EUI WORKING PAPERS IN ECONOMICS

EUI Working Paper ECO No. 95/21

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BADIA FIESOLANA, SAN DOMENICO (FI)

Printed in Italy in June 1995
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Florence, 12,June 1995

Abstract

Exchange rate targets in a stabilization game are considered. The targeting strategy consists on the choice of a desired level for the exchange and the weight assigned to such target in the loss function. The exchange rate target appears then as an intermediate objective and acts as a surrogate to policy coordination. The targeting solution reveals that the targeting strategy can be embedded on a straight line in the policy-instruments space, which greatly facilitates the analysis. It turns out that the targeting strategy is optimal when the reaction of the countries exert a positive externality on the other country. In this case, policymakers have some flexibility in the choice of the target as long as the optimal commitment to such target is selected accordingly.

Keywords: policy coordination, exchange rate targets, optimal commitment.

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*-The author acknowledges the comments of Michael Artis, Mark Salmon and Berthold Herrendorf. Help from Trini Casasus is especially acknowledged. The usual disclaimer applies.

Introduction

This article deals with the design of exchange rate targets and their use as stabilizing device in the face of economic shocks. The actions of policymakers spillover to other countries in interdependent economies, hence the convenience of adopting a strategic game-theoretic setting. This is the standard approach in the policy coordination literature, where welfare considerations determine the gains from coordination. Players in the policy game only agree to follow a cooperative strategy if both gain with respect to the non-cooperative (Nash) outcome; in other words, the outcome from cooperation has to be incentive compatible.

Our approach is somehow different. In our model countries implicitly cooperate through a exchange rate arrangement. The exchange rate plays in this framework a role of intermediate target, but has no value on its own right. This idea is analogous to an optimal institutional contract, where both agents (countries) enjoy the same strategic position. The policymakers have to choose among a set of targeting strategies for the exchange rate the subset which provides the best outcome according to their policy objectives.

The optimal arrangement is defined by two conditions: incentive compatibility and Pareto optimality. Incentive compatibility turns out to be the necessary condition for the arrangement, otherwhise, private agents would realize the incentive to renege that a return to a non-cooperative equilibrium provides. The optimality condition just improves the virtue of the arrangement. Therefore, an incentive compatible target zone might turn out to be just a second best to explicit monetary policy coordination (which is Pareto optimal in the model we use here). We will also see that targeting the exchange rate may be counterproductive under certain circumstances.

The search for an optimal targeting strategy is developed in two stages. In the first stage, we consider all the types of shocks which may hit the economy, making it diverge from its equilibrium level; then we explore the possibility of targeting the exchange rate for the different types of shocks. This is formally done by delimiting the type of shocks for which the exchange rate arrangement is incentive compatible and Pareto optimal. It turns out that the feasibility of targeting the exchange rate depends on the type of shock.

The second stage directly tackles the question of designing optimal exchange rate targets within the relevant shock subset. We will observe that there is some scope for the discretion of the policymakers who can choose between a wide range of exchange rate targets, provided that they also choose the optimal commitment to the selected target.

All these questions are explored in detail in this article. Next section presents a flexible framework to generate the set of targeting strategies. This allows to consider both nominal and real exchange rate targets. Section II describes the model, originally developed by Canzoneri & Henderson (1991). The optimal targeting strategy is derived from the concepts of incentive compatibility and Pareto optimality defined in the third section. Section IV and V develop the two stages to targeting. The conclusions summarise our results and compare them with alternative proposals of exchange rate management and to the recent experience and future prospects of the EMS.

I-The exchange rate as intermediate target

We start by considering two identical and interdependent economies (subscripts *1,2*) and their loss functions (L_1,L_2) defined so as to penalize the deviations of employment (n) and consumer prices (q) from their desired levels (superscript d). Deviations from the desired values imply welfare losses:

$$L_1=\frac{1}{2}[\sigma(n_1-n_1^d)^2+(q_1-q_1^d)^2]$$

$$L_2=\frac{1}{2}[\sigma(n_2-n_2^d)^2+(q_2-q_2^d)^2] \qquad [1]$$

The quadratic form and the arguments of these loss functions are standard in the policy coordination literature, pioneered by *H*amada (1976). Penalty values are normalized with respect to the weight of inflation in the loss function.

Each country is a player in this policy game. The policy instruments are given by the money supplies. When countries do not cooperate, they use their respective money supplies to minimize welfare losses, taking the actions of the other player as given. On the contrary, when countries explicitly cooperate, a common welfare function is jointly minimised.

The implications for the exchange rates differ, depending on the features of the model employed. In *H*amada's deterministic environment, fixing the exchange rate mimics the efficient cooperative outcome; however, in a stochastic setting with rational expectations the conclusion is not so straightforward. In the *H*enderson model (1984), shifts in demand require the exchange rate to float while shifts in asset preferences advise the use of a peg; in the case of supply shocks, there is a conflict between the preferences of the players. The Canzoneri-*H*enderson (1991) model which we use here, highlights- in the case of symmetric supply shocks- the need for a leader to determine the money supply and a follower who pegs the exchange rate, yielding an asymmetric arrangement. In general (see Gemberg (1989)), cooperation in the exchange rate management pays depending on the nature of shocks.

The diversity of results suggests that it is advisable to adopt a flexible approach to exchange rate targeting, in which the different alternatives are considered. The ERM and Bretton Woods regimes targeted the nominal exchange rate around a narrow band while the Williamson (1985) proposal advocated maintaining the real exchange rate around a predetermined level; in this case, the band was loosely defined. The 'Program for Monetary coordination' proposed by McKinnon (1984) suggested an agreement on the global money supply to maintain exchange rates fixed. This global money supply had then to be allocated between countries, on the basis of a price stability target.

The central role of the exchange rate in the practice of policy coordination emphasises the value of exchange rate targets as surrogates for explicit policy coordination. One of the main reasons is observability. In the words of Kenen

'...governments are prone to cheat and will not engage in optimal coordination because they cannot trust each other. A government cannot cheat on a firm commitment to exchange rate pegging without being caught. Therefore exchange rate pegging is viewed as a viable alternative to full-fledged coordination' (Kenen (1989),p.54).

Notwithstanding this, in the policy coordination literature the choice of the exchange rate usually appears as a by-product of the coordination solution and it is not explicitly considered. Nevertheless, a strand of this literature (see *H*ughes *H*allet et. al (1989) and, in particular, *H*ughes *H*allet (1993)) has explicitly included exchange rate targets in the policymakers optimization problem. We can justify this inclusion more formally using an analogy with the optimal contract literature, adapted to the context of policy coordination.

This literature has its origin in the credibility problem of monetary policy pointed out by Kydland & Prescott (1977) and Barro & Gordon (1983). Their contribution revealed the utility of setting up rules for the management of policy to which the monetary authority (principal) has to commit to cancel the inflationary bias in agents expectations. Barro and Gordon underlined the incentive to cheat on these rules, due to time inconsistency. This incentive problem was addressed by Rogoff (1985) which highlighted that it could be overcome if monetary policy was entrusted to the Central Bank through some kind of institutional provision regarding some intermediate target (optimal contract). If the commitment to the rule could be achieved, the incentive to renege would be eliminated[1].

In our case the contract is specified in terms of exchange rate targets, for the reasons we have mentioned above. Two sovereign countries decide to commit to an exchange rate arrangement if they are expected to gain from it; that is, the incentive problem is redefined here in terms of incentive compatibility. Note that principal-agent considerations are no central here. The behaviour of the agents is guided from their rational expectations and both players are on an equal strategic footing. Reneging on the arrangement opens the possibility of retaliation by the second country and the suspension of an agreement which is benefitial for both countries. Therefore the incentive to renege is eliminated.

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[1]-Later works refined these ideas and orientated the research to the design of institutional regulations. See Baron (1989), Walsh (1992), Lohman (1992) and Persson & Tabellini (1993)

The contract (V) is appended to the optimizing problem of the countries. Since the countries are equal from an strategic point of view, the contract is the same for both of them. The function which each country considers is then modified to become:

$$W_1 = L_1 + V$$
$$W_2 = L_2 + V$$

The contract is defined in terms of the real exchange rate (z) and enters in the optimizing problem with a weight β. More precisely, we propose a contract of the following form:

$$V = \tfrac{1}{2}\beta(z - z^d)^2$$

Countries agree on the contract at the beginning of the period in order to minimise the welfare loss derived from unanticipated shocks. The values of β and z^d *should be chosen so as to induce the optimal response of policymakers to attain their final goals: inflation and unemployment. Therefore, the exchange rate is an intermediate target* in the modified loss functions (W_1, W_2), but it is not a final goal itself.

Following Rogoff (1985) we can define the parameter or weight β as the optimal degree of commitment to the intermediate target, in this case the exchange rate. The parameter β is constrained to be positive, otherwise what is being targeted is the exchange rate to avoid!. If β were equal to zero, no constraint is imposed on the exchange rate and the result corresponds to the non-cooperative free-float solution.

The second element to define is the the choice of the exchange rate target (z^d). How do players agree on the desired level for the real exchange rate?. The exchange rate target in our model is inspired by the exchange rate arrangements mentioned above, especially on the nominal ERM regime and the Williamson proposal. The singularity of our approach is the consideration of a continuum of exchange rate targets, which spans between both alternatives. This setup allows for flexibility in the design of the contract; a feature which adds new insights to the question of exchange rate targeting.

The ERM and Williamson's proposal have in common the choice of a target exchange rate which is allowed to fluctuate within a band. If rigidity is defined with respect to the equilibrium exchange rate in terms of Purchasing Power Parity, they represent the polar choices of a rigid system with 'hard' bands and a flexible regime with 'soft' bands, respectively. This suggests the use of an approach which incorporates both of these proposals as special cases, which can be formalised as follows[2].

Let us take the real exchange rate (z) identity, in terms of purchasing power parity:

$$z=e-(p_1-p_2)$$

where p is the price level, the subscripts denote countries one and two respectively and the nominal exchange rate e, is defined as the price of country 2 currrency in terms of country 1 currency.

The ERM regime aims at maintaining a fixed nominal exchange rate parity, i.e. $e^d=0$. Substituting above, we observe that this is equivalent to a real exchange rate target equal to the negative of price differentials:

$$z^d=-(p_1-p_2).$$

The Williamson target zone on the contrary implies a desired value for the real exchange rate equal to zero $z^d=0$ or, equivalently, a depreciation of the nominal exchange rate equal to the price differentials:

$$e^d=(p_1-p_2).$$

Let us now define the parameter ρ, such that $e^d=(1-\rho)(p_1-p_2)$. Note that $(1-\rho)$ represents then the degree which the nominal exchange rate target offsets price

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[2]- Since positive values of β penalize deviations from the desired values, it represents a soft band of fluctuation for the desired exchange rate target; the larger the value of β, the narrower will be the implied band. This specification allows us to think of the targeting strategy as a target zone with soft bands, where z^d represents the central parity.

differentials. Thus, we can write the exchange rate target in general form as a function of the price differentials

$$z^{d}=e^{d}-(p_1-p_2)=-\rho(p_1-p_2) \qquad [2]$$

It immediately follows that $\rho=1$ corresponds to a nominal exchange rate target, as in the ERM regime and $\rho=0$ corresponds to the Williamson target zone, that is, a real exchange rate target. As ρ moves away from zero the desired exchange rate partially accomodates inflation differentials. These intermediate values present special interest because they provide flexibility in the choice of exchange rate target, according to the preferences of policymakers.

We can observe that the design of the targeting strategy is determined by the choice of just two parameters: ρ and β. The first specifies the extent to which the real exchange rate is the target and the second determines the degree of commitment to such a target. We will refer to them as *target parameters*. The range of parameters is constrained to positive values of β and to values of ρ between zero and one, i.e. between real and nominal exchange rate targets.

Countries can choose among a wide combination of exchange rate targets and values for β, which represent the set of targeting strategies. This set, denoted as λ can be formally defined as:

$$\lambda=\{[\beta X\rho],\ \forall\ \beta>0,\ 0\leq\rho\leq 1\}$$

In this way we have a very simple and general method to explore whether targeting the exchange rate pays when countries are placed on an equal strategic footing. When the answer is in the affirmative, our specification will be able to determine which is the optimal targeting strategy within the set. Prior to this, we have still to develop the economic model of reference and to define the concepts which will be used in the formal analysis. This is done in the two next sections.

II-The model

In this section we present the Canzoneri & Henderson (1988,1991) two-country model of symmetric monetary economies. These economies are subject to shocks on the demand (u_1,u_2) and the supply side (x_1,x_2). Rational expectations are assumed, so that only unanticipated shocks can affect equilibrium. The disaggregation of shocks and the treatment of the exchange rates introduce some minor modifications into the Canzoneri-Henderson model.

Two countries are considered, each producing a different good with the corresponding subscripts. All the variables except the interest rates are expressed in logs and represent deviations of actual values from equilibrium. Symmetry holds in the strong sense that all the parameters are the same in both countries (for the exchanges rates they have opposite signs).

The output of each country (y_i $i=1,2$ where the subscript i refers to the variable in each country) is obtained through a Cobb-Douglas production function. It is an increasing function of domestic employment n_i and it decreases when some adverse supply shock x'_i, hits the economy:

$$y_1=(1-\alpha)n_1-x'_1$$
$$y_2=(1-\alpha)n_2-x'_2$$

For convenience we present the next table presents the values and definitions of the parameters appearing in the model and those derived from the transformations which follow.

Par.	**Definition**	**Range**
$1-\alpha$	*Labour coefficient in the production function*	$0<1-\alpha<1$
ε	*Marginal propensity to spend*	$0<\varepsilon<1$
δ	*Effect of exchange rate in demand*	$0<\delta<1$
ν	*Interest rate elasticity*	$0<\nu<1$
ζ	*Share of import goods in domestic basket*	$0<\zeta<\frac{1}{2}$
γ	$\gamma=[2\delta+(1-2\zeta)^2\nu]^{-1}$	$0<\gamma<1$
ς	$\varsigma=1-(1-2\zeta)\varepsilon$	$0<\varsigma<1$
τ	$\tau=\xi\gamma\varsigma$	$0<\tau<\frac{1}{2}$
ϕ	$\phi=\tau(1-\alpha)$	$0<\phi<\zeta$

$\sqrt{\eta}$	$\sqrt{\eta}=(\alpha+\phi)^{-1}$	$0<\sqrt{\eta}<1$?
θ	$\theta=\frac{1}{2}\sqrt{\eta}\phi$	$0<\theta<\frac{1}{2}$ 1/2

Firms hire labour up to the point in which real wages equal the marginal product of labour:

$$w_1-p_1=-\alpha n_1-x'_1$$
$$w_2-p_2=-\alpha n_2-x'_2$$

where w_i and p_i are nominal wages and prices, respectively. We can assume that the supply shocks take the form of adverse labour productivity shocks. Contracts are signed at the beginning of each period, so that shocks are unanticipated. These contracts specify nominal wages and employment rules and workers agree to supply whatever quantity of labour firms want at the nominal wage specified in the contracts.

Consumer price indexes q_i are weighted averages of domestic and foreign goods prices:

$$q_1=(1-\zeta)p_1+\zeta(e+p_2)=p_1+\zeta z$$
$$q_2=(1-\zeta)p_2-\zeta(e-p_2)=p_2-\zeta z$$

The market equilibrium conditions for the demands of goods are:

$$y_1=\delta z+(1-\zeta)\varepsilon y_1+\zeta\varepsilon y_2-(1-\zeta)\nu r_1-\beta\nu r_2+u'_1$$
$$y_2=-\delta z+\zeta\varepsilon y_1+(1-\zeta)\varepsilon y_2-\beta\nu r_1-(1-\zeta)\nu r_2+u'_2$$

where r_i are the real interest rates and u_i stand for positive demand shocks. Uncovered interest parity holds, so that $r_1-r_2=z^e-z$. The superscript stands for expected value.

Finally, the equilibrium in the money market is given by the Cambridge equations:

$$m_1=p_1+y_1$$
$$m_2=p_2+y_2$$

Nominal wages are set as follows. From the output and the wages equations above, and using the money market equilibrium equations, employment can be expressed as a function of the money supplies and nominal wages.

$$n_1=m_1-w_1$$
$$n_2=m_2-w_2$$

Firms and workers choose the nominal wage that minimises the expected square deviations of employments from the full-employment value, set equal to zero. Optimizing the square of the expression above, we observe that the respective nominal wages are set equal to the expected money supplies:

$$\frac{\partial (n_1^2)^e}{\partial w_1}=w_1-m_1^e=0 \quad ; \quad \frac{\partial (n_2)^e}{\partial w_2}=w_2-m_2^e=0$$

The reduced forms are obtained by expressing all the variables of interest in terms of the instruments and the shocks. The expressions for the employments are straightforward:

$$n_1=m_1-m_1^e$$
$$n_2=m_2-m_2^e$$

The expressions for the consumer price indexes require several steps. First, we solve for the output prices and then for the exchange rates. The output prices expression is straightforward. Substituting the equilibrium values for nominal wages and the expression for employment in the product prices, we can express them in reduced form as:

$$p_1=m_1+(\alpha-1)(m_1-m_1^e)+x'_1;$$
$$p_2=m_2+(\alpha-1)(m_2-m_2^e)+x'_2.$$

To obtain the reduced form for the real exchange rate, we note first that the sum of excess demands must be zero. Substracting the expressions for the demand for goods, we obtain

$$-\varsigma(y_1-y_2)+2\delta z-(1-2\zeta)\nu(r_1-r_2)+u_1'-u_2'=0$$

Using the equations for the real exchange rate and the uncovered interest parity, the real interest differential from this expression is given by:

$$r_1-r_2=(1-2\zeta)(z^e-z)$$

Substituting this value above and eliminating y_1-y_2 with the help of the output expressions, we obtain the reduced form for the real exchange rate:

$$z=\varsigma\gamma(1-\alpha)[(m_1-m_1^e)-(m_2-m_2^e)]+(1-2\zeta)^2\nu z^e-\varsigma\gamma(x_1'-x_2')-\gamma(u_1'-u_2')$$

In this expression, we can reasonably assume that the expected real exchange rate is equal to zero ($z^e=0$). On the one hand, the expected values of the disturbances is zero; on the other hand, since nominal wages and prices are perfectly flexible, the expected real exchange rate is independent of today's money supply. Finally, the existence of an exchange rate target does not influence *'a priori'* exchange rate expectations, because they are only binding in the case of shocks.

The expression for the consumer price indexes is obtained by direct substitution:

$$q_1=m_1+(\phi+\alpha-1)(m_1-m_1^e)-\phi(m_2-m_2^e)+(1-\tau)x_1'+\tau x_2'-\zeta\gamma(u_1'-u_2');$$
$$q_2=m_2-\phi(m_1-m_1^e)+(\phi+\alpha-1)(m_2-m_2^e)+(1-\tau)x_2'+\tau x_1'+\zeta\gamma(u_1'-u_2').$$

Finally, in the appendix is shown that the expected money supplies are zero. The shocks are redefined as follows

$$x_i=\sqrt{\eta}x_i' \text{ and } u_i=\sqrt{\eta}\zeta\gamma u_i',\ i=1,2$$

and the reduced forms for the variables of interest take the following form:

$$n_1=m_1\ ;\quad n_2=m_2\cdot$$

$$q_1=(\sqrt{\eta})^{-1}[m_1-2\theta m_2+(1-\tau)x_1+\tau x_2-(u_1-u_2)]$$
$$q_2=(\sqrt{\eta})^{-1}[m_2-2\theta m_1+(1-\tau)x_2+\tau x_1+(u_1-u_2)] \qquad [3]$$
$$p_1=\alpha m_1+(\sqrt{\eta})^{-1}x_1;\quad p_2=\alpha m_2+(\sqrt{\eta})^{-1}x_2$$

The implications of the model are well-known. A domestic monetary expansion positively affects domestic employment and prices and negatively affects foreign prices; adverse supply shocks ($x_1>0$) reduce domestic output and increase domestic consumer prices through the increase in the price of the domestic good. Positive demand shocks in country one ($u_1>0$) push domestic consumer prices down because of the appreciation of the nominal exchange rate induced by the excess demand for the domestic good. More precisely, the reduced forms for the exchange rates are:

$$e=[\alpha+\varsigma\gamma(1-\alpha)](m_1-m_2)+\sqrt{\eta}^{-1}(x_1-x_2)-(\zeta\sqrt{\eta})^{-1}(u_1-u_2)$$
$$z=\varsigma\gamma(1-\alpha)(m_1-m_2)-(\zeta\sqrt{\eta})^{-1}[\tau(x_1-x_2)+(u_1-u_2)] \quad [4]$$

Finally, it is also convenient to write the real exchange rate target derived from the correction mechanism derived in the previous sections. Substituting terms we obtain:

$$z^d=-\rho[\alpha(m_1-m_2)+(\sqrt{\eta})^{-1}(x_1-x_2)]$$
$$z-z^d=[\rho\alpha+\varsigma\gamma(1-\alpha)](m_1-m_2)+(\sqrt{\eta})^{-1}[(\rho-\tfrac{\tau}{\zeta})(x_1-x_2)-\frac{u_1-u_2}{\zeta}] \quad [5]$$

From these expressions, it would be easy to derive the desired exchange rate in the face of a shock, other things being equal. However, shocks also affect the policy goals and countries react to them using their policy instruments to stabilize the economy around the desired levels. For instance, in the face of the asymmetric demand shock considered above, the domestic country has an incentive to inflate and the foreign country an incentive to disinflate. The resulting exchange rate is the result of both influences and consequently the desired exchange rate value (determined by the choice of ρ) has to be chosen so as to induce the optimal response of both countries, to stabilise the economy for any given shocks. This is the issue to be explored in the remainder of the paper.

III-Incentive compatibility and Pareto optimality

In this section we define the conditions to derive optimal targeting strategies. They are encompassed by in the requirements of sustainability and optimality. *H*owever, before reaching a formal definition we need to make use of other related concepts which are now presented.

The derivation of the model allows us to substitute the reduced forms [4,5] in the modified loss functions. Assuming that the desired inflation and unemployment levels are set equal to zero ($n_i^d=0,\ q_i^d=0, i=1,2.$), the expression to minimize turns out to be just a function of the instruments (m_1,m_2) and the different shocks.

$$W_1=L_1+V=\frac{1}{2}\{\sigma(m_1)^2+[m_1-2\theta m_2+(1-\tau)x_1+\tau x_2-(u_1-u_2)]^2+$$
$$+\beta[\sqrt{\rho'}\,(m_1-m_2)+\frac{\rho-\tau/\zeta}{\eta}(x_1-x_2)-\frac{1}{\zeta\sqrt{\eta}}(u_1-u_2)]^2\} \qquad [6]$$
$$W_2=L_2+V=\frac{1}{2}\{\sigma(m_2)^2+[m_2-2\theta m_1+(1-\tau)x_2+\tau x_1+(u_1-u_2)]^2+$$
$$+\beta[\sqrt{\rho'}\,(m_1-m_2)+\frac{\rho-\tau/\zeta}{\sqrt{\eta}}(x_1-x_2)-\frac{1}{\zeta\sqrt{\eta}}(u_1-u_2)]^2\} \qquad [7]$$
$$\textit{where} \quad \sqrt{\rho'}=\rho\alpha+\varsigma\gamma(1-\alpha)$$

The introduction of a exchange rate target in the optimization problem implies that the exchange rate target acts as an indirect cooperation device. It is indirect because the optimization problem facing each country is equivalent to the non-cooperative case; each country maximizes its welfare with respect to its instrument, taking as given the actions of the foreign country, but also taking into account the common exchange rate:

$$\frac{\partial W_1}{\partial m_1}=0 \Rightarrow R_1:\ m_1=\psi_1^{-1}\{\psi_2 m_2-[(1-\tau)+(\rho-\tfrac{\tau}{\zeta})]\psi_3 x_1+[(\rho-\tfrac{\tau}{\zeta})-\tau]\psi_3 x_2+\psi_4(u_1-u_2)\}$$

$$\frac{\partial W_2}{\partial m_2}=0 \Rightarrow R_2:\ m_2=\psi_1^{-1}\{\psi_2 m_1-[(1-\tau)+(\rho-\tfrac{\tau}{\zeta})]\psi_3 x_2+[(\rho-\tfrac{\tau}{\zeta})-\tau]\psi_3 x_1-\psi_4(u_1-u_2)\} \qquad [8]$$

$$\textit{where} \quad \psi_1=1+\sigma+\beta\rho'; \quad \psi_2=2\theta+\beta\rho'; \quad \psi_3=\frac{\beta\sqrt{\rho'}}{\sqrt{\eta}}; \quad \psi_4=1+\frac{\psi_3}{\zeta}.$$

The points where the reaction functions (R_1,R_2) intersect represent the targetting solutions. The reaction functions and the rest of concepts defined in this section are represented in figures 1 and 2, below. We operate in the $[m_1,m_2]$ space, where the ellipses are isoclines of the loss functions and the reaction functions are represented by straight lines.

The solutions depend on the parameters of the model, the shocks and the values of the target parameters; while the two former are taken as given, the latter are chosen by the authorities in some optimal way to be defined.

The choice of the target parameters in the strategy set induce a set of *targeting equilibria* which can be specified as a function of λ, $T(\lambda)=\{m_1^T,m_2^T\}$, where for convenience, here we redefine λ as the product βρ':

$$m_1^T = -\frac{[\psi_1(1-\tau)+\psi_2\tau]x_1+[\psi_1\tau+\psi_2(1-\tau)]x_2}{\psi_1^2-\psi_2^2} + \frac{[(\rho-\tau/\zeta)(\psi_2-\psi_1)\psi_3](x_1-x_2)}{\psi_1^2-\psi_2^2} +$$

$$+\frac{[\psi_4(\psi_1-\psi_2)](u_1-u_2)}{\psi_1^2-\psi_2^2} \qquad [9]$$

$$m_2^T = -\frac{[\psi_1(1-\tau)+\psi_2\tau]x_2+[\psi_1\tau+\psi_2(1-\tau)]x_1}{\psi_1^2-\psi_2^2} - \frac{[(\rho-\tau/\zeta)(\psi_2-\psi_1)\psi_3](x_1-x_2)}{\psi_1^2-\psi_2^2} -$$

$$-\frac{[\psi_4(\psi_1-\psi_2)](u_1-u_2)}{\psi_1^2-\psi_2^2}$$

It is important to explore the characteristics of the targeting solutions because they will be crucial to derive the next propositions. We show in the appendix that the set of targeting solutions is a straight line (*target line*, hereafter); More formally, it is claimed that:

<u>Proposition 1</u>: The set of targeting equilibria, T(λ), is contained in a straight line with slope equal to -1 in the $[m_1,m_2]$ space, where:

$$T(\lambda):\{(m_1^T,m_2^T) \mid m_2^T = -\frac{x_1+x_2}{1+\sigma-2\theta} - m_1^T\} \qquad \textbf{[10]}$$

One particular point of this line refers to the case in which the exchange rate is not targeted, i.e $\beta=0,\ \forall\ \rho$. This is of course the Nash non-cooperative solution $N=T(0)=\{m_1^N,m_2^N\}$ of our model[3]. In this case, where $\psi_1=1+\sigma$, $\psi_2=2\theta$, $\psi_3=0$, $\psi_4=1$, it is straightforward to see by direct substitution into [9] that:

$$m_1^N = -\frac{[(1+\sigma)(1-\tau)+2\theta\tau]x_1+[2\theta(1-\tau)+(1+\sigma)\tau]x_2-(1+\sigma-2\theta)(u_1-u_2)}{(1+\sigma)^2-(2\theta)^2}$$

$$m_2^N = -\frac{[(1+\sigma)(1-\tau)+2\theta\tau]x_2+[2\theta(1-\tau)+(1+\sigma)\tau]x_1+(1+\sigma-2\theta)(u_1-u_2)}{(1+\sigma)^2-(2\theta)^2} \qquad \textbf{[11]}$$

The set of incentive compatible solutions or *bargaining area (A)* is defined

[3]-See Canzoneri & Henderson (1991,pgs.21 and 37). They only consider symmetric supply shocks ($x_1=x_2$) and opposite demand shocks ($u_1/2=-u_2/2$). Substituting in [11] we obtain the same expressions as theirs.

as the set of points which are Pareto superior to the Nash solution:

$$A{:}\{\forall m_1,m_2 \mid W_1(m_1,m_2)\leq W_1(m_1^N,m_2^N)\ ,W_2(m_1,m_2)\leq W_2(m_1^N,m_2^N\}$$

The explicit cooperative solution is obtained by the minimization of the weighted joint loss function, with β=0, such that W^C=L^C,where δ,1-δ are the weights assigned to each country:

$$L^C=\delta L_1+(1-\delta)L_2$$

The contract curve ($C(\delta)$) is obtained by minimizing this loss function with respect to each instrument, and setting the rate of marginal substitution equal to minus one $dm_2/dm_1|_{dL=0}$=-1, so as to fulfill the condition of Pareto optimality:

$$C(\delta){:}\ \{\ m_1^C,m_2^C \mid \frac{\partial L^C}{\partial m_1^C}=-\frac{\partial L^C}{\partial m_2^C}\ \Rightarrow$$

$$\begin{aligned}\Rightarrow\Sigma_1 m_1-2\theta m_2+\delta[(1-\tau)x_1+\tau x_2]-(1-\delta)2\theta[(1-\tau)x_2+\tau x_1]-\\-(\delta+(1-\delta)2\theta)(u_1-u_2)=\end{aligned} \qquad \textbf{[12]}$$

$$\begin{aligned}=-[\Sigma_2 m_2-2\theta m_1-\delta 2\theta[(1-\tau)x_1+\tau x_2]-(1-\delta)[(1-\tau)x_2+\tau x_1]+\\+(\delta 2\theta+(1-\delta))(u_1-u_2)]\ \}\end{aligned}$$

$$where\quad \Sigma_1=\delta(1+\sigma)+(1-\delta)(2\theta)^2;\ \ \Sigma_2=(1-\delta)(1+\sigma)+\delta(2\theta)^2$$

Setting $\delta=1,(\delta=0)$, the instruments of both countries are chosen to maximize the welfare of the first (second) country. These solutions are known as *bliss points* (B_1,B_2)

$$C(1)=B_1|_{\delta=1}=\{m_1^{B1},m_2^{B1}\}=\{0,(2\theta)^{-1}[(1-\tau)x_1+\tau x_2-(u_1-u_2)]\};$$
$$C(0),B_2|_{\delta=0}=\{m_1^{B2},m_2^{B2}\}=,\{(2\theta)^{-1}[(1-\tau)x_2+\tau x_1+(u_1-u_2)],0\}$$

Since the bliss points corresponds to zero welfare losses, B_1,B_2 are placed at the center of the respective ellipses.

Finally, it is convenient to define the segment which joins the bliss points as the *bliss line (B)*. Taking the expressions for the bliss points, it is straightforward to derive the following segment:

$$\begin{aligned}&B{:}\{m_1,m_2\subset[B_1XB_2]|m_2=(\frac{(1-\tau)x_1+\tau x_2}{2\theta}-\frac{u_1-u_2}{2\theta})+bm_1\}\\&where\ \ b=-\frac{(1-\tau)x_1+\tau x_2}{(1-\tau)x_2+\tau x_1},\forall x_i\neq 0;\ \ b=1,\forall u_i\neq 0,i=1,2\end{aligned} \qquad \textbf{[13]}$$

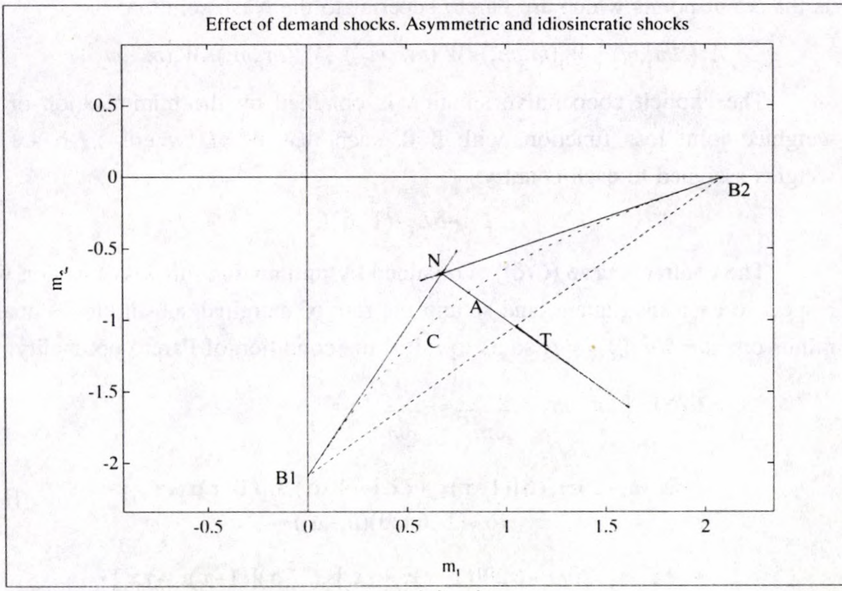

Figure 1-Strategic behaviour and demand shocks

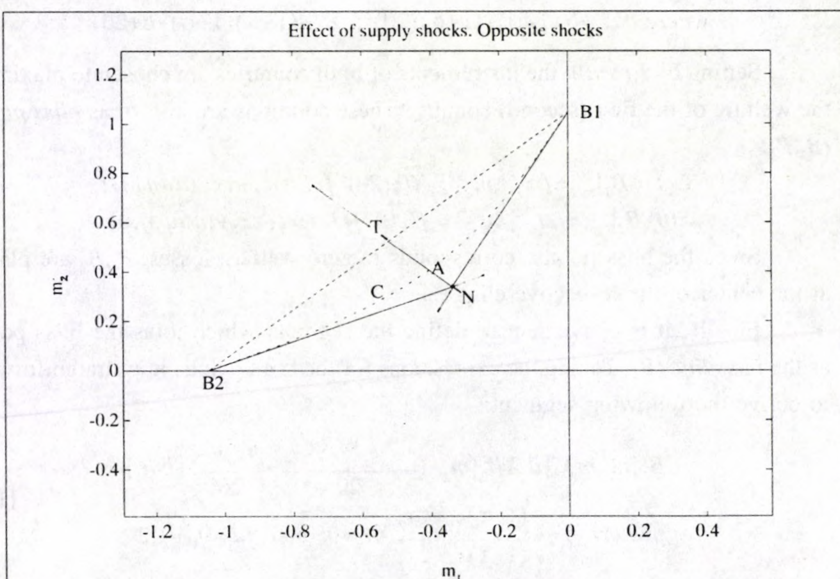

Figure 2.a-Strategic behaviour and opposite supply shocks

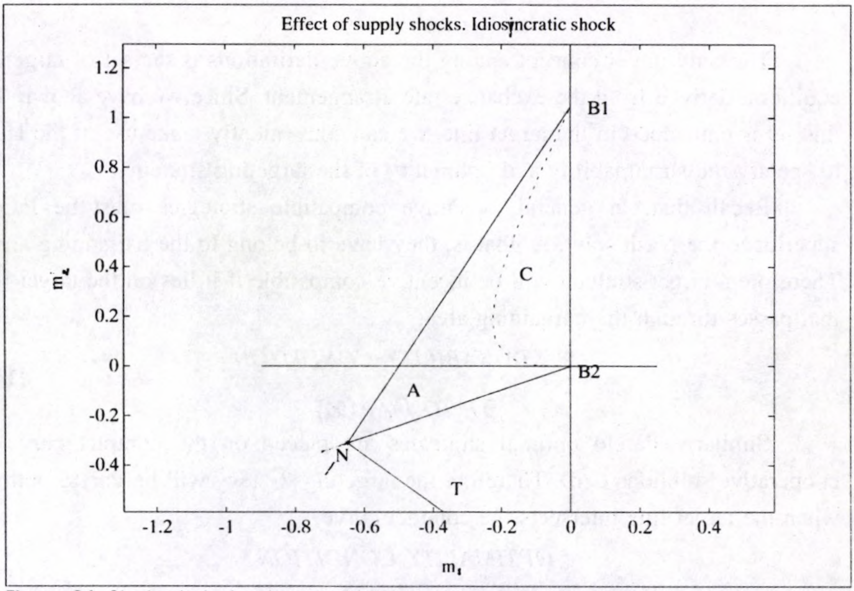

Figure 2.b-Strategic behaviour and idiosyncratic supply shocks

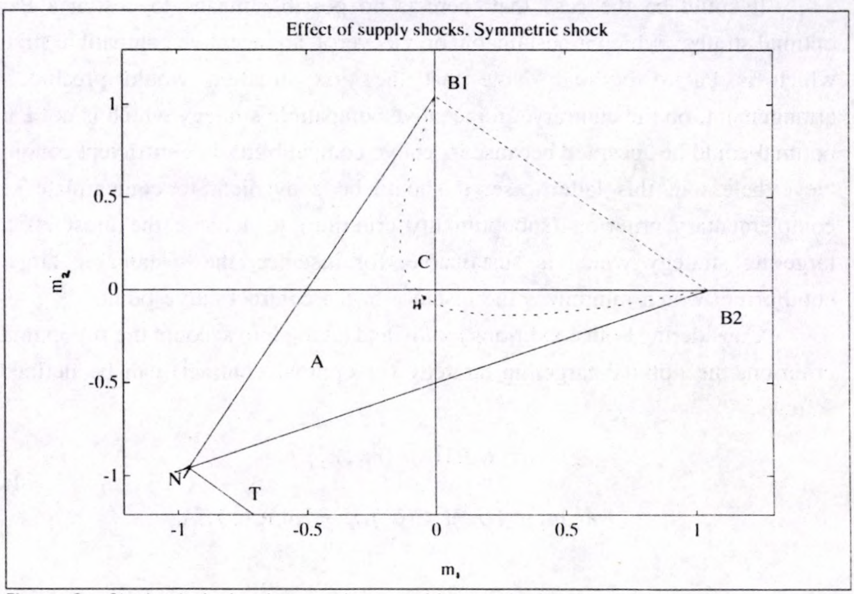

Figure 2.c-Strategic behaviour and symmetric supply shocks

The only novel concept among the above definitions is the set of targeting equilibria derived from the exchange rate arrangement. Since we have shown that this set is embedded in the target line, we can conveniently make use of the latter to specify the sustainability and optimality of the targeting strategy.

Recall that, in general, incentive compatible strategies must be Pareto superior to the Nash solution, that is, they have to belong to the bargaining area. Therefore a target strategy will be incentive compatible if it lies on the target line that passes through the bargaining area:

SUSTAINABILITY CONDITION

$$\exists \lambda \mid T(\lambda) \cap A \neq \{\varnothing\} \tag{14}$$

Similarly Pareto optimal strategies are placed on the contract curve of cooperative solutions *C(δ)*. Therefore the targeting strategy will be Pareto optimal when the target line intersects the contract curve:

OPTIMALITY CONDITION

$$\exists \lambda, \delta \mid T(\lambda) = C(\delta) \tag{15}$$

It could be the case that there is no possible means to design a Pareto optimal strategy which is sustainable or, viceversa, an incentive compatible strategy which is Pareto optimal. Note that the first situation would preclude the arrangement; on the contrary, an incentive compatible strategy which is not Pareto optimal could be accepted because incentive compatibility is a sufficient condition. Nevertheless in this latter case, it should be convenient to contemplate some complementary criterion (suboptimality criterion) to achieve the most efficient targeting strategy which is sustainable; for instance, the sustainable targeting equilibrium which minimizes the distance to the contract curve point.

Considering both conditions jointly and taking into account the suboptimality criterion, the optimal targeting strategy (or optimal contract) can be defined as follows:

$$\begin{gathered} \lambda^* | T(\lambda^*) = \{m_1^*, m_2^*\} \\ \{m_1^*, m_2^*\} = T(\lambda^*) \cap C(\delta^*), if\ T(\lambda) \cap C(\delta) \in A \end{gathered} \tag{16}$$

or, in the case that the Pareto optimal criterion cannot be fulfilled:

$$\{m_1^*,m_2^*\}=\{m_1^*,m_2^*\in A\,|\min(dist[A,C(\delta)])\}\ ,\ if\ T(\lambda)\cap C(\delta)\notin A \qquad [17]$$

IV-Economic shocks and optimal targets

Supply and demand shocks have different effects on welfare as an inspection of [6,7] reveals. Consequently, the scope for targeting may crucially depend on the type and magnitude of the shock hitting the economy. In this section we formally analyse the possibility of designing an optimal targeting strategy for the two different types of shocks we are considering. The results take the form of propositions whose proofs appear in the appendix. We will apply the above conditions when the shocks arise on the demand side and on the supply side: first, we will explore incentive compatibility, then optimality and finally the joint hypothesis.

It is important to keep in mind that in this section we focus on the whole target line, without any constraint on the target parameters. *H*owever, in the next section we will restrict the relevant subset of target strategies, which corresponds to positive values of β and ρ between zero and one[4].

Figures 1 and 2 give a flavour of the results in this section. They represent the concepts defined above in the $[m_1,m_2]$ space when different types of shocks hit the economy. We consider the case of symmetric $(x_1=x_2)$, idiosyncratic $(x_1>x_2=0,u_1>u_2=0)$ and opposite $(x_1=-x_2,u_1=-u_2)$ shocks. From the observation of the reduced forms [4,5], we can see that symmetric demand shocks (u_1-u_2) have no effect whatsoever on the economy.

Figure 1 suggests the feasibility of a targeting strategy in the case of **demand shocks** and advances the conclusions of the formal analysis below. An

[4]-Therefore, strictly speaking the propositions below are necessary but not sufficient conditions for targeting the exchange rate appropiately. Only when the value of of the targeting parameters are specified, the propositions will be completed. In the next section we will focus in more detail on the conditions for which β is positive when ρ is between zero and one. Nevertheless, we can anticipate that for demand shocks positive β can always be found, while for supply shocks the sufficient condition does not apply in all the cases.

opposite demand shock can be interpreted as a shift in demand from one to another country (from country two to country one if u_1 is positive) and an idiosyncratic shock may be the result of an expansionary fiscal policy in any of the countries.

The plot shows that the target line crosses the bargaining area (A) and the contract curve ($C(\delta)$) for both asymmetric and idiosyncratic shocks. This suggests that a incentive compatible and Pareto optimal targeting strategy can be specified. This intuition is confirmed by the formal analysis of the model, which is carried out in the appendix. The results can be summed up in the following three propositions:

Proposition 2: For demand shocks of any type or magnitude, there exists at least one exchange rate arrangement which is incentive compatible.

Proposition 3: For demand shocks of any type or magnitude, there exists one Pareto optimal exchange rate arrangement.

Proposition 4: For demand shocks of any type or magnitude, the Pareto optimal exchange rate arrangement is incentive compatible and corresponds to the point C(½), *where*

$$C(\tfrac{1}{2})=\{m_1^*,m_2^*\}\in T(\lambda)$$

$$m_1^*=\frac{(1+2\theta)(u_1-u_2)}{[\sigma+(1+2\theta)^2]}=-m_2^* \qquad \textbf{[18]}$$

The two first results are linked by proposition four which shows that whatever the demand shock, the targeting equilibrium which intersects the contract curve belongs to the bargaining area, so that the Pareto optimal equilibrium is also incentive compatible. Therefore demand shocks present no problem for the design of optimal targeting strategies.

The question is not so straightforward as in the case of **supply shocks**. The different plots of figure 2.a-c display a quite different picture: only in the case of opposite supply shocks, does the target line cross A and $C(\delta)$.

We can interpret an opposite supply shock as a shift in productivity from one country to another, due, for instance to the transfer of a industry from one country to another. More standard are the other two cases. A symmetric supply disturbance may be due to price shocks on raw materials used to produce both goods (typically an oil shock); if the shock only affects the production of one good, the case of an idiosyncratic supply shock would arise.

The mathematical analysis of the appendix shows that the case for targeting is not general in the case of supply shocks. As before, we can convey the result in three propositions:

Proposition 5: For supply shocks at least one incentive compatible exchange rate target will exists if

$$-\frac{(1+\sigma)-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau}x_i \leq x_j \leq -\frac{2\theta+(1+\sigma-2\theta)\tau}{(1+\sigma)-(1+\sigma-2\theta)\tau}x_i, \ \forall x_i>0 \ \ i,j=1,2,i\neq j$$

Proposition 6: For supply shocks there exists an optimal exchange rate target only if

$$-\frac{(1+\sigma)-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau}x_i \leq x_j \leq -\frac{2\theta+(1+\sigma-2\theta)\tau}{(1+\sigma)-(1+\sigma-2\theta)\tau}x_i, \ \forall x_i>0 \ \ i,j=1,2,i\neq j$$

Proposition 7: For ***opposite*** *supply shocks (x_1=-x_2), the Pareto optimal exchange rate arrangement is incentive compatible and corresponds to the point C(½):*

$$\forall x_1=-x_2 \Rightarrow C(\tfrac{1}{2})=\{m_1^*,m_2^*\}\in T(\lambda)$$
$$m_1^*=-\frac{(1+2\theta)(1-2\tau)x_1}{[\sigma+(1+2\theta)^2]}=-m_2^* \qquad \textbf{[19]}$$

From propositions five and six, it follows that the existence of sustainable <u>or</u> Pareto optimal targeting strategies is restricted to a range of shocks determined by the values of the rest of the parameters of the model. The parameters θ and τ are positive and less than ½ (see table) and σ is positive. Therefore, it is straightforward to show that

$$-\frac{(1+\sigma)-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau}<-1, \quad -\frac{2\theta+(1+\sigma-2\theta)\tau}{(1+\sigma)-(1+\sigma-2\theta)\tau}>-1$$

and consequently $x_1=-x_2$ always belongs to this range. The implications of this result are the following:

-Idiosyncratic and symmetric supply shocks (figures 2.b,c) preclude the design of incentive compatible or Pareto optimal targeting strategies.

-A necessary condition for the exchange rate arrangement to be incentive compatible is that the shocks are of opposite sign.

-In particular, opposite shocks (figure 2.a) allow for incentive compatible targeting strategies, for a range of parameters to be determined in the next section.

Furthermore, proposition seven states that only in the case of opposite supply shocks is the existence of an incentive compatible strategy which is Pareto optimal attainable. For the rest of the cases in the relevant range we have had to proceed by numerical simulation. The outcome depends on the values of σ and θ. In particular, for values close to the extremes of the range the Pareto optimal point does not fall within the bargaining area. In any case, for these latter situations, the suboptimality criterion indicated above (see expression [17]) can be applied and the incentive compatible targeting equilibrium which minimizes the distance to the contract curve point would be chosen.

Interpretation of the results

Note that in our model the cases for which a targeting strategy is feasible have some features in common. Comparison of figure 1 (demand shocks) with figure 2.c (opposite supply shocks) actually reveals an equivalent outcome in graphical terms. Note that in both cases, the money supplies have different signs, that is, when one country reacts by expanding and the other by contracting the money supply in the face of a shock, there is scope for an optimal targeting strategy. This suggests the following claim:

Proposition 8: ***The necessary condition for the existence of a incentive compatible or Pareto optimal exchange rate arrangement is that, for any type of shocks***

$$sign(m_N^1) \neq sign(m_N^2)$$

This conjecture is proved in the appendix. The economic significance of this result is quite clear: when the reaction of one country exerts a positive externality, that is, when the Nash response induce a move of the exchange rate in the same direction, there is scope for an optimal exchange rate strategy.

The magnitude of the desired exchange rate change is what differs between countries; for instance, in the case of a positive global demand shock *(u_1-u_2>0)*, the individual effort to depreciate the exchange rate is too cautious when countries act non-cooperatively and it will result in an insufficient depreciation, yielding an inefficient outcome. *H*owever, the joint effort to depreciate derived from the targeting strategy will induce an optimal outcome.

Note that this implies a more activist role for monetary policy derived from the targeting strategy. Comparing the expressions for the Nash solution in [11] and the optimal targeting strategy for demand and opposite supply shocks (expressions [18] and [19] respectively), we can express the latter as a function of the Nash solution; it turns out that:

$$|m_i^N| = \frac{(1-2\tau)x_i + u_i - u_j}{1+\sigma+2\theta} < |m_i^*| = \frac{(1+2\theta)(1+\sigma+2\theta)}{\sigma+(1+2\theta)^2}|m_i^N| < (1-2\tau)x_i + u_i - u_j \qquad \textbf{[20]}$$
$$i,j=1,2$$

This result shows that the optimal strategy will always imply a larger change in the money supply, both for the expansionary and the deflationary country. This result is confirmed by the graphical analysis where we can observe that, in the relevant figures, the optimal solution is more distant from the origin than the Nash solution.

Finally, the slope of the target line being equal to -1 implies that the global money supply does not change when the solution shifts from the Nash to the targeting equilibrium. More formally, the expression for the target line in [10] shows that at the targeting equilibrium the global money supply remains constant and equal to the Nash solution. For supply shocks

$$m_1+m_2=-(1-2\tau)(x_1+x_2)/(1+\sigma+2\theta)$$

and for demand shocks the global money supply is simply zero.

Thus, the effect of the targeting strategy is to allocate more efficiently a given global money supply than in a non-cooperative situation, which is a conclusion similar to McKinnon's (1984,1988) proposal for Monetary Stabilization.

V-The design of optimal targeting strategies

Up to now, we have shown the feasibility of designing optimal targeting strategies. Once the set of possible shocks has been determined, attention can be shifted to the more concrete issue of designing optimal contracts.

As a matter of fact, the analysis of the previous section is incomplete unless the characteristics of the target line in the bargaining area are determined. The position on the target line depends on the target parameters β,ρ. In principle, they are independent parameters which are chosen at the discretion of policymakers, but the range of values that each of them can take is constrained. The parameter ρ, which determines the desired exchange rate target is bounded between real and nominal exchange rate targets and β, the optimal commitment to the desired exchange rate target, must be positive[5]. Thus, the feasible range for the parameters are:

$$0\leq\rho\leq 1; \;\; \beta>0$$

We will first explore the conditions to obtain a positive degree of commitment, for the considered range of exchange rate targets and then we will specify the relationship between them.

Let us recall first that the quadratic optimization solution minimizes deviations from the desired targets; hence, when β is positive, it is obvious that the new solution must reduce the deviation from the now binding exchange rate target relative to the Nash solution, where the exchange rate is not targeted.

Therefore, comparing the effects of a particular exchange rate target at the optimal solution with the Nash solution determines the existence of a positive value for β. More precisely if

$$|(z-z^{d})^{N}|>|(z-z^{d})^{*}|\Rightarrow\beta>0 \qquad \textbf{[21]}$$

and vice versa. The appendix shows that

---

[5]-From [5],The exchange rates and the targets are defined with respect to one country. Countries one and two have then to be labelled, depending on the type of shocks, such that a nominal exchange rate target correspond to ρ=*1*, not to ρ=*-1* (the nominal exchange rate target for country two).

<u>Proposition 9</u>: *In the case of demand shocks, the degree of commitment is positive for both nominal and real exchange rate targets, that is,*

$$\forall\ 0 \le \rho \le 1 \Rightarrow |(z-z^d)^N| > |(z-z^d)^*| \Rightarrow \beta > 0 \qquad [22]$$

<u>Proposition 10</u>: *In the case of opposite supply shocks, targeting the <u>real</u> exchange rate is counterproductive (ρ=0 implies β<0), while a nominal exchange rate target may be appropriate. More precisely*

$$\forall \rho \ge \rho^+ = \frac{2\theta}{1+2\theta+\sigma/(1+2\theta)-\zeta\sqrt{\eta}} > 0 \Rightarrow |(z-z^d)^N| > |(z-z^d)^*| \Rightarrow \beta > 0 \qquad [23]$$

Thus, for demand shocks the existence of a feasible targeting strategy is confirmed, while existence is not clear for opposite supply shocks because ρ^+ may indeed be larger than one[6]. Note that expression [23] imposes an additional condition on the existence of an optimal targeting strategy (with positive β) in addition to the conditions derived in the previous section. Targeting the real exchange rate ($\rho=0$) is therefore discarded for supply shocks, because ρ^+ is strictly positive.

The optimal degree of commitment (β^*) to the exchange rate target is the value of β which attains an optimal solution for a given value of ρ. The previous expressions have shown that the sign of β depends on the value ρ. This suggests that the optimal degree of commitment (β^*) can be expressed as a function of the exchange rate target and the structural parameters of the economy: $\beta^*=f(\rho,.)$. Two of these parameters are particularly important: the weight given to the employment objective (σ) and the degree of openness of the economy (ζ).

The function $f(\rho,.)$ can be obtained as follows. The optimal money supplies in the cases of demand and opposite supply shocks must belong to the target solution which appears in [9]. Noting that $x_1=-x_2$ and

$$(\psi_1-\psi_2)/(\psi_1^2-\psi_2^2)=1+\sigma+2\theta+2\beta\rho'$$

[6]- In particular,we will see below that low levels of goods market integration (low ζ) would make even nominal exchange rates (ρ=1) inappropiate. For low values of σ, a similar result holds. See figures 3.b and 4.b.

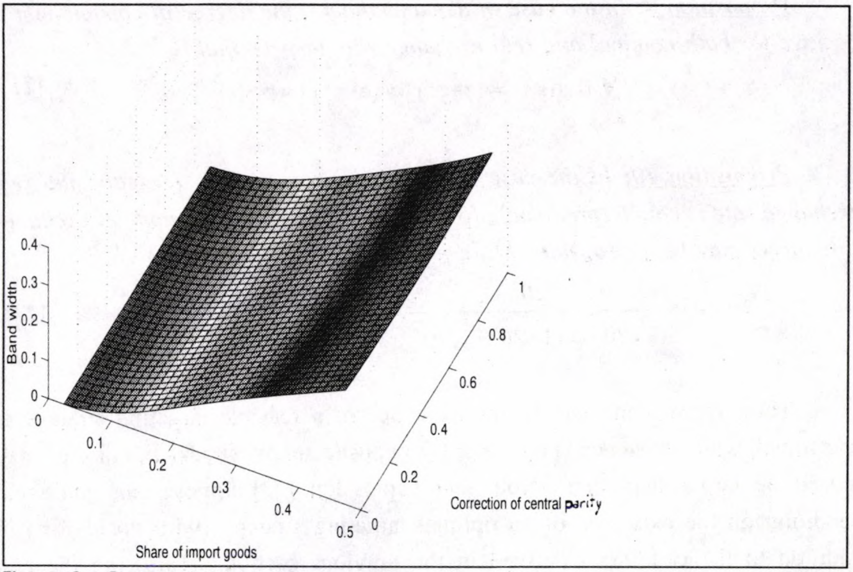

Figure 3.a-Demand shocks. Optimal commitment for a given exchange rate target when the degree of integration varies.

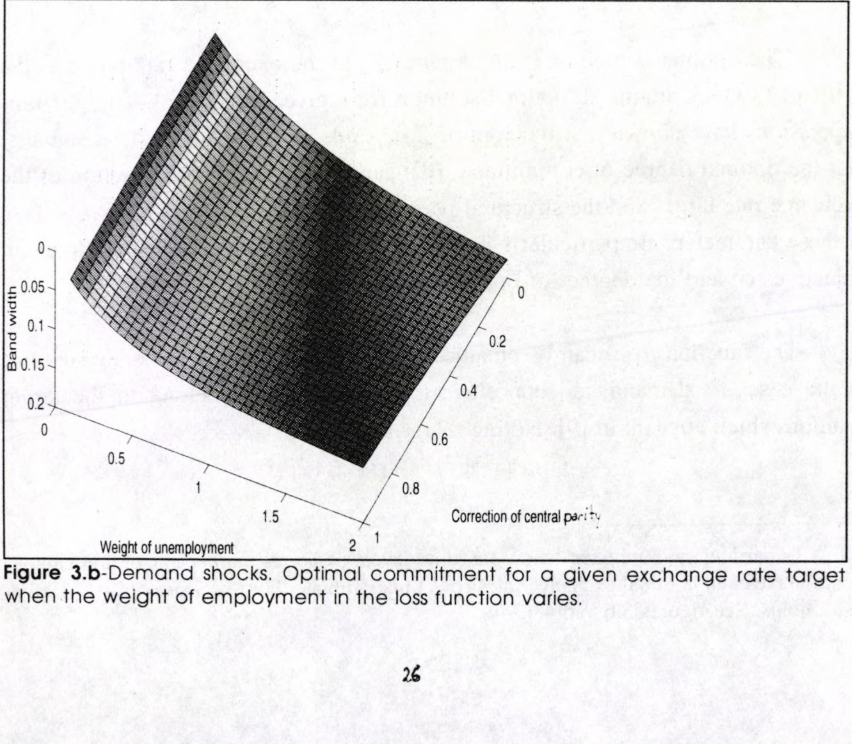

Figure 3.b-Demand shocks. Optimal commitment for a given exchange rate target when the weight of employment in the loss function varies.

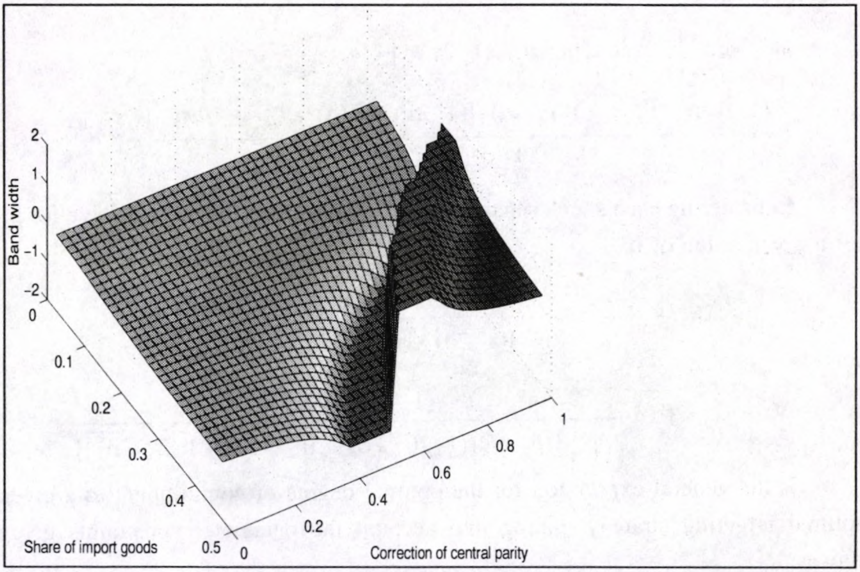

Figure 4.a-Supply shocks. Optimal commitment for a given exchange rate target when the degree of integration varies.

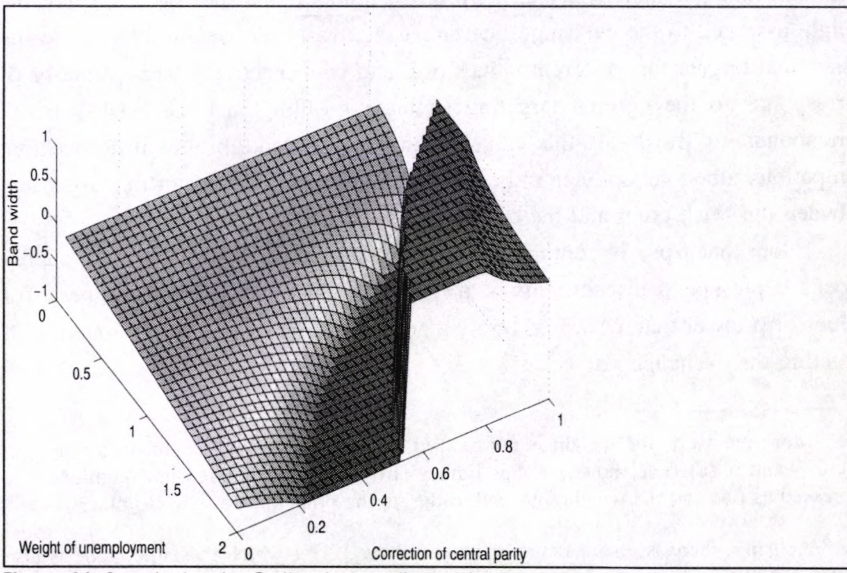

Figure 4.b-Supply shocks. Optimal commitment for a given exchange rate target when the weight of employment in the loss function varies.

it follows that:

$$m_1^*|_C = \frac{(1+2\theta)}{[\sigma+(1+2\theta)^2]}[(u_1-u_2)-(1-2\tau)x_1] =$$

$$= \frac{(1+\beta\sqrt{\rho'}/(\zeta\sqrt{\eta}))(u_1-u_2)-[(1-2\tau)+2\beta(\rho-\tau/\zeta)\sqrt{\rho'}/\sqrt{\eta}]x_1}{1+\sigma+2\theta+2\beta\rho'} = m_1^*|_T$$

Considering each shock separately, we can equate both terms to solve for β^*, for a given value of ρ:

$$\forall u_1-u_2,\quad \beta^* = \frac{\sigma 2\theta\sqrt{\eta}\,\zeta}{\sqrt{\rho'}\,[(1+2\theta)^2+\sigma)-2+\zeta\sqrt{\eta}\,(1+2\theta)\sqrt{\rho'}\,]}$$

$$\forall x_1=-x_2\ ,\ \beta^* = \frac{(1-2\tau)\sigma 2\theta\sqrt{\eta}}{2\sqrt{\rho'}\,[(\rho-\tau/\zeta((1+2\theta)^2+\sigma)-\sqrt{\eta}\,(1+2\theta)(1-2\tau)\sqrt{\rho'}\,]}$$

is the general expression for the optimal degree of commitment to a given optimal targeting strategy, taking into account the parameter constraints given above.

Given the complexity of the expression, it is helpful to plot $f(\rho,.)$ for the most relevant parameters: $f(\rho,\zeta,.)$, $f(\rho,\sigma,.)$. Figures 3,4.a and 3,4,b. display the weight assigned to the exchange rate target relative to the weight attached to the other final targets for different values of ζ and σ, respectively[7]. The value of β^* corresponds to the optimal targeting strategy; recalling that the Nash solution corresponds to $\beta^*=0$, all the values between zero and β are also incentive compatible, albeit suboptimal and corresponding to the segment of the target line between the Nash point and the contract curve in the figures 1 and 2[8].

Note that $f(\rho,.)$ is continuous for demand shocks, but for opposite supply shocks it presents a discontinuity at $\rho=\rho^+$ (the vertical plane in the figures); for values of ρ lower than ρ^+ would imply a negative β^*, precluding the possibility of targeting the exchange rate.

---

[7]-More precisely, the weight is normalized relative to the unemployment penalty . In figure 3 and 4 (a) $\sigma=1$; however, but figures (b) the optimal degree of commitment is expressed as β/σ and the weight attached to the to the price objective is $1/\sigma$ otherwise.

[8]-Actually, there is also a range of values above β^* for which the target zone is also sustainable. This range corresponds to the segment of the target line between the contract curve and the outer limit of the bargaining area in figures one and two.

It may also be interesting to comment briefly the consequences of changes in the relevant parameters for the targeting strategy. The derivatives of β with respect to these parameters are:

Demand shocks

$$\frac{\partial\beta}{\partial\zeta}>0;\frac{\partial\beta}{\partial\sigma}<0;$$

Supply shocks$(\forall\beta>0)$

$$\frac{\partial\beta}{\partial\zeta}<0;\frac{\partial\beta}{\partial\sigma}<0$$

The effects of the level of market integration (ζ) on the targeting strategy are different, depending on the type of shocks. We already mentioned that low and medium values of ζ preclude exchange rate targets in the case of opposite supply shocks. For demand shocks, we observe that higher levels of integration which increase the spillover effects call for tighter exchange rate targets (larger β), as intuition suggests.

The parameter σ-the weight assigned to the employment goal- has equivalent effects for both cases. Let us note from [6,7] that the unemployment goal penalizes any deviation of the money supplies from zero. Since the optimal policy is more activist than the Nash solution, an increase in σ will reduce the need for targeting.

A first apparent result is that in the case of demand shocks (Fig 3,a.b) the emphasis on targeting is less than that on the final goals in L_1,L_2; this seems reasonable, given that the exchange rate is an intermediate objective,. For opposite supply shocks this is also the general result, although for values of ζ close to the discontinuity term, we find $\beta^*>1$.

Another interesting feature of the outcome is that it depends on the type of shock affecting the economy, but not on the magnitude nor the sign of the shocks. This is a result which is also found in the existing policy coordination literature, and it greatly facilitates the design of the optimal contract. As a matter of fact, for any demand shock the formula above can be applied; for supply shocks, we already know that only in certain cases will it be possible to find an optimal targeting strategy. In this case, the corresponding expression can be applied. Otherwise, an alternative type of targeting strategy should be employed, as we observed above.

The third and most relevant conclusion of this analysis is that there is not an unique optimal design for the exchange rate target. Although the optimal degree of commitment is determined by [24], it ultimately depends on the definition of the optimality embraced by the policymakers who can choose between different combinations of commitment and exchange rate targets given the function *f(ρ,.)*. This trade-off is conveyed in the derivative of β* with respect to ρ in [24] and it gives an idea of the type of targeting strategy to adopt:

$$\textit{Demand shocks}: \frac{\partial \beta^*}{\partial \rho} > 0;$$

$$\textit{Supply shocks}: \frac{\partial \beta^*}{\partial \rho} < 0 \;, \forall \beta^* > 0$$

If the policymaker's goal is to design a target zone which minimizes exchange rate volatility relative to the desired target, the higher β*, the better. On the contrary, if the aim is to provide exchange rate flexibility reaping the full benefits of coordination, the value of ρ which allows for the highest exchange rate flexibility will be chosen. According to this second criterion, a real exchange rate target would be the optimal choice in the case of demand shocks while for the case opposite supply shocks, a nominal peg would be the solution.

VI-Conclusions. The need for flexibility

Welfare considerations should be the basis for any exchange rate arrangement among countries. Consequently, exchange rate targets which are not incentive compatible cannot be sustained. Given this idea we have set up a framework for analysing exchange rate targeting in the form of an optimal contract between countries which are on an equal strategic basis.

The exchange rate target is viewed as an intermediate objective. The policymakers in order to attain their final targets, agree on a targeting strategy consisting of a desired exchange rate target and their optimal commitment to it. The approach allows us to design simple rules which do not depend on the nature of the shock, but on its magnitude and this appears to be general enough to encompass all reasonable exchange rate arrangements.

Despite this generality, targeting the exchange rate in such a way turns out not to be always appropiate. While for demand shocks of any type or magnitude an optimal contract can be devised, for supply shocks the answer depends on their differential impact on each country. The reason is that the optimal contract can only be designed when both countries are interested in moving the exchange rate in the same direction; this is the case of demand shocks and opposite supply shocks. Even in this latter case, the feasibility of the targeting strategy may be constrained by the structural parameters of the model.

The assumption of an identical strategic role for each country in the targeting strategy turns out to be a crucial feature. The resulting optimal contract allocates a fixed global money supply more efficiently than in a non-cooperative Nash situation but it does not pay when the reactions of one country exert a negative externality on the other country.

The following table compare our results with those of Canzoneri and Henderson (1991). It is interesting to make this comparison, not only because the model is the same but also because they devise a different type of targeting strategy.

TARGETING STRATEGY

<table>
<tr><th colspan="2">DOES TARGETING PAY ?</th><th>OPTIMAL CONTRACT (Our model)</th><th>LEADER-FOLLOWER (Canz&Hen)</th></tr>
<tr><td rowspan="3">S
H
O
C
K
S</td><td>DEMAND SHOCKS (u)</td><td>General
YES</td><td>General
YES, but suboptimal</td></tr>
<tr><td rowspan="2">SUPPLY SHOCKS (x)</td><td>Opposite shocks
YES
(but parameter dependent and may be suboptimal)</td><td rowspan="2">Symmetric shocks
YES</td></tr>
<tr><td>Rest of cases
NO</td></tr>
</table>

Canzoneri and Henderson consider an exchange rate target from strategically asymmetric perspective, where one country (the follower) pegs the exchange rate to the leader. The leader sets the value of its money supply to minimize its own welfare function and the follower only cares about maintaining the parity. Note that in this situation, there is no exchange rate arrangement but simply an unilateral exchange rate peg by the follower.

In the table we observe that this asymmetric strategy pays in the case of symmetric supply shocks. In this case, as it is apparent in figure 2,a. both countries respond by changing their money supplies in the same direction, provoking an overshooting of the exchange rate with respect to the efficient solution. Therefore, the result of a leader-follower strategy is to offset this negative externality and place the economy on the point *H*, which is optimal.

Note that in this case, the existence of a leader exerts a disciplinary effect on the actions of the follower because changes in the money supplies are smaller. Thus, when the optimal response to a shock requires a restraint or discipline in the management of the money supply a leader-follower strategy is desirable because the leader provides an anchor to the monetary policy. From the table we can observe that this is the only situation in which the Canzoneri-*H*enderson strategy is superior.

*H*owever, when countries act on an equal strategic basis, they can only agree on an optimal contract which has the same effect on the behaviour of both countries; in this case, no disciplinary effect can be attained. Therefore, the optimal contract strategy may only be beneficial when a more activist response is required. This implies that our alternative dominates for demand and opposite supply shocks[9].

These results emphasize the importance of the environment to design exchange rate regimes. The risks of devising a targeting strategy in inappropiate circumstances becomes apparent. The rules and goals with which the arrangements were conceived may not apply in practice and the likely result is a collapse of the system.

[9]-As we have mentioned, Canzoneri and Henderson only consider shifts in demand (opposite demand shocks) and common (symmetric) supply shocks. Notwithstanding this, the results for the demand shocks can be generalised, as it suggested by the table.

The principle which has guided this research is that a more flexible approach to exchange rate management is advisable. In the light of the subsequent analysis, the advantages of flexibility are manifest.

On the one hand, there is a flexibility of response. Our outcome suggests that the adequate targeting strategy depends on the type of shock hitting the economy: in certain situations it will be convenient to adopt a leader-follower strategy; in others, both countries should play an equal strategic role; in this latter cases, sometimes it will be convenient to target the real exchange rate, in others it may be possible to target both, etc. Thus, a flexible approach to exchange rate targeting may cover most of the possible range of shocks.

On the other hand, there is a flexibility of design. We have shown that the trade-off between the exchange rate target and the optimal commitment to it leaves some room for discretion in the choice of the target to policymakers, as long as the optimal degree of commitment to the selected target is chosen.

We have not shown a general dominance of a nominal exchange rate target on a real target or vice-versa. Indeed, we have proved that in certain cases (demand shocks) both are valid and in others neither of them is (a wide range of supply shocks). Only for the case of opposite supply shocks the nominal exchange rate target-if any- is superior to a real exchange rate target. As we have mentioned, our results encompass McKinnon's proposal because the global money supply target can be agreed beforehand and then allocated according to the optimal strategy. *H*owever, the choice of final targets also includes here unemployment explicitly, not only prices, as in MacKinnon's formulation.

The message from this paper is then twofold:

-First, it is the economic and not the political environment which should determine the targeting strategy. Therefore, when the outcome of the bargaining process does not adjust to the economic demands the system will be inadequate and it is no wonder that it cannot satisfy the goals for which it was originally devised. This remark recognises the objective difficulties to designing optimal exchange rate targets.

-Second, the nature of the regime should be revised when the economic environment or the goals of the system change.

These conclusions provide ammunition against the excessive rigidity envisaged in the new EMS. On the one hand, major demand shocks as German reunification are at odds with a nominal target plus narrow bands; The optimal response would have been a move to a real exchange rate target or a widening of the band, as the markets ultimately achieved through the crisis of 1992-93. On the other hand, when the emphasis shifts from exchange rate stability to inflation convergence to attain a Common Currency, a reflection on the adequacy of the old rules is in order.

It goes without saying that the convergence process needed in Europe to attain a common currency includes dynamic considerations which fall beyond the scope of this analysis. In the conclusions to the dissertation we will examine possible extensions to improve on this analysis and reconcile it with the previous work. We have also omitted the issue of policy delegation as a means by which conducting policy. The concept of the optimal contract is assumed in our approach to concern sovereign countries, tied by a commitment to respect the contract. This contract could also have been viewed as the constitution of a supranational Central Bank, which in a first stage has the responsability to monitor the behaviour of the exchange rate between the countries, much in the way that the European Monetary Institute is supposed to operate at present.

All in all, we wish to point out that in the transition to a Common Currency, where sound stabilization strategies are required, some sort of exchange rate management is clearly needed. From the analysis above, we suggest that the approach be flexible and adapted to the circumstances.

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Appendix

This appendix shows that expectation on money supplies equal zero and develops the proofs to propositions one to ten.

Money supply expectations

Substituting the reduced forms in which expectations explicitly appear in the functions to optimize and taking the derivative with respect to the instruments, we obtain:

$$\frac{\partial W_1}{\partial m_1}=0 \Rightarrow \sigma(m_1-m_1^e)+\eta(\phi+\alpha)(m+(\phi+\alpha-1)(m_1-m_1^e)-$$

$$-\phi(m_2-m_2^e)+(1-\tau)x_1'+\tau x_2'-\zeta\gamma(u_1'-u_2')+$$

$$+\beta\{\sqrt{\rho'}\ [(m_1-m_2)-(m_1^e-m_2^e)]+(\rho-\tfrac{\tau}{\zeta})(x_1'-x_2')-\gamma(u_1'-u_2')\}=0$$

$$\frac{\partial W_2}{\partial m_2}=0 \Rightarrow \sigma(m_2-m_2^e)+\eta(\phi+\alpha)(m+(\phi+\alpha-1)(m_2-m_2^e)-$$

$$-\phi(m_2-m_2^e)+(1-\tau)x_2'+\tau x_1'+\zeta\gamma(u_2'-u_1')+$$

$$+\beta\{\sqrt{\rho'}\ [(m_1-m_2)-(m_1^e-m_2^e)]+(\rho-\tfrac{\tau}{\zeta})(x_1'-x_2')-\gamma(u_1'-u_2')\}=0$$

Taking expectations from these expressions, and noting that xie=u_i^e=0, i=1,2, because they represent unanticipated shocks, it is straightforward to conclude that the expected money supplies equal zero. Setting $m_1^e=m_2^e=0$ the reduced forms net of expectation which appear in [4,5] are obtained.

Proof to proposition 1 (Target line)

The slope of $T(\lambda)$ in the $[m_1,m_2]$ space is obtained by the cocient of the derivatives of the target solutions appearing in [9] with respect to λ:

$$dm^T_2/dm^T_1=[\partial m^T_2/\partial\lambda]/[\partial m^T_1/\partial\lambda].$$

Let us consider the different terms in equation [9]. We observe that the last two terms in the expressions ,and consequently their partial derivatives, are equal and of opposite sign.

On the contrary, the first term is different in both expressions. Let us denote these term as m_{11}^T, m_{21}^T, respectively and let us express x_2 in terms of x_1, $x_2=Kx_1, K \in \mathbb{R}$. Taking the partial derivative with respect to β of $m_1^T(t1), m_2^T(t1)$, we get:

$$\frac{\partial m_{11}^T}{\partial \lambda} = \frac{(1-K)(1-2\tau)(1+\sigma-2\theta)^2}{[(1+\sigma+\beta\rho')^2-(2\theta+\beta\rho')^2]^2} = -\frac{\partial m_{21}^T}{\partial \lambda}$$

Therefore

$$dm^T_2/dm^T_1=[\partial m^T_2/\partial\lambda]/[\partial m^T_1/\partial\lambda]=-1$$

Finally, from [11] the Nash solution is known to represent one point in this line, so that we can derive the equation of the straight line:

$$T(\lambda):\{(m_1^T, m_2^T) \mid m_2^T = -\frac{x_1+x_2}{1+\sigma-2\theta} - m_1^T\}$$

<u>Proofs to propositions 2 and 5. (Incentive compatibility)</u>

Taking as reference the m_1-axis, the slope of the target line is equal to -1, so that $tg(\omega_T)=-1$, where $\omega_T=135°,315°$ and ω represents the angle formed by the tanget line and the m_1-axis at the Nash point.Let us note first that the bargaining area, A, is formed by the area within the ellipses crossing at the Nash solution (N). Thus A is placed between the tangent lines to the two ellipses at N. Secondly, from [10,11], N is known to be a point on the target line. Therefore, as the figures suggest, if the target line lies between the angle formed by those two tangents: $\omega_{Wi}<\omega_T<\omega_{Wj}$, $\{i,j\}=1,2$, the target line will cross the bargaining area. The general expression for the ellipses slope at Nash point are given by:

$$\frac{dm_2}{dm_1}\Big|_{dW_1=0} = -\frac{\partial W_1/\partial m_1}{\partial W_1/\partial m_2} = \frac{(1+\sigma)m_1^N - 2\theta m_2^N + (1-\tau)x_1 + \tau x_2 - (u_1-u_2)}{2\theta[m_1^N - 2\theta m_2^N + (1-\tau)x_1 + \tau x_2 - (u_1-u_2)]}$$

$$\frac{dm_2}{dm_1}|_{dW_2=0}=-\frac{\partial W_2/\partial m_1}{\partial W_2/\partial m_2}=\frac{(1+\sigma)m_2^N-2\theta m_1^N+(1-\tau)x_2+\tau x_1+(u_1-u_2)}{2\theta[m_2^N-2\theta m_1^N+(1-\tau)x_2+\tau x_1+(u_1-u_2)]}$$

Let us consider first <u>*demand shocks*</u> *($x_1=0,x_2=0$). Substituting the Nash solution [11] into the previous expression, we obtain*

$$\frac{dm_2}{dm_1}|_{dW_1=0}=-\frac{0}{\sigma}(u_1-u_2)=0\ ;\quad \frac{dm_2}{dm_1}|_{dW_2=0}=\frac{\sigma}{0}(u_1-u_2)=\infty$$

The angles formed by these tangent lines depend on the sign of (u_1-u_2). In particular, for the ellipse corresponding to W_1:

$$\forall u_1,u_2, \lim_{m_1\to m_1^N}\frac{dm_2}{dm_1}|_{dW_1=0}=0\Rightarrow tg(\omega_{W_1})=0$$

and $\exists\varepsilon>0\ |$

$$\forall u_1-u_2<0, m_1\in +[m_1^N-\varepsilon, m_1^N],\ \Rightarrow\frac{dm_2}{dm_1}|_{dW_1=0}>0\ ;$$

$$\forall u_1-u_2>0, m_1\in [m_1^N-\varepsilon, m_1^N],\Rightarrow\frac{dm_2}{dm_1}|_{dW_1=0}<0.$$

Thus $\forall u_1-u_2<0, \omega_{W_1}=0°=360°;\ \forall u_1-u_2>0, \omega_{W_1}=180°$

and for the second ellipse W_2:

$$\forall u_1,u_2, \lim_{m_1\to m_1^N}\frac{dm_2}{dm_1}|_{dW_2=0}=\infty\Rightarrow tg(\omega_{W_1})=\infty$$

and $\exists\varepsilon>0\ |$

$$\forall u_1-u_2<0, m_2\in +[m_2^N-\varepsilon, m_2^N],\ \Rightarrow\frac{dm_1}{dm_2}|_{dW_1=0}<0\ ;$$

$$\forall u_1-u_2>0, m_2\in [m_2^N-\varepsilon, m_2^N],\Rightarrow\frac{dm_1}{dm_2}|_{dW_2=0}>0.$$

Thus $\forall u_1-u_2<0, \omega_{W_2}=90°\ ;\ \forall u_1-u_2>0, \omega_{W_1}=270°$

It follows then that

$$\forall u_1-u_2<0\Rightarrow\omega_{W_2}<\omega_T<\omega_{W_1};$$
$$\forall u_1-u_2>0\Rightarrow\omega_{W_1}<\omega_T<\omega_{W_2}$$

and the target line is precisely the bisectrix of the angle formed by the tangents to both ellipses. Thus, the target zone will always cross the bargaining area.#

Proceeding as before we obtain for <u>*supply shocks*</u> *($u_1=0, u_2=0$):*

$$\frac{dm_2}{dm_1}\Big|_{dW_1=0} = -\frac{0}{\sigma 2\theta[(1+\sigma)x_1+2\theta x_2+(1+\sigma-2\theta)\pi(x_2-x_1)]} = 0$$

$$\frac{dm_2}{dm_1}\Big|_{dW_2=0} = -\frac{\sigma 2\theta[(1+\sigma)x_2+2\theta x_1+(1+\sigma-2\theta)\pi(x_1-x_2)]}{0} = \infty$$

Applying the same reasoning, we have for W_1 and W_2, respectively:

$$x_2 \le -\frac{1+\sigma-(1+\sigma-2\theta)\pi}{2\theta+(1+\sigma-2\theta)\pi}x_1 \Rightarrow \omega_{W_1}=0°=360° \;;\; x_2 \ge -\frac{1+\sigma-(1+\sigma-2\theta)\pi}{2\theta+(1+\sigma-2\theta)\pi}x_1 \Rightarrow \omega_{W_1}=180°$$

$$x_2 \le -\frac{2\theta+(1+\sigma-2\theta)\pi}{1+\sigma-(1+\sigma-2\theta)\pi}x_1 \Rightarrow \omega_{W_2}=90° \;;\; x_2 \ge -\frac{2\theta+(1+\sigma-2\theta)\pi}{1+\sigma-(1+\sigma-2\theta)\pi}x_1 \Rightarrow \omega_{W_2}=270°$$

Looking at the table of parameters in the text, it is straightforward to show that $2\theta+(1+\sigma-2\theta)\tau<(1+\sigma)-(1+\sigma-2\theta)\tau$. Thus, the following cases arise:

$\forall x_1<0$:

(a) $$-\frac{2\theta+(1+\sigma-2\theta)\pi}{1+\sigma-(1+\sigma-2\theta)\pi}x_1 \le x_2 \le -\frac{1+\sigma-(1+\sigma-2\theta)\pi}{2\theta+(1+\sigma-2\theta)\pi} \Rightarrow tg(\omega_{W_1})=360°; tg(\omega_{W_2})=270°$$

(b) $$x_2 > -\frac{1+\sigma-(1+\sigma-2\theta)\pi}{2\theta+(1+\sigma-2\theta)\pi} \Rightarrow tg(\omega_{W_1})=180°; tg(\omega_{W_2})=270°$$

(c) $$x_2 < -\frac{2\theta+(1+\sigma-2\theta)\pi}{1+\sigma-(1+\sigma-2\theta)\pi} \Rightarrow tg(\omega_{W_1})=360°; tg(\omega_{W_2})=90°$$

$\forall x_1>0$:

(a) $$-\frac{1+\sigma-(1+\sigma-2\theta)\pi}{2\theta+(1+\sigma-2\theta)\pi}x_1 \le x_2 \le -\frac{2\theta+(1+\sigma-2\theta)\pi}{1+\sigma-(1+\sigma-2\theta)\pi} \Rightarrow tg(\omega_{W_1})=90°; tg(\omega_{W_2})=270°$$

(b) $$x_2 < -\frac{1+\sigma-(1+\sigma-2\theta)\pi}{2\theta+(1+\sigma-2\theta)\pi} \Rightarrow tg(\omega_{W_1})=360°; tg(\omega_{W_2})=90°$$

(c) $$x_2 > -\frac{2\theta+(1+\sigma-2\theta)\pi}{1+\sigma-(1+\sigma+2\theta)\pi} \Rightarrow tg(\omega_{W_1})=180°; tg(\omega_{W_2})=270°$$

Thus, the target zone constitutes the bisectrix of the angle formed by the tangents to both ellipses in cases labelled (a); for the rest of cases, the target line is perpendicular to the bisectrix and consequently are ruled out. The range of shocks for which, the target zone crosses the bargaining area can then be *established:*

$$\forall x_i>0, i,j=1,2, i\neq j,\ if -\frac{(1+\sigma)-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau}x_i \leq x_j \leq -\frac{2\theta+(1+\sigma-2\theta)\tau}{(1+\sigma)-(1+\sigma-2\theta)\tau}x_i \Rightarrow \exists\lambda \mid T(\lambda)\cap A$$

#

<u>*Proof of propositions 3 and 6 (Pareto optimal points)*</u>

Let us consider the bliss line B, instead of the contract curve, since the latter is too complex to work with. As a previous step, it is claimed that if the target line intersects the bliss line it also implies intersects the contract curve. We prove this claim as follows.

Since the contract curve, the target line and the bliss line are continuous and differentiable, we can express:

$m_2^C=f(\delta)$ *as a function of* $m_1^C=g(\delta)$: $m_2^C=f(g^{-1}(m_1^C)=C'(m_1^C)$

$m_2^T=f'(\lambda)$ *as a function of* $m_1^T=g'(\lambda)$: $m_2^T=f'(g'^{-1}(m_1^T)=T'(m_1^T)$

m_2^B *as a function of* m_1^B: $m_2^B=B(m_1^B)$

Then the lemma below, based on the Bolzano-Weierstrass theorem can be directly applied and our claim is proved.

The coordinates for which T=B are now found for the two different types of shocks. The intersection between T and B is obtained by equating expressions [10] and [13].

For <u>demand shocks</u> ($x_1=0, x_2=0$)*, we get*

$$m_1^T=m_1^B=\frac{1}{2}\frac{u_1-u_2}{2\theta};\ m_2^T=m_2^B=-\frac{1}{2}\frac{u_1-u_2}{2\theta}$$

which corresponds precisely to the middle point of the bliss line. Thus, in the case of demand shocks the target line will always cross the contract curve.

The resolution is more complex when <u>supply shocks</u> hit the economies ($u_1=0, u_2=0$)*. Equating the target and bliss lines, the solution is given by*

$$m_1^T=m_1^B=-\left[\frac{(1+\sigma)x_1+2\theta x_2}{2\theta(1+\sigma-2\theta)}+\frac{\tau(x_2-x_1)}{2\theta}\right]\frac{(1-\tau)x_2+\tau x_1}{(1-2\tau)(x_2-x_1)};$$

$$m_2^T=m_2^B=\left[\frac{(1+\sigma)x_2+2\theta x_1}{2\theta(1+\sigma-2\theta)}+\frac{\tau(x_1-x_2)}{2\theta}\right]\frac{(1-\tau)x_1+\tau x_2}{(1-2\tau)(x_2-x_1)}$$

where it is not straightforward to ascertain whether this point falls within the relevant segment of the bliss line. Thus, all the possible combinations of supply shocks are examined to obtain the range of shocks which make the target line to intersect the bliss segment. The solution turns out to be given by the following range:

$\forall x_i > 0, i,j=1,2, i\neq j,$

$$if - \frac{(1+\sigma)-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau} x_i \le x_j \le - \frac{2\theta+(1+\sigma-2\theta)\tau}{(1+\sigma)-(1+\sigma-2\theta)\tau} x_i \Rightarrow \exists \lambda,\delta \mid T(\lambda)=C(\delta)$$

the same than above#

Lemma (Bolzano-Weierstrass)

The lines $C(\delta)$ and B have at least two common points at $\delta=0$, $\delta=1$. Then,

$$if\ \exists m_1' \mid T(\lambda)=B \Rightarrow \exists m_1'' \mid T(\lambda)=C(\delta).$$

PROOF: The claim is that $\exists m_1'' \mid (T'-C')m_1''=0$.

Adding and substracting B, we get $(T'-B+B-C')m_1''$

Let us assume that $\exists m_1' \mid B(m_1')=T'(m_1')=m_2'$.

Recall that $C(0)=B_2, C(1)=B_1$ so that $(C'-B)m_1^{B1}=(C'-B)m_1^{B2}=0$.

Since B_2, B_1 are the extremes of the bliss line, this implies that if

$$B(m_1^{Bi})=C'(m_1^{Bi})>T'(m_1^{Bi}), B(m_1^{Bj})=C'(m_1^{Bj})<T'(m_1^{Bj}), i,j=\{1,2\}, i\neq j$$

it follows that

$$\exists\, m_1'' \mid C'(m_1'')=T'(m_1'')$$

by Bolzano-Weierstrass, and the lemma is proved #.

Proof of proposition 4 (and 7). (Optimal and incentive compatible points)

From [10], we observe that the $m_1^T=-m_2^T$ on the target line in the absence of supply shocks. Substituting m_1 for $-m_2$ in the first order conditions of the cooperative solution (which correspond to the left-side term and right-side term of the expression for $C(\delta)$ in [12]) and substituting Σ_i for the respective values, the following equalities must hold:

$$[\delta(1+\sigma)+(1-\delta)(2\theta)^2+2\theta]m_1^T=(\delta+(1-\delta)2\theta)(u_1-u_2);$$
$$[(1-\delta)(1+\sigma)+\delta(2\theta)^2+2\theta]m_1^T=(\delta 2\theta+(1-\delta))(u_1-u_2)$$

Given the demand shocks, this is a non-linear system in δ *and* m_1^T. *However, we showed that T intersects the bliss line at the middle point; this suggest that a reasonable value for solving the system is* $\delta=1/2$. *Substituting this guess above, it is immediate to see that* $\delta=1/2$ *satisfy both equations. The Pareto optimal point on the target line is then given by:*

$$C(\tfrac{1}{2})=\{m_1^*,m_2^*\}\in T(\lambda)$$

$$m_1^*=\frac{(1+2\theta)(u_1-u_2)}{[\sigma+(1+2\theta)^2]}=-m_2^*$$

Substituting N and C(1/2) in the loss functions, the welfare loss is obtained:

$$W_1^N=W_2^N=\frac{\sigma}{2}\frac{1+\sigma}{(1+\sigma+2\theta)^2}(u_1-u_2);$$

$$W_1^*=W_2^*=\frac{(1+\sigma+2\theta^2)}{(1+\sigma+2\theta)^2+(2\theta)^2\sigma}W_1^N\Rightarrow$$

$$\Rightarrow W_i^*<W_i^N,\ i=1,2$$

and consequently the Pareto optimal point is incentive compatible. #

<u>Proof of proposition 8 (Positive externality)</u>

Substituting the value of the shocks in the Nash solution [11] we get

$$\forall x_i>0, x_j\notin[-\frac{1+\sigma-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau}x_i,-\frac{2\theta+(1+\sigma-2\theta)\tau}{1+\sigma-(1+\sigma-2\theta)\tau}x_i], i=1,2, i\neq j\Rightarrow$$

$$\Rightarrow sign(m_i^N)=sign(m_j^N)$$

$$\forall x_i>0,-\frac{1+\sigma-(1+\sigma-2\theta)\tau}{2\theta+(1+\sigma-2\theta)\tau}x_i\leq x_j\leq-\frac{2\theta+(1+\sigma-2\theta)\tau}{1+\sigma-(1+\sigma-2\theta)\tau}x_i, i=1,2. i\neq j\Rightarrow$$

$$\Rightarrow sign(m_i^N)\neq sign(m_j^N)$$

$$\forall u_1,u_2\Rightarrow m_1^N=-m_2^N$$

Note that the first case covers just the range of values for which neither optimal nor incentive compatible exchange targeting strategies can be devised and other two cases conveyed the range of shocks for which propositions 2-7 apply. Thus, the proposition is proved #

Proof of propositions 9 and 10

Exchange rate deviations appear in [5]. Substituting the Nash [11] and optimal solutions [18,19] for the values of the instruments, the expressions to compare are expressed in function of the shocks. Rearranging terms, we can write, in the case of demand shocks:

$$[z-z^d]^N = 2\left(\frac{\sqrt{\rho'}}{1+\sigma+2\theta} - \frac{1}{2\zeta\sqrt{\eta}}\right)(u_1-u_2)$$

$$[z-z^d]^* = 2\left[\frac{\sqrt{\rho'}\ (1+2\theta)}{\sigma+(1+2\theta)^2} - \frac{1}{2\zeta\sqrt{\eta}}\right](u_1-u_2)$$

and, when the shock arise in the supply side (opposite shocks):

$$[z-z^d]^N = -2\left(\frac{\sqrt{\rho'}\ (1-2\tau)}{1+\sigma+2\theta} - \frac{\rho-\tau/\zeta}{\sqrt{\eta}}\right)x_1$$

$$[z-z^d]^* = -2\left[\frac{2\sqrt{\rho'}\ (1+2\theta)(1-2\tau)}{\sigma+(1+2\theta)^2} - \frac{\rho-\tau/\zeta}{\sqrt{\eta}}\right]x_1$$

From these expressions, where we note that only source of divergence is the term in brackets, we can deduct the sign of β sustracting the optimal strategy from the Nash strategy. If the result is positive this is indication that β is posiive.

Let us start by considering the demand shocks. After consulting the parameter table, we can see that this term is negative in both expressions. However, the first term in the brackets is less than one for the considered range of ρ, and the second larger than one and it is straightforward to show that the Nash solution in absolute value is larger than the optimal targeting solution. Thus, for demand shocks:

$$\forall\ 0\leq\rho\leq 1 \Rightarrow |(z-z^d)^N| > |(z-z^d)^*| \Rightarrow \beta>0$$

The outcome is not so straightforward for opposite supply shocks because ρ *appears both in the numerator of the first and second term. However, operating and simplifying, the following condition for a positive* β *can be derived:*

$$\forall\rho \geq \rho^{+} = \frac{2\theta}{1+2\theta+\frac{\sigma}{1+2\theta}-\zeta\sqrt{\eta}} > 0 \Rightarrow |(z-z^{d})^{N}| > |(z-z^{d})^{*}| \Rightarrow \beta > 0$$

where we have made use of $2\theta=(\sqrt{\eta})\phi$*. Given the values of the parameters, it follows that real exchange targets produce negative* β *and that, for reasonable values of the structural parameters, nominal targets are valid.#*

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