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Working Paper

Teaching New Keynesian Open Economy Macroeconomics at the Intermediate Level

W.E.P. - Würzburg Economic Papers, No. 66

Provided in Cooperation with:
University of Würzburg, Department of Economics

Suggested Citation: Bofinger, Peter; Mayer, Eric; Wollmershäuser, Timo (2006) : Teaching New Keynesian Open Economy Macroeconomics at the Intermediate Level, W.E.P. - Würzburg Economic Papers, No. 66, University of Würzburg, Department of Economics, Würzburg

This Version is available at:
https://hdl.handle.net/10419/22359

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W. E. P.

Würzburg Economic Papers

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Teaching New Keynesian Open Economy Macroeconomics at the Intermediate Level

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Teaching New Keynesian Open Economy Macroeconomics at the Intermediate Level

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---Abstract---

For the open economy the workhorse model in intermediate textbooks still is the Mundell-Fleming model, which basically extends the IS-LM model to open economy problems. The purpose of this paper is to present a simple New Keynesian model of the open economy, that introduces open economy considerations into the closed economy consensus version and that still allows for a simple and comprehensible analytical and graphical treatment. Above all, our model provides an efficient tool kit for the discussion of the costs and benefits of fixed and flexible exchange rates, which also was at the core of the Mundell-Fleming model.

JEL classification: A 20, E 10, E 50, F 41

Keywords: open economy, inflation targeting, monetary policy rules, New Keynesian macroeconomics

The authors would like to thank Carol Osler, Stefan Reitz and Michael Woodford for extremely helpful and valuable comments.

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For the open economy the workhorse model in intermediate textbooks still is the Mundell-Fleming model, which basically extends the IS-LM model to open economy problems. The purpose of this paper is to present a simple New Keynesian model of the open economy, that introduces open economy considerations into the closed economy consensus version and that still allows for a simple and comprehensible analytical and graphical treatment. Above all, our model provides an efficient tool kit for the discussion of the costs and benefits of fixed and flexible exchange rates, which also was at the core of the Mundell-Fleming model.

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1 Introduction

In recent years a range of papers have been published trying to present an alternative intermediate macroeconomic textbook model to the outdated IS-LM-AS-AD model. Among them the most influential have been the IS-MP (monetary policy)-IA (inflation adjustment) model by Romer (2000), the inflation targeting model by Walsh (2002), the AD (aggregate demand)-PA (price adjustment) model by Weerapana (2003), the IS-PC (Phillips curve)-MR (monetary policy rule) model by Carlin and Soskice (2004), and the BMW model by Bofinger, Mayer and Wollmershäuser (2005). Similar to the class of dynamic New Keynesian macro models popularised by Clarida, Gali and Gertler (1999) the main building blocks in all models are an IS equation, that links the output gap to the real interest rate, a Phillips curve that relates the inflation rate to the output gap, and a monetary policy rule that is evaluated in terms of or derived from a social loss function. While the IS equation has survived the New Keynesian revolution (even though it is nowadays derived from solid micro-foundations), the major innovations with respect to the IS-LM-AS-AD model are

- that monetary policy is described by an interest rate rule (instead of a money supply rule),
- that inflation enters the model (instead of the price level),
- and that the supply side of the economy is summarised by a Phillips curve (instead of the inconsistent AS apparatus).

For the open economy the workhorse model in intermediate textbooks still is the Mundell-Fleming model, which basically extends the IS-LM model to open economy problems. The purpose of this paper is to present a simple New Keynesian model of the open economy, that introduces open economy considerations into the closed economy consensus version and that still allows for a simple and comprehensible analytical and graphical treatment. Above all, our

model provides an efficient tool kit for the discussion of the costs and benefits of fixed and flexible exchange rates, which also was at the core of the Mundell-Fleming model. However, we tried to carry over the major innovations of the New Keynesian model cited above so that we are able to discuss modern monetary policy issues.

2 The basic New Keynesian open economy model

For an extension of the closed-economy New Keynesian model to the open economy the effects of international goods markets and international financial markets on the domestic economy have to be taken into account. On the demand side of the economy which is described by the IS equation we have to include net exports as an additional determinant besides domestic demand. Thus, the output gap is not only dependent on the real interest rate r, which is under the control of the central bank, but also on the real exchange rate q:[i]

(1) $$y = a - b\,r + c\,q + \varepsilon_1,$$

where a, b, and c are positive structural parameters of the open economy, and ε_1 is a demand shock. The parameter a reflects the fact that there may be positive neutral values of r. The interest rate elasticity b and the exchange rate elasticity c take values smaller than one. If c is equal to zero, equation (1) corresponds to the closed economy version of the IS-curve.

For the determination of the inflation rate we will differentiate between two polar cases. In the first case, which represents a long-run perspective especially for a small open economy the domestic inflation rate is completely determined by the foreign rate of inflation expressed in domestic currency terms (π^f), and hence by purchasing power parity (PPP):

(2) $$\pi = \pi^f = \pi^* + \Delta s.$$

Because of the long-run perspective we do not include a shock term. Thus, the domestic inflation rate equals the foreign inflation rate (π^*) plus the nominal depreciation of the domestic currency (Δs). In other words, we assume that the real exchange rate remains constant at its long-run level (i.e. $q = \overline{q}$) as changes in the real exchange rate, which are defined by $\Delta q \equiv \Delta s + \pi^* - \pi$ are equal to zero.

In the second case we adopt a short-run perspective. We assume that companies follow the strategy of pricing-to-market so that they leave prices unchanged in each local market even if the nominal exchange rate changes. As a consequence, changes in the exchange rate mainly affect the profits of enterprises. One can regard this as an open-economy balance-sheet channel where changes in profitability are the main lever by which the exchange rate affects aggregate demand. In this case the Phillips curve is identical with the domestic version:

(3) $$\pi = \pi_0 + d\,y + \varepsilon_2 .$$

An alternative explanation for this simplified open economy Phillips curve has been given by McCallum and Nelson (2000). Under the assumption that imports do not enter consumption, but are used entirely as intermediate inputs, there is no distinction between domestic inflation and consumer price inflation, and no direct exchange rate channel into consumer prices.

Of course, it would be interesting to discuss an intermediate case where the real exchange has an impact on the inflation rate. But using an equation like

(4) $$\pi = (1-e)\pi^d + e\pi^f = \pi_0 + d\,y + e\Delta q + \varepsilon_2 ,$$

would make the presentation very difficult, above all the graphical analysis. According to (4) the overall inflation rate would be calculated as a weighted average (by the factor e) of domestic inflation π^d (determined by (3)) and imported inflation π^f (determined by (2)).

As a further ingredient of open economy macro models we have to take into account the behaviour of international financial markets' participants which is in general described by the uncovered interest parity condition (UIP):

(5) $$\Delta s + \alpha = i - i^* .$$

According to equation (5) the differential between domestic (i) and foreign (i^*) nominal interest rates have to be equal to the percentage rate of nominal depreciation (Δs) and a stochastic risk premium (α). If UIP holds, risk averse investors are indifferent between an investment in domestic and one in foreign assets.

As in the Mundell-Fleming model we will use our model in the following to discuss monetary policy in two exchange rate regimes: flexible exchange rates (Section 3) and fixed exchange rates (Section 4). The fundamental difference of each regime lies in the way of how central banks set their basic operating target, the short-term interest rate.

3 Monetary policy under flexible exchange rates

For a discussion of monetary policy under flexible exchange rates it is important to decide how the flexible exchange rate is determined. In the following we discuss three different variants:

- PPP and UIP hold simultaneously (Section 3.1),
- UIP holds, but deviations from PPP are possible (Section 3.2),

- both, UIP and PPP do not hold, and the exchange rate is a pure random variable (Section 3.3).

3.1 Monetary policy under flexible exchange rates if PPP and UIP hold simultaneously (long-run scenario)

As it is well known that PPP does not hold in the short-term, the first case can mainly be regarded as a long-run perspective. PPP implies that the real exchange remains constant by definition:

(6) $$\Delta q = \Delta s + \pi^* - \pi = 0 .$$

For the sake of simplicity we assume a UIP condition that is perfectly fulfilled and thus, without a risk premium:

(7) $$\Delta s = i - i^* .$$

This expression can be transformed with the help of the Fisher equation

(8) $$i = r + \pi \text{ and } i^* = r^* + \pi^* ,$$

and equation (6) into real UIP

(9) $$\Delta q = r - r^* ,$$

which implies, if PPP is fulfilled (and hence $\Delta q = 0$), that

(10) $$r = r^* .$$

Thus, one can see that in a world where PPP and UIP hold simultaneously there is no room for an independent real interest rate policy, even under flexible exchange rates. As the domestic real

interest rate has to equal the real interest rate of the foreign (world) economy, the central bank cannot target aggregate demand by means of the real rate.

This does not imply that monetary policy is completely powerless. As equation (8) shows, the central bank can achieve a given real rate (which is determined according to equation (10) by the foreign real interest rate) with different nominal interest rates. Changing nominal interest rates in turn go along with varying rates of nominal depreciation or appreciation of the domestic currency Δs, for a given nominal foreign interest rate (see equation (7)). If i^* and r^* are exogenous, then π^* is exogenous as well, and the chosen (long-run) nominal interest rate finally determines via the related nominal depreciation and the PPP equation (6) the domestic inflation rate. If monetary policy is credible, the domestic inflation rate should on average be equal to the inflation target set by the central bank.

Thus, the long-run scenario with valid UIP and valid PPP leads to the conclusion that monetary policy has

- no real interest rate autonomy for targeting aggregate demand, but
- a nominal interest rate autonomy for targeting the inflation rate.

This comes rather close to the vision of the proponents of flexible exchange rates in the 1960s who argued that this arrangement would allow each country an autonomous choice of its inflation rate (see Johnson, 1972). It can be regarded as an open-economy version of the classical dichotomy according to which monetary policy can affect nominal variables only without having an impact on real variables.

3.2 Monetary policy under flexible exchange rates if UIP holds but not PPP (short-run scenario)

In our second scenario for flexible exchange rates we assume that the domestic inflation rate is not affected by the exchange rate. This assumption corresponds with empirical evidence that in the short-run the real exchange is rather unstable and mainly determined by the nominal exchange rate (see Chart 1).

Chart 1: Nominal and real exchange rate

3.2.1 Optimal monetary policy under flexible exchange rates

As in the closed economy models it is assumed that the ultimate goal of monetary policy is to promote welfare. In systems of flexible exchange rates this goal is usually interpreted in terms of keeping the inflation rate close to the inflation target π_0 which can be freely determined by the central bank or the government, and stabilizing output around its potential. In the literature it is common practice to summarize these goals by a quadratic loss function:[ii]

(11) $$L = \left(\pi - \pi_0\right)^2 + \lambda y^2,$$

where λ denotes the central bank's preferences. The intuition behind the quadratic loss function is that positive and negative deviations of target values impose an identical loss on economic agents. Large deviations from target values generate a more than proportional loss. The popularity of the linear quadratic framework also stems from the fact that it is able to deal with different notions of inflation targeting. If the parameter λ, which depicts the weight policymakers attach to stabilizing the output gap compared to stabilizing the inflation rate, is equal to zero policymakers only care about inflation. This type of inflation targeting is called strict inflation targeting. If λ is greater than zero, the strategy is called flexible inflation

targeting. At the limit, if λ goes to infinity, policymakers only care about output. This preference type is typically referred to as an output junkie.

Given the monetary policy transmission structure of the model, which runs from the real interest rate over economic activity to the inflation rate, optimal monetary policy can be derived by applying the following two-step procedure. First, we insert the Phillips curve (3) into the loss function (11). Second, we minimize the modified loss function with respect to y. The solution gives an optimal value of the output gap:

(12) $$y = -\frac{d}{\left(d^2 + \lambda\right)}\varepsilon_2 .$$

Under a strategy of inflation targeting one way to conduct monetary policy is to follow an instrument rule (Svensson and Woodford, 2003). Such a rule makes the reaction of the instrument of monetary policy depend on all the information available at the time the instrument is set and the structure of the economy. In our framework, the instrument rule can be derived by inserting equation (12) into the IS equation (1) and by solving the resulting expression for r:

(13) $$r^{opt} = \frac{a}{b} + \frac{1}{b}\varepsilon_1 + \frac{d}{b\left(d^2 + \lambda\right)}\varepsilon_2 + \frac{c}{b}q .$$

According to this reaction function the central bank responds to demand and supply shocks (ε_1 and ε_2), which are exogenous to the monetary policy decision, as well as to the real exchange rate. In contrast to the domestic shocks, however, the real exchange rate is dependent on the domestic real interest rate. This relationship is given by real UIP (equation (9)). Thus, for the case of flexible exchange rates where UIP holds the real exchange rate in (13) has to be substituted.

The major problem, however, is to approximate UIP, which prescribes a dynamic and forward-looking law of motion of the exchange rate in a comparative-static model. In accordance with Dornbusch (1986, Part I) we assume that the real exchange rate adjusts to its long-run level $\overline{q}$ asymptotically, so we can write

$$q_{+1} = \overline{q} + g\left(q - \overline{q}\right), \quad 0 < g < 1, \tag{14}$$

where q_{+1} is the real exchange rate in the next period and g is a key parameter determining the average speed of adjustment.[iii] Combining equation (14) and the real UIP condition (9) (augmented for risk premium shocks α) yields an equation for the real exchange rate in terms of the current real interest rate differential and the risk premium shock:

$$q = \overline{q} - \frac{1}{1-g}\left(r - r^{*} - \alpha\right). \tag{15}$$

Note that we assumed that $\Delta q = q_{+1} - q$. Equation (15) shows that a rise in the domestic real interest rate will lead to an immediate real appreciation, which then is followed by a gradual depreciation to the initial long-run equilibrium. The higher the parameter g, the lower the speed of adjustment of the real exchange rate, and the larger the impact of real interest rate changes on the current real exchange rate. Chart 2 shows the adjustment of the real exchange rate after an increase of the domestic real interest rate by one percent for $g = 0$ and $g = 0.8$. For simplicity we assumed that the long-run level of the real exchange rate is equal to zero.

Chart 2: The dynamics of the real exchange rate after an increase of the domestic real interest rate

For a comparative-static model, such as the one presented here, it is convenient to set $g = 0$. Equation (15) then simplifies to

(16) $$q = r^* - r + \alpha .$$

Thus, the real exchange rate appreciates in a one-to-one relationship with the domestic real interest rate.

In order to calculate the optimal interest rate rule of a central bank in a system of flexible exchange rates where UIP holds (with the possibility of risk premium shocks) while PPP does not hold we have to insert equation (16) into (13) and to solve the resulting equation for r (by assuming that $r = r^{opt}$):

(17) $$r^{opt} = \frac{a}{b+c} + \frac{1}{b+c}\varepsilon_1 + \frac{d}{(b+c)(d^2+\lambda)}\varepsilon_2 + \frac{c}{b+c}(r^* + \alpha).$$

Equation (17) shows that real interest rate has to respond to the following types of shocks:

- domestic shocks: supply and demand shocks,
- international shocks: foreign real interest rate shocks and risk premium shocks.

The optimal interest rate response to shocks affecting the demand side (ε_1, α, r^*) does not depend on the central bank's preferences λ. In the case of these shocks the central bank changes the interest rate in a way, which guarantees that the output gap remains closed and that inflation remains at its target level, irrespective of the preference type (see also equation (12)). Thus, as long as shocks solely hit the demand side of the economy they do not inflict any costs on the society. The reaction of the central bank to supply shocks ε_2 depends on its preferences λ. A central bank that only cares about inflation ($\lambda = 0$), requires a strong real rate response and, accordingly, a large output gap. With an increasing λ the real interest rate response declines. In

equilibrium $\left(\varepsilon_1 = \varepsilon_2 = \alpha = r^* = 0\right)$ the real interest rate will be given by the neutral real short-term interest rate $r_0 = a/\left(b+c\right)$.

The strategy of inflation targeting under flexible exchange rates can also be presented graphically. In the spirit of the IS-LM-AS-AD approach the graphical treatment requires two diagrams (see Chart 3). The IS curve and the representation of monetary policy are depicted in the $y-r$ space. The IS curve relates the output gap to the real interest rate and the exogenous shocks affecting the demand side of the economy. Thus, we have to replace q in equation (1) by equation (16), which leads to a downward sloping curve in the $y-r$ space:

(18) $$y = a - \left(b+c\right)r + c\left(r^* + \alpha\right) + \varepsilon_1 .$$

Note that the slope of the IS-curve is flatter in an open economy ($1/(b+c)$) compared to a closed economy ($1/b$) in which $c = 0$. This implies that an identical increase of the real interest rate has a weaker effect on aggregate demand in closed economy than in the open economy since in the latter interest rate changes are accompanied by an appreciation of the real exchange rate. The instrument rule enters as a horizontal line in the $y-r$ space (marked by $r\left(\cdot\right)$ where the dot indicates the shift parameters of the monetary policy line $\varepsilon_1, \varepsilon_2, \alpha$ and r^*). In equilibrium, at the intersection of $r\left(\varepsilon_1 = \varepsilon_2 = \alpha = r^* = 0\right) = r_0$ and IS_0, the output gap y is closed. The Phillips curve is depicted as an upward sloping curve in the $y-\pi$ space. If $y = 0$, inflation is at its target level. For $\lambda = 1$ the loss function of the central bank can be illustrated by circles around a bliss point in the $y-\pi$ space. The bliss point that represents the first best outcome with a loss of zero is defined by an inflation rate π equal to the inflation target π_0 and an output gap of zero. We can derive the geometric form of the circle by transforming the loss function (11) into

(19) $$1 = \frac{(\pi - \pi_0)^2}{\left(\sqrt{L}\right)^2} + \frac{(y - 0)^2}{\left(\sqrt{L}\right)^2}\Bigg|_{\lambda=1}$$

where $(0, \pi_0)$ is the centre of the circle and the radius is given by $\sqrt{L}$.[iv]

Chart 3: Interest rate policy in the case of shocks affecting the demand side

Chart 3 illustrates the interest rate reaction of the central bank in the presence of a negative shock affecting the demand side of the economy. From equation (18) we can see that such shocks have their origin either in the behaviour of domestic actors such as the government or consumers ($\varepsilon_1 < 0$), or in the international environment in the form of a change in the foreign real interest rate ($r^* < 0$) or the risk premium ($\alpha < 0$). The latter group of shocks affects domestic demand via the real exchange rate. In the case of a negative shock the IS-curve shifts to the left, resulting in a negative output gap (y_1) and a decrease of the inflation rate (π_1). As a consequence, the central bank lowers the real interest rate from r_0 to r_1 so that the output gap disappears, and hence, the deviation of the inflation rate from its target.

Chart 4: Interest rate policy in the case of a supply shock

For the case of a supply shock Chart 4 shows that the central bank is confronted with a trade-off between output and inflation stabilisation. A positive supply shock ($\varepsilon_2 > 0$) shifts the Phillips curve upwards. If there is no monetary policy reaction (the real interest rate remains at r_0), the output gap is unaffected, but the inflation rate rises to π_1 (point B). If, on the other hand, the central bank tightens monetary policy by raising the real interest rate to r_1, the output gap

becomes negative, and the inflation rate falls back to its target level π_0 (point A). The optimum combination of y and π depends on the preferences λ of the central bank. If π and y are equally weighted in the loss function, the iso-loss locus is a circle, and PC_1 touches the circle at (π_2, y_2). In any case there is a social cost represented by the positive radius of the iso-loss circle.

3.2.2 Simple interest rate rules under flexible exchange rates

Instead of relying on all available information, a central bank can also restrict its information to a small sub-set of directly observable variables. At the very heart of simple interest rate rules lies the notion that they are not derived from an optimisation problem. Instead, the coefficients are chosen ad hoc, based on the experiences and skills of the monetary policymakers.[v] The most prominent version of a simple rule is the Taylor (1993) rule. According to this rule the actual real interest rate is defined as the sum of the equilibrium real interest rate (r_0) and two additional factors accounting for the actual economic situation that is assumed to be observable by movements in the inflation rate and in the output gap:

(20) $$r = r_0 + e(\pi - \pi_0) + f\,y \text{ with } e, f > 0.$$

In our graphical analysis the Taylor rule can be represented by an upward-sloping monetary policy (MP) line in the $y - r$ space (see Chart 5). While variations of the output gap lead to changes in the real interest rate, which constitute movements along the MP line, the inflation rate represents a shift parameter.

The IS-curve is derived in the same way as in Section 3.2:

(21) $$y = a - (b + c)r + c(r^* + \alpha) + \varepsilon_1.$$

In contrast to the previous section, under simple interest rate rules an explicit construction of an aggregate demand (AD) curve in the $y-\pi$ space is required, which depends on the simple interest rate rule that is implemented by the central bank. Algebraically, the AD-curve can be easily derived by inserting the Taylor rule (20) into the IS-curve (21), by replacing r_0 with $a/(b+c)$, and by solving the resulting equation for π:

$$\pi = \pi_0 - \frac{1+(b+c)f}{(b+c)e} y + \frac{c(r^* + \alpha) + \varepsilon_1}{(b+c)e}. \tag{22}$$

Chart 5: Simple instrument rules and the aggregate demand curve

Graphically, it can be constructed in the same spirit as the aggregate demand curve in the AS-AD model. We start with an MP line for an inflation rate equal to π_0 and an output gap of zero (see Chart 5). This combination of output and inflation gives point A in the lower panel. Then we derive a MP line for an inflation rate $\pi_1 > \pi_0$. According to the Taylor principle (Taylor, 1999) which states that real interest rates should be raised in response to an increase in the inflation rate, this line is associated with higher real interest rates than MP(π_0). Hence, the new equilibrium is characterised by a negative output gap y_1. The combination of y_1 and π_1 gives the Point B in the lower panel. Connecting Point A with Point B results in a downward-sloping aggregate demand curve AD_0.

Because of the downward-sloping AD-curve the graphical analysis of shocks under a Taylor rule is more complex than under optimal monetary policy. If the economy is hit by a negative demand shock the IS-curve in the upper panel of Chart 6 shifts leftwards. In response to the

decrease of the output gap from 0 to y' the central bank lowers real interest rates – by moving along the MP(π_0)-line – from r_0 to r', which leads to the output gap y'. In the lower panel the aggregate demand curve has to shift. Its new locus is determined by the fact that it has to go through a point (A), which is defined by the new output gap (y') and the (so far) unchanged inflation rate π_0. The new equilibrium is reached by the intersection of the shifted aggregate demand curve with the unchanged Phillips-curve in point (B). It is characterized by an output decline to y_1 (which is less than y') and an inflation rate π_1. The decline of the output gap from y' to y_1 and the inflation rate to π_1 (instead of π') is due to fact that the central bank additionally reduces the real interest rate, because the Taylor rule requires a lower real rate as a consequence of the decline in the inflation rate.

Chart 6: Simple rules and shocks affecting the demand side

In the upper panel this is reflected by a shift of the MP line to the right, which intersects with the IS_1 line at the same output level that results from the intersection of the AD_1 line with the Phillips curve in the lower panel. This may sound somewhat difficult but the mechanics of the shifts are completely identical with the shifts in the IS-LM-AS-AD model in the case of the same shock. Although in our model the decline in inflation implies an expansionary monetary impulse because it lowers the real interest rate, in the IS-LM-AS-AD model the decrease in the price level increases the real money stock, which also has an expansionary effect since it lowers the nominal interest rate.

For a graphical discussion of a supply shock we only need to consider the $y - \pi$ space (see Chart 7). The Phillips curve is shifted upwards which increases the inflation rate to π'. In this case the

Taylor rule requires a higher real interest rate, which leads to a negative output gap y_1. The reduced economic activity finally dampens the increase of the inflation rate to π_1.

Chart 7: Simple rules and supply shocks

3.3 Monetary policy under flexible exchange rates that behave like a random walk

One of the main empirical findings on the determinants of exchange rates is that in a system of flexible exchange rates no macroeconomic variable is able to explain exchange rate movements (especially in the short and medium-run which is the only relevant time horizon for monetary policy) and that a simple random walk out-performs the predictions of the existing models of exchange rate determination (Meese and Rogoff, 1983). In a very simple way such random walk behaviour can be described by

(23) $$q = \overline{q} + \eta$$

where η is a random white noise variable. Inserting equation (23) into (13) yields the following optimum interest rate:

(24) $$r^{opt} = \frac{a}{b} + \frac{1}{b}\varepsilon_1 + \frac{d}{b\left(d^2 + \lambda\right)}\varepsilon_2 + \frac{c}{b}\eta .$$

Random exchange rate movements constitute an additional shock to which the central bank has to respond with its interest rate policy. At first sight, even under this scenario monetary policy autonomy is still preserved. However, there are limitations, which depend on

- the size and the persistence of such shocks, and
- the impact of real exchange rate changes on aggregate demand, which is determined by the coefficient *c* in equation (1).

Empirical evidence shows that the variance of real exchange rates exceeds the variance of underlying economic variables such as money and output by far. This so-called "excess volatility puzzle" of the exchange rate is excellently documented in the studies of Baxter and Stockman (1989) and Flood and Rose (1995). Based on these results we assume that $Var[\eta] \gg Var[\varepsilon_1]$. Thus if a central bank would try to compensate the demand shocks created by changes in the real exchange rate, it could generate highly unstable real interest rates. While this causes no problems in our purely macroeconomic framework, there is no doubt that most central banks try to avoid an excessive instability of short-term interest rates ("interest rate smoothing") in order to maintain sound conditions in domestic financial markets.[vi] If this has the consequence that the central bank does not sufficiently react to a real exchange rate shock, the economy is confronted with a sub-optimal outcome for the final targets y and π.

For the graphical solution the IS-curve is simply derived by inserting equation (23) into (1) which eliminates q:

(25) $$y = a - b\,r + c\eta + \varepsilon_1 .$$

Exchange rate shocks η lead to a shift of the IS-curve, similar to what happens in the case of a demand shock. In Chart 8 we introduced a smoothing band that limits the room of manoeuvre of the central bank's interest rate policy. In order to avoid undue fluctuations of the interest rate, the central bank refrains from a full and optimal interest rate reaction in response to a random real appreciation ($\eta < 0$) that shifts the IS-curve to the left. As a result, the shock is only partially compensated so that the output gap and the inflation rate remain below their target levels.

Chart 8: Interest rate smoothing and exchange rates that behave like a random walk

4 Monetary policy under fixed exchange rates

With fixed exchange rates a central bank completely loses its leeway for a domestically oriented interest rate policy. In order to avoid destabilising short-term capital inflows or outflows, the central bank has to follow UIP in a very strict way. If the fixed rate system is credible, $\Delta s = 0$ and the UIP condition simplifies to:

(26) $$i = i^* + \alpha .$$

Inserting equation (26) into (8) shows how the real interest rate is determined under fixed exchange rates:

(27) $$r = i^* + \alpha - \pi .$$

4.1 Fixed exchange rates as a destabilising policy rule

As the real interest rate is only determined by foreign variables and as it depends negatively on the domestic inflation rate, the central bank can no longer pursue an autonomous real interest rate policy. In principle, this interest rate rule can be interpreted as a special case of a simple interest rate rule. Equation (27) can easily be transformed into

(28) $$r = \left(i^* + \alpha - \pi_0\right) + \left(-1\right)\left(\pi - \pi_0\right) + 0 \cdot y ,$$

that is, a specific simple rule with $e = -1$ and $f = 0$ (see equation (20) for a general definition of simple rules). It is interesting to see that under fixed exchange rates real interest rates have to fall when the domestic inflation rate rises. Thus, monetary policy becomes more expansive in situations of accelerating price increases which questions the stabilizing properties of fixed exchange rates in times of shocks.

This can also be shown with our graphical analysis. Since the real rate is not affected by the domestic output gap, the monetary-policy line (MP) enters the $y-r$ space as a horizontal line. The IS-curve is given by:

$$y = a - (b+c)r + c(r^* + \alpha) + \varepsilon_1, \tag{29}$$

which is equal to the IS curve under flexible exchange rates. The corresponding interest-rate-rule-dependent AD-curve in the $y-\pi$ space is derived in a similar way as in the case of simple interest rate rules. By inserting the interest rate rule (27) in equation (29) we get:

$$\pi = \pi^* + \frac{1}{b+c}\left[y - a + b(r^* + \alpha) - \varepsilon_1\right]. \tag{30}$$

This implies that the AD-curve has a positive slope. Compared with the negative slope of the AD-curve under a Taylor rule (see Section 3.2.2), the positive slope reveals again the destabilising property of the "interest rate rule" generated by fixed exchange rates. For the graphical analysis it is important to see that

- the slopes of the IS-curve and the AD-curve have the same absolute value, but the opposite sign;
- the slope of the AD-curve $1/(b+c)$ is greater than one as $0 < (b+c) < 1$. Thus, the AD-curve is steeper than the Phillips curve whose slope is d and which is assumed to be positive and smaller than one.

4.2 The impact of demand and supply shocks

In Chart 9 we use this framework to discuss the consequences of a negative shock that affects the demand side of the domestic economy (ε_1, r^*, α). The result is a shift of the IS-curve to the left.

Without repercussions on the real interest rate the output gap would fall to y' and the inflation rate to π'. However, in a system of fixed exchange rates the initial fall in π increases the domestic real interest rates since the nominal interest rate is kept unchanged on the level of the foreign nominal interest rate. Thus, in a first step, we use the new output gap (y') and an unchanged inflation rate (π_0) to construct the new location of the AD-curve in the $y-\pi$ space. It also shifts to the left to AD_1.[vii] This finally leads to the new equilibrium combination (y_1, π_1), which is the intersection between the Phillips curve and the new AD-curve. This equilibrium goes along with a rise of the real interest rate from r_0 to r_1, which is equal to the fall of the inflation rate from π_0 to π_1. It is obvious from Chart 9 that the monetary policy reaction in a system of fixed exchange rates is destabilising since $\pi_1 < \pi'$ and $y_1 < y'$.

Chart 9: Fixed exchange rates and shocks affecting the demand side

In Chart 10 we discuss the effects of a supply shock. Initially, the shock shifts the Phillips curve upwards, which leads to a higher inflation rate (π') with an unchanged output gap. Since the rise in inflation lowers the real interest rate, a positive output gap emerges which leads to a further rise of π. The final equilibrium is the combination (y_1, π_1). Again, one can see that the "policy rule" of fixed exchange rates has a destabilising effect as it increases the effects of the shock compared to a situation in which there would have been no monetary policy reaction ($0, \pi'$).

Chart 10: Fixed exchange rates and supply shocks

Chart 11 shows that this combination is also sub-optimal compared with the outcome a central bank chooses under optimal policy behaviour in a system of flexible exchange rates (see Chart

4). Assuming again that the central bank equally weights π and y in its loss function, the dotted circle (y^{flex}, π^{flex}) depicts the loss under flexible exchange rates. If the central bank had followed a policy of constant real interest rates (that is absence of any policy reaction) the dashed circle would have been realised with ($0, \pi'$). Under fixed exchange rates, however, the iso-loss circle expands significantly, and the final outcome in terms of the central bank's target variables is (y_1, π_1).

Chart 11: Loss under different strategies in an open economy

4.3 Fixed rates can also be stabilising

From this analysis one would be tempted to draw the conclusion that a system of fixed exchange rates always performs poorly. However, this result is difficult to reconcile with the empirical fact that for example countries like the Netherlands and Austria could follow a very successful macroeconomic policy under almost absolutely fixed exchange rates in the 1980s and 1990s.

An explanation for this observation is that our analysis leaves it open how the foreign real interest rate is determined. A stabilising movement of the domestic real interest rate can be generated if the foreign central bank is confronted with and reacts to the same demand shocks as the domestic economy. This was certainly the case in the Netherlands and Austria, which pegged their currency to the D-Mark until 1998. The economies in both countries are very similar to the German economy. Thus, in the literature on optimum currency areas the correlation of real shocks plays a very important role (see e.g. Bayoumi and Eichengreen, 1992).

5 Summary and comparison with the results of the Mundell-Fleming model

For many central banks open economy considerations are of major importance for the conduct of monetary policy. Above all the choice between absolutely fixed exchange rates (like unilateral pegs or monetary unions) and perfectly flexible exchange rates is still a matter of debate. Today the workhorse open economy model in intermediate textbooks is the Mundell-Fleming (MF) model, even though our understanding of monetary policy has shifted away in recent years from money supply rules and fixed-price models to interest rate rules and inflation targeting. This paper presents an open economy model that ties in with the tradition of modern New Keynesian (NK) macro models. It provides students taking an intermediate-level macroeconomics course with a tool that allows a simple analytical and graphical analysis of monetary policy aspects under both, fixed and flexible exchange rates.

For a summary of the open-economy version of the NK macro model it seems useful to compare it with the main policy implications of the MF model. Under fixed exchange rates the MF model comes to the conclusion that

- monetary policy is completely ineffective, while
- fiscal policy is more effective than in a closed-economy setting.

The NK model shows that monetary policy is not only ineffective but rather has a destabilising effect on the domestic economy. Compared with the MF model the sources of demand shocks can be made more explicit (above all the foreign real interest rate and the risk premium) and it is also possible to analyse the effects of supply shocks. As far as the effects of fiscal policy are concerned the NK model also comes to the conclusion that it is an effective policy tool, and that it is more effective than in a closed economy. A restrictive fiscal policy has similar effects as a

negative demand shock so that we can use the results of Chart 9. It is obvious that the initial effect on the output gap is magnified by the destabilising nature of the fixed exchange rate rule.

Under flexible exchange rates the MF models provides two main results:

- monetary policy is more effective than in a closed-economy setting, while
- fiscal policy becomes completely ineffective.

It is important to note that the MF model implicitly assumes that PPP is violated as it assumes absolutely fixed prices. As far as UIP is concerned, the MF model makes the same assumption as the baseline NK model: An increase in domestic interest rates is associated with an appreciation of the domestic currency. For the three versions of flexible exchange rates the NK models comes to results that are partly compatible and partly incompatible with the MF model.

For a world where PPP and UIP (long-run perspective) simultaneously hold the NK model produces the contradictory result that there is no monetary policy autonomy with regard to the real interest rate. Thus, the central bank is unable to cope with demand shocks. However, because of its control over the nominal interest rate it can target the inflation rate and thus react to supply shocks. For fiscal policy the NK model also differs from the MF model. As it assumes an exogenously determined real interest rate, i.e. a horizontal monetary policy line, fiscal policy has the same effects as in a closed economy. By shifting the IS-curve it can perfectly control the output-gap and indirectly also the inflation rate.

Under a short-run perspective (UIP holds, PPP does not hold) the results of the NK model are identical with regard to monetary policy. The central bank can control aggregate demand and the inflation rate by the real interest rate. Fiscal policy is again effective and if one assumes that the

central bank does not react to actions of fiscal policy (constant real rate) it is as effective as in a closed economy.

In the third scenario for flexible exchange rates (random walk) the results of the NK model are in principle identical with those of the short-term perspective. However, the ability of monetary policy to react to exchange rate shocks can be limited by the need to follow a policy of interest rate smoothing. Thus, there can be clear limits to the promise of monetary policy autonomy made by the MF model. Again fiscal policy remains fully effective.

In sum, the NK model shows that for flexible exchange rates a much more differentiated approach is needed than under the MF model. Above all, the results of the MF model concerning fiscal policy are no longer valid if monetary policy is conducted in the form of interest rate rule instead of a monetary targeting rule on which the MF model is based. In the NK model fiscal policy remains a powerful policy tool in all three version of flexible exchange rates, provided that the central bank does not instantaneously off-set the fiscal impulse.

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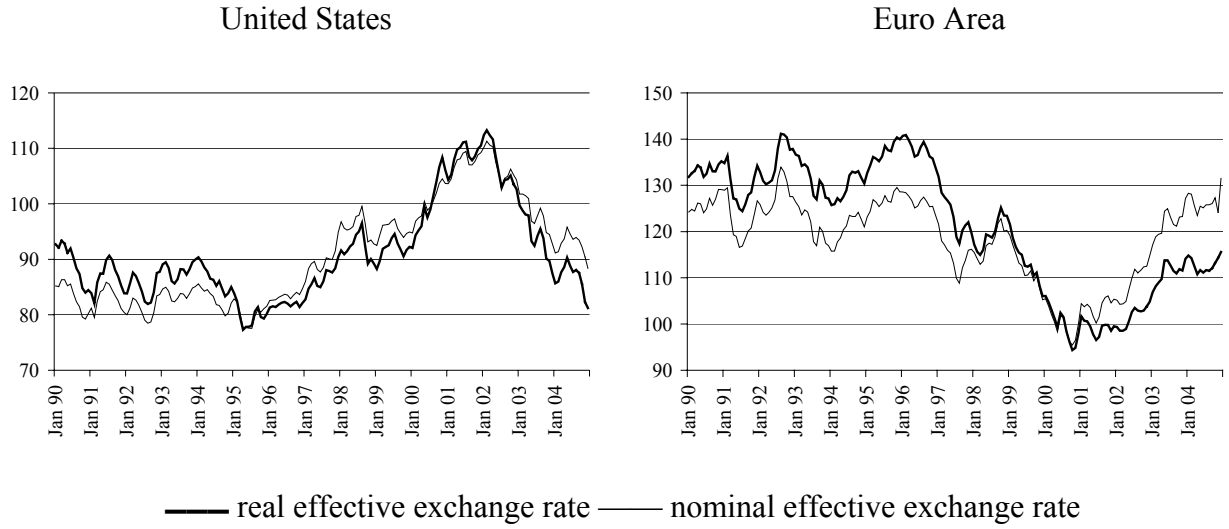
Chart 1: Nominal and real exchange rate



Source: IMF

Chart 2: The dynamics of the real exchange rate after an increase of the domestic real interest rate

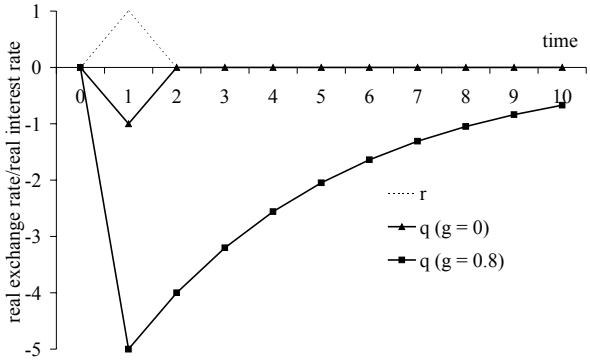


Chart 3: Interest rate policy in the case of shocks affecting the demand side

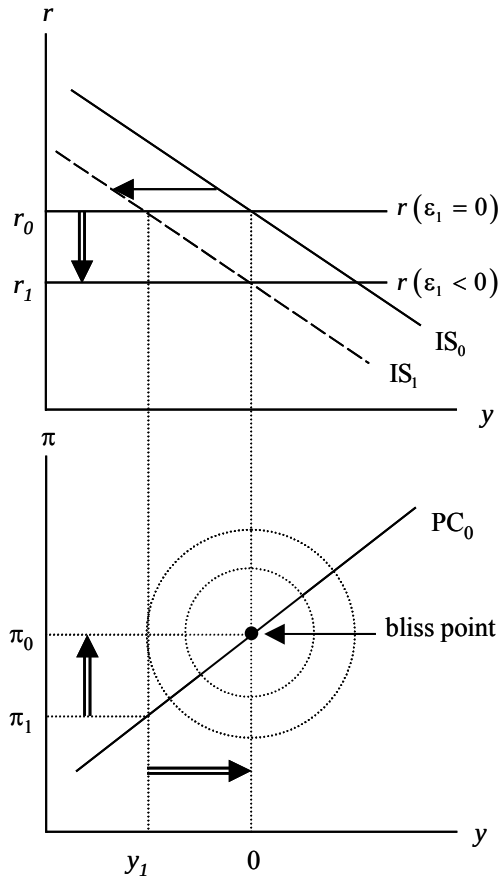


Chart 4: Interest rate policy in the case of a supply shock

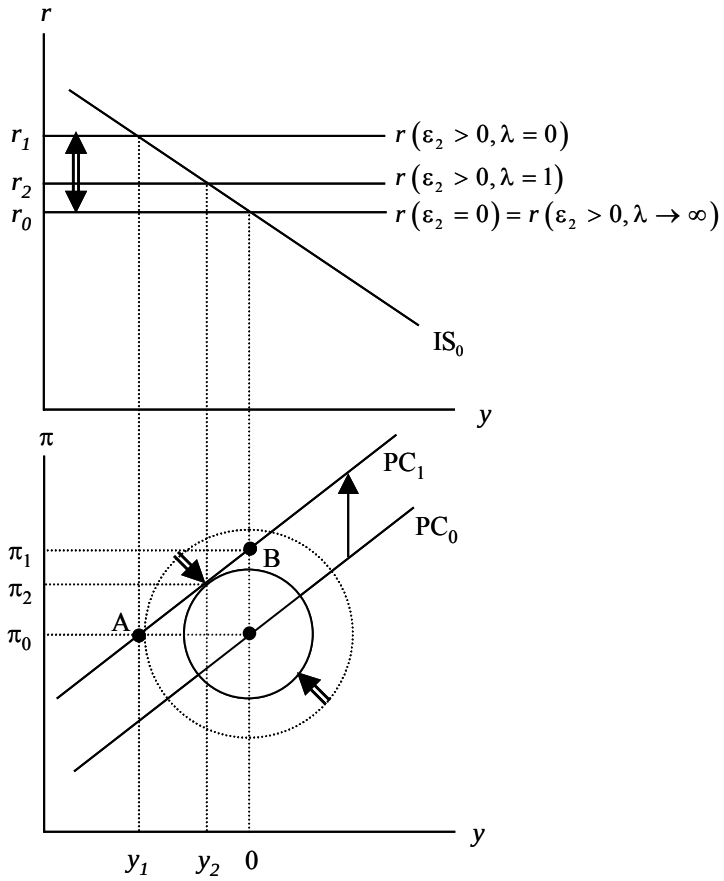


Chart 5: Simple instrument rules and the aggregate demand curve

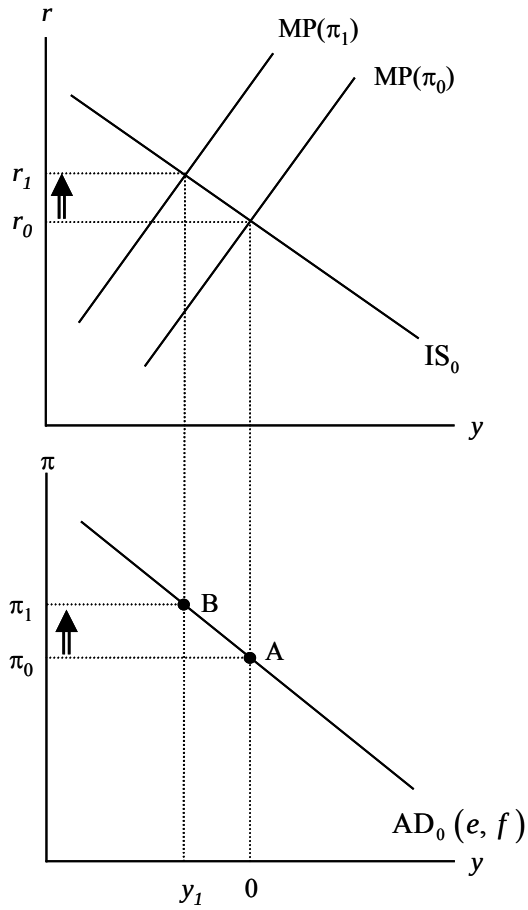


Chart 6: Simple rules and shocks affecting the demand side

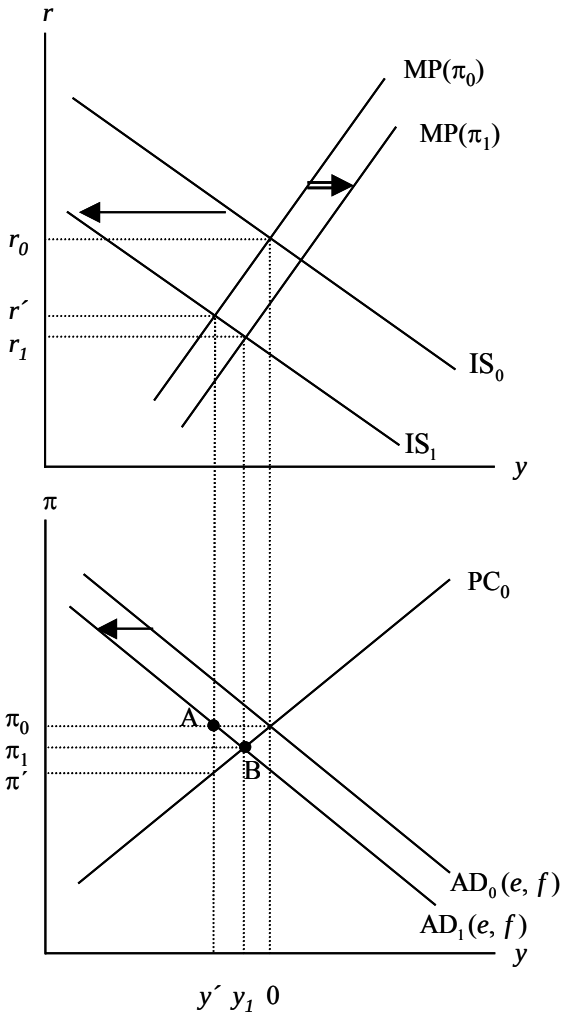


Chart 7: Simple rules and supply shocks

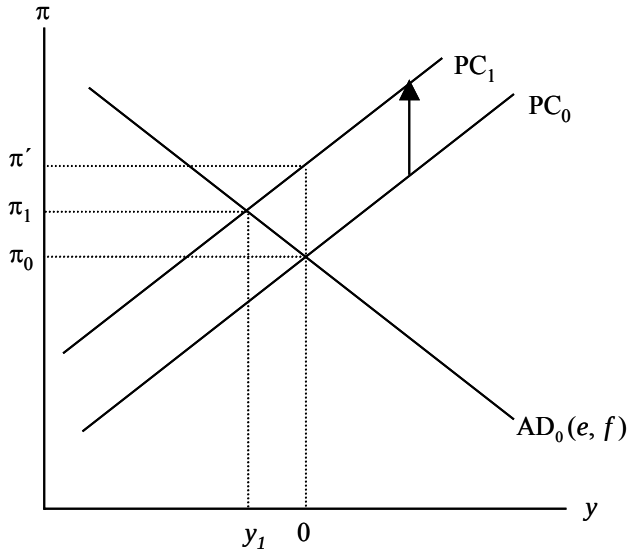


Chart 8: Interest rate smoothing and exchange rates that behave like a random walk

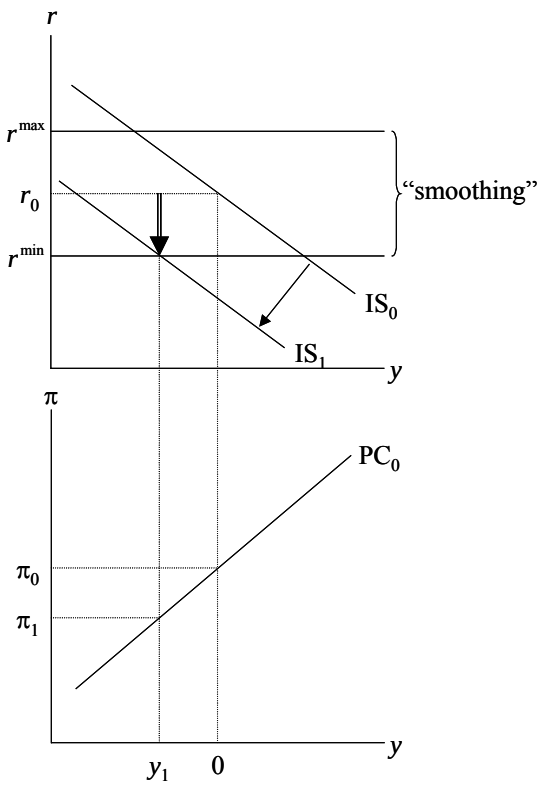


Chart 9: Fixed exchange rates and shocks affecting the demand side

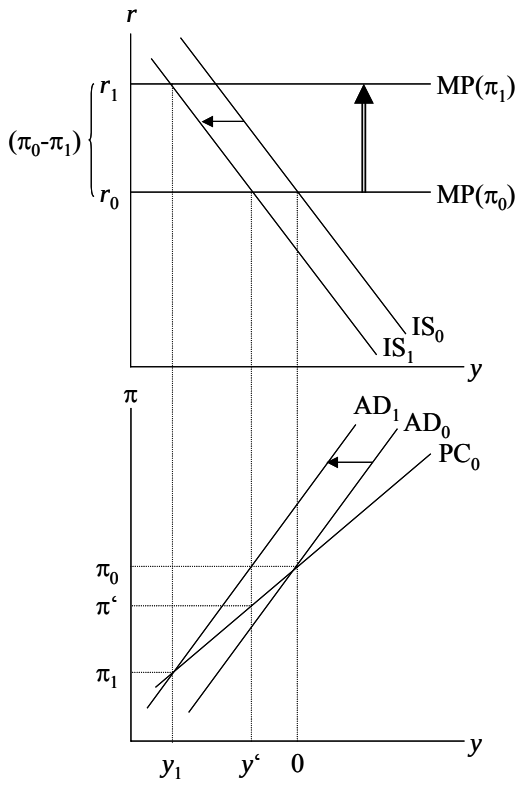


Chart 10: Fixed exchange rates and supply shocks

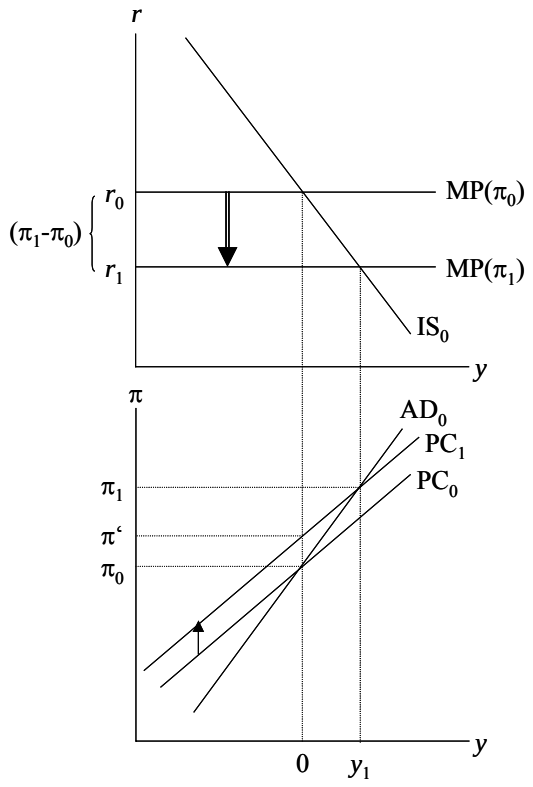
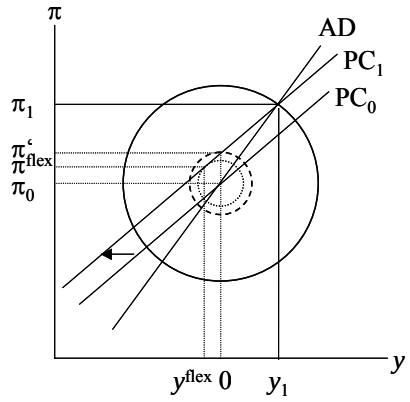


Chart 11: Loss under different strategies in an open economy



[i] Following standard conventions, an increase in q is a real depreciation of the domestic currency.

[ii] For a microfounded derivation of the standard loss function see Woodford (2003, ch. 6).

[iii] The speed of adjustment can be expressed in terms of periods for a deviation of the real exchange rate from its long-run level to decay by 50 percent: $g / (1-g)$.

[iv] For $\lambda \neq 1$, the geometric form of the loss function is an ellipse.

[v] Note that there is also an enormous literature on optimal simple rules that derives the coefficients of the simple rule by minimizing the central bank's loss function (see Rudebusch and Svensson, 1999). Although such an approach would also be feasible within our model, we think that optimal simple rules are too complicated to be taught in intermediate macro courses.

[vi] However, most models, as the one presented here, fail to integrate the variance of interest rate changes and its consequences into a macroeconomic context.

[vii] In fact, the described shift of the AD-curve is only true in the case of ε_1-shocks which affect the AD-curve and the IS-curve by exactly the same extent (see equations (29) and (30)). If, however, the economy is hit by a α-shock or a r^*-shock, the AD-curve shifts by a larger amount than the IS-curve as b is typically greater than c.

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