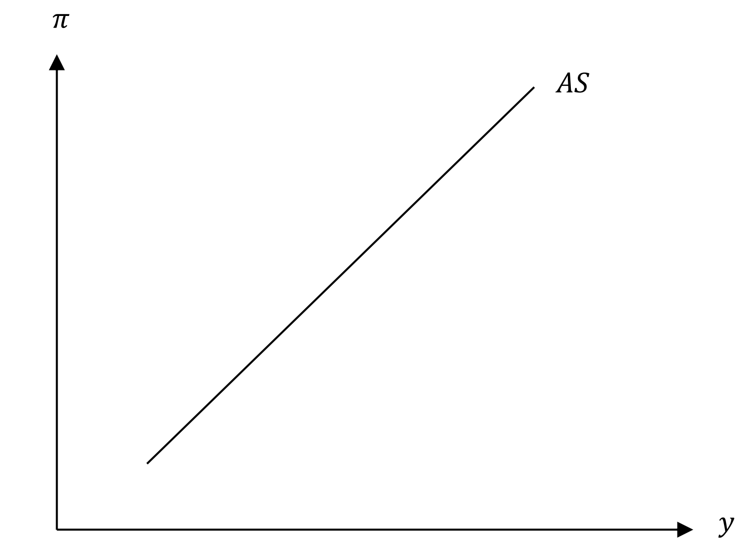
2.2 Aggregate supply

Aggregate supply is a version of the Phillips curve, as expressed in equation (6). Inflation is a direct function of expected inflation, the output gap and a supply shock expressed by parameter c_1.

$$\pi = \pi^e + c_0(y - \bar{y}) + c_1 \tag{6}$$

Figure 4

Aggregate supply

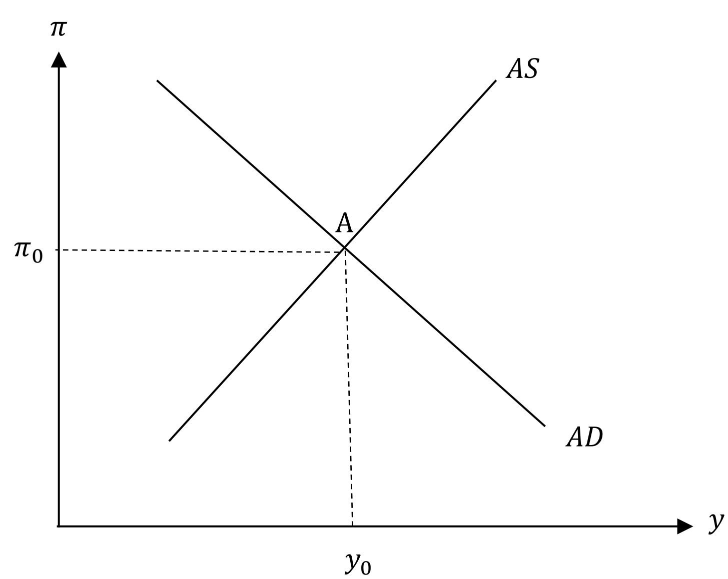


2.3 Aggregate demand and supply

The aggregate demand and supply equations allow us to determine the equilibrium values of inflation and output, as in Figure 5.

Figure 5

Aggregate demand and supply



The full model is then given by the IS, MR, AD, and AS equations. Output, inflation and the interest rate are the model's endogenous variables. The monetary policy instrument is the inflation target, while the fiscal policy's is public expenditure.

$$r = \bar{r} + \frac{a_0(g-\bar{g})+a_2+\bar{y}}{a_1} - \frac{y}{a_1} \tag{2}$$

$$r = \bar{r} + b_0(\pi - \bar{\pi}) - b_1\bar{y} + b_1 y \tag{4}$$

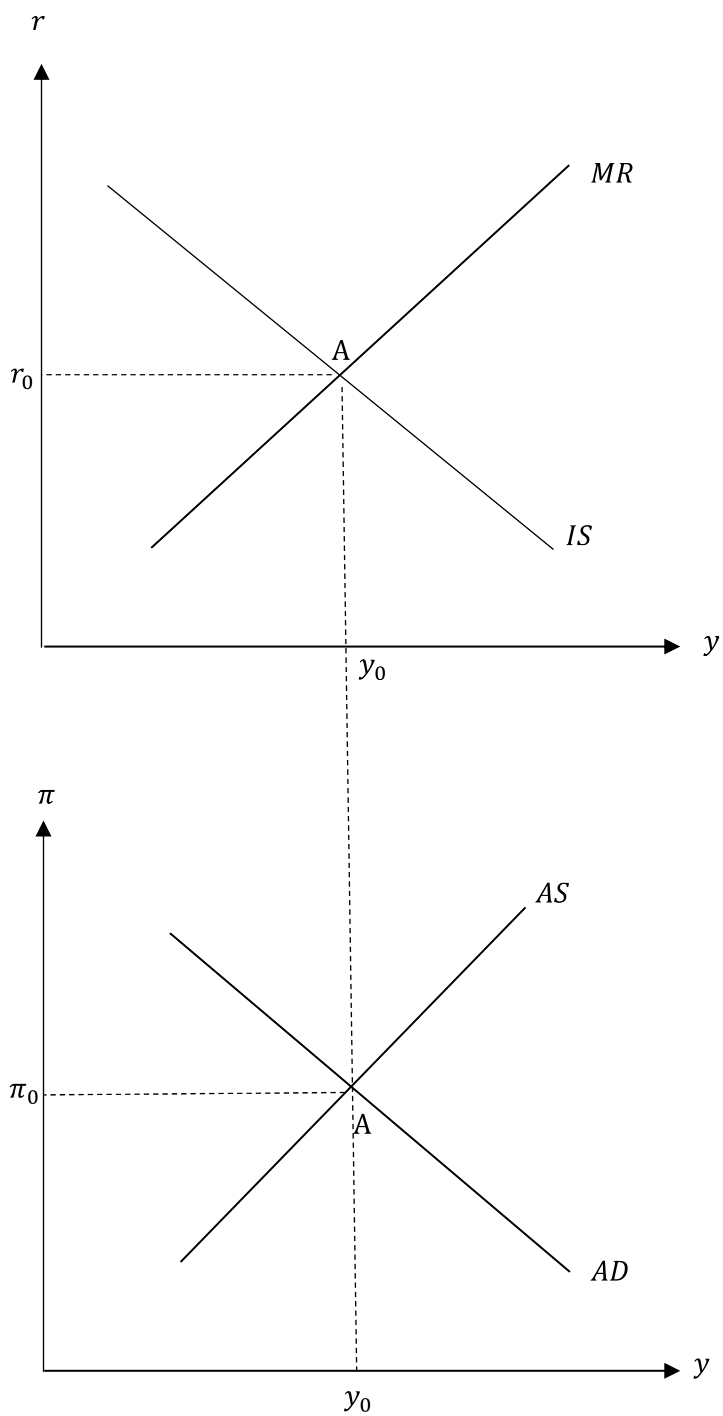
$$\pi = \bar{\pi} + \left[\frac{a_0(g-\bar{g})+a_2+(1+a_1b_1)\bar{y}}{a_1b_0}\right] - \left[\frac{1+a_1b_1}{a_1b_0}\right]y \tag{5}$$

$$\pi = \pi^e + c_0(y - \bar{y}) + c_1 \tag{6}$$

Figure 6 shows the full model.

Figure 6

General equilibrium



3. THE GENERAL MODEL AND THE SUBSYSTEMS

This section deals with the subsystems resulting from the general model, i.e. the short-term, steady-state equilibrium, the transit to steady-state equilibrium, and the rational expectations subsystems.

The short run is defined as a situation where the expected inflation is given, is exogenous ($\pi^e = \pi_0^e$). A steady-state equilibrium is reached when the expected inflation equals observed inflation, public expenditure is at its trend level and there are no demand or supply shocks $(\pi = \pi^e;\ g = \bar{g};\ a_2 = c_1 = 0)$. In the transition toward a steady–state equilibrium, expectations are static $(\pi^e = \pi_{t-1})$, while the expected inflation shifts $(\dot{\pi^e} \neq 0)$. Finally, in the deterministic version of rational expectations, the expected inflation equals the expected steady-state equilibrium inflation $(\pi^e = \pi^{eseq})$.

3.1 The short term subsystem

Expected inflation is exogenous in the short run $(\pi^e = \pi_0^e)$. Under these conditions, equations (5) and (6) help us to determine short-run equilibrium output and inflation. Introducing the resulting expressions into equation (4) results in the real short-term equilibrium interest rate. This is the reduced form of the short-term model.

$$y^{eq} = \bar{y} + \beta[a_1 b_0(\bar{\pi} - \pi_0^e - c_1) + a_0(g - \bar{g}) + a_2] \quad (7)$$

$$\pi^{eq} = \beta[(1 + a_1 b_1)(\pi_0^e + d_1) + a_1 b_0 c_0 \bar{\pi} + c_0 a_0(g - \bar{g}) + c_0 a_2] \quad (8)$$

$$r^{eq} = \bar{r} + \beta[b_0(\pi_0^e - \bar{\pi} + c_1) + (b_1 + b_0 c_0)(g - \bar{g} + a_2] \quad (9)$$

Where $\beta = \frac{1}{1 + a_1 b_1 + a_1 b_0 c_0}$

In this short term subsystem, output is determined in the goods market, the interest rate by the monetary policy rule, and inflation in the aggregate supply equation.

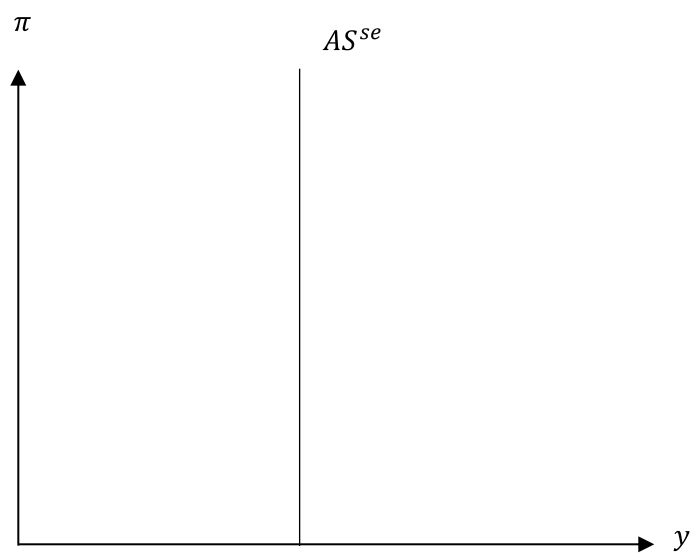
3.2 The steady-state equilibrium subsystem

A steady-state equilibrium is reached when the expected inflation equals observed inflation, when public expenditure is at its trend level and when there are no demand or supply shocks ($\pi = \pi^e$; $g = \bar{g}$; $a_2 = c_1 = 0$). Since $\pi = \pi^e$ and $c_1 = 0$, the short-run aggregate supply equation becomes the aggregate supply equation (10) in the steady-state equilibrium. This curve, shown in Figure 7, is perfectly inelastic.

$$y = \bar{y} \tag{10}$$

Figure 7

Steady-state equilibrium aggregate supply



In addition, once equation (10) is known, and since in a steady-state equilibrium $g = \bar{g}$ and $a_2 = 0$ in equation (1), it follows that in this subsystem the real interest rate equals the natural interest rate.

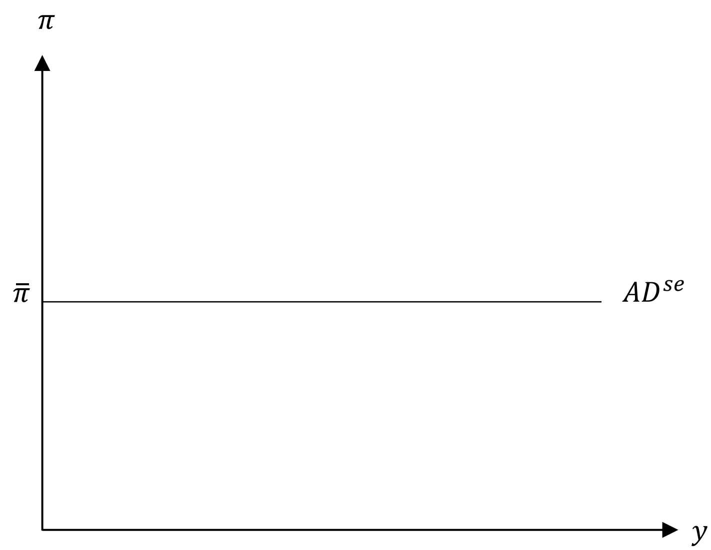
$$r = \bar{r} \tag{11}$$

Finally, if we introduce equations (10) and (11) in monetary policy rule's equation (4), in the steady-state equilibrium inflation equals the inflation target set by the monetary authority. This is also the aggregate demand equation for steady-state equilibrium. As Figure 8 shows, aggregate demand is perfectly elastic.

$$\pi = \bar{\pi} \tag{12}$$

Figure 8

Steady-state equilibrium aggregate demand



The reduced form of this steady-state equilibrium subsystem is given by equations (13), (14) and (15).

$$y^{seq} = \bar{y} \tag{13}$$

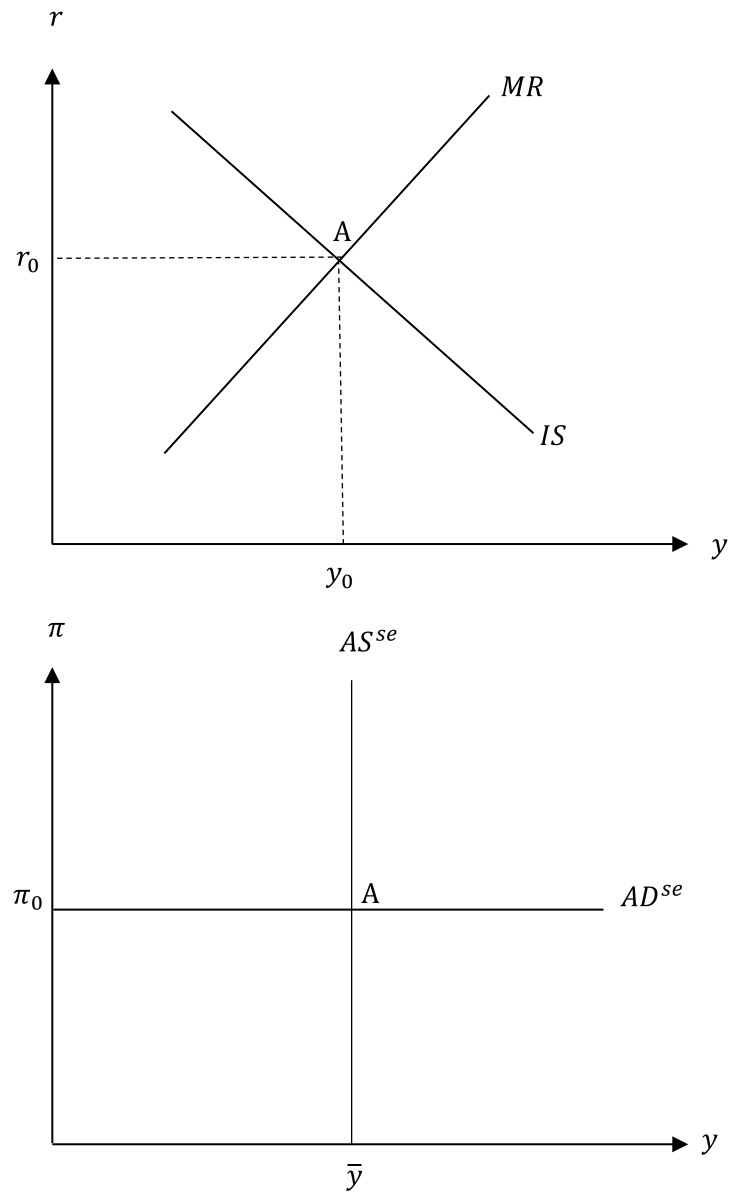
$$r^{seq} = \bar{r} \tag{14}$$

$$\pi^{seq} = \bar{\pi} \tag{15}$$

This model's steady-state equilibrium resembles the classical, pre-Keynesian model. As there, output is determined in the aggregate supply; the real interest rate in the goods market through the balance between savings and investment; and inflation is a monetary phenomenon determined in the monetary policy rule. These remarks are worth remembering for the next section's exercise.

Figure 9

Steady-state general equilibrium



3.3 The subsystem for the transition to steady-state equilibrium

For this section, we assume that the expectations are static, that is, the expected inflation in this period is the same as that observed in the previous period $(\pi^e = \pi_{t-1})$. Thus, in the transition towards the steady-state equilibrium, the expected inflation is in full swing $(\dot{\pi^e} \neq 0)$. In this subsystem, aggregate supply is given by equation (16), a linear and first degree difference equation, whereby the short-term static model is transformed into a discrete time dynamic model.

$$\pi = \pi_{t-1} + c_0(y - \bar{y}) + c_1 \tag{16}$$

Solving the (5), (16) and (4) equations system results in the following equilibrium values for the endogenous variables:

$$y^{eq} = \bar{y} + \beta[a_1 b_0(\bar{\pi} - \pi_{t-1} - c_1) + a_0(g - \bar{g}) + a_2] \tag{17}$$

$$\pi^{eq} = \beta[(1 + a_1 b_1)(\pi_{t-1} + d_1) + a_1 b_0 c_0 \bar{\pi} + c_0 a_0(g - \bar{g}) + c_0 a_2] \tag{18}$$

$$r^{eq} = \bar{r} + \beta[b_0(\pi_{t-1} - \bar{\pi} + c_1) + (b_1 + b_0 c_0)(g - \bar{g} + a_2] \tag{19}$$

This is the reduced form of the transition to the steady-state equilibrium subsystem. This subsystem is dynamically stable and the transition to a steady-state equilibrium proceeds without oscillations because, in equation (18), the coefficient that precedes lagged inflation is positive and smaller than one[6].

$$0 < \frac{1 + a_1 b_1}{1 + a_1 b_1 + a_1 b_0 c_0} < 1$$

3.4 The rational expectations subsystem

In the deterministic version of rational expectations, the expected inflation is equal to the expected steady-state equilibrium inflation $(\pi^e = \pi^{eseq})$. In steady-state equilibrium, inflation equals the target inflation rate, as shown in equation (15). The expected steady-state equilibrium inflation then equals the expected inflation target rate, i.e.

$$\pi^e = \pi^{eseq} = \bar{\pi}^e \tag{20}$$

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

$$\pi = \bar{\pi}^e + c_0(y - \bar{y}) + c_1 \tag{21}$$

The model's reduced form results from combining equations (21), (5) and (4).

$$y^{eq} = \bar{y} + \beta[a_1 b_0(\bar{\pi} - \bar{\pi}^e - c_1) + a_0(g - \bar{g}) + a_2] \tag{22}$$

[6] See Mendoza (2015, chapter 9).

$$\pi^{eq} = \beta[(1 + a_1 b_1)(\bar{\pi}^e + d_1) + a_1 b_0 c_0 \bar{\pi} + c_0 a_0 (g - \bar{g}) + c_0 a_2] \quad (23)$$

$$r^{eq} = \bar{r} + \beta[b_0(\bar{\pi}^e - \bar{\pi} + c_1) + (b_1 + b_0 c_0)(g - \bar{g} + a_2] \quad (24)$$

In this subsystem only unexpected shocks impact the real output and interest rate variables. An unexpected shock happens, for instance, when the inflation target is modified without changing the inflation target expected by the public. If the expected inflation target does not change, the expected inflation does not change, which puts us in the short-term world of exogenous expected inflation where monetary policy affects the real variables.

In contrast, when shocks are anticipated, the inflation target and the expected inflation target shift simultaneously, without effect on the real variables, placing us in the world of ineffective monetary policy.

We have thus concluded the presentation of a family of simple Neo-Keynesian aggregate demand and supply models. Let's now turn our attention to these models predictions through an expansive monetary policy exercise.

4 MONETARY POLICY IN THE IS-MR-AD-AS MODEL

This section simulates the effects of an expansive monetary policy on the model's endogenous variables, i.e. output, inflation and the real interest rate. The starting point for the exercise is a steady-state equilibrium point. Output has reached its potential level, inflation equals target inflation and the real interest rate is the natural interest rate.

In this model, an expansionary monetary policy raises the inflation target $(d\bar{\pi} > 0)$. We will evaluate the short run effects, and the effects on the transition towards the steady-state equilibrium and on the steady-state equilibrium, as well as on the model with rational expectations.

Short term effects

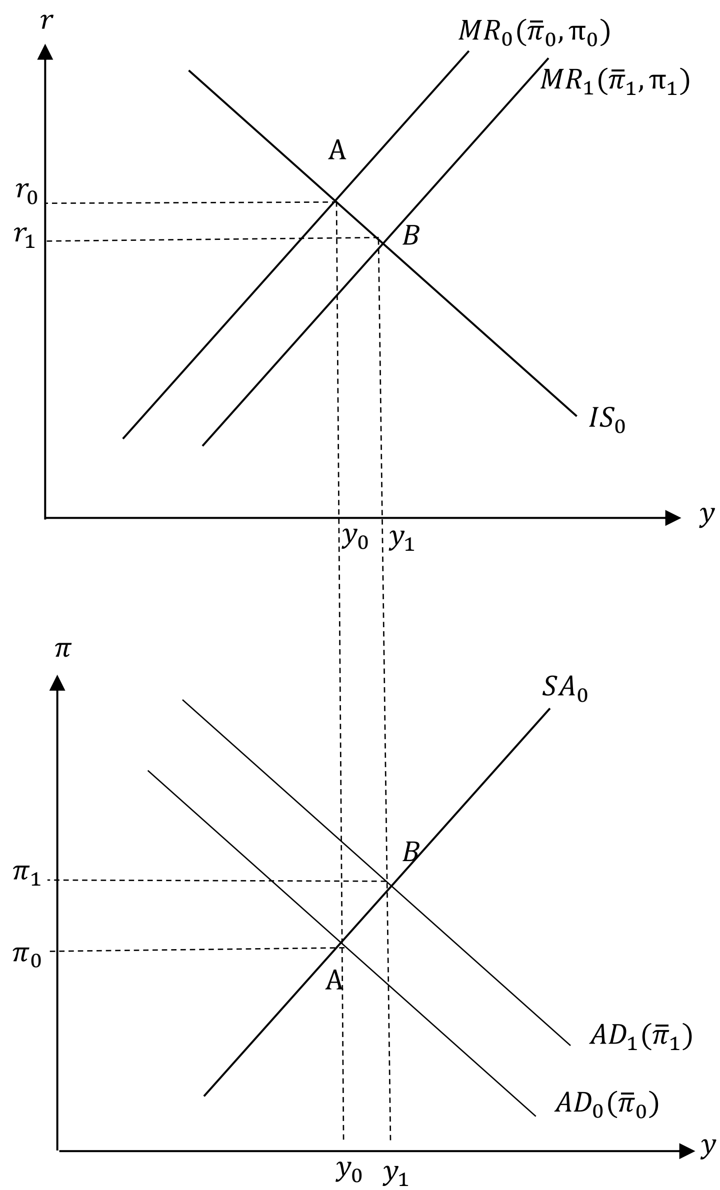
In line with its monetary policy rule, and given the rising target inflation, the monetary authority cuts down the real interest rate. The lower real interest rate increases the demand for goods and consequently output. Such higher output creates a positive output gap and therefore increases inflation. Through the MR, higher inflation raises the interest rate, which in turn weakens but does not totally obliterate the initial interest rate cut.

In sum, in the short run, the rising target inflation reduces the interest rate and raises output and inflation.

The lower section of Figure 10 shows how the higher inflation target drives the aggregate demand curve to the right, thus raising both output and inflation. At the top, the MR shifts to the right as a net effect of the rising target inflation (MR to the right) and the rise in inflation (MR's leftward shift). The MR moves to the right because of the rise in inflation, as mathematics demonstrate, is in fact a fraction of the increase in target inflation.

Figure 10

Rising target inflation: the short term



The mathematical answers result from equations (7), (8) and (9).

$$dy = \frac{a_1 b_0}{1 + a_1 b_1 + a_1 b_0 c_0} d\bar{\pi} > 0$$

$$d\pi = \frac{a_1 b_0 c_0}{1 + a_1 b_1 + a_1 b_0 c_0} d\bar{\pi} > 0$$

$$dr = -\frac{b_0}{1+a_1b_1+a_1b_0c_0}d\bar{\pi} < 0$$

Note that in the short run inflation goes up only by a fraction of the rise in target inflation.

Transition toward steady-state equilibrium

After the impact period or the short run, the expected inflation's shifts may result in further subsequent changes in the endogenous variables, even if the target inflation is no longer shifting. This is the passage to the steady-state equilibrium that will persist until the economy reaches a new level of steady-state equilibrium.

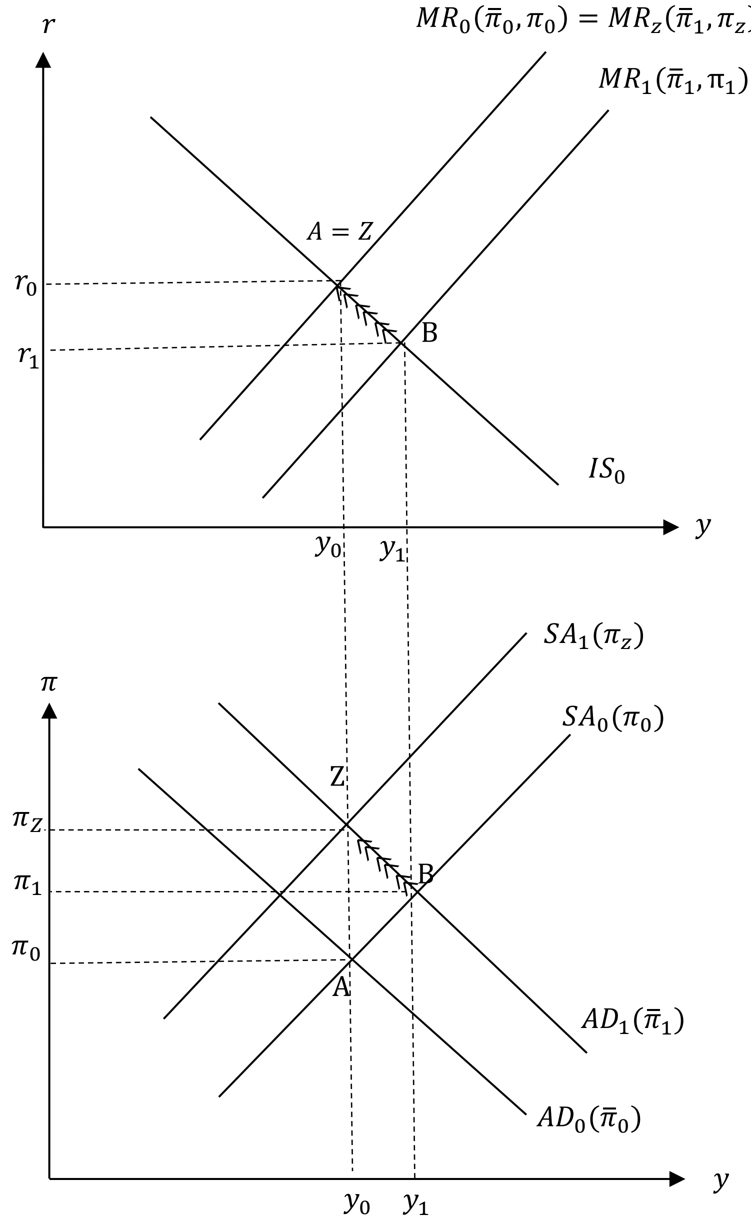
In the second period, since inflation in the impact period rose, the expected inflation also rises, which is equal to inflation in the prior period. The higher expected inflation pushes actual inflation upward. Higher inflation induces the monetary authority to raise the interest rate, thus depressing demand and output. Slower activity narrows the output gap and causes inflation to fall, but not enough to offset the rise in inflation caused by expectations of higher inflation. Inflation in this period continues to pick up, while the interest rate starts to rise and output gets on a downward path.

This dynamic of lower output and higher inflation and real interest rate will continue until the economy reaches a new steady-state equilibrium where output and the real interest rate return to their initial, albeit with higher inflation.

Figure 11 depicts these effects. At the bottom, after the short-term impact of the expansive monetary policy, which shifts the equilibrium from point A to point B, in subsequent periods the aggregate supply curve shifts to the left in successive periods to the ongoing rise in lagged inflation. This is shown by the arrows between points B and Z, which is the new steady-state equilibrium point. At the top, the MR moves between B and Z in successive periods due to the persistent rise of inflation.

Figure 11

Rising target inflation: the transition toward steady-state equilibrium



The mathematical formulations for the second period result from solving equations (17), (18) and (19)[7].

[7] In the mathematical response for the second period, the change in expected inflation equals the change in inflation in the preceding period, i.e. the change in inflation in the short term.

$$dy = -(\beta a_1 b_0)^2 c_0 d\bar{\pi} < 0$$

$$d\pi = \beta \frac{(1+a_1 b_1) a_1 b_0 c_0}{(1+a_1 b_1 + a_1 b_0 c_0)} d\bar{\pi} > 0$$

$$dr = (\beta b_0)^2 a_1 c_0 d\bar{\pi} > 0$$

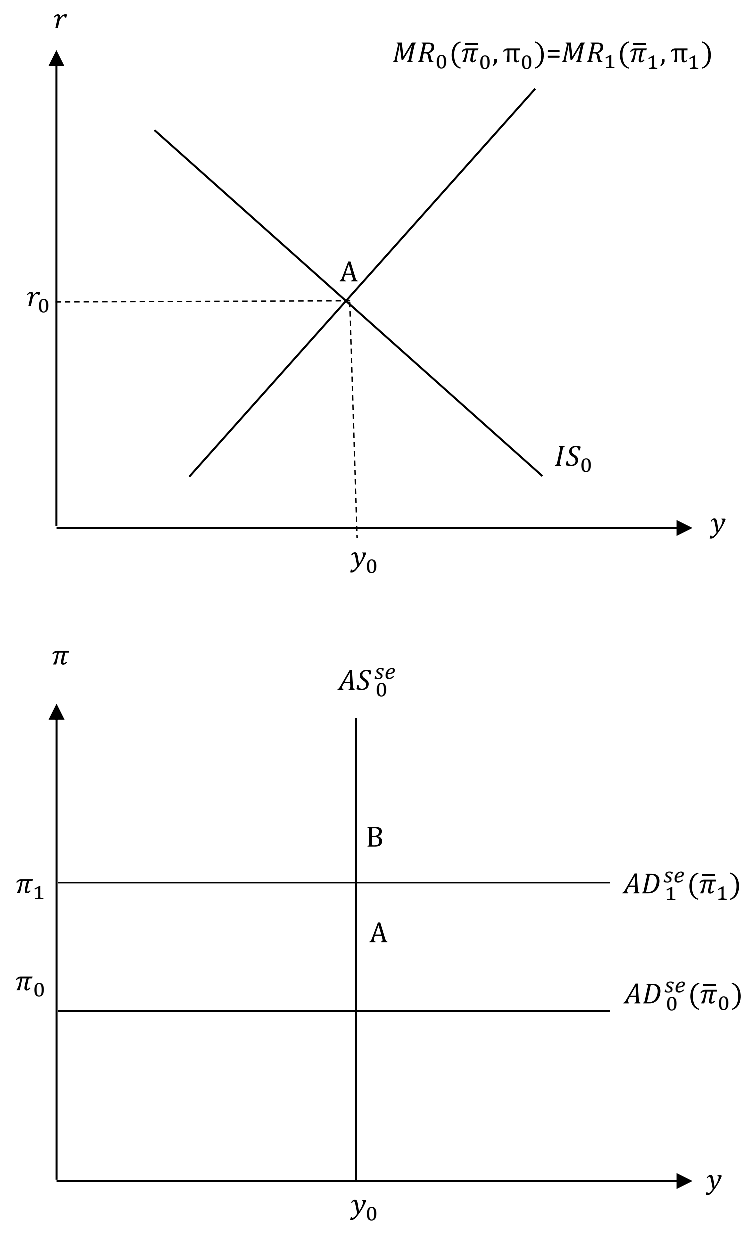
These mathematical results show how output starts on a downward path while inflation and the interest rate climb. In addition, it is shown that the strength of these ascents or decreases falls as time goes by, and is eventually annulled when the economy reaches a new steady-state equilibrium.

Steady-state equilibrium

In steady-state equilibrium, a rise in target inflation translates entirely into higher inflation, and since output and the interest rate do not hinge on inflation, these variables remain constant. Figure 12 shows these outcomes. At the bottom, the rise in target inflation shifts the aggregate demand curve upwards, raising inflation, but without affecting output. In the upper part of the figure, the MR does not move, because it depends on the inflation gap, $\pi - \bar{\pi}$, which has not shifted. As a result, the interest rate remains constant.

Figure 12

Rising target inflation: steady-state equilibrium



Equations (13), (14) and (15) provide the mathematical responses for steady-state equilibrium.

$$dy = 0$$

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

$$dr = 0$$

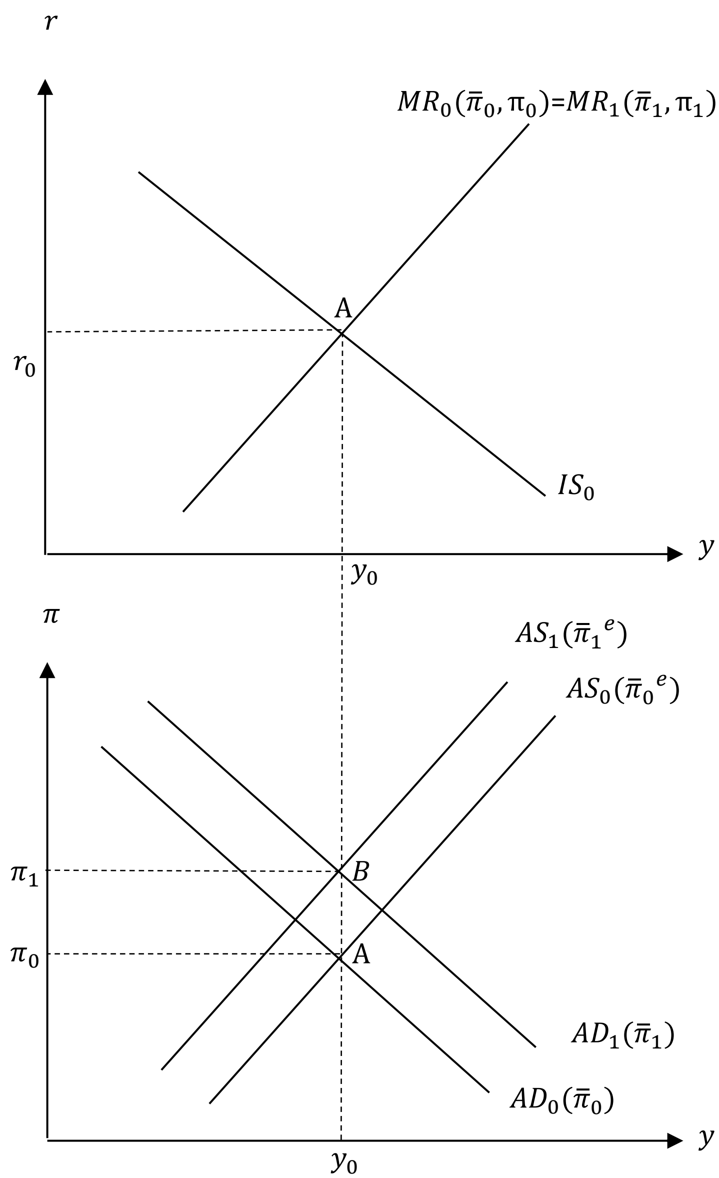
Assuming rational expectations

With rational expectations, on the one hand, when the expansionary monetary policy is anticipated and pursuant to the monetary policy rule, the rising inflation target should induce the monetary authority to cut down the real interest rate. But on the other hand, the higher expected inflation, due to the expected increase in the inflation target, pushes inflation up, which would therefore induce an interest rate hike.

As higher inflation equals the higher expected target inflation and the latter is equal to the rise in target inflation, the inflation gap $(\pi - \bar{\pi})$ does not move. Consequently, pursuant to the monetary policy rule, there is no reason for the monetary authority to change the interest rate. If the interest rate does not change, output remains constant. Only inflation shifts, upwards.

Figure 13

Upward moving target inflation: rational expectations



The mathematical answers with rational expectations come from equations (22), (23) and (24).

$$dy = 0$$

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

$$dr = 0$$

It may be noted that these mathematical results are identical to those found in steady-state equilibrium. With rational expectations, then, when the monetary policy is anticipated, the proposition of an ineffective monetary policy is fulfilled: the monetary policy has no effect on output or on the real interest rate.

5 CONCLUSIONS

Neo-Keynesian models have proliferated in recent years to address the intermediate macroeconomics of closed economies, with the purported objective of explaining the evolution of output, inflation and the interest rate. These models, however, lack the charm afforded by the simplicity of more traditional models of the IS-LM-AD-AS type, and have thus failed to put their stamp on undergraduate macroeconomics textbooks.

This paper depicted a simple New-Keynesian model of aggregate supply and demand. Presented in a language similar to that of traditional macroeconomics textbooks' models, this one has the virtue of its simplicity. It nevertheless allows addressing slightly more advanced concerns, including the short run, the road to a steady-state equilibrium, steady-state equilibrium and rational expectations.

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