ABSTRACT
The standard IS/LM/BP macroeconomic model with infinite capital mobility, the so-called Mundell-Fleming model, remains a mainstay of teaching undergraduate open-economy macroeconomics. But Mundell-Fleming does not handle longer term issues including money neutrality, purchasing power parity and the long-run irrelevance of the exchange rate regime so well. University economics teachers usually move to augmented aggregate supply-aggregate demand frameworks to consider these matters with all the attendant complexity of building multiple frameworks. This paper argues that introducing an implicit aggregate supply inflation mechanism to the standard Mundell-Fleming model overcomes its limitations for addressing long run issues without the need to build alternative structures. This can also facilitate discussion of elementary dynamics and terminal conditions. It thus represents a potentially more efficient way of handling such issues in undergraduate open economy courses.

Keywords: Money neutrality, purchasing power parity, dynamics.
JEL classifications: A20, A22

1. INTRODUCTION
The standard IS/LM/BP macroeconomic model with infinite capital mobility, the so-called Mundell-Fleming model, remains a mainstay of teaching undergraduate open-economy macroeconomics. This is
reflected in the range of popular texts that continue to develop, explain and employ this model (see, for example, Dornbusch et al. 2006, pp.278-286). The model has some important features that underpin this continued treatment in the textbooks, most notable of which is its accessible analytics and the ready application of these analytics to common policy problems. For example, the Mundell-Fleming model can be used to discuss the relative effectiveness of fiscal and monetary policies in a world of floating exchange rates.¹

But Mundell-Fleming does not handle longer term issues so well. These include money neutrality, purchasing power parity and the long-run irrelevance of the exchange rate regime. In order to consider these matters, university economics teachers usually move to augmented aggregate supply-aggregate demand frameworks. I have found, however, that a simple extension of the standard Mundell-Fleming model enables me to deal with money neutrality, purchasing power parity and the long-run irrelevance of the exchange rate regime as well as elementary dynamics and terminal conditions all within the same framework.² The extension consists of introducing an implicit aggregate-supply inflation mechanism and the objective of this paper is to outline this extension and to show how it can be used to inform the teaching of these long run concepts.³

The structure of the paper is as follows. The next section recaps the key features of the standard *Mundell-Fleming* model and its application to the use of fiscal and monetary policies. Section 3 then outlines the implicit aggregate-supply inflation mechanism and explains how this modifies the standard model. Section 4 applies the extended model to a discussion of money neutrality, purchasing power parity and the long-run irrelevance of the exchange rate regime as well

¹ This, of course, assumes the absence of a zero lower bound to interest rates which is currently causing so many problems.
² This teaching innovation was developed without reference to Abel, Bernanke and Croushore (2010), an undergraduate text in macro which utilizes a full employment level of output on the *IS/LM* diagram to discuss inflation and deflation. I thank an anonymous referee for directing me to that reference. This paper uses the full employment output level, which they do, but appends it to the standard infinite capital mobility case, which they don’t. See their appendix 13.B.
³ This is not to deny the value of an extended discussion of aggregate supply facilitated by the *AS/AD* diagrams. However, all that is required for some crucial policy discussions is the bland assertion that accentuated or attenuated GDP growth causes price changes, after some delay. Students who understand the importance of these delayed price changes may be inspired to ask why there is a delay.
as to elementary dynamics and terminal conditions. Section 5 then reflects upon the benefits of this exposition before Section 6 draws some conclusions for the teaching of open economy macroeconomics.

2. THE STANDARD MUNDELL-FLEMING MODEL

The standard Mundell-Fleming model is outlined in Figure 1. Panel A shows a fiscal expansion under the assumption of floating exchange rates. From its initial position at point A, the fiscal expansion increases output from $y_1$ to $y_2$ via a shift in the IS curve from $IS_1$ to $IS_2$. With higher interest rates at $i_1$ rather than $i^*$ (the interest rate in the rest of the world), greater capital flows are attracted and increased demand for the local currency appreciates the exchange rate. This discourages exports and encourages imports, leading to a contraction in net exports which shifts the IS curve back to $IS_1$. The economy thus returns to point A where the increased government spending has completely crowded out net exports of the same value to leave output and interest rates at their original levels. Fiscal policy has thus been completely ineffective.

Panel A

Panel B shows the impact of an expansionary monetary policy under the same assumption of flexible exchange rates. From the economy’s initial position at point A, a monetary expansion that shifts the LM curve from $LM_1$ to $LM_2$, reduces interest rates, discourages capital flows and depreciates the exchange rate. This leads to an expansion in net exports which causes a rightward shift of the IS curve from $IS_1$ to $IS_2$. The higher level of output places pressure on interest rates which return to their previous level at $i^*$. There is, therefore, a sustained increase in GDP in this case, in contrast to the first case considered above.

Figure 1: The Mundell-Fleming Model and Relative Policy Effectiveness
As suggested in the introduction, the analytics of this model are simple enough to be understood by students at the intermediate level, but rich enough to convey sufficient detail about how the economy reacts to particular policy shocks and why monetary policy will be more effective than fiscal policy under a regime of flexible exchange rates. But longer term issues are harder to deal with due to the absence of information about the supply side of the economy. The following section, therefore, outlines a simple extension of the Mundell-Fleming framework to incorporate supply side conditions without the need to develop a completely alternative structure.

3. AN EXTENSION OF THE MUNDELL-FLEMING MODEL
An extension of the simple framework outlined in the previous section that I have used in second and third year open economy macro classes can be described in terms of four assumptions:

A1) the initial equilibrium is characterized by full employment with an associated level of output of $y_f$;
A2) departures from full employment output ($y \neq y_f$) cause inflation or deflation;
A3) exchange rate adjustment in the face of disequilibrium ($i \neq i_f$) occurs more quickly than price level adjustment in the face of disequilibrium ($y \neq y_f$);
A4) final equilibrium can be inferred from the GDP identity.

The benefits of this extension can be demonstrated by considering the same set of policy shocks as examined in Section 2 as well as an additional shock to export demand. I do this in the following section.

4. LONG RUN ISSUES IN THE REVISED MUNDELL-FLEMING MODEL
Let us use the Mundell-Fleming model augmented with the assumptions outlined in the previous section to consider expansionary fiscal and monetary policy shocks as well as a shock to export demand, each in turn.

(a) A Fiscal Expansion
There are two cases to consider here: a fiscal expansion within a fixed exchange rate regime and the same expansion within a floating rate regime. These cases are dealt with sequentially.
The fiscal expansion moves the IS curve from $IS_1$ to $IS_2$ in Figure 2. To maintain interest rates at the world rate (i.e. $i = i^*$), the monetary authorities expand the money supply, moving the $LM$ curve from $LM_1$ to $LM_2$. The economy thus moves from Point $A$ to Point $C$. Under the classic Mundell-Fleming exposition outlined in Section 2, the analysis stops at this point, and the policy is pronounced ‘effective’ since output has been permanently increased. However, because the economy was initially at full employment with output at $y_f$ (according to assumption A1), we now have a level of output that exceeds its full employment level ($y > y_f$) so that prices begin to rise (according to assumption A2).

![Figure 2: A Fiscal Expansion in the Revised Mundell-Fleming Model](image)

To see this, we can make use of standard expressions for the IS and LM curves as follows:

$$y = f[A, i, N X (s \cdot P / P^*)]$$

(1)

$$\frac{M}{P} = \alpha \cdot y - \beta \cdot i$$

(2)

Equation (1) represents the IS curve according to which output, $y$, is a function of a set of autonomous components of expenditure (including government spending), $A$, the interest rate ($i$), and net exports, $NX$, which in turn depends on the real exchange rate, where $s$ is the nominal exchange rate (measured so that an increase in $s$ represents an appreciation), $P$ is the domestic price level, and $P^*$ is the foreign price
level. Equation (2) represents the \( LM \) curve according to which the real money supply, \( M/P \), is equated with the money demand where \( \alpha \) and \( \beta \) are parameters assumed to be strictly positive. From (1) and (2) it is clear that an increase in the price level will result in a loss of competitiveness (as the real exchange rate appreciates) and a real money contraction. Thus the \( IS \) and \( LM \) curves will both shift back to the left.

Given that prices will rise as long as \( y > y_f \), the \( IS \) and \( LM \) curves will continue to shift left until \( y = y_f \). Given the fixed exchange rate policy we are considering, and which we express in terms of the condition \( i = i^* \), we know that the final equilibrium must occur at \( y = y_f \) and \( i = i^* \). By assumption A4, this immediately allows us to make strong statements about the final equilibrium based on the GDP identity shown in equation (3), even if the path back to this final equilibrium is complex.\(^4\)

\[ y = C + I + G + NX \quad (3) \]

where \( C, I, \) and \( G \) represent the usual components of aggregate demand, consumption, investment and government spending, and we assume that \( C \) is increasing in \( y \), \( I \) is decreasing in \( i \), \( G \) is exogenous and \( NX \) is decreasing in the real exchange rate. Our statements about final equilibrium can be supported by working through a comparative static analysis of each of the components of (3) where a plus sign (+) indicates an increase compared with the original equilibrium, a minus sign (−) indicates a decrease, and a zero (0) indicates no change. For the fiscal expansion case, these changes are shown in expression (4):

\[ y = C + I + G + NX \quad (4) \]

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Since at the new equilibrium we are back at \( y_f \), the left hand side of the GDP equation is unchanged, indicated by the zero under \( y \) in expression (4). Since \( y \) is unchanged, \( C \) must also be unchanged. Since \( i = i^* \), \( I \) is also unchanged. The value of \( G \) is higher due to the fiscal expansion being considered. Thus in equilibrium, \( NX \) must have

\(^4\) The path could be very complex indeed. If the \( IS \) and \( LM \) curves move back at different speeds, there will have to be small adjustments to nominal money \( M \) to keep \( i = i^* \), as required by a fixed rate regime.
fallen by precisely the increase in \( G \) to make the GDP identity hold. The reduction in \( NX \) must also be attributable to a real exchange rate appreciation.\(^5\) Since both \( P^* \) and \( s \) are fixed (the latter by virtue of the fixed exchange rate regime), the entire increase in the real exchange rate must have come about by an increase in the domestic price level. How much has the price increased? In the final equilibrium, the right hand side of (2) must be unchanged from its initial value (with \( y = y_f \) and \( i = i^* \)), implying that the left hand side must also be unchanged. Thus prices must have increased exactly in proportion to the increase in money supply associated with maintaining the fixed exchange rate.

The second case of fiscal expansion is that under floating exchange rates. By virtue of assumption A3, which states that any exchange rate adjustment precedes any price adjustment, this case is exactly the same as in the standard Mundell-Fleming model. In Figure 2, the IS curve shifts out from \( IS_1 \) to \( IS_2 \), taking the economy from point A to point B. Since \( i > i^* \), the exchange rate appreciates and competitiveness is eroded. The IS curve shifts back to \( IS_1 \) prior to any price effects taking hold, and the economy reverts to the original equilibrium. The classic analysis ends here, pronouncing the policy ineffective, and our implicit aggregate supply extension arrives at precisely the same conclusion.

The comparative static analysis of (4) also remains valid since the components of aggregate expenditure are determined by the final values of \( y \) and \( i \). However, one difference is that the money supply is unchanged. This is a hallmark of a floating rate regime.\(^6\) Thus, from (2), the money supply and prices are unchanged, and the entire real appreciation required to reduce \( NX \) by the increase in \( G \) must occur through the nominal appreciation of \( s \).\(^7\) That is, \( s.P/P^* \) increases by the same amount under both regimes, but the choice of policy

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\(^5\) Although I have assumed away income effects on net exports, they would be irrelevant in the final equilibrium even if they were present, since \( y = y_f \).

\(^6\) In any presentation of the Mundell-Fleming model, or the extension proposed in this paper, it is problematic to talk as though the monetary policy instrument were the money supply rather than an interest rate. This is often glossed over at second year undergraduate level, but an alternative would be to redefine \( M \) as a nominal income (level) target.

\(^7\) Actually, this would be true even without A3. If prices increased over the time that \( y > y_f \), both the IS and LM curves would shift back, and the exchange rate would appreciate until an equilibrium occurred where \( i = i^* \) and \( y < y_f \). But this would necessarily reduce prices until \( y = y_f \). Without a change in the money supply, (2) ensures that prices cannot ultimately rise.
determines whether it comes quickly through changes in $s$ in the floating rate regime, or slowly through changes in $P$ in the fixed rate regime.

(b) A Monetary Expansion

There are also two cases to consider here: a monetary expansion within a fixed exchange rate regime and the same expansion within a floating rate regime. Once again, we consider these cases sequentially.

In the fixed exchange rate case, a monetary expansion is not an effective policy as is true in the standard Mundell-Fleming model. Any monetary expansion reduces $i$ below $i^*$, causing significant capital outflows and weak demand for the local currency that places downward pressure on the exchange rate. The central bank must deal with this situation under a fixed exchange rate regime with currency purchases that increase the money supply and reverse the original policy action.

In the floating exchange rate case, the $LM$ curve in Figure 2 shifts out to $LM_1$, taking the economy from point $A$ to point $D$. Since $i < i^*$ at point $D$, the exchange rate depreciates and competitiveness improves. Net exports increase, shifting $IS$ from $IS_1$ to $IS_2$ and the economy moves from $D$ to $C$. The Mundell-Fleming analysis concludes at this point and the policy is deemed a success since output is permanently higher.

Our extension of the standard model, however, shows that this position is unsustainable in the long run. With $y > y_f$, prices rise and both the $IS$ and $LM$ curves shift back to their original levels. The economy follows an unspecified path back from point $C$ to point $A$ in Figure 2. If the $IS$ and $LM$ curves move at different rates, $i$ will depart from $i^*$ and there will be a nominal exchange rate adjustment (either a depreciation or an appreciation, depending on the path of interest rates).

Despite the prospect of a complex adjustment path, we obtain clear predictions about the final equilibrium, where $y = y_f$ and $i = i^*$. This can be understood in terms of expression (5):

$$ y = C + I + G + NX $$

Since we are back at $y_f$, the left hand side of (5) is unchanged. Since $y$ is unchanged, $C$ must also be unchanged. Since $i = i^*$, $i$ is unchanged.
Thus, in equilibrium, $NX$ must be unchanged because $G$ (which is exogenous) has not changed. Therefore the real exchange rate is unchanged. At the final equilibrium, the right hand side of (2) is unchanged from its initial value (with $y = y_f$ and $i = i^*$), implying that the left hand side must also be unchanged. Thus prices must have increased exactly in proportion to any increase in the money supply. But if this is the case, only $s$ remains undetermined in the expression for the real exchange rate $sP/P^*$. For the real exchange rate to be unchanged, $s$ must fall exactly in proportion to the rise in $P$, which is in turn equal to the expansion of money.

This is the classic money neutrality result. Prices rise in proportion to the increase in liquidity, and the nominal exchange rate depreciates by the same proportion as prices (and the money supply) increase. Nothing real changes – neither the expenditure components nor the real exchange rate. I like to ask students what would be the outcome if the government decreed that all holders of money could move the decimal place one step to the right (i.e. increasing liquidity tenfold by fiat). Many can see that the money neutrality result would obtain more or less immediately.

Taking money neutrality further, this extension is an ideal vehicle for introducing students to the thinking behind modern central banking. The actions of the monetary authorities are very important for short run growth and therefore employment, but the skepticism about long run effects is behind the move to inflation targeting.

Finally, the unchanged real exchange rate following a monetary shock gives rise naturally to a discussion of Purchasing Power Parity (PPP). Provided shocks are nominal, the extended model leads us to expect exchange rate changes to offset inflation. This is not the case following a real shock, as the following example makes clear.

(c) A Real Trade Shock

Suppose, in Figure 2, that $NX$ receives a positive exogenous shock; say an increase in the demand for the economy’s exports unrelated to the real exchange rate. In this case, the $IS$ curve would shift out from $IS_1$ to $IS_2$. Under the fixed rate regime, the $LM$ curve shifts out from $LM_1$ to $LM_2$ to keep $i = i^*$. Under the floating rate regime, the $IS$ curve is pulled back as the nominal exchange rate appreciates and $NX$ falls. As before, the implicit aggregate supply extension pulls the equilibrium back to $y = y_f$ and $i = i^*$ regardless of the regime. However, the analysis of the final equilibrium is now different.
\[ y = C + I + G + NX \]  

We may consider this in terms of expression (6). Since we are back at \( y_f \), the left hand side of (6) is unchanged. Since \( y \) is unchanged, \( C \) must be too. Since \( i = i^* \), \( i \) is unchanged. Thus, in equilibrium \( NX \) must be unchanged because \( G \) (which is exogenous) is unchanged. However, it no longer follows that the real exchange rate is unchanged. Since \( NX \) has received a positive exogenous shock from increased demand, the real exchange rate must have appreciated enough for a fall in \( NX \) to exactly offset this. At the final equilibrium, the right hand side of (6) is unchanged from its initial value (with \( y = y_f \) and \( i = i^* \)), implying that the left hand side must also be unchanged. Thus, as before, prices must have increased exactly in proportion to any increase in the money supply. As before, only \( s \) remains undetermined in the real exchange rate \( sP/P^* \), but the real exchange rate has increased.

In the fixed rate case, which is the simplest, \( s \) is unchanged and the entire increase in the real exchange rate comes through prices. This, in turn, must be accommodated by an expansion of the money supply, from (2). In the floating rate case, prices are unchanged so the entire increase comes through variations in \( s \). Either way, students can see that the real exchange rate can change following a real shock, violating \( PPP \).

5. WHAT IS GAINED BY EXTENDING THE STANDARD MUNDELL-FLEMING MODEL?

The implicit-aggregate-supply extension, like its Mundell-Fleming parent, can guide students towards many interesting policy discussions using accessible analytics. First, students can engage with issues of long run vs short run. In the short run, a fiscal expansion is effective under a fixed rate regime, but this unravels in the long run. Whichever policy is chosen, a real appreciation will erode competitiveness. Second, the monetarist assertion that inflation is always and everywhere a monetary phenomena is borne out by the model. In the final equilibrium, \( M \) and \( P \) must increase proportionately. For this not to occur, there must be a structural change in the \( LM \) relation, and this was precisely the issue that derailed monetary targeting.

Third, students can be introduced to notions of dynamics without sophisticated mathematics. Furthermore, they can perceive that sometimes
economics provides insights about the final state of affairs, as read from equilibrium conditions, even if the adjustment path is difficult or impossible to discover.

6. CONCLUSION
Despite the fact that the standard Mundell-Fleming model remains a mainstay of teaching undergraduate open-economy macroeconomics, this paper has argued that a simple extension of the standard model possess some important attributes that commend it over its common textbook version. The extension of introducing an implicit aggregate-supply inflation mechanism allows the model to deal with issues of money neutrality, purchasing power parity and the long-run irrelevance of the exchange rate regime as well as elementary dynamics and terminal conditions all within the same framework. The extended version thus makes it possible to deal with a wider range of issues than the standard version without having to develop an alternative aggregate demand-aggregate supply structure. For this reason it may represent a more efficient pedagogical tool than the aggregate demand-aggregate supply structure in teaching elementary university economics.

REFERENCES