Should the core fear the outs?

Price setting practices and international monetary transmission

Richard Friberg*

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Abstract

This paper examines the response of national consumption, production and welfare to asymmetric monetary shocks. We do so in a two-country model (country "core" and country "out") characterized by monopolistic competition and price rigidities. A large degree of goods market segmentation and local currency pricing leads to monetary policy having beggar-thy-neighbor effects. Increased price setting in the "core" currency by "outs" lessens the negative spill-over on "core" from "out" monetary policy. It also makes the welfare spill-overs on "outs" from "core" monetary policy negative.

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†Richard Friberg, Stockholm School of Economics, P.O. Box 6501, S-113 83, Stockholm, Sweden. Tel: +46-8-736 9645, fax: +46-8- 31 32 07, e-mail: nerf@hhs.se

1 Introduction

Welfare effects of monetary policy are important for a great number of issues in international economics. The choice of nominal exchange rate regime is just one such issue. However, the Mundell-Fleming framework that has been the workhorse in international macroeconomics lacks microfoundations and is therefore not well suited for welfare analysis. Recently Obstfeld and Rogoff (1995a, 1996, Ch. 10) have proposed an intertemporal two-country framework that they claim maintains the empirical realism of a Mundell-Fleming world while allowing for explicit welfare results since it builds from optimizing agents. One of the starkest results in their model is that a monetary expansion in one country raises welfare in both countries proportionately. This suggests that fears of "beggar-thy-neighbor" effects of a depreciating exchange rate are misguided or at least exaggerated. Their analysis thus has potentially important ramifications for e.g. the relationship between the ins and outs of a European Monetary Union. In their main analysis Obstfeld and Rogoff assume that the law of one price holds and that prices are set in the exporter's currency.[1] This is a potentially important assumption. Real effects of monetary policy depend on price rigidities and it follows that it is not unimportant in which currency that prices are rigid.

This paper investigates welfare effects of international monetary transmission under different assumptions of price setting practices. We do so in a simple one-period version of the Obstfeld and Rogoff model that has been developed by Betts and Devereux (1995, 1996).[2] Betts and Devereux assume that the price of a share of goods are set in the importer's currency and that the law of one price does not hold for these goods. Betts and Devereux (1996) use the model to study how

[1] Obstfeld and Rogoff (1996) also perform a welfare analysis of international monetary transmission under two variations of the main model. In one (1996, p.689-694) each country has a non-traded goods sector and a traded goods sector that is perfectly competitive with a flexible price. In that set-up monetary policy has real effects only in the originating country. They also sketch a formulation (1996, p.709-712) where wages are pre-set but output prices are flexible. In that set-up the effects of monetary policy on consumption differentials and the exchange rate are the same as in the main analysis. We return to a discussion of this last formulation in our concluding comments.

[2] Obstfeld and Rogoff (1995b) develop a one-period version of their model.

price stability in the importers' currency affects exchange rate volatility. Their framework produces the result that separation of national markets and pre-set prices increases the volatility of exchange rates relative to what would be the case if the law of one price held.[3] A working paper version (1995) of the article contains a brief welfare analysis of monetary transmission. We expand that discussion. We also extend their model to allow for the possibility that a share of goods produced in one country, for which the law of one price holds, are priced in foreign currency. A short motivation for the assumptions are given below.

The assumption of Obstfeld and Rogoff that the law of one price holds is at odds with the large body of evidence on the breakdown of the law of one price for many traded goods, see e.g. Alexius and Vredin (1996) or Goldberg and Knetter (1996). Further, many studies suggest that prices for a large share of traded goods are stabilized in the importer's currency, a phenomenon known as Pricing-to-market (PTM) or limited exchange rate pass-through. The assumption below that a share of goods has prices that are pre-set in the local currency and that markets are segmented is a simple way to model this.

Why would an exporter of goods for which the law of one price holds set price in foreign currency? We illustrate with the case of a Volvo car. Today prices on different national markets tend to be stable in local currency and prices differ when expressed in common currency.[4] As the common market grows in age it is likely that the law of one price will hold to a greater extent. It is reasonable to assume that a share of Swedish (British, Norwegian,...) exporters will then choose to keep prices stable to the large Euro market rather than to the smaller domestic market. Support for this is the belief that many large firms based in countries outside an EMU will switch to using Euro as their functional currency.[5] Further support may be given by studying currency use in Canadian-US

[3]The result holds for empirically reasonable values of the consumption elasticity of money demand and the price elasticity of demand.

[4]See Flam and Nordström (1995) for a study of car prices on different European markets.

[5]For Sweden this is argued in e.g. the contributions by the Swedish Employers' Confederation and the Stockholm Chamber of Commerce in Finansdepartementet (1997). For Denmark see Olsen (1997).

trade. There is a case to made for there being similarities in the situation of Canada vis-a-vis the US and that of potential "ins" and "outs" of EMU. Feenstra and Kendall (1997) argue that Canadian exports to the US are almost exclusively denominated in US dollars.

The Obstfeld-Rogoff framework is quite new and in that sense there is little precedent to the present article apart from the one's mentioned above.[6] Of course welfare issues are implicit in the huge literature on e.g. optimal exchange rate arrangements that use a Mundell-Fleming type framework; see for instance the survey by Genberg (1989). The implications of PTM for how exchange rates affect consumption and production have been noted informally by previous observers. For instance Krugman (1989, p. 39) states that "the exchange-rate changes since the dollars peak in 1985 dwarf those that were central to great historical disputes. Yet, looking at the domestic performance of the major economies, one sees only marginal impacts from these changes....that exchange rates do not affect trade flows or aggregate prices as much as one might expect is due in large part to [Pricing-to-Market]".

In the next section we set out our simple extension of the Betts and Devereux model. Section 3 presents our analysis and the last section concludes.

2 The model

Assume that the world is inhabited by a continuum of agents. Let $[0, n]$ agents be located in the country denoted Out and $(n, 1]$ agents be located in the country denoted Core. There are the same number of goods produced in a country as there are agents in that country. Each good i is only produced by firm i. Each firm produces only one good and all goods are sold on both markets. A share s of firms from both countries produce a good for which markets are segmented and price is set

[6] Kollmann (1997) provides extensive references to related literature, e.g. international real business cycle research. Beaudry and Devereux (1995), Chari, Kehoe and McGrattan (1997) and Kollmann (1997) use related models to make quantitative studies of how price stability in importers' currencies affect variability and persistence of deviations from Purchasing Power Parity. Svensson and van Wijnbergen (1989) study production and consumption responses to monetary shocks in a world similar to that of Obstfeld and Rogoff.

in the local currency on both markets. We call these PTM goods. $x(i)$ denotes the quantity of PTM good i produced for the home market and $z(i)$ the quantity produced for the foreign market. Denote goods produced by Core with a star. A share $1-s$ of firms in each country produce a good for which markets are not separated so that the law-of-one price always holds. We call these non-PTM goods. The $y^*(i)$ non-PTM goods produced in the Core country are all priced in the Core currency. A share $1-a$ of the non-PTM firms from Out set price on their goods $y(i)$ in the Out currency. A share a of non-PTM firms from Out set price in the Core currency. Denote each of these goods by $w(i)$. This is the extension that we make compared to Betts and Devereux (1995, 1996). Let $p(i)$ be a price denominated in the Out currency and $q(i)$ a price denominated in the Core currency. Figure 1 illustrates our assumptions about the home country and price setting behavior of firms.

Figure 1 about here

An Out country agent maximizes the utility function given by

$$U = logC + \frac{\gamma}{1-\varepsilon}\left(\frac{M}{P}\right)^{1-\varepsilon} + \eta log(1-h) \tag{1}$$

where C is a consumption index, M are nominal balances, P is the price level in Out and h denotes the time worked.[7] Expressions for C and P are given in appendix 1. Maximization is subject to the individual's budget constraint given by $PC+M = Wh+\pi+M_0+TR$. The cost of consumption and money holdings at the end of the period equal wage earnings (Wh) plus profits from ownership (π), government transfers (TR) and initial nominal money holdings (M_0).[8] The output of firms depends

[7]One may ask why an Out agent would not receive utility by holding Core money. For the issues we focus on it is realistic to assume that agents hold wealth in their domestic currency and only exchange it for foreign currency the moment they buy something denominated in foreign currency. See Obstfeld and Rogoff (1996, p. 551-554) for a discussion of inclusion of foreign currency holdings in the utility function. The issue of interest there is "Dollarization", when there is widespread substitution away from the use of domestic currency, such as under a hyper-inflation.

[8]Assume that all individuals work in, and own shares of, one firm of each type from his own country in equal proportions. In this sence the situation for all agents from a country is the same. Assume that wage is pre-set so that changes in firm revenue are distributed through profits rather than through wages.

linearly on employment in the firm by a factor A.

Below we set out profits of an Out PTM firm (2), an Out non-PTM firm which prices in the Out currency (3) and an Out non-PTM firm which prices in the Core currency (4). e is the nominal exchange rate expressed as units of Out currency needed to buy one unit of Core currency.

$$\pi(i) = p(i)x(i) + eq(i)z(i) - (W/A)(x(i) + z(i)) \quad (2)$$

$$\pi(i) = p(i)y(i) - (W/A)y(i) \quad (3)$$

$$\pi(i) = eq(i)w(i) - (W/A)w(i) \quad (4)$$

Price of each good is set to maximize profits. The set-up is analogous for the Core country. Denote Core variables with a star. The government of each country finances lump sum money transfers to its residents by printing money. Note that demand elasticities are the same for all goods. In equilibrium price will thus be equal for all goods and we suppress i from here on. Output in the Out country is given by $nY = n(1-s)((1-a)y + aw) + ns(x+z)$.

Following a number of steps (given in appendix 1) we can characterize a sticky price equilibrium by the equations (5) through (15) below.

A sticky price equilibrium is characterized by; the money market clearing equations in each country,

$$\frac{M}{P} = (\gamma C)^{1/\varepsilon} \quad (5)$$

$$\frac{M^*}{P^*} = (\gamma C^*)^{1/\varepsilon} \quad (6)$$

the national balance of payments equations for each country, stating that national consumption (on the left hand side) should equal national revenue (right hand side).

$$nPC = n(1-s)\left(aweq + (1-a)yp\right)) + ns(px + eqz) \quad (7)$$

$$(1-n)P^*C^* = (1-n)(1-s)q^*y^* + (1-n)s(\frac{p^*}{e}x^* + q^*z^*) \tag{8}$$

Equations (9)-(15) below give the market clearing condition for each good (all goods of the same type are symmetrical). The demand for an Out non-PTM good priced in the Out currency is thus given by equation (9) and equation (10) gives the demand for the good produced by an Out non-PTM firm that prices in the Core currency. Equation (11) gives demand for Core non-PTM goods. Demand for Out PTM goods on the Out market is given by (12) and for PTM goods from Out sold on the Core market by (13). (14) gives demand on the Out market for PTM goods from the Core and finally (15) gives demand for Core PTM goods on the Core market.

$$y = \left(\frac{p}{P}\right)^{-\rho} nC + \left(\frac{p}{eP^*}\right)^{-\rho} (1-n)C^* \tag{9}$$

$$w = \left(\frac{eq}{P}\right)^{-\rho} nC + \left(\frac{q}{P^*}\right)^{-\rho} (1-n)C^* \tag{10}$$

$$y^* = \left(\frac{eq^*}{P}\right)^{-\rho} nC + \left(\frac{q^*}{P^*}\right)^{-\rho} (1-n)C^* \tag{11}$$

$$x = \left(\frac{p}{P}\right)^{-\rho} nC \tag{12}$$

$$z = \left(\frac{q}{P^*}\right)^{-\rho} (1-n)C^* \tag{13}$$

$$x^* = \left(\frac{p^*}{P}\right)^{-\rho} nC \tag{14}$$

$$z^* = \left(\frac{q^*}{P}\right)^{-\rho} (1-n)C^* \tag{15}$$

3 Transmission of monetary shocks

We are interested in how the system (5) through (15) responds to monetary shocks. We will study effects on consumption, production and welfare from monetary surprises. Use price indexes from appendix 1, totally differentiate and let a^denote percentage change (dX/X) where X is the initial

zero-shock value of a given variable. The symmetry of equilibrium prices, consumption and production is used to solve the model and greatly simplifies expressions. All individual prices are fixed in the currency in which they are denominated.

3.1 The exchange rate, production and consumption

The exchange rate change depends on the change in nominal money in the two countries as given in equation (16) below. The derivation is outlined in appendix 2. We note that setting $a = 0$ implies that (16) collapses to the same expression as in Betts and Devereux (1996), setting $a = s = 0$ makes the expression identical to the expression for exchange rate in a one-period version of the Obstfeld and Rogoff (1995b) model.

$$\widehat{e} = \frac{\varepsilon(\widehat{M} - \widehat{M^*})}{(1-s)(\varepsilon + (1-na)(\rho - 1)) + s} \tag{16}$$

Pricing-to-market, $s > 0$, implies that the response of the exchange rate to monetary shocks will be greater than would be the case if the law of one price held. This is true if $\varepsilon > 2 - \rho$, that is if the consumption elasticity of money demand $(1/\varepsilon)$ is low enough relative to the price elasticity of demand. This can be expected to hold quite generally. ε is positive and estimates of ρ are typically larger than 2. This result is due to Betts and Devereux (1996). When $a = 0$ a differential monetary shock affects the exchange rate through the reallocation of demand $(\rho - 1)$ that takes place on the goods whose price is allowed to change to consumers $(1 - s)$. A higher degree of price setting in the Core currency, a, also implies a higher response of the exchange rate to differential money growth. When $a > 0$ a monetary shock tends to switch consumption from Core to Out goods to a lesser extent (equation (39) in appendix 2) and the response of the exchange rate is unambiguously higher. Now turn to production and consumption as a function of monetary surprises in the two countries.

A monetary expansion raises demand and hence production since production is demand driven in the short run when prices are pre-set at a level above marginal cost. After some algebra we can express the percentage response of Out country production (both total and average production) to Out and Core monetary shocks. We show in appendix 3 that the change in Out production can be

written as a function of the change in world money and the relative production difference, (17). Use (40) and (41) from appendix 3 and that in equilibrium $C = C^*$ to reach (18). Using (16) in (18) establishes (19).

$$\widehat{Y} = \varepsilon\left[\widehat{M}n + (1-n)\widehat{M}^*\right] + (1-n)\left[\widehat{Y} - \widehat{Y}^*\right] \quad (17)$$

$$= \varepsilon\left[\widehat{M}n + (1-n)\widehat{M}^*\right] + (1-n)\left[\widehat{e}(1-s)(1-a)\rho\right] \quad (18)$$

$$= \varepsilon\left[\widehat{M}n + (1-n)\widehat{M}^*\right] + (1-n)\left[\frac{(1-s)(1-a)\varepsilon\rho\left(\widehat{M} - \widehat{M}^*\right)}{(1-s)(\varepsilon + (\rho-1)(1-na)) + s}\right] \quad (19)$$

We note from (19) that Out production is a positive function of Out monetary policy. The intuition behind how a and s affect the production response to monetary shocks is perhaps easiest brought out by (18). The first term is the higher production that is induced by the increase in world demand. The second term gives the production switching effect due to the exchange rate change that is associated with asymmetric monetary policy in Out and Core. Think of the case where $\widehat{M}^* = 0$. The exchange rate depreciation will only shift production on the $(1-s)(1-a)$ goods whose prices are set in the Out currency. The shift in production will be dependent on how elastic demand is, ρ. The more elastic demand, the larger shifts in production.

We note that the effect of Core monetary surprises on Out production are ambiguous. The appreciation of the exchange rate leads to less demand for Out goods which counteracts the positive effect from increased global demand. The higher s and a are, the less likely is it that the appreciation will lead to lower Out production.

Now focus on consumption. Use (36) and (37) from appendix 2 and that in equilibrium $C = C^*$ to take us from (20) to (21). Finally, collecting terms and using (16) we establish Out consumption as a function of Out and Core monetary policy, (22).

$$\widehat{C} = \varepsilon\left[\widehat{M}n + (1-n)\widehat{M}^*\right] + (1-n)\left[\widehat{C} - \widehat{C}^*\right] \quad (20)$$

$$= \varepsilon\left[\widehat{M}n + (1-n)\widehat{M}^*\right] + (1-n)\left[\widehat{e}((1-s)\rho + s + (1-s)(na - \rho na))\right]\left(-\widehat{P} + \widehat{P}^*\right) \quad (21)$$

$$= \varepsilon\left[\widehat{M}n + (1-n)\widehat{M}^*\right] + (1-n)\left[\frac{\varepsilon\left(\widehat{M} - \widehat{M}^*\right)((1-s)(\rho-1)(1-na) + s)}{(1-s)(\varepsilon + (\rho-1)(1-na)) + s}\right] \quad (22)$$

We focus on (21). The first term is as before the increase in consumption due to the increase in world money. The second term gives the consumption switching effect due to changing relative prices as the exchange rate changes. The term within brackets gives the consumption switching due to the change in the exchange rate. Take the case of a monetary expansion in Out which leads to a depreciation of the exchange rate. When $a = 0$ consumption switching (dependent on ρ) will take place on the share of goods where the price to consumers is allowed to change, $(1 - s)$. These goods will become cheaper relative to goods priced in their own currency for Core consumers (and $(1 - s)$ of the imports from Core will become more expensive to Out consumers). The second term, s, is the higher consumption that is due to the wealth effect, the revenue that Out producers collect on sales of PTM goods on the Core market are worth more when translated into the Out currency. When $a > 0$ there is a wealth effect as well given by $(1 - s)na$. This moderates the consumption switching effect $(1 - s)na\rho$ that tends to lower the effect of a depreciation on Out consumption. Finally, the consumption switching is moderated by the movements in the aggregate price indexes, $-\widehat{P} + \widehat{P}^* = -\widehat{e}(1 - s)$.

In (22) we have collected terms and also taken into account how the exchange rate responds to differential money shocks. We see that a higher share of PTM goods increases the effect of Out monetary shocks on Out consumption and that a higher degree of Out goods priced in the Core currency, a, lowers the effect. Intuitively, the more goods that are priced in the Out currency, the more will Out monetary policy be able to affect Out consumption.

We discuss Core consumption and production when focusing on Core utility in section (3.2.3).

3.2 Welfare effects of monetary surprises

We go on to study the welfare effects of monetary policy. As in Obstfeld and Rogoff (1995a,b, 1996) there is a potential welfare-enhancing role for monetary policy. Prices are pre-set and there is an initial distortion due to monopoly pricing which implies that output is suboptimally low in equilibrium. This is seen by noting that in the decentralized equilibrium $h = \frac{(\rho-1)/\rho}{(\rho-1)/\rho+\eta}$ whereas the

socially efficient level of work is given by $h^{opt} = \frac{1}{1+\eta}$[9]. In the decentralized equilibrium the marginal value of additional consumption exceeds the value of foregone leisure. As all stake holders in firms are also consumers they would be better off if markups were lower but since each firm has monopoly power, the individual incentive is to charge a price that maximizes the private profit, not taking into account the externality bestowed on the economy. A monetary expansion raises consumption (equations (5) and (6)) , thus alleviating this distortion. Since price is above marginal cost in equilibrium it is profitable to accommodate the increased demand. The ability to study welfare effects is one advantage of this model compared to a Mundell-Fleming framework. As demonstrated by Obstfeld and Rogoff it can be quite misleading to equate effects on production and consumption individually with effects on welfare. Some terms may cancel, as is indeed the case in the simplest form of the model when $s = a = 0$.

We now proceed to find how the representative agent's utility is affected by monetary surprises. We will discuss how these welfare effects depend on price setting practices. Use (1) and log-linearize (steps given in appendix 4). We can then write the change in Out utility as

$$dU = \widehat{C} + \gamma \left(\frac{M}{P}\right)^{1-\varepsilon} \left(\widehat{M} - \widehat{P}\right) - \left(\frac{\rho - 1}{\rho}\right) \widehat{Y} \tag{23}$$

Following Obstfeld and Rogoff we define the real component of utility as

$$dU^R = \widehat{C} - \left(\frac{\rho - 1}{\rho}\right) \widehat{Y} \tag{24}$$

3.2.1 Out welfare and its own monetary policy

Substituting from (22) and (19) into (24) allows us to write the change in Out utility as a function of the percentage change in Out monetary policy (letting $\widehat{M}^* = 0$).

$$dU^R(\widehat{M}) = \widehat{M}\varepsilon \left[\frac{n}{\rho} + \frac{(1-n)s + (1-n)^2(1-s)(\rho-1)a}{(1-s)(\varepsilon + (\rho-1)(1-na)) + s}\right] \tag{25}$$

Equation (25) shows that the effectiveness of Out monetary policy increases when markets are segmented ($s > 0$). The first term is not dependent on s or a, this is the effect that would be present

[9] This is seen by maximizing $logY - \eta log(1 - AY)$.

if the law of one price held and all prices were set in the producers' currencies. The change in utility would be dependent only on the size of the monetary shock - not on which country it originates in (compare with (26)).[10] When markets are integrated the monetary expansion is coupled with Core goods becoming more expensive since the Out exchange rate depreciates and Core good prices are set in the Core currency.

Now, an additional share of $(1-n)s$ prices are set in the Out currency (Core PTM goods). This leads to a further increase in utility. We also see that a higher degree of Out non-PTM goods being priced in the Core currency (a) *increases* the welfare effect of Out's monetary policy. This result is perhaps counterintuitive. We noted above that increasing the share of non-PTM goods priced in the Core currency lead to Out production and consumption responding *less* to Out monetary policy than if a were lower. The intuition comes from referring back to (24) and noting that an increase in a affects the impact of an exchange rate change on consumption $(1-na)$ less than it does monetary transmission on production $(1-a)$. A monetary expansion implies that agents work harder and consume more. Agents like consumption but dislike work. As in Obstfeld and Rogoff it thus shows that effects on production and consumption can not be equated with welfare effects.

Figure 2 a, b and c below plot Out production, consumption and utility as functions of an Out monetary shock when $n = 0.2$, $\varepsilon = 1$ and $\rho = 6$. That is 20% of world population lives in Out, the consumption elasticity of money demand is unity and the price elasticity of demand is 6.[11]

Figure 2a, 2b, 2c about here

[10] This is the only effect present in Obstfeld and Rogoff (1995a,b, 1996). In equilibrium the marginal value of consumption is set to equal the marginal disutility of work. When $s = a = 0$ the welfare effects of consumption and production switching cancel when taken together. The only first-order effect on welfare is the one due to the relaxing of the distortion caused by monopoly pricing.

[11] We use the same (empirically sensible) parameter values as Betts and Devereux (1996) do when they calibrate the variance of the exchange rate. The implied markup is $1.2 = \rho/(\rho-1)$.

3.2.2 Should Out fear the Core?

Equation (26) below measures the Out welfare effects of a Core monetary policy shock (letting $\widehat{M} = 0$).

$$dU^R(\widehat{M}^*) = \widehat{M}^*\varepsilon\left[\frac{(1-n)}{\rho} - \frac{((1-n)s + (1-n)^2(1-s)(\rho-1)a)}{(1-s)(\varepsilon + (\rho-1)(1-na)) + s}\right] \tag{26}$$

The symmetry with respect to (25) is apparent. The first term is the change in utility that would result if there was no PTM. The presence of PTM means that the positive spill-over from a Core monetary expansion is lowered. Is the change in utility due to a Core monetary expansion positive when we allow for PTM? For simplicity set $a = 0$. From (26) we see that the effect will be positive if and only if

$$\varepsilon > (\rho - 1)\left(\frac{2s-1}{1-s}\right) \tag{27}$$

ε is positive and $\rho > 1$ so that (27) will necessarily hold for $s < 0.5$. For $s > 0.5$ we can have the result that a foreign monetary expansion lowers home welfare - this is the case if PTM is prevalent ($s > 0.5$), the price elasticity of demand is high (high ρ) and the consumption elasticity of money demand is high (low ε). The lower ε, the less must consumption respond to an increase in the real money supply for money markets to clear. The monetary expansion raises world demand so that Out works harder, but Out only gets to reap a limited amount of the benefits of lower prices as a large share of prices are fixed in their own currency. The higher the price elasticity of demand, the more will Out work in response to the monetary shock.

What about a? How should Out view expansionary monetary policy by the Core when a share a of prices for Out goods for which the law of one price holds are set in the Core currency? It is easily shown that the change in utility is always negative in a. This means that if the degree of PTM is large enough that Core monetary policy affects Out utility negatively, a higher degree of non-PTM goods priced in the Core currency (higher a) makes the response even more negative. Figure 3 a, b and c below illustrate the effects on Out production, consumption and welfare for the same parameter values as in Figure 2, $n = 0.2, \varepsilon = 1, \rho = 6$.

Figure 3a, 3b, 3c about here

3.2.3 Should the Core fear Out?

What about the other way around? Should the Core be fearful of competitive depreciations by Out? Equation (28) gives Core utility as a function of Out monetary policy (letting $\widehat{M}^* = 0$).

$$dU^{*R}(\widehat{M}) = \widehat{M}\varepsilon \left[\frac{n}{\rho} + \frac{na(1-s)(\rho-1) - sn}{(1-s)(\varepsilon + (\rho-1)(1-na)) + s} \right] \tag{28}$$

Setting a to zero gives us a mirror image of (26). Below we give the change in Core production and consumption as a function of the increase in Out money and the exchange rate which together form (28). This will help us with the intuition.

$$\widehat{Y}^* = \varepsilon n\widehat{M} - n\widehat{e}(1-s)(1-a)\rho \tag{29}$$

$$\widehat{C}^* = \varepsilon n\widehat{M} - n\widehat{e}\left((1-s)(\rho-1)(1-na) + s\right) \tag{30}$$

Start with (29). The first term is the increase in production that comes from higher global demand. When there is no PTM the associated shift in production $(\widehat{Y}^* - \widehat{Y})$, which is the second term, reduces to $n\widehat{e}\rho$. The appreciation of the Core currency associated with an Out monetary expansion implies that Core goods become more expensive for Out consumers and Out goods become cheaper for Core consumers. This effect leads to Core producing less. Both PTM (s) and pricing by Out in the Core currency (a) serve to reduce this production switching effect.

Now turn to (30). The second term now is $(\widehat{C}^* - \widehat{C})$, the consumption switching effect. A share s of Out goods will not become cheaper to Core consumers, this lowers the positive spill-over relative to the no PTM case. Also on the non-PTM goods will there be less consumption switching due to the share na of goods that are priced in the Core currency and will not become cheaper. The total utility change, (28), is increasing in a reflecting that monetary transmission on consumption is affected less than production by an increase in a. A higher a lessens the beggar-thy-neighbor effect of an Out monetary expansion. Figure 4a, b and c plot Core production, consumption and utility as a function of Out monetary policy using the same parameter values as in Figures 2 and 3.

Figure 4a, 4b, 4c about here

We see that for a high degree of PTM Out monetary surprises may affect Core negatively. To the extent that our model is applicable to a future EMU we see that both increasing market integration (lower s) and increasing pricing in the Core currency (higher a) tend to make the welfare spill-over from Out monetary policy to Core positive.

4 Concluding Comments

The framework that we have used in this paper is very stylized and we view the results as preliminary. Nevertheless we would like to sum up the findings of the present paper. The paper was motivated by issues regarding the relationship between "ins" (Core) and "outs" of an EMU. Should the Core fear monetary expansion by Out? The answer that this paper gives is, maybe today, but there will be less grounds for fear tomorrow. Both increased market integration (lower s in our model) and more use of the Core currency by Out (for goods for which the law of one price holds, higher a in our model) work towards creating positive welfare spill-overs on Core utility from Out monetary policy. Increased price setting in the Core currency by Out firms (higher a in our model) works towards creating negative welfare spill-overs from Core monetary policy onto Out utility. There would be grounds for Out to fear expansionary monetary policy by the Core, also tomorrow.

We also noted that (holding a constant) a lower s, increased market integration, decreases the extent to which Out monetary policy can affect Out utility. This should have implications for how the attractiveness of joining a monetary union evolves over time. The classical case for a monetary union builds on a trade-off between microeconomic benefits on the one hand and the loss of not having access to an independent monetary policy in the face of asymmetric shocks on the other hand. Increased market integration, other things equal, would thus decrease the value of having access to an independent monetary policy. Note that such an argument for "wait-and-integrate" does not depend on changing patterns of trade as in Frankel and Rose (1997). Frankel and Rose show that stronger trade ties between two countries have historically been associated with a higher correlation between business cycles in those countries. The argument of Frankel and Rose is that if the creation

of an EMU leads to stronger trade ties between members this should lead to more correlated business cycles and therefore less need for an independent monetary policy. The mechanism that we point to here is that increasing goods market integration will affect the extent to which monetary policy can affect utility. The argument does not rest on changing trade flows. Of course, we do not fully understand the mechanisms that allow prices on different national markets to differ to the extent that they typically do. However it seems reasonable to expect that a project such as the EU common market will make it harder for firms to segment national markets. The abolishing of formal trade restrictions as well as harmonization of technical standards and legal rules should all work in this direction.

The model is extendable in a number of directions and can be used to study other issues than we have done now. Study of intertemporal concerns, productivity shocks (to A) as well fiscal policy shocks should be straightforward although perhaps messy. Another important issue that we have disregarded concerns the time-inconsistency of monetary policy. Rational price setters will recognize the incentive to expand the monetary base and incorporate this when setting prices. In the absence of some mechanism that lets the policy maker commit to not changing the monetary stock this should lead to an inflationary bias in equilibrium. The result of this paper that a monetary expansion raises domestic utility should not be seen as an argument for a systematic expansion of the monetary base. Our motivation is rather the possibility to use monetary policy to counter some shock. Just as the kind of model that we use in this paper should be extendable to study credibility issues it should be extendable to the study of international policy coordination. See e.g. Canzoneri and Henderson (1991) or Persson and Tabellini (1995).[12] Since the international spill-overs change with changing

[12]The work that we are aware of on credibility and international monetary policy coordination relies on postulated social welfare or "loss" functions that do not build from microfoundations. The basic story is that the policymaker would like to raise output above its equilirium level by surprise inflation (which he does not like). He will do so to the point where the marginal utility of output equals the marginal disutility of inflation. In the kind of world that we study in this paper the policymaker would wish for a big enough monetary surprise to reach first-best, there is no trade-off against a dislike for inflation. Another issue that complicates the application of the kind of model used in this paper to the study of credibility or coordination then is that the linearizations that one relies on are only valid

price setting behavior, the policy coordination game would also change.

Empirical studies of international monetary transmissions should also be valuable. For the issues we have discussed here, monetary transmission between Canada and US regions that have extensive trade with Canada should be especially interesting.

We should also comment on the PTM assumption. Obstfeld and Rogoff (1996, p. 711) study a similar framework as the one above but with flexible output prices (but pre-set wages). They note that the model features the same demand elasticities in both countries so that equilibrium prices should be equal even if markets are separated. There will be full pass-through of exchange rate changes onto import prices since it is assumed that the demand elasticity is constant.[13] If prices were flexible we would have full pass-through of exchange rates onto prices. So we would see no PTM. However when prices are pre-set and markets are separated, the law of one price does not hold. So PTM in the above model depends on nominal rigidities and not on properties of the demand schedule. In principle one could also study a "pure" PTM case with different demand elasticities in the different national markets. However, the symmetry of demand elasticities contributes greatly to the (relative) simplicity of the model.

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for small shocks.

[13] Pass-through depends on how the demand elasticity changes as the price changes. See e.g. Feenstra, Gagnon and Knetter (1996).

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Appendix 1

The consumption index that enters Out utility is given by $C = \left[\int_0^1 c(i)^{\frac{\rho-1}{\rho}} di\right]^{\frac{\rho}{\rho-1}}$ where $c(i)$ denotes the representative individuals consumption of good i. The definition of the Core consumption index is exactly analogous (specifically ρ is the same.) Each consumer's demand for a good i is given in standard Dixit-Stiglitz fashion $c(i) = \left(\frac{\vartheta(i)}{P}\right)^{-\rho} C$ where $\vartheta(i)$ is the price of the good i.

Rewrite the budget constraint as $M = Wh + \pi + M_0 + TR - PC$ and substitute into the utility function, (1). Maximize utility over h and C. We can then easily solve for the optimal demand for

real balances (M/P) and time worked.

$$\frac{M}{P} = (\gamma C)^{1/\varepsilon} \tag{31}$$

$$\frac{\eta}{1-h} = \frac{W}{PC} \tag{32}$$

Setting price as to maximize profit, equations (2)-(4), we establish that

$$p(i) = eq(i) = \frac{\rho}{\rho - 1}\frac{W}{A}\,\forall i \tag{33}$$

The price index in the Out country is given by (where we have used that in equilibrium prices are equal since ρ, the demand elasticity is the same for all goods).

$$P = \left[\begin{array}{c} n(1-s)a(eq)^{1-\rho} + n(1-s)(1-a)p^{1-\rho} + nsp^{1-\rho} + (1-n)(1-s)(eq^*)^{1-\rho} \\ +(1-n)s(p^*)^{1-\rho} \end{array} \right]^{\frac{1}{1-\rho}} \tag{34}$$

The terms are in order; the Out non-PTM goods that are priced in the Core currency, the Out non-PTM goods priced in the Out currency, Out PTM goods, Core non-PTM goods, Core PTM goods. Now solve for equilibrium when prices are flexible. Use (31) in (32) and that equilibrium consumption is equal to production $C = Y = Ah$ to find the equilibrium time worked $h = \frac{(\rho-1)/\rho}{(\rho-1)/\rho+\eta}$. We also note that in a flexible price equilibrium Purchasing Power Parity will hold so that $P = eP^*$. Using (31) and its Core counterpart we can thus write $e = \frac{M}{M^*}\left(\frac{C^*}{C}\right)^{1/\varepsilon}$.

The situation for the Core country is exactly analogous except for the price index which is given by

$$P^* = \left[ns(q)^{1-\rho} + n(1-s)a(q)^{1-\rho} + n(1-s)(1-a)\left(\frac{p}{e}\right)^{1-\rho} + (1-n)(q^*)^{1-\rho} \right]^{\frac{1}{1-\rho}} \tag{35}$$

That is in order of appearance; Out PTM goods, Out non-PTM goods priced in the Core currency, Out non-PTM goods priced in the Out currency, goods produced in Core (and priced in Core).

Appendix 2

In this appendix we derive the response of the sticky-price equilibrium to monetary shocks. Totally differentiate the Out price index while holding prices fixed in the currency in which they are set. We then establish that the percentage change in the home price index as a function of exchange

rate changes is given by $\widehat{P} = (1-s)(an+(1-n))\widehat{e}$. Following the same procedure we can express the percentage change in the Core price index as $\widehat{P}^* = -n(1-s)(1-a)\widehat{e}$. Differentiate the balance of payments equations (7) and (8) and use the demand equations, (9) through (15). We can then write

$$\widehat{C} = \frac{\left(\rho\widehat{P}+\widehat{C}\right)nC + \left(\rho\widehat{P}^*+\widehat{C}^*\right)(1-n)C^* + \widehat{e}(C^*(1-n)(\rho-s\rho+s)+Can(1-s)(1-\rho))}{nC+(1-n)C^*} - \widehat{P} \tag{36}$$

$$\widehat{C}^* = \frac{\left(\rho\widehat{P}+\widehat{C}\right)nC + \left(\rho\widehat{P}^*+\widehat{C}^*\right)(1-n)C^* - \widehat{e}(snC+Cn\rho(1-s))}{nC+(1-n)C^*} - \widehat{P}^* \tag{37}$$

We can then establish that

$$\widehat{C} - \widehat{C}^* = \widehat{e}\,((1-s)(\rho-1)(1-na)+s) \tag{38}$$

where we have used that in equilibrium $C = C^*$. Linearize around the equilibrium exchange rate we can establish that $\widehat{P} - \widehat{P}^* = \widehat{M} - \widehat{M}^* - \frac{1}{\varepsilon}\left(\widehat{C} - \widehat{C}^*\right)$. Using the results for price indexes we establish that

$$\widehat{e}(1-s) = \widehat{M} - \widehat{M}^* - \frac{1}{\varepsilon}\left(\widehat{C} - \widehat{C}^*\right) \tag{39}$$

Using (38) in (39) we establish equation (16).

Appendix 3

Note that the change in world consumption (and analogously production) is given by $\widehat{C}^W = n\widehat{C} + (1-n)\widehat{C}^*$. We can thus express Out consumption as $\widehat{C} = \widehat{C}^W + (1-n)(\widehat{C} - \widehat{C}^*)$. Using results from appendix 1 we can establish that $\widehat{C}^W = \varepsilon\widehat{M}^W$. Using this and the result for consumption difference from appendix 2 we establish (20).

We now turn to production. (17) is established following the same logic as for consumption. Total production is given by $nY = n(1-s)((1-a)y+aw) + ns(x+z)$. Log-linearize Y and Y^* to reach

$$\widehat{Y} = \frac{nC\left(\widehat{C}+\rho\widehat{P}\right) + (1-n)C^*\left(\widehat{C}^*+\rho\widehat{P}^*\right) + (1-s)\rho\widehat{e}((1-n)C^*(1-a) - nCa)}{nC+(1-n)C^*} \tag{40}$$

$$\widehat{Y}^* = \frac{nC\left(\widehat{C}+\rho\widehat{P}\right) + (1-n)C^*\left(\widehat{C}^*+\rho\widehat{P}^*\right) - (1-s)nC\rho\widehat{e}}{nC+(1-n)C^*} \tag{41}$$

In the same fashion we find $\widehat{C}^*$ and $\widehat{Y}^*$.

Appendix 4

Totally differentiating the utility function (1) yields $dU = \widehat{C} + \gamma \left(\frac{M}{P}\right)^{1-\rho} (\widehat{M} - \widehat{P}) - \eta \frac{1}{1-h} dh$. Use that $Y = Ah$ and that in equilibrium $h = \frac{(\rho-1)/\rho}{(\rho-1)/\rho+\eta}$ and finally disregard the term that depends on real balances to establish that $dU^R = \widehat{C} - \left(\frac{\rho-1}{\rho}\right) \widehat{Y}$.

Figure 2a. Out production as a function of Out monetary shocks

Figure 2b. Out consumption as a function of Out monetary shocks

Figure 2c. Out utility as a function of Out monetary shocks.