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Optimum Currency Areas Under Inflation Targeting

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Abstract

Several countries face the choice between targeting inflation independently and entering a monetary union that targets inflation. The present paper extends the theory of optimum currency areas to deal with this choice. In contrast to the conventional theory, countries might form more of an optimum currency area the more asymmetric supply shocks are.

By studying the stabilization properties of independent inflation targeting in contrast to inflation targeting within a monetary union, this paper extends the theory of optimum currency areas (OCA). Initiated by Mundell (1961), the theory has received increased attention in recent years, mainly because of the introduction of the Euro. In the literature, four relationships between the members of a potential OCA are highlighted:[1] 1) the similarity of shocks; 2) the extent of trade between the potential members; 3) the degree of labor mobility; and 4) the system of fiscal transfers. As regards the similarity of shocks, Mundell (1961) focused on demand shocks in his pioneering contribution. Asymmetric demand shocks were shown to weaken the case for a monetary union. In much of the subsequent literature on OCA, asymmetric shocks of *any* type have been taken as arguments against a monetary union. For instance, when discussing whether Europe is an optimum currency area, Bayoumi and Eichengreen (1993, p. 223) conclude that "...our finding that supply shocks are larger in magnitude and less correlated across regions in Europe than in the United States underscores the possibility that the European Community may find it more difficult, initially, to operate a monetary union than the United States."

In this paper, we show that when the choice is between targeting inflation independently and doing so within a monetary union, the presence of asymmetric supply shocks might in fact be an argument in favor of a union. As regards asymmetric demand shocks, it is the case also under inflation targeting that this is an argument against introducing a common currency.

Among industrialized countries, explicit or implicit inflation targeting has become the principal guideline for monetary policy. This has lead to an increasing literature on various aspects of inflation targeting. Although most of the earlier theoretical literature on inflation targeting was limited to studying closed economies, increased attention is now being given to inflation targeting in open economies. Among the contributors are Rødseth (1996), Ball (1998), Batini and Haldane (1998), Svensson (2000), Galí and Monacelli (2000), and Clarida, Galí, and Gertler (2001). Berger, Jensen, and Schelderup (2001) discuss the flexibility loss for a small open economy by pegging the exchange rate. Leitemo and Røisland (2003) compare inflation targeting and exchange rate targeting within an estimated model with a traded and a non-traded sector. Only a few papers consider inflation targeting within a multi-country framework. Persson and Tabellini (1996) consider Stage III of the EMU within a two-country framework with focus on the relationship between the "ins" and the "outs." However, they do not consider entering a monetary union that targets inflation as an alternative to independent inflation targeting. In our view, this is the most relevant alternative to independent inflation targeting for many countries.[2] Furthermore, Persson and Tabellini consider only supply shocks, while we distinguish between supply and demand shocks. This distinction will be shown to be of crucial importance for the differences in the stabilisation properties of various regimes. Canzoneri, Nolan, and Yates (1997) compare inflation targeting with the ERM in a two-country model, in which one of the countries ("Germany") has low inflation and an optimal degree of stabilization and the other country ("Great Britain") lacks the credibility to implement the optimal monetary policy rule. Their focus is on credibility rather than stabilization.

Although not considering inflation targeting, another paper related to ours is Lane (2000), who considers the stabilization properties of a currency union versus alternative exchange rate regimes. Lane assumes that the Central Bank minimises a general loss function, and that welfare in alternative regimes is compared using the same loss function as that minimised by the Central Bank. In contrast to Lane we start out by following the approach of Persson and Tabellini (1996), Frankel and Chinn (1995), and others by assuming that the Central Bank must commit to a monetary policy target for credibility reasons. Moreover, the central issue in our paper is to derive implications with respect to optimum currency areas. By starting out studying strict inflation targeting the intuition behind our new results becomes clear. We then extend the approach to flexible inflation targeting, and show under which conditions the conclusions from the strict inflation targeting case also holds under this type of regime. The distinction between strict and flexible inflation targeting may be interpreted institutionally as the distinction between a hierarchical mandate for monetary policy where price stability is the primary objective, and a dual mandate where price and output stability are put on an equal footing. Laurence Meyer (2001), member of the Board of Governors of the US Federal Reserve System, argues that Central Banks with hierarchical mandates conduct inflation targeting in a stricter way and thereby accept higher output volatility than Central Banks with dual mandates. Cecchetti and Ehrmann (1999) provide some empirical support for this view.

The paper is organized as follows: In Section 1 we set up the model. The alternative regimes under strict inflation targeting are discussed in Section 2, as are some new international transmission channels introduced by inflation targeting. Section 3 is devoted to the implications with respect to optimum currency areas. In Section 4 we extend our approach to allow for flexible inflation targeting. We show that the conclusions from the strict inflation targeting case might also hold under this type of regime, provided that the weight on output stabilization relative to inflation stabilization is sufficiently small. Section 5 concludes.

1. The model

In order to facilitate comparison with the OCA literature, we apply the standard assumption of two countries of the same size. Each country has specialised in producing a single good which is different between the two countries. The countries are termed the home country (H) and the foreign country (F). Our model is a modified version of the two-country models formulated in Canzoneri and Henderson (1988, 1991), Persson and Tabellini (1995) and Lane (1996, 2000) and, except for the multi-country framework, it is similar to that of Rødseth (1996). We assume that the choice of monetary policy regime has no long-run real effects on the economy. All real variables are then measured as deviations from an exogenously given steady state equilibrium with a given natural rate of unemployment. In order to obtain a simple linear structure, we model these deviations in logs (except the interest rate), as in Bean (1983), Genberg (1989) and Lane (1996, 2000). Shocks are assumed to have an expectation of zero and to be independent between periods, and there are no other lags in the model. The rational expectations value of any next period real variable is thus zero, since agents expect the economy to be in a steady state in the next period.

The short run supply function for country i is given by

$$y^H = \lambda(p^H - w^H) + u^{H*} \tag{1.1}$$

$$y^F = \lambda(p^F - w^F) + u^{F*} \tag{1.2}$$

where y^i is the output gap in country $i = H, F$, p^i is the log of the price of country i's good in country i's currency, w^i is the log of the wage level in country i, and u^{i*} is a supply shock to country i. The producer real wage, $-(p^i - w^i)$, is measured as a deviation from the steady state equilibrium producer real wage.

Equations (1.1) and (1.2) may be derived from a standard profit maximisation problem. Note that we can write $w^i = Ew^i + \varepsilon^i$, where $\varepsilon^i = w^i - Ew^i$ and Ew^i

denotes the expected wage. Wage setters are assumed to set wages one period in advance based on expected consumer prices, so that $Ew = Ep_c$, where p_c is the consumption price index. The supply functions may then be written as

$$y^H = \lambda(p^H - Ep_c^H) + u^H \tag{1.1'}$$
$$y^F = \lambda(p^F - Ep_c^F) + u^F \tag{1.2'}$$

where $u^i = u^{i*} - \lambda\varepsilon^i$. The supply function can thus be expressed as standard expectations-augmented Phillips curves.

The real exchange rate is defined by

$$e = p^F + s - p^H \tag{1.3}$$

where s is the nominal exchange rate. As for other real variables, the equilibrium real exchange rate is assumed to be unaffected by monetary policy, and it is measured as a deviation from its exogenously given equilibrium level.

The foreign exchange market is represented by uncovered interest rate parity (UIP) adjusted for a stochastic risk premium shock z, i.e.,

$$i^H = i^F + Es - s + z \tag{1.4}$$

where i^H and i^F are the home and foreign nominal interest rate respectively and Es is the expected exchange rate next period.

The consumer price indices (CPIs) of the home country, p_C^H, and the foreign country, p_C^F, are weighted averages of the prices of both goods. The share of imported goods in the price indices is given by β.

$$p_C^H = \beta(p^F + s) + (1 - \beta)p^H = p^H + \beta e \tag{1.5}$$
$$p_C^F = \beta(p^H - s) + (1 - \beta)p^F = p^F - \beta e \tag{1.6}$$

If $\beta = 1/2$ the shares of the two goods are the same in both countries, so that the share of home country goods in the foreign price index is the same as in the home country price index, and vice versa. However, we shall only consider the realistic case of $0 < \beta < 1/2$, so that the share of home goods is higher in the home country price index than in the foreign country price index, and the share of foreign goods is higher in the foreign country price index than in the home country price index. Indeed, if this were not the case, the price index in the two countries would be the same. With independent inflation targeting, monetary policy would then also be the same. But then there would be no difference between targeting inflation independently and in a union. Since we know that, for instance, the share of British goods in the CPI of Great Britain is larger than the share of British goods in the CPI of France, it is reasonable to assume that $\beta < 1/2$.

Since the two countries are of equal size, the CPI of the union is given by

$$p_C^U = \frac{1}{2}p_C^H + \frac{1}{2}p_C^F = \frac{1}{2}p^H + \frac{1}{2}p^F \tag{1.7}$$

Aggregate demand in the two countries is given by

$$y^H = -\alpha_1 r^H + \alpha_2 e + v^H \tag{1.8}$$

$$y^F = -\alpha_1 r^F - \alpha_2 e + v^F \tag{1.9}$$

where

$$r^i = i^i - (Ep^i - p^i) \tag{1.10}$$

is the real interest rate in country $i = H, F$.

With both intra-period and inter-period substitution, demand for home goods depends on the steady state income (which in our setting is exogenous and normalised to zero), the real interest rate, and the real exchange rate. α_1 and α_2 are positive constants, so that demand for home goods decreases with the real interest rate and increases with the real exchange rate. The home goods and foreign goods demand shocks are denoted v^H and v^F, respectively.

2. Alternative regimes

The model is closed by specifying the monetary policy regime. As mentioned in the introduction, we shall focus on what seem to be the most relevant alternatives for many countries today; independent inflation targeting or monetary union inflation targeting.

Since the main rationale for adopting explicit inflation targets is to enhance credibility of monetary policy, one may argue that, at least in a transition period until credibility is fully obtained, monetary policy must give higher priority to achieving the inflation target than is the case with a discretionary policy. In this section follow the approach used by Persson and Tabellini (1996) and Frankel and Chinn (1995) in considering strict specifications of the regimes. The Central Bank sets the interest rate in order to achieve the inflation target. Although we denote the regime as strict inflation targeting, it should be noted that the regime does *not* necessarily correspond to what King (1997) calls an "inflation nutter." Since the dynamics of the monetary policy transmission mechanism is not modelled, one should interpret the inflation targeting regime such that the Central Bank targets inflation at a horizon where most of the intermediate dynamics has taken place. An "inflation nutter" would, however, target inflation at the shortest possible horizon, for example, by extensive use of the exchange rate channel. In Section 4, we consider a more flexible version of inflation targeting. As discussed in the introduction, the distinction could be interpreted as the distinction between a hierarchical mandate and a dual mandate for monetary policy.

2.1. Independent inflation targeting

When the home and foreign countries do not form a union, the two countries target inflation independently. For the sake of simplicity, we normalize the price index such that the log of the price level in the previous period is zero. The regime of independent inflation targeting, where the home country and the union target their respective CPIs, can thus be specified as follows:

$$p_C^H = p^H + \beta(p^F + s - p^H) = 0 \tag{2.1}$$
$$p_C^F = p^F - \beta(p^F + s - p^H) = 0. \tag{2.2}$$

Equilibrating supply and demand for the home and the foreign goods, respectively, and inserting from (2.1) and for the real exchange rate from Equation (1.3), yields

$$\lambda p^H + u^H = -\alpha_1(i^H + p^H) + \alpha_2(p^F + s - p^H) + v^H \tag{2.3}$$
$$\lambda p^F + u^F = -\alpha_1(i^F + p^F) - \alpha_2(p^F + s - p^H) + v^F. \tag{2.4}$$

Equations (1.4) and (2.1)–(2.4) determine i^H, i^F, p^H, p^F and s as functions of u^H, u^F, v^H, v^F and z. Since the countries are symmetric, we present only the solutions for the home country, which are

$$p^H = \frac{\beta}{2\beta\lambda + \alpha_1 + 2\alpha_2}(v^H - v^F - u^H + u^F - \alpha_1 z) \tag{2.5}$$

$$\begin{aligned} i^H = {} & \frac{\beta\lambda + \alpha_1(1-\beta) + \alpha_2}{\alpha_1(2\beta\lambda + \alpha_1 + 2\alpha_2)}(v^H - u^H) \\ & + \frac{\beta(\lambda + \alpha_1) + \alpha_2}{\alpha_1(2\beta\lambda + \alpha_1 + 2\alpha_2)}(v^F - u^F + \alpha_1 z) \end{aligned} \tag{2.6}$$

$$s = \frac{(1-2\beta)(u^H - u^F - v^H + v^F + \alpha_1 z)}{2\beta\lambda + \alpha_1 + 2\alpha_2}. \tag{2.7}$$

Inserting (2.5) into the supply function (1.1′), and remembering that $Ep^H = 0$, yields the following solution for home output under independent inflation targeting:

$$y_I^H = \eta_I u^H + (1 - \eta_I)u^F + (1 - \eta_I)(v^H - v^F + \alpha_1 z) \tag{2.8}$$

where

$$\eta_I \equiv \frac{\beta\lambda + \alpha_1 + 2\alpha_2}{2\beta\lambda + \alpha_1 + 2\alpha_2}.$$

Home output is affected by a weighted average of home and foreign supply shocks, where the weight attached to home supply shocks is greater than the weight attached to foreign supply shocks. The intuition can be explained as follows: A positive home supply shock gives rise to lower prices on home goods. The Central Banks in both counties must respond by lowering their interest rates in order to achieve their inflation targets. Since the share of home goods in the home country's price index is higher than the share of home goods in the foreign country's price index, the interest rate reduction is larger in the home country than in the foreign country. Demand for home country goods is thus stimulated more strongly, both as a direct consequence of the larger interest rate reduction and because the home nominal (and real) exchange rates depreciate while those of the foreign country appreciate. The home supply shock thus has a stronger effect on home output than on foreign output. The more open the economy, measured by β, the lower the share of home goods in the home price index, and the higher the share of home goods in the foreign price index. Therefore, the more open the economy, the smaller the effect of a home supply shock on home output and the larger the effect on foreign output.

A positive demand shock to home goods gives rise to higher prices on home goods. The Central Banks in both counties must raise their interest rates in order to achieve the inflation target. Due to the larger increase in the home price index, the home Central Bank must raise the interest rate more than the foreign Central Bank. The interest rate increase and the resulting appreciation of the home currency dampens the output effect of the shock in the home country. But despite the tightening of monetary policy, output will increase in the home country. The reason is home country exchange rate appreciation. The appreciation leads to lower imported inflation, and the prices of home goods must therefore increase in order to prevent undershooting of the inflation target. A part of the demand shock must then result in higher prices and output in the home country.

In contrast to standard textbook models, such as Blanchard (1997), in this model, the more open the economy, the larger the output effect of a demand shock. The reason is that the more open the economy, the greater the weight of imported goods in the CPI. Thus, the more open the economy, the greater the dampening effect on CPI inflation of an exchange rate appreciation, and the interest rate response to achieve the inflation target may consequently be smaller.

Note that a positive demand shock in the foreign country has a negative effect on home output. This is contrary to traditional multi-country models (see Cooper, 1985), where positive foreign demand shocks lead to higher home output. The reason for the opposite result is the monetary policy response under inflation targeting. A positive demand shock in the foreign country leads to an exchange rate appreciation for the foreign country and thereby depreciation for the home country. In order to offset higher imported inflation due to the depreciation and the higher foreign prices, prices on home goods must be brought down by a tight monetary policy.

2.2. Monetary union

In a monetary union, the home country and the foreign country have a common currency and monetary policy. The union now targets the CPI of the union. The monetary policy regime can thus be specified as

$$p_C^U = \frac{1}{2} p^H + \frac{1}{2} p^F = 0. \tag{2.9}$$

In addition, we have that $s = z = 0$, and the two interest rates i^H and i^F are replaced by a common interest rate i. Equations (2.3), (2.4), and (2.9) determine i, p^H and p^F. The solutions for the home country are:

$$p^H = \frac{1}{2(\lambda + \alpha_1 + 2\alpha_2)}(v^H - v^F - u^H + u^F) \tag{2.10}$$

$$i = \frac{1}{2\alpha_1}(v^H - u^H + v^F - u^F). \tag{2.11}$$

By inserting (2.10) into the supply function (1.1′) we can write output in the home country under monetary union, y_U^H, as

$$y_U^H = \eta_U u^H + (1 - \eta_U)u^F + (1 - \eta_U)(v^H - v^F) \tag{2.12}$$

where

$$\eta_U = \frac{\lambda + 2(\alpha_1 + 2\alpha_2)}{2(\lambda + \alpha_1 + 2\alpha_2)}. \tag{2.13}$$

By comparing (2.8) and (2.12) we see that the difference between the solutions for output under independent inflation targeting and inflation targeting in a monetary union lies in the coefficients η_I and η_U. By inspection, we find that $\eta_I > \eta_U$. Thus, output is less affected by domestic supply shocks, but more affected by demand shocks and foreign supply shocks, in a monetary union.

In the case of a positive demand shock to home goods, the Central Bank in the monetary union must raise the interest rate such that lower prices on the foreign country's goods offset higher prices on the home country's goods. With a positive home supply shock under independent inflation targeting, however, the home Central Bank must raise the interest rate by more than the rise in the (common) interest rate in the monetary union, since home goods have a larger share in the home country's CPI. Likewise, the foreign country's Central Bank raises the interest rate by less than it would in a monetary union, since home goods have a smaller share than foreign goods in the foreign country's CPI. Thus, output in both the home country and the foreign country is sheltered from home demand shocks to a larger extent than is the case under monetary union.

When domestic supply shocks occur, output in the home country is less affected in a monetary union than under independent inflation targeting. The reason is that the monetary policy response to supply shocks exacerbates the effect of the supply shocks on output under inflation targeting. Under independent inflation targeting, the interest rate in the home country becomes lower than in the monetary union, and output is thus more destabilised. The decrease in the foreign country's interest rate is smaller under independent inflation targeting than in a monetary union, and output is thus more stabilized.

3. Optimum currency areas

In the previous section, we investigated the effects of different home and foreign shocks, and reasoned as if the different shocks were independent. We now abandon this assumption, and turn to the question of optimum currency areas with inflation targeting. When should the countries form a monetary union, and when should they pursue independent inflation targeting instead? In short, the conventional wisdom regarding shocks and optimum currency areas can be summarised by saying that the more asymmetric shocks countries face, the less of an optimum currency area they constitute. With inflation targeting, we will see that this conventional wisdom holds for demand shocks, but not for supply shocks.

Ideally, a welfare comparison of the alternative regimes should include all the welfare factors that they affect. While the tradition in the OCA literature is to focus on output stability, it has become standard in the monetary policy literature to represent welfare by a loss function which takes account of both output and inflation variability. In this section we stick to the OCA tradition in focusing solely on output variability, while we depart from the OCA tradition and measure welfare by a standard monetary policy loss function in Section 4.

We assume for the sake of simplicity that supply shocks, demand shocks, and risk premium shocks are uncorrelated. Denoting the standard deviations of home and foreign supply shocks as σ_H and σ_F, respectively, and the coefficient of correlation between the supply shocks in the two countries as ρ, the variance of output for a given monetary policy regime i is given by

$$\begin{aligned}\mathrm{var}\big(y_i^H\big) &= \eta_i^2\sigma_H^2 + (1-\eta_i)^2\sigma_F^2 + 2\eta_i(1-\eta_i)\,\sigma_H\sigma_F\rho \\ &\quad + (1-\eta_i)^2\mathrm{var}(v^H - v^F + \alpha_1 z),\end{aligned} \tag{3.1}$$

$i = H, F$. We have shown in the previous section that with demand shocks, independent inflation targeting provides better output stabilization for each country than monetary union does. In the following, we thus disregard the last term in Equation (3.1) and focus on supply shocks. To make the intuition of various effects clear, we will proceed in three steps. First, we assume that the variances of the supply shocks are equal in the two countries and that supply shocks in each country are independent. Second, we abandon the assumption that shocks are independent. Third, we also abandon the assumption that the standard deviation is the same in the two countries.

When the standard deviations in the two countries are equal and the shocks are uncorrelated, it can be seen from Equation (3.1) that a monetary union yields the lowest output variance if

$$\eta_U^2 + (1-\eta_U)^2 < \eta_I^2 + (1-\eta_I)^2 \Leftrightarrow \eta_U(1-\eta_U) > \eta_I(1-\eta_I) \tag{3.2}$$

Inserting Equations (2.10) and (2.15) into (3.2), this condition reduces to

$$(1-2\beta)2(\alpha_1+2\alpha_2) + (1-4\beta^2)\lambda > 0 \tag{3.3}$$

which is satisfied, since $\beta < 1/2$. Thus, with independent supply shocks and equal standard deviations, the stabilization properties of an extended union are better than they are with independent inflation targeting. The intuition for this result can best be illustrated by means of a numerical example. Assume that in both countries the probability of a positive shock of size 1 is 1/2, and that the probability of a negative shock of size 1 is also 1/2. Since shocks are independent, we have four possible states that each enter with probability 1/4: Both countries face positive shocks (PP), both countries face negative shocks (NN), the home country faces a negative and the foreign country a positive shock (NP), and the home country faces a positive shock and the foreign country a negative shock (PN). We know that the output response to a home shock of size 1 in regime i is given by η_i and to a foreign shock of size 1 by $(1-\eta_i)$. Furthermore, since $\eta_I > \eta_U > 1/2$, assume for instance that $\eta_I = 0.8$ and $\eta_U = 0.6$. The table below gives the output responses in the four different states, as well as the calculated output variance.

The table is set up in the following way: With independent inflation targeting (I) and the state PP, the home country shock contributes to an output increase of 0.8 and the union shock to an output increase of 0.2. The total output increase in this event is therefore equal to 1.

When shocks are symmetrical, the output response is independent of the monetary policy regime, since the sum of the output responses equals one in both regimes. But in those instances where the shocks have opposite signs in the two countries, a monetary union produces less output fluctuations than independent inflation targeting. Consequently, the output variance is higher under independent inflation targeting than under a monetary union. By pursuing common rather than independent inflation targeting, the two countries take a greater advantage of shocks with opposite signs, since the difference from home and

Table 1. Output responses.

	PP	NN	NP	PN	$Var(y^H)$
I	$0.8+0.2=1$	$-0.8-0.2=-1$	$-0.8+0.2=-0.6$	$0.8-0.2=0.6$	0.68
U	$0.6+0.4=1$	$-0.6-0.4=-1$	$-0.6+0.4=-0.2$	$0.6-0.4=0.2$	0.52

foreign shocks is smaller under a monetary union than under independent inflation targeting. The reason for this is that the nominal exchange rate response under independent inflation targeting strengthens the output response from domestic shocks and weakens the output response from foreign shocks. This is contrary to the standard theory of optimum currency areas. According to this theory, when countries do not form a common currency area, a positive supply shock in the home country is met by an appreciation that dampens the home output response (see De Grauwe, 1994, pp. 41–44). But under independent inflation targeting, a positive supply shock must be met by a lower interest rate, and hence an exchange rate depreciation.

Assume next that shocks are not independent between the two countries. If supply shocks in the two countries are negatively correlated, it can be seen from Equation (3.1) that this further contributes to $var(y_U^H) < var(y_I^H)$ if $\eta_U(1-\eta_U) > \eta_I(1-\eta_I)$. From (3.2) and (3.3) we already know that this condition is fulfilled. Consequently, contrary to the conventional wisdom, the more negatively correlated supply shocks are, the larger the gain from forming a common currency area. The intuition for this result can also be understood from the numerical example given above. In the example, the two policy regimes yielded the same output instability when shocks were symmetrical, while a monetary union reduced instability when the shocks were asymmetric. With negative correlation between shocks, the asymmetric case is the typical one, and consequently the more negatively correlated the supply shocks are, the stronger the argument for forming a common currency area. For the same reason, when supply shocks are positively correlated, this weakens the argument for a common currency. When shocks are perfectly correlated (and the variance in supply shocks is the same) independent inflation targeting and monetary union give rise to the same output stability. The intuition behind this result should also be clear from the numerical example above, since in this case the events where both countries face the same shocks are the only ones of relevance.

Finally, assume that the variance of supply shocks differs between the two countries. Then, if the variance of home supply shocks is higher than that of foreign supply shocks, this will pull in the direction of an advantage for the home country to enter a union. The reason for this is simply that the output effect of home shocks is smaller under monetary union than under independent inflation targeting, i.e., that $\eta_I > \eta_U$. Since supply shocks are destabilised under inflation targeting, it is an advantage for the home country if the monetary policy response to supply shocks is determined to a larger degree by the shocks in a country with smaller variations in supply shocks. By contrast to the case above, however, in this case there is a potential conflict between the countries. While the country with a relatively high variance of supply shocks will have a more stable output under monetary union, the opposite holds true for the other country.

The results are in some contrast to the standard ones in the OCA literature.[3] There, heterogeneity of shocks is taken as signs that countries should not form a common currency area. Under inflation targeting, this result is confirmed when it comes to demand shocks. But we have seen that when the choice is between independent and monetary union inflation targeting, negative correlation in supply shocks is actually an argument in favor of entering a monetary union. Therefore, when the choice is between targeting inflation independently or within an extended union, as is the case for e.g., Britain and Sweden, it is not certain that arguments against a common currency based on the view that shocks will be more asymmetric due to specialisation in the EU by Krugman (1993) or arguments in favor of a common currency based on the view that shocks are likely to be more correlated with integration by Frankel and Rose (1997), are valid. The question is not how asymmetric shocks are, but how asymmetric demand shocks are compared to supply shocks.

4. Flexible inflation targeting

We now extend the analysis in two directions. First, we allow for flexible inflation targeting, where the Central Bank minimizes a standard loss function in price and output variability. Second, we leave the tradition in the OCA literature of focusing solely on output stability and measure the effects of the alternative regimes with the loss function instead.

Under independent flexible inflation targeting, the Central Bank minimises a loss function given by

$$L^I = \frac{1}{2}\left[\left(p_C^H\right)^2 + \gamma(y^H)^2\right] \tag{4.1}$$

As shown in the Appendix, the first-order conditions for the home and the foreign country respectively can be written as

$$\begin{aligned}&\left(1+\frac{\beta\lambda}{\alpha_1+2\alpha_2}\right)p_C^H + \gamma\lambda y^H \\ &\quad = \left(1+\frac{\beta\lambda}{\alpha_1+2\alpha_2}\right)(p^H + \beta(p^F + s - p^F)) + \gamma\lambda(\lambda p^H + u^H) = 0\end{aligned} \tag{4.2}$$

$$\begin{aligned}&\left(1+\frac{\beta\lambda}{\alpha_1+2\alpha_2}\right)p_C^F + \gamma\lambda y^F \\ &\quad = \left(1+\frac{\beta\lambda}{\alpha_1+2\alpha_2}\right)(p^F - \beta(p^F + s - p^H)) + \gamma\lambda(\lambda p^F + u^F) = 0\end{aligned} \tag{4.3}$$

The model is solved in an equivalent way as in Section 2.1, except that Equations (2.1) and (2.2) are replaced by (4.2) and (4.3).

If the two countries form a monetary union, we assume that the union minimises

$$L^U = \frac{1}{2}\left[\left(p_C^U\right)^2 + \gamma(y^U)^2\right] \tag{4.4}$$

where $y^U = \frac{1}{2}y^H + \frac{1}{2}y^F$.[4]

As shown in the Appendix, the first-order condition for the union can be written as

$$p_C^U + \gamma\lambda y^U = \left(\frac{1}{2}p^H + \frac{1}{2}p^F\right) + \gamma\lambda\left(\frac{1}{2}\lambda p^H + \frac{1}{2}\lambda p^F + \frac{1}{2}u^H + \frac{1}{2}u^F\right) = 0 \qquad (4.5)$$

As the solutions are quite complex, we here present a numerical illustration of the results. The benchmark parameter values are as follows. The supply elasticity is set equal to $\lambda = 1$, which is in line with the estimate for UK in Burgess (1988). The parameter values for the demand elasticities are set to $\alpha_1 = 0.2$ and $\alpha_2 = 0.5$, which are equal to the parameter values in Batini and Haldane (1998). The standard deviations of all the exogenous shocks are for simplicity set to 1 percent, and $\gamma = 1$ which we also assume is the weight in the true welfare function. The variance-covariance matrix of the shocks have implications for welfare comparisons between the two regimes. For instance, if the standard deviation of risk premium shocks is sufficiently large, entering a monetary union will always produce lower expected loss than targeting inflation independently. The focus of this paper is, however, on how the welfare comparison depends on the *correlation* of shocks, which is also the focus in the traditional OCA literature.

Table 2 presents the variance of inflation, output, and the expected loss as functions of the correlation coefficient between home and foreign supply shocks and home and foreign demand shocks, respectively. The welfare loss under both regimes is lower the more positively correlated the demand shocks are. In line with the traditional OCA literature, the gain from positively correlated demand shocks is higher under monetary union than under independent inflation targeting.

The welfare loss under both regimes is, however, higher the more positively correlated the supply shocks are. Thus, irrespective of the choice of monetary policy regime, both inflation and output is more stabilized if supply shocks are negatively correlated. The reason is that both domestic and foreign supply shocks lead to lower domestic inflation, while higher domestic output. The conflict between price stability and output stability is therefore less marked if domestic and foreign supply shocks are negatively correlated.

As seen from the table, the extra welfare loss due to positive correlation of supply shocks is (marginally) lower under a monetary union than under

Table 2. Variances and expected loss.[a]

	$var(p_C^H)$	$var(y^H)$	EL
Independent inflation targeting	$0.16 + 0.05\rho_u - 0.02\rho_v$	$0.30 + 0.08\rho_u - 0.04\rho_v$	$0.46 + 0.13\rho_u - 0.07\rho_v$
Union inflation targeting	$0.16 + 0.11\rho_u - 0.02\rho_v$	$0.37 + 0.01\rho_u - 0.14\rho_v$	$0.53 + 0.12\rho_u - 0.15\rho_v$

[a]The numbers are scaled by 10^{-4}.

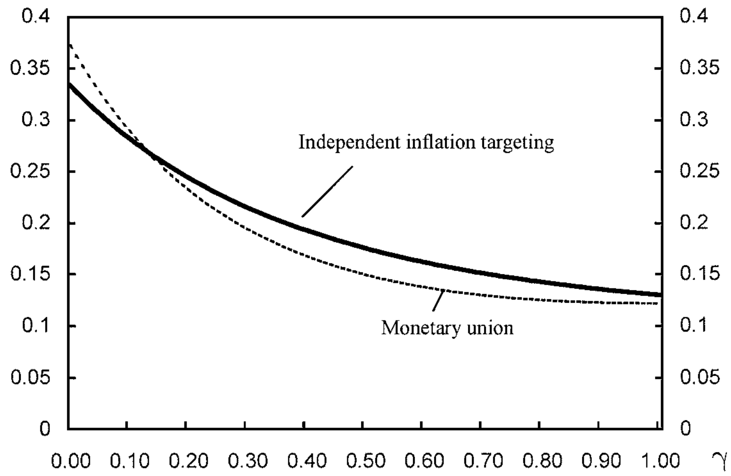

Figure 1. Inflation target flexibility and welfare loss.

independent inflation targeting. Although positively correlated supply shocks lead to lower welfare irrespective of the monetary policy regime considered, positively correlated supply shocks give, in isolation, an argument in favor of a monetary union. This result is in contrast to the result in Section 3, which suggests that the degree of flexibility of the inflation target is important for the conclusions as regards to optimum currency areas under inflation targeting. To investigate this we now allow for $\gamma \leq 1$. Figure 1 shows how the coefficient on the correlation coefficient on supply shocks in the welfare loss (see Table 2) varies with the degree of strictness in the inflation targeting, i.e., how conservative the Central Bank is. When $\gamma = 1$, the weight on the inflation target in the Central Bank's loss function is equal to the corresponding weight in the true welfare function. The lower γ is, the more weight the Central Bank places on the inflation target. If there is a high weight on the inflation target, i.e., low γ, positive correlation of supply shocks tends to give an argument against a monetary union. A weight on the inflation target that is closer to the weight in the true welfare loss function tends to give an argument in favor of a monetary union if there is positive correlation in supply shocks.

How much weight the Central Bank puts on achieving the inflation target may reflect the credibility of monetary policy. A low credibility Central Bank must give higher priority to achieving the inflation target than a high credibility Central Bank. When the inflation targeting regime is relatively young, there are arguments for giving high priority to achieving the inflation target in order to invest in future credibility. Over time, however, it can be argued that it will be politically difficult for Central Banks to minimize a loss function that deviates significantly from the true welfare loss function. Whether positive correlation of supply shocks is an argument in favor of or against a monetary union may thus depend on the age of the inflation targeting regime. It may also depend on whether the Central Bank has a hierarchical or a dual mandate.

5. Conclusion

Inflation targeting, either explicit or implicit, has become the dominant rule for monetary policy. Many countries face, or might face in the future, the choice between targeting inflation independently or entering a monetary union that targets inflation within the union. The earlier debate on optimum currency areas focused on the general choice between a common currency versus a flexible exchange rate. The question was whether the exchange rate was an appropriate adjustment instrument. The conventional answer was that adjusting the nominal exchange rate provides greater output stability when countries are hit by asymmetric shocks. The existence of asymmetric shocks would then be an argument against forming a monetary union.

Does modelling inflation targeting explicitly add any new insights to the theory of OCA? The answer is yes, because implicit in the OCA literature is the assumption that the exchange rate is always adjusted in a way that improves output stability. However, when Central Banks target inflation, this is not generally true. For instance, when the economy is hit by an adverse supply shock (cost-push shock), the Central Bank must tighten monetary policy in order to achieve its inflation target. If the inflation target is credible, the monetary tightening leads to an exchange rate appreciation, which exacerbates the negative effect of the supply shock. Only when the economy is hit by shocks that drive output and prices in the same direction, that is, demand shocks, does inflation targeting imply that the exchange rate is adjusted in a way that improves output stability. While the conventional wisdom in the OCA literature holds as regards demand shocks, the presence of asymmetric supply shocks may in fact be an argument in favor of a monetary union. This is more likely to be the case the greater the weight placed on achieving the inflation target by the Central Bank.

Appendix: The analytics of flexible inflation targeting

A.1. Independent inflation targeting

Under independent inflation targeting, the home and the foreign Central Bank minimize the loss function (4.1) independently, by treating the other country's monetary policy as exogenous. The equilibrium is thus a Nash equilibrium.

The Central Bank is assumed to set the interest rate so as to minimize the loss function (4.1). However, since per assumption there is no control error in monetary policy, one may choose to treat any variable as the policy instrument. For analytical convenience, we will treat p^H and p^F as the policy instruments in country H and country F, respectively. The interpretation is that the Central

Bank in each country adjusts the interest rate so as to bring about the appropriate change in domestic prices in order to minimize the loss. In order to solve the optimization problem, we need to solve for y^i and p_C^i as functions of $p^i (i = H, F)$. Since the two countries are symmetric, we focus on the home country.

There is no persistence in the model, so that deviations of output from equilibrium output and deviations of inflation from the inflation target are expected to last for only one period. We thus have that $Ep_C^H = 0$. Since $w = Ep_C^H + \varepsilon^H = \varepsilon^H$, we can write the supply function as

$$y^H = \lambda p^H + u^H. \tag{A.1}$$

In order to solve for $p_C^H = p^H + \beta e$, we need to solve for the real exchange rate. Subtracting Equation (1.9) from Equation (1.8) yields

$$y^H - y^F = -\alpha_1(r^H - r^F) + 2\alpha_2 e + v^H - v^F. \tag{A.2}$$

We have that

$$\begin{aligned} r^H - r^F &= i^H - (Ep^H - p^H) - i^F + (Ep^F - p^F) \\ &= Es - s + z - (Ep^H - p^H) + (Ep^F - p^F) \\ &= -e + z \end{aligned} \tag{A.3}$$

where we in the second row have inserted the UIP condition (1.4). The last equality follows from the property that the expected real exchange rate is zero, because of the existence of non-persistent shocks. Inserting (A.3) into (A.2), substituting $y^H - y^F$ by $\lambda(p^H - p^F) + u^H - u^F$ and solving for e gives

$$e = \frac{1}{\alpha_1 + 2\alpha_2}[\lambda(p^H - p^F) + (u^H - u^F) - (v^H - v^F) + \alpha_1 z]. \tag{A.4}$$

The solution for p_C^H is then given by

$$\begin{aligned} p_C^H &= p^H + \beta e \\ &= \left(1 + \frac{\beta\lambda}{\alpha_1 + 2\alpha_2}\right)p^H + \frac{\beta}{\alpha_1 + 2\alpha_2}[-\lambda p^F + (u^H - u^F) - (v^H - v^F) + \alpha_1 z]. \end{aligned} \tag{A.5}$$

Since there is no persistence in the model, the optimization problem is reduced to a one-period problem. The Central Bank is assumed to control p^H through adjusting the interest rate. The problem of the home Central Bank is then to minimize the loss

$$L = \frac{1}{2}\left[\left(p_C^H\right)^2 + \gamma(y^H)^2\right] \tag{A.6}$$

with respect to p^H, subject to (A.1) and (A.5), and treating p^F as given.[5] The first-order condition is given by

$$\left(1+\frac{\beta\lambda}{\alpha_1+2\alpha_2}\right)p_C^H+\gamma\lambda y^H=0. \tag{A.7}$$

Inserting (A.1) and (A.5) into (A.7) gives p^H as a function of p^F and the exogenous shocks. Since the two countries are symmetric, the solution for p_c^F and the first-order condition for the foreign country can be obtained by simply substituting the superscipt H by F and noting that the real exchange rate and the risk premium shock enter the foreign country with the opposite sign as the home country. The reduced-form solutions are then obtained by solving for p^F from the first-order condition for the foreign country and inserting this into the first-order condition for the home country. Straight forward substitution yields the (very space demanding) analytical solution which is the basis for our numerical solution in Section 4.

A.2. Monetary union

The Central Bank of the union minimizes the loss function

$$L^U=\frac{1}{2}\left[\left(p_C^U\right)^2+\gamma(y^U)^2\right] \tag{A.8}$$

where $p_C^U=\frac{1}{2}p_C^H+\frac{1}{2}p_C^F=\frac{1}{2}p^H+\frac{1}{2}p^F$ and $y^U=\frac{1}{2}y^H+\frac{1}{2}y^F$. By making use of the supply function (A.1) and the corresponding function for y^F, we have that

$$y^U=\frac{1}{2}(\lambda p^H+u^H)+\frac{1}{2}(\lambda p^F+u^F)=\lambda p_C^U+\frac{1}{2}u^H+\frac{1}{2}u^F. \tag{A.9}$$

The problem of the Central Bank is then analoge to the problem in Section A.1, and we can treat p_C^U the monetary policy instrument. The first-order condition is

$$p_C^U+\gamma\lambda\left(\lambda p_C^U+\frac{1}{2}u^H+\frac{1}{2}u^F\right)=0. \tag{A.10}$$

Solving for p_C^U and inserting this into (A.9) gives

$$p_C^U=-\frac{\gamma\lambda}{1+\gamma\lambda^2}\left(\frac{1}{2}u^H+\frac{1}{2}u^F\right) \tag{A.11}$$

$$y^U=\frac{1}{1+\gamma\lambda^2}\left(\frac{1}{2}u^H+\frac{1}{2}u^F\right). \tag{A.12}$$

In order to solve for p^H and p^F separately, and thereby for y^H and y^F, we must determine how the union aggregate inflation, p_C^U is divided between the two countries. Under a monetary union we have that

$$e = p^F - p^H \tag{A.13}$$

$$\begin{aligned} r^H - r^F &= (i^H - (Ep^H - p^H)) - (i^F - (Ep^F - p^F)) \\ &= -(Ep^H - p^H) + (Ep^F - p^F) \\ &= -(p^F - p^H) \end{aligned} \tag{A.14}$$

where the last equality follows from $Ee = Ep^F - Ep^H = 0$, because the economy is expected to be in steady state in the next period. Inserting (A.13) and (A.14) into (A.2) and making use of $y^H - y^F = \lambda(p^H - p^F) + u^H - u^F$ gives

$$\lambda(p^H - p^F) + u^H - u^F = (\alpha_1 + 2\alpha_2)(p^F - p^H) + v^H - v^F \tag{A.15}$$

(A.10) and (A.15) determine p^H and p^F, which in turn determine y^H and y^F. Again, straight forward substitution yields the (very space demanding) analytical solution which is the basis for our numerical solution in Section 4.

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Notes

1. See e.g., Frankel and Rose (1996).
2. To support the objective of price stability, the ECB has announced that money supply is to be one of the operational indicators. However, it is unlikely that anticipated shocks to money demand would be allowed to affect prices and output, so that, in our view, inflation targeting is a more realistic interpretation of the monetary policy pursued by the ECB than money supply targeting.
3. The result is also in some contrast to results in literature not explicitly considering OCA, e.g., Lane (2000). In Lane's model, the presence of asymmetric supply shocks is an argument against forming a monetary union, and the greater the weight placed on inflation, the stronger the argument.
4. An alternative specification of the union loss function is the sum of each country's individual loss function. However, if the two countries are perfectly symmetric, as assumed here, it can be shown that the alternative specifications give identical results.
5. This implies that we consider the Nash equilibrium.

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