This paper discusses the relative effectiveness of monetary and fiscal policies in a series of dynamic models of the open economy, by embodying in a unified general framework some different assumptions previously stated in the literature. In addition to the final steady-state results, we also examine those effects arising both on impact of policy measures, and on announcement when such policies are perfectly anticipated by the agents.
1. Introduction

Since the seminal contributions of Fleming (1962) and Mundell (1963), the so-called Mundell-Fleming model has been extensively used for the analysis of open economies, in particular the effects of monetary and fiscal policies. The original model was further extended to incorporate different supply side specifications (Sachs, 1980), as well as dynamics (Dornbusch, 1976). As a result, this "modified-Mundell-Fleming´ model" makes up "the workhorse of international-policy analysis" (Krugman, 1995, p. 512), and, despite its simplicity and ad hoc nature, still provides a useful framework to assess the behaviour of open economies in the short run.

The purpose of this paper is to examine the relative effectiveness of monetary and fiscal policies in a series of dynamic models of the open economy by using a common unified framework, distinguishing their impact as well as their steady-state effects, and discussing the role of each model's different assumptions in order to get the final results. In Section 2 we will develop a dynamic Mundell-Fleming-type model with perfect capital mobility, for which the effects of monetary and fiscal policies will be shown in Section 3. Next, in Section 4 several assumptions of Section 2's model, both from the supply and demand sides, are modified, and the effects of monetary and fiscal policies in the resulting models are compared with those of Section 3. Finally, in Section 5 the main conclusions are summarized, and some possible extensions of the analysis in the paper are briefly outlined.
2. A dynamic model of the open economy

In this section, we will construct a dynamic model for an open economy, which will be used as a reference to discuss the short-run and long-run effects of monetary and fiscal policy measures in Section 3. The economy analysed is assumed to be small, so that foreign variables are taken as exogenous. The model dynamics stems from the exchange rate and the price level, which will adjust themselves in response to interest rate differentials and the divergence between aggregate demand and supply, respectively1.

As in the standard Mundell-Fleming model, we begin by postulating simple IS and LM relationships. First, the IS equation, in reduced form and linear in logs, is given by

$$ y = -\sigma r + \gamma g + \delta (e + p^* - p) + \psi y^* $$

(1)

where $y$ is the log of real output, $r$ the nominal interest rate, $g$ the log of government spending, $e$ the log of the exchange rate (measured as the domestic currency price of one unit of foreign currency), $p$ the log of the domestic price level, and starred variables denote foreign variables. Notice that, for simplicity, we have not included wealth effects, real interest rates or taxes (alternatively, we could think of the multipliers, denoted by Greek letters, as being inclusive of the effects of tax rates). Indeed, it is assumed that the Marshall-Lerner condition holds, which entails a positive effect of the real exchange rate $(e+p^*-p)$ on trade balance and hence on the level of output.

In a similar way, the LM equation, also linear in logs, can be written as

$$ m - p = \theta y - \lambda r $$

(2)

where $m$ is the log of nominal money supply. Again for simplicity, we have not included either wealth effects on money demand or the effect of the exchange rate on real money

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1 The model in this section is based on Bajo-Rubio (1993), where the detailed solution can be found, and follows Buiter and Miller (1981, 1982).
supply; the latter assumption will be relaxed in Section 4.

Next, the dynamic behaviour of the exchange rate will be given by uncovered interest parity. Assuming that domestic and foreign assets are perfect substitutes, arbitrage will lead to the equalization of their returns (i.e., the domestic interest rate in the case of domestic assets, and the foreign interest rate plus the expected rate of depreciation of the domestic currency in the case of foreign assets):

\[ r = r^* + \dot{e}^E \]  \hspace{1cm} (3)

where \( \dot{e}^E \) is the expected rate of depreciation\(^2\). If rational expectations are assumed (or, better, since we are in a deterministic setting, perfect foresight): \( \dot{e}^E = \dot{e} \), so that rearranging (3) we get

\[ \dot{e} = r - r^* \]  \hspace{1cm} (4)

and the exchange rate will move along with interest rate differentials.

Finally, the price level is assumed to change as a function of the divergence between aggregate demand and supply:

\[ \dot{p} = \phi(y - y^*) \]  \hspace{1cm} (5)

where aggregate demand \( y \) is determined by the IS-LM equations (1) and (2). Regarding aggregate supply \( y^* \), it is assumed to be a decreasing function of factor prices (i.e., the real wage in terms of domestic prices \( w - p \) and the real price of an imported intermediate input, measured in domestic currency \( q^* + e - p \)):

\[ y^* = -\alpha(w - p) - \beta(q^* + e - p) \]  \hspace{1cm} (6)

On the other hand, we assume full indexation of wages to prices, so workers try to

\(^2\) Along this paper, a dot over a variable will denote its time derivative. Hence, since most variables are in logs, a dotted variable will denote the rate of change of its level.
keep a constant real wage $v$ in terms of consumption prices\(^3\)

$$v = w - p_c$$

(7)

where $p_c$ is the consumption price index, a weighted average of domestic and foreign prices (both measured in domestic currency):

$$p_c = (1 - \eta)p + \eta(p^* + e) \quad 0 < \eta < 1$$

(8)

so that the nominal wage becomes

$$w = v + p_c = v + (1 - \eta)p + \eta(p^* + e)$$

(9)

which, after replacing in (6) and rearranging, yields

$$\dot{y} = -\alpha v + (\alpha \eta + \beta)p - (\alpha \eta + \beta)e - \alpha \eta p^* - \beta q^*$$

(10)

This supply function is assumed to proxy, because of the costs associated with changing production plans, the level of output which results from a steady-state position (i.e., when the rate of change of all variables is zero). In the short-run, the divergence between aggregate demand and supply will be covered by changes in inventories. Making the additional assumption of sluggish price adjustment (i.e., the price level, unlike the exchange rate, does not "jump" instantaneously in the presence of a divergence between aggregate demand and supply, but responds with a certain lag), we can obtain the final equation for the rate of change of the domestic price level by replacing (10) in (5):

$$\dot{p} = \phi[y - (-\alpha v + (\alpha \eta + \beta)p - (\alpha \eta + \beta)e - \alpha \eta p^* - \beta q^*)]$$

(11)

Then, the model is given by equations (1), (2), (4) and (11):

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\(^3\) This assumption was firstly made by Sachs (1980). Notice that, unlike this paper, Sachs does not include imported inputs in the production function, and takes as dynamic variables the exchange rate and the nominal wage (instead of the domestic price level).
and includes four endogenous variables ($y$, $r$, $e$, $p$), along with seven exogenous variables: four of them are determined by the rest of the world ($p^*, y^*, r^*, q^*$), two are economic policy variables ($g$, $m$), and the other is an institutional variable ($v$).

Writing the subsystem formed by (1) and (2) in matrix form

$$\begin{bmatrix} 1 & \sigma \\ -\theta & \lambda \end{bmatrix} \begin{bmatrix} y \\ r \end{bmatrix} = \begin{bmatrix} \delta e - \delta p + \gamma g + \delta p^* + \psi y^* \\ p - m \end{bmatrix}$$

and solving (by Cramer's rule) for $y$ and $r$, we obtain

$$y = \frac{\delta \lambda e - (\delta \lambda + \sigma) p + \sigma m + \gamma \lambda g + \delta \lambda p^* + \psi \lambda y^*}{\Delta}$$

$$r = \frac{\delta \theta e + (1 - \delta \theta) p - m + \gamma \theta g + \delta \theta p^* + \psi \theta y^*}{\Delta}$$

where $\Delta = \lambda + \theta \sigma > 0$.

Replacing (13) and (12) in (4) and (11), and rearranging, we have a system of two differential equations in $e$ and $p$:

$$\dot{e} = \frac{\delta \theta e + \frac{1 - \delta \theta}{\Delta} + \frac{1}{\Delta} m + \frac{\gamma \theta}{\Delta} g + \frac{\delta \theta}{\Delta} p^* + \frac{\psi \theta}{\Delta} y^*}{\Delta}$$
which, in matrix form, becomes

\[
\begin{bmatrix}
\dot{e} \\
\dot{\rho}
\end{bmatrix} = \frac{1}{\Delta} \begin{bmatrix}
\delta \theta & 1 - \delta \theta \\
\phi(\delta \lambda + \Delta(\alpha \eta + \beta)) & -\phi(\delta \lambda + \alpha \eta + \beta))
\end{bmatrix} \begin{bmatrix}
e \\
\rho
\end{bmatrix} + \begin{bmatrix}
m \\
g \\
\rho^* \\
y^* \\
r^* \\
v \\
q^*
\end{bmatrix}
\]

or, more simply:

\[
\begin{bmatrix}
\dot{e} \\
\dot{\rho}
\end{bmatrix} = A \begin{bmatrix}
e \\
\rho
\end{bmatrix} + B
\]

Notice that \(|A| = -\frac{\phi(\delta + \alpha \eta + \beta)}{\Delta} < 0\), which means that the dynamics of the system (16)
is a saddlepoint. The dynamic behaviour of the system is shown in Figure 1, with

\[
\frac{dp}{de}\bigg|_{\lambda=0} = -\frac{\delta \theta}{1-\delta \theta} \quad < 0
\]

and

\[
\frac{dp}{de}\bigg|_{\theta=0} = \frac{\delta \lambda + \Delta (\alpha \eta + \beta)}{\delta \lambda + \sigma + \Delta (\alpha \eta + \beta)} > 0.
\]

\footnote{We will assume throughout the paper that \(1-\delta \theta > 0\). On the other hand, the opposite assumption (i.e., \(1-\delta \theta < 0\)) would not alter the steady-state results, but the short-run effect on the exchange rate would be lower than the long-run effect; in other words, there would be an "undershooting", instead of an "overshooting", of the exchange rate (see the next section).}
3. Long-run and short-run effects of monetary and fiscal policies

Starting from the model developed in the preceding section, we will go next to discuss the effects of monetary and fiscal policies. Only expansive policies, consisting of increases in \( m \) (the log of nominal money supply) and in \( g \) (the log of government spending) will be examined; contractive policies are symmetrical and will not be considered here.

The whole set of effects when both policies are not anticipated by the economic agents are shown graphically in Figures 2 and 3. Every figure includes the steady-state relationship between the exchange rate and the domestic price level (i.e., equations (14) and (15) when \( \dot{e} = \dot{p} = 0 \) ) in panel (a), the aggregate demand and supply schedules (12) and (10) in panel (b), and the IS and LM schedules (1) and (2) in panel (c). The steady-state value of a variable is denoted by a circumflex, subscripts 0 and 1 refer to the initial and final steady-state positions, and subscript \( i \) refers to the situation arising on impact of policy measures. In this context, "impact" means the situation previous to a change in the price level (which was assumed to adjust slowly), i.e., including both the own effect of the policy measure (monetary or fiscal expansion) and that derived from the initial exchange rate overshooting.

Beginning with Figure 2, a unanticipated monetary expansion from \( m_0 \) to \( m_1 \) at points \( E_0 \) lowers the interest rate and raises aggregate demand; moreover, the lower interest rate leads to a capital outflow and hence to an exchange rate depreciation which increases aggregate demand even more. Then, on impact (points \( E_i \)), the exchange rate depreciates (overshooting its final steady-state value due to price rigidity in the short-run), income (as measured by aggregate demand) increases, and the interest rate decreases since we are assuming \( 1 - \delta \theta > 0 \); the initial expansion will be lower the higher is the response lag of the trade balance to the depreciated exchange rate.

Until here the impact or short-run effects. Then, at the initial price level, the depreciated exchange rate induces employers to decrease aggregate supply (since both the real wage in terms of domestic prices and the relative price of the imported inputs measured in
domestic currency are now higher), which, together with the previous increase in aggregate demand, raises the domestic price level. The interest rate also increases (because of the smaller real money balances) and this leads to an exchange rate appreciation along the stable manifold, offsetting only partially its initial overshooting; both the higher interest rate and the exchange rate appreciation reduce the level of aggregate demand. In the final situation (points E_f) the exchange rate depreciates and the domestic price level increases in the same proportion, so the real exchange rate, output and interest rate remain unchanged. The steady-state multipliers for the exchange rate, domestic price level, real exchange rate (assuming p* constant), output and interest rate are then:

\[
\frac{\partial \hat{e}}{\partial m} = 1, \quad \frac{\partial \hat{p}}{\partial m} = 1, \quad \frac{\partial (\hat{e} - \hat{p})}{\partial m} = 0, \quad \frac{\partial \hat{y}}{\partial m} = 0, \quad \frac{\partial \hat{r}}{\partial m} = 0
\]  

(17)

On the other hand, a unanticipated fiscal expansion from g_0 to g_1 at points E_0 in Figure 3 raises aggregate demand and the interest rate; however, the higher interest rate, by creating a capital inflow, leads to an exchange rate appreciation (overshooting again its final steady-state value because of the short-run price rigidity), which will tend to decrease aggregate demand via the trade balance deficit. Then, the impact effect of a unanticipated fiscal expansion on income (as well as on the interest rate) would be ambiguous. We have assumed in Figure 2 (points E_i) both an increase in aggregate demand and the interest rate, together with the exchange rate appreciation, and this would be the case if trade flows respond to exchange rate variations with a longer lag than that of aggregate demand to government spending (i.e., if the "J-curve" effect is working); therefore, an initial expansion will be more likely (or will be higher if it actually happens) the higher is the response lag of the trade balance to the appreciated exchange rate.

Once the impact effects have taken place, at the initial price level employers are induced to raise aggregate supply because of the exchange rate appreciation (given that both the real wage in terms of domestic prices and the relative price of the imported inputs
measured in domestic currency are now smaller), that, together with the ambiguous effect on aggregate demand (since, even if an expansion initially occurs, the effect of appreciation on the trade balance will begin to work), tends to decrease domestic prices. Because of the higher real money balances, the interest rate is also reduced, leading to an exchange rate depreciation along the stable manifold, which offsets only partially the initial overshooting; both effects entail a unambiguous increase in aggregate demand. Then, in the final situation (points E₁), the exchange rate appreciates, the domestic price level decreases, the real exchange rate appreciates (since the nominal exchange rate appreciation is larger than the reduction in the domestic price level), output increases, and the interest rate is unchanged, since the foreign interest rate is also unchanged. As before, the steady-state multipliers are:

\[
\frac{\partial \hat{e}}{\partial g} = -\gamma [1 + \theta (\alpha \eta + \beta)] < 0, \quad \frac{\partial \hat{p}}{\partial g} = -\gamma \theta (\alpha \eta + \beta) < 0, \quad \frac{\partial (\hat{e} - \hat{p})}{\partial g} = -\gamma < 0, \\
\frac{\partial \hat{y}}{\partial g} = -\gamma (\alpha \eta + \beta) > 0, \quad \frac{\partial \hat{p}}{\partial g} = 0
\]

Therefore, we have seen how the conclusions about the relative effectiveness of monetary and fiscal policies are reversed in the steady-state solution of this model as compared with those of the standard static Mundell-Fleming model. Notice, on the other hand, that in this model there are two different and independent channels through which fiscal policy gets expansive effects on output: first, the real wage concerning employers (i.e., in terms of the domestic price level) falls despite the constancy of the real wage concerning workers (i.e., in terms of the consumption price index), and second, the price in real terms of the imported intermediate input also falls, and in both cases the ultimate reason is the real exchange rate appreciation. The dependence of these results on relaxing some of the model's assumptions will be discussed in the next section.

Finally, we will analyse the possibility of the policy measures being previously
anticipated by the economic agents, their effects being shown in Figures 4 and 5. As before, subscripts 0 and 1 denote the initial and final steady-state positions, whereas now subscripts a and i denote those situations arising, respectively, on announcement and on implementation of policy measures. Notice that "implementation" positions are equivalent to those we called "impact" positions in the case of unanticipated policies.

Figure 4 shows the effects of a previously anticipated future monetary expansion. Now, on announcement (points $E_a$), a lower interest rate is anticipated so there is an immediate jump in the exchange rate, which depreciates raising the level of aggregate demand. When the increase in money supply is actually implemented (points $E_i$), aggregate excess demand leads to an increase in domestic prices, and both the monetary expansion and the additional exchange rate depreciation raise aggregate demand even more. The remaining effects are the same than in the unanticipated case.

When a future fiscal expansion is previously anticipated (Figure 5), the exchange rate appreciates on announcement (points $E_a$), since a higher interest rate is anticipated, which tends to reduce the level of aggregate demand. Then, when the increase in government spending is finally implemented (points $E_i$), the domestic price level decreases, and aggregate demand can later increase or decrease according to the relative effects of the higher government spending and exchange rate appreciation; once again, as in the unanticipated case, an expansive effect on implementation of the fiscal expansion has been assumed. As before, the final steady-state outcome will be the same than that of the unanticipated fiscal policy case.

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5 These effects were firstly analysed, for the monetary policy case, by Wilson (1979).
4. Alternative specifications of the model

In this section, some of the assumptions underlying the reference model presented in Section 2 will be modified, so that we will be able to check the robustness of the results stated in Section 3. In this way, we will develop some different alternative model specifications related to several popular contributions to the literature, which will proved to be particular cases of our basic model. Changes in assumptions include taking as rigid nominal (instead of real) wages, removing imported intermediate inputs from the production function, and incorporating exchange rates into the money market equilibrium condition.

Nominal wage rigidity

If the nominal wage is assumed to be rigid, \( w \) would be a exogenous variable in (6), so that adding up terms the steady-state supply function (10) would become

\[
y^* = -\alpha w + (\alpha + \beta) p - \beta e - \beta q^*
\]

and the equation governing the movement of the price level

\[
\dot{p} = \phi[y - (-\alpha w + (\alpha + \beta) p - \beta e - \beta q^*)]
\]

so the model would be given by equations (1), (2), (4) and (11').

Notice that the supply function (10') is more elastic than (10): as before, a domestic price increase reduces the price in real terms of both the imported input and labour, increasing output; however, as consumption prices also increase, nominal wages in (10) should increase too in order to keep the real wage \( v \), which would reduce the size of the output increase. Since the latter effect is absent when nominal wages are rigid, the supply curve is now flatter.

Turning now to the influence of nominal wage rigidity on the effectiveness of monetary and fiscal policies, notice first that the impact or short-run effects (as well as the announcement effects, in the perfectly anticipated policy cases) would be similar than those described in Section 3, since we are assuming that the supply function applies to the steady-
With regard to the steady-state or long-run effects, the multipliers for the exchange rate, domestic price level, real exchange rate, output, and interest rate are now, for monetary policy

\[
\frac{\partial \hat{e}}{\partial m} = \frac{\delta + \alpha + \beta}{\delta + \beta + \delta \alpha} > 0, \quad \frac{\partial \hat{p}}{\partial m} = \frac{\delta + \beta}{\delta + \beta + \delta \alpha} > 0, \quad \frac{\partial (\hat{e} - \hat{p})}{\partial m} = \frac{-\alpha}{\delta + \beta + \delta \alpha} > 0, \quad (19)
\]

\[
\frac{\partial y}{\partial m} = \frac{\delta \alpha}{\delta + \beta + \delta \alpha} > 0, \quad \frac{\partial \hat{p}}{\partial m} = 0
\]

and for fiscal policy

\[
\frac{\partial \hat{e}}{\partial g} = -\frac{\gamma [1 + \theta (\alpha + \beta)]}{\delta + \beta + \delta \alpha} < 0, \quad \frac{\partial \hat{p}}{\partial g} = -\frac{\gamma \theta \beta}{\delta + \beta + \delta \alpha} < 0, \quad \frac{\partial (\hat{e} - \hat{p})}{\partial g} = -\frac{\gamma [1 + \theta \alpha]}{\delta + \beta + \delta \alpha} < 0, \quad (20)
\]

\[
\frac{\partial y}{\partial g} = \frac{\gamma \beta}{\delta + \beta + \delta \alpha} > 0, \quad \frac{\partial \hat{p}}{\partial g} = 0
\]

That is, with nominal wage rigidity a monetary expansion raises the level of output (and the real exchange rate depreciates), a fiscal expansion also increases output (but by less than with real wage rigidity, since now the real exchange rate appreciates more), and their relative effectiveness is ambiguous, depending on parameter values.

The reason for these results (which would correspond to those of Findlay and Rodríguez (1977)) is the lower shift of the supply curve with nominal wage rigidity in response to an exchange rate variation (compare (10) and (10')), together with its lower slope. So, after a monetary expansion, the exchange rate depreciation raises the real price of the imported input and shifts \( y^* \) leftwards; the resulting increase in the domestic price level lowers the real price of both inputs, which tends to increase output slowing down the previous state.
contractive effect. On the other hand, the exchange rate appreciation after a fiscal expansion, on lowering the price of the imported input, would shift $y^*$ rightwards, reducing the domestic price level, which in this case would slow down the previous expansive effect on output.

The role of imported inputs

If we remove the presence of imported intermediate inputs from the production function in Section 2’s model (where real wage rigidity is assumed), the steady-state supply function becomes

$$y^* = -\alpha\gamma + \alpha\eta \rho - \alpha\eta e - \alpha\eta p^*$$  \hspace{1cm} (10'')

(i.e., steeper than (10)), and the equation governing price movements

$$\dot{p} = \phi[y - (-\alpha\gamma + \alpha\eta \rho - \alpha\eta e - \alpha\eta p^*)]$$  \hspace{1cm} (11'')

so the full model would be given by equations (1), (2), (4) and (11'').

As before, the impact and announcement effects would be similar to those in Section 3\(^6\), being the steady-state multipliers

$$\begin{align*}
\frac{\partial \delta}{\partial m} &= 1, \quad \frac{\partial \phi}{\partial m} = 1, \quad \frac{\partial (\delta - \phi)}{\partial m} = 0, \quad \frac{\partial \gamma}{\partial m} = 0, \quad \frac{\partial \rho}{\partial m} = 0 \hspace{1cm} (21)
\end{align*}$$

for monetary policy, and

$$\begin{align*}
\frac{\partial \delta}{\partial g} &= -\gamma[1 + \theta + \alpha \eta] < 0, \quad \frac{\partial \phi}{\partial g} = -\gamma \theta + \alpha \eta < 0, \quad \frac{\partial (\delta - \phi)}{\partial g} = -\gamma < 0, \\
\frac{\partial \gamma}{\partial g} &= -\gamma \alpha \eta > 0, \quad \frac{\partial \rho}{\partial g} = 0 \hspace{1cm} (22)
\end{align*}$$

for fiscal policy.

\(^6\) Notice that, in the case of fiscal policy, when the model assumes nominal wage rigidity there would be no exchange rate overshooting (i.e., the exchange rate appreciation would be the same both in the short-run and in the long-run) since domestic prices would be unchanged in the steady-state (see the multipliers below).
We can see that in this case (which parallels the results of Sachs (1980)) a monetary expansion would have no effect on output, whereas a fiscal expansion would raise it (but by less than in the model including imported inputs). The reason for these results would be that, unlike the previous case of nominal wage rigidity, the exchange rate now shifts the supply function through a different channel, namely, the price of labour instead of the price of the imported input. So, the depreciation caused by a monetary expansion would shift $y^*$ leftwards, raising the domestic price level, but the higher consumption prices lead now to higher nominal wages (in order to keep $v$ fixed) which reinforce the contractive effect on output. In a similar way, the appreciation associated with a fiscal expansion shifts $y^*$ rightwards, so the decrease in consumption prices reduces nominal wages, reinforcing the expansive effect on output. In other words, the imported inputs channel (operating in the rigid nominal wage with imported inputs case) slows down the effect of the exchange rate on aggregate supply, whereas the real wage channel (operating in the rigid real wage without imported inputs case) reinforces it.

On the other hand, if imported inputs are removed from the production function in the model assuming nominal wage rigidity, the steady-state supply function would be

$$y^* = -\alpha w + \alpha p \quad (10^{'''})$$

(i.e., steeper than $(10')$, but flatter than $(10''')$), and the equation governing price movements

$$\dot{p} = \varphi(y - (-\alpha w + \alpha p)) \quad (11^{'''})$$

so the full model would be now given by equations $(1)$, $(2)$, $(4)$ and $(11^{'})$.

The steady-state multipliers would be

$$\frac{\partial \delta}{\partial m} = \frac{\delta + \alpha}{\delta + \delta \theta \alpha} > 0, \quad \frac{\partial \tilde{p}}{\partial m} = \frac{\delta}{\delta + \delta \theta \alpha} > 0, \quad \frac{\partial (\delta - \tilde{p})}{\partial m} = \frac{\alpha}{\delta + \delta \theta \alpha} > 0,$$

$$\frac{\partial \psi}{\partial m} = \frac{\delta \alpha}{\delta + \delta \theta \alpha} > 0, \quad \frac{\partial \tilde{r}}{\partial m} = 0 \quad (23)$$

for monetary policy, and
for fiscal policy. Therefore, in this case a monetary expansion would increase output (and by more than in the model with imported inputs), whereas a fiscal expansion would not be able to do it. The ultimate reason for these results (analogous to those of the standard Mundell-Fleming model) is the unresponsiveness of the supply function to the exchange rate.

Summarizing, the assumption of real wage rigidity is both a necessary and sufficient condition for rendering monetary policy fully ineffective (with or without imported intermediate inputs in the supply function), whereas for fiscal policy is just a sufficient condition for its effectiveness if the supply function does not include imported inputs; if otherwise they are included, the assumption of real wage rigidity provides an additional channel of operation to fiscal policy, so increasing its effectiveness. On the other hand, the introduction of imported intermediate inputs in the supply function worsens the effectiveness of monetary policy (lowering it with nominal wage rigidity, and not affecting its ineffectiveness with real wage rigidity), improving that of fiscal policy (increasing it with real wage rigidity, and rendering it effective with nominal wage rigidity).

**Exchange rate and money market**

Hitherto, in all the models we have examined, domestic prices have been used to deflate the nominal money supply. However, it might be possible (as suggested by Branson and Buiter (1983))\(^7\) to use the consumption price index, rather than the domestic price level, when defining real money balances. Then, the LM equation \((2)\) would become

\[
\frac{\partial \hat{e}}{\partial g} = -\gamma [1 + \theta \alpha] < 0, \quad \frac{\partial \hat{p}}{\partial g} = 0, \quad \frac{\partial (\hat{e} - \hat{p})}{\partial g} = -\gamma [1 + \theta \alpha] < 0, \quad \frac{\partial \hat{y}}{\partial g} = 0, \quad \frac{\partial \hat{\rho}}{\partial g} = 0
\]

or, replacing \(p_c\) by its value in \((8)\)

\(^7\) Notice that, unlike this paper, Branson and Buiter (1983) do not develop the supply-side of their model.
which would shift in response to exchange rate changes.

Before going through the steady-state results, we will first refer to the consequences of this new specification of the money market equilibrium condition for the impact effects of policy measures. As can be seen from (2'), introducing the exchange rate into the LM equation leads to lower initial movements in interest rates, so that the size of the exchange rate overshooting is now reduced as compared with that of Section 2's model. In terms of the schedules in panel (a) of Figures 2 and 3, their shifts in response to an exchange rate variation would be larger for the former and smaller for the latter, so reducing overshooting.

In this way, the expansive effect on impact from a unanticipated increase in nominal money supply would be lower in this case, since the initial depreciation, on increasing consumption prices and reducing real money balances, would partially offset the previous decrease in the interest rate, so the total depreciation on impact would be lower. Conversely, in the case of a unanticipated fiscal expansion, the possibility of an expansive effect on impact (or its size if it actually happens) would be now higher since the initial appreciation, on raising real money balances, would lead to a partial reduction in interest rates so the total appreciation on impact would be smaller; and, if the fiscal expansion led to a domestic price increase in the steady-state (see the multipliers below), the appreciation on impact would be lower than steady-state appreciation, that is, an exchange rate "undershooting" would happen on impact in that case.

On the other hand, notice that the announcement effects of perfectly anticipated policy measures would be now unambiguously smaller, since economic agents would expect a lower variation in interest rates after the policy announcement, so that their effect on exchange rates

\[ m-(1-\eta)p-\eta p^*-\eta e=\theta y-\lambda r \]  

(2')

---

8 The required conditions for an exchange rate undershooting to occur would be [see below for the definition of cases (i) to (iv)]: \( \eta > \theta (\alpha \eta + \beta) \) in case (i), \( \eta > \theta \beta \) in case (ii), \( \eta > \theta \alpha \eta \) in case (iii), and it would always arise in case (iv).
and hence on aggregate demand would be also lower for both kinds of policy.

Turning now to the steady-state effects, the new money market equilibrium condition will be embodied within the four alternative models discussed above, according to the supply-side specification, namely:

(i) Rigid real wage with imported inputs
(ii) Rigid nominal wage with imported inputs
(iii) Rigid real wage without imported inputs
(iv) Rigid nominal wage without imported inputs

Hence, the new models consist of equations (1), (2'), (4) and, respectively, (11), (11'), (11'') or (11'''). Next, we will show for each model the steady-state multipliers for the exchange rate, domestic price level, real exchange rate, output and interest rate, and then they will be compared with those for the same model without the exchange rate into the LM equation (i.e., equations (17) to (24)), in order to assess the sensitivity of the results to this assumption.

(i) Rigid real wage with imported inputs

The steady-state multipliers are in this case, for monetary policy

\[ \frac{\partial \hat{e}}{\partial m} = 1, \quad \frac{\partial \hat{\rho}}{\partial m} = 1, \quad \frac{\partial (\hat{e} - \hat{\varphi})}{\partial m} = 0, \quad \frac{\partial \hat{\rho}}{\partial m} = 0, \quad \frac{\partial \hat{\varphi}}{\partial m} = 0 \]  \hspace{1cm} (25)

and, for fiscal policy

\[ \frac{\partial \hat{e}}{\partial g} = \frac{-\gamma[(1-\eta)\alpha \eta + \beta]}{\delta + \alpha \eta + \beta} < 0, \quad \frac{\partial \hat{\rho}}{\partial g} = \frac{-\gamma[-\eta + \delta(\alpha \eta + \beta)]}{\delta + \alpha \eta + \beta} < 0, \quad \frac{\partial (\hat{e} - \hat{\varphi})}{\partial g} = \frac{-\gamma}{\delta + \alpha \eta + \beta} < 0, \quad \frac{\partial \hat{\rho}}{\partial g} = \frac{\gamma(\alpha \eta + \beta)}{\delta + \alpha \eta + \beta} > 0, \quad \frac{\partial \hat{\varphi}}{\partial g} = 0 \]  \hspace{1cm} (26)

Then, whereas a monetary expansion would be again ineffective on the level of output (raising the exchange rate and the domestic price level in the same proportion, so the real exchange rate remains unaltered), the steady-state effects of a fiscal expansion on the real
exchange rate, output and interest rate would be the same than in the case in which the LM equation did not include the exchange rate. But, unlike the latter case and by the same reasons than on impact, the exchange rate appreciation would be now lower, so that domestic prices would decrease less or could even increase (since, in terms of the demand and supply schedules in panel (b) of Figures 2 and 3, the lower appreciation would lead to a larger demand shift, and to a smaller supply shift, both of them rightwards).

(ii) Rigid nominal wage with imported inputs

Now the multipliers become, for monetary policy

\[
\frac{\partial \hat{e}}{\partial m} = \frac{\delta + \alpha + \beta}{\delta + \alpha \eta + \beta + \delta \theta \alpha} > 0, \quad \frac{\partial \hat{p}}{\partial m} = \frac{\delta + \beta}{\delta + \alpha \eta + \beta + \delta \theta \alpha} > 0, \quad \frac{\partial (\hat{e} - \hat{p})}{\partial m} = \frac{\alpha}{\delta + \alpha \eta + \beta + \delta \theta \alpha} > 0, \quad (27)
\]

\[
\frac{\partial \hat{y}}{\partial m} = \frac{\delta \alpha}{\delta + \alpha \eta + \beta + \delta \theta \alpha} > 0, \quad \frac{\partial \hat{r}}{\partial m} = 0
\]

and for fiscal policy

\[
\frac{\partial \hat{e}}{\partial g} = -\gamma[1 - \eta + \theta(\alpha + \beta)] < 0, \quad \frac{\partial \hat{p}}{\partial g} = -\gamma(-\eta + \theta \beta) < 0, \quad (28)
\]

\[
\frac{\partial (\hat{e} - \hat{p})}{\partial g} = -\gamma[1 + \theta \alpha] < 0, \quad \frac{\partial \hat{y}}{\partial g} = \frac{\gamma(\alpha \eta + \beta)}{\delta + \alpha \eta + \beta + \delta \theta \alpha} > 0, \quad \frac{\partial \hat{r}}{\partial g} = 0
\]

Therefore, the introduction of the exchange rate into the LM equation means that a monetary expansion would lead to smaller nominal and real exchange rate depreciations, together with a lower domestic price increase and a lower expansive effect on output (graphically, the lower nominal depreciation would cause the rightwards demand shift and the leftwards supply shift being both smaller). Otherwise, a fiscal expansion would lead now to smaller nominal and real exchange rate appreciations, together with an ambiguous effect on domestic prices (they can decrease, always by less than in the alternative model, or increase), and a higher output expansion (graphically, the lower nominal appreciation would make larger the rightwards demand shift, and smaller the rightwards supply shift).
(iii) Rigid real wage without imported inputs

The steady-state multipliers are in this case

\[ \frac{\partial \hat{e}}{\partial m} = 1, \quad \frac{\partial \hat{\phi}}{\partial m} = 1, \quad \frac{\partial (\hat{\epsilon} - \hat{p})}{\partial m} = 0, \quad \frac{\partial \hat{y}}{\partial m} = 0, \quad \frac{\partial \hat{\rho}}{\partial m} = 0 \]  \hspace{1cm} (29)

for monetary policy, and

\[ \frac{\partial \hat{e}}{\partial g} = -\gamma[(1 - \eta) + \theta \alpha \eta] < 0, \quad \frac{\partial \hat{\phi}}{\partial g} = -\gamma[-\eta + \theta \alpha \eta] > 0, \quad \frac{\partial (\hat{\epsilon} - \hat{p})}{\partial g} = \frac{-\gamma}{\delta + \alpha \eta} < 0, \]  \hspace{1cm} (30)

\[ \frac{\partial \hat{y}}{\partial g} = \frac{\gamma \alpha \eta}{\delta + \alpha \eta} > 0, \quad \frac{\partial \hat{\rho}}{\partial g} = 0 \]

for fiscal policy. As in case (i), the introduction of the exchange rate into the LM equation does not affect the steady-state results for the monetary expansion, and the same applies to the fiscal expansion, except for the smaller nominal exchange rate appreciation and the ambiguous effect on domestic prices (which can decrease by less, or increase).

(iv) Rigid nominal wage without imported inputs

Finally, the steady-state multipliers in this case are

\[ \frac{\partial \hat{e}}{\partial m} = \frac{\delta + \alpha}{\delta + \alpha \eta + \delta \theta \alpha} > 0, \quad \frac{\partial \hat{\phi}}{\partial m} = \frac{\delta}{\delta + \alpha \eta + \delta \theta \alpha} > 0, \quad \frac{\partial (\hat{\epsilon} - \hat{p})}{\partial m} = \frac{\alpha}{\delta + \alpha \eta + \delta \theta \alpha} > 0, \]  \hspace{1cm} (31)

\[ \frac{\partial \hat{y}}{\partial m} = \frac{\delta \alpha}{\delta + \alpha \eta + \delta \theta \alpha} > 0, \quad \frac{\partial \hat{\rho}}{\partial m} = 0 \]

for monetary policy, and

\[ \frac{\partial \hat{e}}{\partial g} = -\gamma[(1 - \eta) + \theta \alpha] < 0, \quad \frac{\partial \hat{\phi}}{\partial g} = \gamma \eta > 0, \quad \frac{\partial (\hat{\epsilon} - \hat{p})}{\partial g} = \frac{-\gamma [1 + \theta \alpha]}{\delta + \alpha \eta + \delta \theta \alpha} < 0, \]  \hspace{1cm} (32)

\[ \frac{\partial \hat{y}}{\partial g} = \frac{\gamma \alpha \eta}{\delta + \alpha \eta + \delta \theta \alpha} > 0, \quad \frac{\partial \hat{\rho}}{\partial g} = 0 \]

for fiscal policy. As in case (ii), when the exchange rate is introduced into the money market equilibrium condition the effectiveness of a monetary expansion is weakened (with smaller
nominal and real exchange rate depreciations, and also lower increases in output and domestic prices), as well as that of a fiscal expansion is strengthened (the nominal and real exchange rate appreciations would be smaller, and, unlike the alternative model, both output and domestic prices would increase).
We have examined in this paper the relative effectiveness of monetary and fiscal policies in a series of dynamic models of the open economy. To this end, we firstly developed a reference dynamic model with perfect capital mobility and sluggish price adjustment which, in its steady-state version, included as particular cases those previously analysed by Findlay and Rodríguez (1977) and Sachs (1980), as well as the standard Mundell-Fleming model. The model was further enlarged by including exchange rate effects into the money market equilibrium condition, which allowed to extend the analysis of Branson and Buiter (1983) to the presence of several alternative supply-side specifications. The model also allowed us to discuss, together with the steady-state or long-run results, the short-run or impact effects stemming from unanticipated policy measures, by looking at the dynamic behaviour of the exchange rate and domestic price level (unlike Sachs (1980), who used instead the exchange rate and nominal wage). Finally, we also examined the announcement effects arising when policy measures were perfectly anticipated by the economic agents, extending the analysis of Wilson (1979) to the fiscal policy case.

The steady-state or long-run effects of monetary and fiscal policies on the real exchange rate, domestic prices, and the level of output, are shown in Table 1 for the models embodying the "standard" LM equation. As can be seen, in the model including the assumptions of both rigid real wage and imported intermediate inputs (i. e., Section 2's model) monetary policy does not affect output, whereas fiscal policy does (that is, the opposed to the conventional result). When relaxing the first assumption (i. e., the Findlay and Rodríguez case), both policies affect output, being uncertain its relative effectiveness, but when relaxing the second (i. e., the Sachs case), the first outcome is regained; finally, if both assumptions are relaxed (i. e., the standard Mundell-Fleming model) the conventional result of monetary policy effectiveness together with fiscal policy ineffectiveness appears. Turning to the quantitative results in these four cases, monetary policy is more effective in case 4 than in case 2, whereas the highest effectiveness of fiscal policy is obtained in case 1, being uncertain its relative power in cases 2 and 3.
Next, the steady-state effects of monetary and fiscal policies when the exchange rate is included into the money market equilibrium condition are shown in Table 2. Now, the output effects in cases 1 and 3 (i.e., when real wage rigidity is assumed) are the same than those in Table 1, but in cases 2 and 4 (i.e., when nominal wage rigidity is assumed) monetary policy effectiveness still remains, though with a reduced power, whereas fiscal policy effectiveness is reinforced, being uncertain in both cases its relative power; in particular, and unlike the results in Table 1, fiscal policy is effective on output also in case 4, that is, in the otherwise standard Mundell-Fleming case. As before, the output effects of monetary policy are stronger in case 4 than in case 2; similarly, the strongest output effects of fiscal policy are those of case 1, while its relative power in cases 2 and 3 remains uncertain, being weaker its effects in case 4.
### TABLE 2

STEADY-STATE EFFECTS OF MONETARY AND FISCAL POLICIES

(LM equation including the exchange rate)

<table>
<thead>
<tr>
<th>Model specification</th>
<th>Steady-state effects on:</th>
<th>Monetary expansion</th>
<th>Fiscal expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Real exchange rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Domestic prices</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rigid real wage</td>
<td>Unchanged</td>
<td>Appreciates</td>
<td></td>
</tr>
<tr>
<td>with imported inputs</td>
<td>Increase</td>
<td>?</td>
<td>Increases</td>
</tr>
<tr>
<td>Rigid nominal wage</td>
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<td>Increase</td>
<td>?</td>
<td>Increases</td>
</tr>
</tbody>
</table>

On the other hand, notice that the models in this paper also allow us to analyse the effects from other disturbances in addition to monetary and fiscal policies. So, and limiting ourselves to the steady-state effects on output, an increase in foreign output would also increase domestic output (except for case 4 in Table 1, where would be ineffective), an increase in foreign prices would increase domestic output in the models including imported inputs (being ineffective in the models not including them), an increase in the foreign interest rate would reduce domestic output in the models assuming real wage rigidity (being ambiguous its effect in the models assuming nominal wage rigidity, except for case 4 in Table 1, in which domestic output would be increased), and an increase in nominal factor prices (real or nominal wage, and the foreign-currency price of the imported input) would always reduce domestic output.
To conclude, we will outline several possible extensions of the analysis carried out along this paper. First, the wealth effects associated with current account imbalances have been ignored. To take them into account, the IS and LM functions should be amended to include wealth-depending terms:

\[ y = -\sigma r + \gamma g + \delta (e + p^* - p) + \psi y^* + \mu f \]

\[ m - p = \Theta y - \lambda r + \rho f \]

where \( f \) denotes the net domestic claims on the rest of the world (for simplicity, we abstract from the effect of other components of wealth), and a balance of payments equation should also be added:

\[ \dot{f} = \chi (e + p^* - p) + \xi y^* - \pi y + r^* f \]

so that changes in \( f \) would match current account imbalances, appearing in the right-hand side of the equation as the sum of the trade and services accounts (the terms in square brackets and \( r^* f \), respectively).

Second, we have dealt above with the two polar cases of real wage rigidity and nominal wage rigidity, even though intermediate cases might be actually the rule. Hence, we could assume that workers try to get as nominal wage some desired level of real wage plus a fraction of the consumption price index

\[ w = \nu + \varepsilon p_c \quad 0 < \varepsilon < 1 \]

where \( \varepsilon = 1 \) and \( \varepsilon = 0 \) would indicate real and nominal wage rigidity, respectively. Then, the dynamic equation for the domestic price level would become

\[ \dot{p} = \phi [y - (\alpha + (\alpha(1 - \varepsilon) + a \varepsilon \eta + \beta)p^* - \alpha \varepsilon \eta p^* - \beta q^*)] \]

of which (11), (11'), (11'') and (11'''') would be particular cases.

Third, other policy measures could be also considered. So, imposing a tariff \( t \) on final goods imports (or a subsidy on domestic exports) would modify equation (1) to
\[ y = -\sigma r + \gamma g + \delta (e + p^* + t - p) + \psi y^* \]

and equation (11) to

\[ \dot{\phi} = \phi [y - (\alpha + \alpha \eta) p - (\alpha + \beta) e - \alpha \eta (p^* + t) - \beta q^*] \]

so that setting \( t \) would be equivalent to an increase in the foreign price level. Similarly, a tariff \( t' \) on intermediate imports would lead to replace (11) by

\[ \dot{\phi} = \phi [y - (\alpha + \alpha \eta) p - (\alpha + \beta) e - \alpha \eta p^* - \beta (q^* + t')] \]

and would be equivalent to an increase in the foreign-currency price of the imported input. Lastly, a tax \( z \) on capital outflows (or a subsidy on capital inflows) would turn equation (4) into

\[ \dot{e} = r - (r^* - z) \]

and its effect would be similar to a reduction in the foreign interest rate.
References


Fleming, J. Marcus (1962): "Domestic financial policies under fixed and under floating exchange rates", International Monetary Fund Staff Papers 9, 369-379.

