

The Nominal-Real Volatility Trade-off and the Selection of the Exchange Rate Regime

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Abstract

This paper studies the way a rational policymaker endogenously selects the exchange rate regime. To this end, two main ideas are intensively explored: i) the exchange rate regimes are non-neutral; and ii) there exists a trade-off between nominal volatility and real volatility. Regarding the empirical evidence, it is proposed a methodology to analyze the underlying factors of the exchange rate regime choices. The central empirical result is that the policymaker desired degree of exchange rate flexibility is influenced by both nominal and real volatility. Furthermore, these empirical results are in the same line of the theoretical findings.

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Introduction

This paper explores some key issues regarding the exchange rate regime selection. The primary aim is to empirically test the proposition that nominal volatility and real volatility are crucial factors underlying a particular exchange rate regime choice. To this end, it is used an econometric methodology which has not been employed yet: ordered probit models. This methodology can exploit the existence of an implicit order in the categorical data which are present in a *de facto* exchange rate regime classification.

But the before mentioned empirical motivation does not mean this is only an empirical paper. On the contrary, the implicit discussion concerning the empirical hypothesis is mainly a theoretical one. The first theoretical subject that arises with respect to the alternative exchange rate systems is connected to the discussion of the exchange rate regime neutrality. The second theoretical issue is related to the existence of a dilemma between flexibility and credibility. In relation to this last issue, I use both the most recent results of the new open economy macroeconomic literature and a model in the long standing tradition of economic policy selection with a limited number of policy instruments, to collect supporting arguments about the existence of a trade-off between nominal volatility and real volatility.

The paper is divided in six sections. In section 1 it is carefully discussed the idea of exchange rate regime neutrality. Section 2 summarizes some central results of the exchange rate regime selection literature. In sections 3 and 4 the theoretical models which are closely connected to the main empirical hypotheses of this paper are presented. The empirical methodology and the empirical results are described in section 5. Section 6 concludes.

1. Exchange rate regime neutrality

The only way in which the exchange rate regime selection may be relevant is challenging the proposition of "exchange rate regime neutrality" which, in turn, implies a disparity with the basic intertemporal model often used as a benchmark in international macroeconomics.

According to Obstfeld and Rogoff (1996), a complete market structure is a sufficient condition for the exchange rate regime neutrality. This being the case, the rules adopted by policymakers in the foreign exchange market operations and the particular monetary policy followed by the monetary authority, only matter for the equilibrium values of nominal variables. In this sense, the selection of a particular regime does not have any real effect.

The conditions the model has to fulfill are actually quite restrictive in the real world (Olivei, 2000): i) full price flexibility; ii) the existence of Arrow-Debrew securities to cover any possible risks due to changes in the state of nature; iii) full capital mobility and no trade barriers to exchange any desired level of present and future consumption; and iv) tradable gross domestic product which allows to diversify all the idiosyncratic risks.

A powerful and common demonstration of the absence of the previously described characteristics in the real world, is the low correlations in domestic consumption growth rates among countries in relation to the correspondent correlation in per capita real GDP (Backus et al., 1992). If it is believed that domestic and international financial markets have a similar structure to the Arrow-Debrew paradigm, then, it is a puzzle that international consumption correlations are so low even among the biggest industrial economies (Obstfeld and Rogoff, 2000a). Remember that one of the most striking conclusions of the intertemporal model is that

domestic consumption growth rate is a linear function of the respective world consumption growth rate.

In a context of transactions cost, sovereign risk, uncertainty, and asymmetric information, small countries are unable to diversify a good deal of their national risks. The impossibility of fully exploiting the potential of international financial markets have enormous economic costs for developing countries. Additionally, this impossibility makes issues as the exchange rate regime selection, balance of payments disequilibria or countercyclical policy acquire an extreme relevance for emerging economies.

As it has been stated, a departure from the basic intertemporal model implies accepting the possibility that the nominal exchange rate regime is non-neutral. But literature has not found yet a standard approach to define what neutrality means and how neutrality must be interpreted and empirically tested. It is attractive to analyze this last issue by a division of international macroeconomics literature into three major groups.

A first way of thinking about neutrality is from a theoretical point of view related to the equilibrium models of exchange rate determination developed in the early eighties by Stockman (1980), Helpman (1981) and Lucas (1982). In this kind of models, nominal exchange rate depends on deep parameters (technology, tastes) and, as a consequence, economic policy cannot affect the real exchange rate by changing the nominal exchange rate, for instance, through managed floating, a crawling peg system, a full dollarization process or any similar mean (Sarno and Taylor, 2002).

In relation to this, it is particularly significant to be aware of the fact that recent work on equilibrium models has fallen within the general area of the “new open economy macroeconomics”. The core of this new research program initiated by Obstfeld and Rogoff (1995) is to explore exchange rate determination in a context of dynamic general equilibrium models with explicit microfoundations, nominal rigidities and imperfect competition (Lane, 2001). In this wide theoretical framework, some papers explicitly pose the question about regime neutrality and regime properties as in the case of Devereux (1998), Obstfeld and Rogoff (2000b), Devereux and Engel (2000) or Collard and Dellas (2001). In this point, it can be said, as a general conclusion, that the results of new open economy macroeconomics models in relation to exchange rate agreements are highly sensitive to the particular specification of pricing and nominal rigidities.

A second approach to deal with the idea of exchange rate regime neutrality is taking into account the high correlation between nominal and real changes in exchange rates or, conversely, the weak empirical connection between exchange rates and national prices (Rogoff, 1996; Devereux and Engel, 2002). This is the cornerstone of the purchasing power parity puzzle. Even if the results of some relatively new investigations¹ -which found that real exchange rate could exhibit mean reversion- are taken into account, it still remains the issue of slow adjustment of RER towards its PPP equilibrium value. Researches have repeatedly found very long half lives for shocks to real exchange rates (Obstfeld and Rogoff, 2000a). Recent efforts to solve this puzzle have explored new approaches in both theoretical and empirical fronts, including incorporating non-linearity in modeling exchange rate dynamics (Taylor and Peel, 2000; Taylor, Peel and Sarno, 2001) or introducing pricing to market in a new open economy macroeconomic model (Betts and Devereux, 2000).

¹For instance, Froot and Rogoff (1995), Frankel and Rose (1995), Lothian and Taylor (1996) or Papell (1998).

But there also exists a third way in which literature has studied the exchange rate regime neutrality. This way, mainly related to empirical papers, rests on the interaction among three crucial factors: the real exchange rate, the real side of the economy and the exchange rate regime. From this point of view, two kinds of related papers emerge: those which try to inquire on the effect of the exchange rate system on the real exchange rate level and volatility, and those which look for the possible connections between the exchange rate regime and other real macroeconomic variables as GDP growth, consumption growth, GDP growth volatility or employment volatility. In both cases there are mixed results.²

Mussa (1986), Eichengreen (1988), Baxter and Stockman (1989) or Grilly and Kaminsky (1991) are long-established references on the issue of RER volatility and the exchange rate regime. On the relationship between the later and RER level, Goldfajn and Valdés (1999) is a clear example.

Baxter and Stockman (1989), Edwards (1993), Flood and Rose (1995), Ghosh et al. (1997), Basu and Taylor (1999) or Levy-Yeyati and Sturzenegger (2001) are works of the so-called studies on macroeconomic performance under different exchange rate agreements.

Summing up, there exists an open discussion over the issue of regime neutrality and the way in which it must be empirically approached. But it is clear that if neutrality is not the case, then the exchange rate regime selection could carry some dilemmas. The theoretical discussion of the next section is directed to this last subject.

2. Exchange rate regime selection

In international macroeconomics there exists a long standing practice of comparing the exchange rate regime properties, particularly comparing differences between two possible corner solutions: fully fixed or fully flexible systems.

The traditional keynesian view of regime selection placed particularly emphasis on the external and internal equilibrium dilemma under a fixed exchange rate system. Friedman (1953), argued in favor of flexibility. He maintained that with sticky prices it is necessary an unemployment-real exchange rate depreciation circle to restore equilibrium after a negative shock occurs. Those who believed in fixed regimes traditionally stressed the benefits for the international trade and investment resulting from the reduction of the exchange rate uncertainty.

Around the seventies, the exchange rate regime selection debate begins to discuss the importance of analyzing the source of macroeconomic shocks.³ Later, the research on regime selection focuses the attention on the credibility-flexibility dilemma (Frenkel, 1995; Edwards, 1996a). Flexible exchange rates could reach internal and external equilibriums using monetary policy. But this flexibility must pay the price of a low credibility level which tends to be associated with an inflationary bias. In a credible fixed exchange rate system, economic agents believe that the fundamental objective of monetary authority is maintaining the fixed parity. Then, the expectations about future inflation are reduced and the economy is conducted to a low inflation equilibrium situation. This analysis assumes that under a fixed parity the policymaker is always

²In brief, the discussion here revolves around the appropriateness of the exchange rate disconnect puzzle first highlighted by Meese and Rogoff (1983).

³Pioneering work correspond to Poole (1970), Turnovsky (1976) and Flood (1979). For a recent and unified treatment on this issue see Gandolfo (2000).

more disciplined and, thus, the fixed system is rarely abandoned. This is, of course, an oversimplification. History has shown many times that pegged exchange rates often fail to impose macroeconomic discipline (Edwards and Savastano, 1999).

Dealing with the credibility-flexibility dilemma is not a straightforward task. Relatively simple solution attempts could be an inflation targeting framework for monetary policy or intermediate exchange rate regimes as crawling peg, crawling bands or pegged-but-adjustable systems (Edwards, 2002).

But the credibility-flexibility dilemma is not the only issue the policymaker must have in mind when he has to select the rules that govern the nominal exchange rate behavior. The desired level of monetary policy autonomy and the degree of tolerance to capital movements should be necessarily taken into account. There is no possibility to maintain, at the same time, a fixed exchange rate, independent monetary policy and full capital mobility (Frankel, 1999).

All the considerations so far, achieve a greater significance for developing economies. In those countries, the lack of markets (or failure in them) and/or in other institutions make the exchange rate regime selection consider a greater number of aspects. For instance, Fanelli and González Rozada (1998) suggest that an optimal exchange rate regime should: i) allow a real exchange which is compatible with a high country external competitiveness; ii) minimize the resource allocation losses in the RER transition toward a new equilibrium point; iii) serve as a nominal standard for private contracts; iv) guarantee economic policy credibility; and v) minimize the risk of sudden and compulsory changes in exchange rate system. In developed economies there are several institutions which can help to reach one (or more) of these objectives. But in developing countries these institutions do not exist or they have to reach additional objectives. Then, it is simple to imagine all the possible contradictions the exchange rate regime selection faces.

The main conclusion of this section is that there are reasons to believe that there exists a trade-off between credibility and flexibility. Literature recognizes a conflict between nominal and real volatility. Every particular exchange rate regime tends to solve this conflict in a different way.

The traditional method of modeling the described trade-off was primarily by *ad hoc* models as the stochastic IS-LM model. In the next section it is presented an up to date model that predicts real volatility and nominal volatility trade-off in relation to exchange rate regime selection with solid microfoundations. This is to say, the old debate about regime selection could be revised in the light of the recent new open economy macroeconomics developments.

3. Rethinking the inflation volatility output volatility trade-off

Among the few papers that introduce clearly the exchange rate regime in a new open economy macroeconomic model, Devereux and Lane (2003) put particularly emphasis in the nominal-real volatility trade-off and its consequences for regime selection.

The model is constructed to investigate the effects of exchange rate regime and monetary policy on an emerging market economy that experiences external shocks to world interest rates and terms of trade. In this theoretical framework, it is possible to compare three different types of monetary rules: fixed exchange rates and two types of inflation targeting rules. The authors recognize that a fixed exchange rate is a well defined rule for a small economy, while there is an infinite variety of different types of floating exchanges rates. In fact, they restrict the attention to two important rules, a policy of CPI inflation targeting and a policy of targeting inflation in a subset of the CPI consisting of non-traded goods prices.

The complexity of the model makes it impossible to present it in full. But is attractive to analyze its basic structure on the one hand, and the implications it has for the discussion of the nominal-real volatility trade-off and the exchange rate regime selection on the other hand.

3.1. A brief outline of the model

In the Devereux and Lane model two goods are produced (a domestic non-traded good and a export good, the price of which is fixed in world markets) and two goods are consumed (the domestic non-traded good and an import good). Three crucial aspects of the model are: i) the presence of nominal rigidities; ii) the possibility of lending constraints on investment financing, combined with the requirement that corporate liabilities are denominated in foreign currency; and iii) the degree of exchange rate pass-through in import prices.

Nominal rigidities are explicitly introduced to motivate a role for the exchange rate regime. The important assumption here is that the prices of non-traded goods are set by individual firms and adjust slowly over time. Borrowing constraints on investment are motivated by the evidence of balance sheet constraints in developing economies. Additionally, it is important to analyze alternative velocities of adjustments of import prices to exchange rate movements.

The representative consumer has the following preferences:

$$(1) \quad u = \frac{1}{1-\sigma} C^{1-\sigma} + \frac{\chi}{1-\varepsilon} \left(\frac{M_t}{P_t} \right)^{1-\varepsilon} - \eta \frac{H_t^{1+\varphi}}{1+\varphi}$$

where C is a composite consumption index, $\frac{M_t}{P_t}$ represents real balances and H_t is labor supply.

Composite consumption is a CES function of non-traded goods and an import good. Nominal price setting in the non-traded goods sector is introduced incorporating imperfect competition in this sector.

Consumers do not face capital market imperfections, and may borrow and lend freely in bonds denominated in domestic (at i_t interest rate) or foreign currency (at i_t^* interest rate). Consumers also own the home production firms and receive its profits. The consumer optimum can be characterized by two Euler equations for the purchase of foreign and domestic bonds, an equation for the labor supply and an implicit equation for the money demand.

Production is carried out by firms in each sector and they differ in their production technologies. Both types of goods are produced by combining labor and capital. The overall production technology for a firm in the non-traded sector is:

$$(2) \quad Y_{Nit} = A_n K_{Nit}^\alpha L_{Nit}^{1-\alpha}$$

where labor L_{Nit} comes from both consumer/households and entrepreneurs combined according a Cobb-Douglas technology. Exporters had a similar function form for its production technology. From cost minimizing behavior, there are found four equations describing the

optimal employment choice for firms in each sector and two equations for the optimal choice of capital in each sector.

It is important to note that there are three price settings: one for the non-traded goods, another one for the exported good and a third one for the imported goods.

The non-trade sector set prices in advance. Firms face a probability of $1 - \kappa$ in every period of altering their price. The non-traded goods price follows the partial adjustment rule:

$$(3) \quad P_{Nt}^{1-\lambda} = (1 - \kappa) \tilde{P}_{Nt}^{1-\lambda} + \kappa P_{Nt-1}^{1-\lambda}$$

where \tilde{P}_{Nt} represents the newly set price for a firm that does adjust its price at time t , and κ determines the degree of nominal rigidity. Additionally, it can be derived the forward-looking inflation equation:

$$(4) \quad \pi_{Nt} = \zeta mcn_t + E_t \pi_{Nt+1}; \quad \zeta = \frac{(1 - \kappa)(1 - \beta\kappa)}{\kappa}$$

where mcn_t represents the log deviation of real marginal cost in the non-trade sector for its steady state level.

Concerning local currency pricing of tradeable goods, it is assumed that the law of one price holds for export goods, so that:

$$(5) \quad P_{Xt} = S_t P_{Xt}^*$$

But, for import goods, it is allowed the possibility of some delay between movements in the exchange rate and the adjustment of imported goods prices. Assuming that imported goods prices are adjusted in the same form as prices in the non-traded sector -that is a measure of $1 - \kappa^*$ of foreign firms adjust their prices in every period- the imported good price index for domestic consumers moves as follows:

$$(6) \quad P_{Mt}^{1-\lambda} = (1 - \kappa^*) \tilde{P}_{Mt}^{1-\lambda} + \kappa^* P_{Mt-1}^{1-\lambda}$$

where \tilde{P}_{Mt} represent the newly set price for a foreign firm that adjusts price at time t . The coefficient κ^* determines the delay in "pass through" of exchange rates to prices in the domestic market. The inflation equation for the import good is:

$$(7) \quad \pi_{Mt} = \zeta^* (\hat{s}_t + \hat{p}_{mt}^* - \hat{p}_{mt}) + E_t \pi_{Mt+1}; \quad \zeta^* = \frac{(1 - \kappa^*)(1 - \beta\kappa^*)}{\kappa^*}$$

where π_{Mt} is the domestic-currency inflation rate for the imported good, and \hat{s}_t and \hat{p}_{mt}^* represents the log deviation of the exchange rate and the world price of the import good from the steady state.

The last crucial issue refers to the monetary policy rules and the exchange rate regime. The important assumption here is that the monetary authority uses a short-term interest rate as the monetary instrument. Given the interest rate, the money supply will be determined by the aggregated demand for money derived from the consumer sector. The general form of the interest rate rule is:

$$(8) \quad (1+i_{t+1}) = \left(\frac{P_{Nt}}{P_{Nt-1}} \frac{1}{1+\pi_n} \right)^{\mu_{\pi_H}} \left(\frac{P_t}{P_{t-1}} \left(\frac{1}{1+\pi} \right) \right)^{\mu_{\pi}} \left(\frac{S_t}{\bar{S}} \right)^{\mu_S} (1+i)$$

where it is assumed that $\mu_{\pi_H} \geq 0$, $\mu_{\pi} \geq 0$, $\mu_S \geq 0$. The parameter μ_{π_H} allows the monetary authority to control inflation rate in the non-traded goods sector around the target rate of π_n . The parameter μ_{π} governs the degree to which the CPI inflation rate is targeted around the desired level of π . Finally, μ_S controls the degree to which interest rates attempt to control variations in the exchange rate, around a target of \bar{S} .

3.2. The trade-off between nominal and real volatility under different exchange rate agreements.

The complete model of Devereux and Lane could be reviewed to check the equilibrium conditions and the details of the solution procedure and the calibration choices. But in this part of the paper, the attention is centered on those aspects of the Devereux and Lane model which are closely related to the main topic of the present study.

In this sense, one significant issue refers to the value for the import pass-through coefficient, κ^* . Two possible cases are analyzed by the authors: complete pass-through ($\kappa^* = 0$) and a case of price stickiness in the traded sector ($\kappa^* = \kappa = 0.75$).⁴

Another key aspect refers to the way the monetary rules must be interpreted. The first possibility is a target on non-traded goods prices (NTP rule), so that $\mu_S = \mu_{\pi} = 0$, $\mu_{\pi_H} \rightarrow \infty$. The rationale for such rule is that by adjusting the monetary instrument to prevent inflation in non-traded goods, it is eliminated the need for non-traded goods producers to adjust their prices, so that their inability to quickly change prices becomes irrelevant. This policy replicates the real response of the flexible price economy provided there are no other nominal rigidities or distortions. The second rule is a simple fixed exchange rate regime in which the policymaker adjusts interest rate in order to keep nominal exchange rate from changing, $\mu_{\pi_H} = \mu_{\pi} = 0$, $\mu_S \rightarrow \infty$. Finally, the last rule is a CPI target, which is the most common rule used by countries that follow a policy of inflation targeting ($\mu_{\pi_H} = \mu_S = 0$, $\mu_{\pi} \rightarrow \infty$).

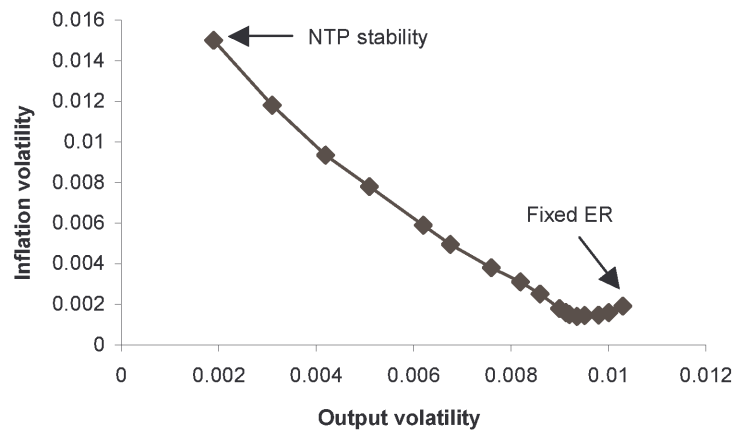
The evaluation of the overall performance under alternative regimes requires to analyze the standard deviations of key macroeconomic variables. Here the model is driven by a shock process obtained by means of a VAR exercise for the Asian region. There are three possible

⁴In equation (6), a complete pass through implies that all the adjustment in the imported goods prices at time t comes from the newly set of prices at time t . That is equivalent to say, that there is no delay in the adjustment to the new set of prices.

scenarios analyzed by Devereux and Lane: (1) no credit constraints and full pass-through; (2) credit constraints and full pass-through; and (3) credit constraints and delayed pass-through.

In the first two scenarios, the NTP rule delivers lower output volatility than the other rules. The volatility of consumption, investment and employment (i.e. hours worked), are also lower under NTP. However, at the same time, this policy generates a much higher volatility of inflation. According to the authors, this result is consistent with the traditional view about regime selection. Graph 1 illustrates the output inflation trade-off –scenario (1)- as presented by Devereux and Lane.

Graph 1. Output volatility inflation volatility trade-off (full pass-through).



If there is a delay in pass-through, then there exists a downward sloping output-inflation volatility trade-off, but only for a limited range. As policy moves from a non-traded goods prices targeting towards a fixing exchange rate, the trade-off reverses the sign. Consequently, fixing the exchange rate leads to an increase in both output and inflation volatility (this last result is not graphically shown).

As it was mentioned in the introductory section, the main objective of this paper is to empirically study the selection of exchange rate regime stressing the role of the dilemma between inflation volatility and output volatility. But before presenting empirical results, it is interesting to develop a model which highlights the way in which the policymaker faces this dilemma when he has to select the degree of flexibility in the exchange rate regime.

4. A simple model of exchange rate regime selection under inflation-output volatility trade-off

As it was seen in sections the two previous sections, there are solid theoretical reasons to believe that there exists a conflict between nominal and real volatility.

In this section it is constructed a model to observe how a rational policymaker selects a particular exchange rate regime. This policymaker knows that in his attempts to attack nominal volatility he will affect the real side of the economy and vice versa.

In the model, the policymaker worries about inflation and output deviations from its equilibrium value. It is assumed the following policymaker loss function:

$$(9) \quad L = a_t \sum_{t=1}^n (\Pi_t)^2 + b_t \sum_{t=1}^n (y_t - \hat{y})^2$$

where Π_t is the inflation rate of each period, y_t is the effective output level, \hat{y} is the potential output level and a_t , b_t are time varying parameters which measure the relative importance of each objective.

If it can be assumed that in the long run the output mean (\bar{y}) is an exact proxy of potential output (\hat{y}), then:

$$(10) \quad L = a \sum_{t=1}^n (\Pi_t)^2 + c \sigma_{GDP}$$

where $a_t = a$, $b_t = b$, $c = b(n-1)$ and σ_{GDP} is the variance of real GDP. A similar reasoning applied to the first term in the right side of equation (10) highlights the fact that we are in the presence of the previously described trade-off.

It is assumed that there exists only one instrument, named the degree of flexibility in exchange rate regime (λ_t), which is positively associated to the inflation rate. Additionally, I incorporate the nominal-real volatility trade-off which, as we have recently seen, could be obtained from a model with explicit microfoundations.

For the sake of simplicity, let us suppose that: i) there are only two periods; ii) inflation rate is a linear function of the exchange rate regime flexibility; and iii) the trade-off could be expressed by a linear function. Thus, the respective functional forms are:

$$(11) \quad \Pi_1 = \theta_1 \lambda_1 - A$$

$$(12) \quad \Pi_2 = \theta_2 \lambda_2 - B$$

$$(13) \quad \sum_{t=1}^2 \Pi_t = \alpha - \beta \sigma_{GDP}$$

Replacing equations (11) and (12) into the trade-off equation (13), it is obtained the following expression:

$$(14) \quad \sigma_{GDP} = \frac{1}{\beta} [\alpha - (\theta_1 \lambda_1 - A) - (\theta_2 \lambda_2 - B)]$$

Then, the loss function is:

$$(15) \quad L = a[\theta_1 \lambda_1 - A]^2 + a[\theta_2 \lambda_2 - B]^2 + c \frac{1}{\beta} [\alpha - (\theta_1 \lambda_1 - A) - (\theta_2 \lambda_2 - B)]$$

The values of λ_1 and λ_2 are obtained from the first order conditions:

$$(16) \quad \begin{aligned} 2a\theta_1^2\lambda_1 - 2a\theta_1A - c\frac{1}{\beta}\theta_1 &= 0 \Rightarrow \lambda_1 = \frac{A}{\theta_1} + \frac{c}{2a\beta\theta_1} \\ 2a\theta_2^2\lambda_2 - 2aB\theta_2 - c\frac{1}{\beta}\theta_2 &= 0 \Rightarrow \lambda_2 = \frac{B}{\theta_2} + \frac{c}{2a\beta\theta_2} \end{aligned}$$

It is interesting to note that the policymaker does not set $\lambda_1 = \frac{A}{\theta_1}$ or $\lambda_2 = \frac{B}{\theta_2}$ in order to eliminate inflation. The reason is that he can obtain a lower value of expression (15) if he sets $\lambda_1 > \frac{A}{\theta_1}$ and $\lambda_2 > \frac{B}{\theta_2}$. This is a typical result of this kind of models.

The other important aspect to emphasize, is the way in which the policymaker reacts when the relative importance of each objective is changed. As it can be easily observed:

$$(17) \quad \frac{\partial \lambda_i}{\partial a} = -\frac{c}{2\beta\theta_i a^2} < 0$$

Thus, when nominal volatility acquires a higher importance, the optimal response is to reduce the degree of flexibility of the exchange rate regime. On the contrary, if the issue of real volatility gains a higher significance, the optimal response is to move to a regime more closely to a full floating system:

$$(18) \quad \frac{\partial \lambda_i}{\partial c} = \frac{1}{2\beta\theta_i} > 0$$

In brief, this simple model is an illustrative way of theoretically including two subjects which will be considered in the empirical part of this work. The first subject refers to the fact that any particular exchange rate system is an endogenous rule selected by policymakers and this rule depends on the relative importance between the nominal volatility and the real volatility objectives. The second issue is that exchange rate regime is not a decision between two “extreme” solutions.

Then, it is highly relevant to incorporate the two previously mentioned issues in an empirical model through an econometric methodology that could account for the idea of “continuousness” in the alternative exchange rate regimes (λ_i). In this point, ordered probit models are the appropriate methodological response because they explicitly recognize the fact that different categories (i.e. exchange rate regimes) could be ranked according to some criteria. The next section deals with these subjects in much more detail.

5. Empirical evidence

The empirical studies on the exchange rate regime selection have made use of probit models - as in the case of Edwards (1996b), Ghosh et al. (1997) or Alesina and Wagner (2003)- or multinomial probit models -as in the case of Levy-Yeyati and Sturzenegger (2001) or von Hagen and Zhou (2004)-. Both methodologies use discrete data obtained from some particular classification of exchange rate regimes. Even when it is selected a classification that allows to

identify more than two categories (i.e. exchange rate regimes), the empirical literature on this subject has not yet exploited the fact that there exists an implicit order in the data of exchange rate agreements.

As it is known, some multinomial variables have the particular characteristic that they can be ranked according to some criteria. The idea explored in the empirical part of this work is that a classification of the exchange rate regimes can be transformed to obtain a unique variable that takes a few ordered values. The main argument of doing this is related to what was exposed in the model of the previous section: the exchange rate regime selection may be seen as a rational decision of the policymaker about the desired degree of flexibility of the exchange rate system.

Even though the outcome of a particular exchange rate regime classification has a discrete information structure, a multinomial probit model that studies regime selection does not recognize this implicit order and, because of that, it does not take advantage of all the available information.

To clarify the exposition, the rest of the empirical section has been divided into three parts. In the first part, the key characteristics of ordered probit models are analyzed. In the second part, the model to be tested, the data sources and the sample characteristics are presented. The empirical section concludes by showing and discussing the empirical results.

5.1. Ordered probit models

An ordered regression model is constructed from a latent variable model as in the case of binomial response model (Greene, 2000). The equation for the structural model is:

$$(19) \quad y_i^* = \beta'x_i + \varepsilon_i$$

The researcher does not observe y_i^* . But he knows his data have the following structure:

$$(20) \quad y = 0 \text{ if } y^* \leq 0$$

$$(21) \quad y = 1 \text{ if } 0 \leq y^* \leq \mu_1$$

$$(22) \quad y = 2 \text{ if } \mu_1 \leq y^* \leq \mu_2$$

...

$$(23) \quad y = J \text{ if } \mu_{J-1} \leq y^*$$

where J is the total number of categories or possible results, and the threshold parameters μ_{j-1} are jointly estimated with the vector of coefficients β . If ε_i has a normal distribution -as in the traditional probit model-, then the probability for each category is:

$$(24) \quad \Pr(y = 0) = \phi(-\beta'x)$$

$$(25) \quad \Pr(y = 1) = \phi(\mu_1 - \beta'x) - \phi(-\beta'x)$$

$$(26) \quad \Pr(y = 2) = \phi(\mu_2 - \beta'x) - \phi(\mu_1 - \beta'x)$$

...

$$(27) \quad \Pr(y = J) = 1 - \phi(\mu_{J-1} - \beta'x)$$

where $\phi(\cdot)$ is the normal density function. As in the case of the probit model, the marginal effects do not correspond to the estimated coefficients. In order to note this, let us suppose that there are only three categories, then the probability for each category is:

$$(28) \quad \Pr(y = 0) = \phi(-\beta'x)$$

$$(29) \quad \Pr(y = 1) = \phi(\mu - \beta'x) - \phi(-\beta'x)$$

$$(30) \quad \Pr(y = 2) = 1 - \phi(\mu - \beta'x)$$

Thus, the marginal effects are:

$$(31) \quad \frac{\partial \Pr[y = 0]}{\partial x} = -\phi(\beta'x)\beta$$

$$(32) \quad \frac{\partial \Pr[y = 1]}{\partial x} = [\phi(-\beta'x) - \phi(\mu - \beta'x)]\beta$$

$$(33) \quad \frac{\partial \Pr[y = 2]}{\partial x} = \phi(\mu - \beta'x)\beta.$$

There are two conclusions to be made: i) the marginal effect of a change in an explanatory variable on the probability of an outcome $y = 0$ has the opposite sign than β ; and ii) the change in $\Pr(y = 2)$ -or the change in $\Pr(y = J)$ in the more general case- must have the same sign than β . A central observation is that with this information it is only possible to know the direction of the changes in the extreme categories, but not to have a quantitative idea of their magnitudes. Another significant issue is that nothing could be said of intermediate categories only with the information of the estimated coefficients. This is because the value of the expression (32) depends on both the estimated β and a subtraction (between two densities) which could take a positive or negative value.

5.2. The empirical model: main characteristics and data sources⁵

The empirical model to be estimated is a relatively simple one. The explanatory variables to be included in the ordered probit model are: i) the real volatility; ii) the nominal volatility; iii) the

⁵Further details on the dataset characteristics, the data sources, and a copy of the dataset used to obtain the empirical results of this paper are available upon author request.

institutional setting; iv) the openness to international trade; and v) binary variables that allow to identify the period to which each observation belongs.

The reason to include the nominal and real volatility variables is that they can be viewed as proxies of the true underlying parameters of the policymaker loss function. The intuitive idea here is that the higher the level of real volatility is, the lower the importance the policymaker will give to that objective (i.e. the lower is the level of c in equation (15)). A similar reasoning applies to the nominal volatility variable.

To empirically find an accurate measure for the volatility variables is not an obvious task. In order to construct measures of nominal volatility and real volatility I follow the criterion of Easterly (2000) et al. and Denizer et al. (2001). The idea is to obtain volatility measures by dividing the complete sample into different periods and computing the standard deviation of the variable of interest within each period. This is a simple way to obtain volatility measures which do not have autocorrelation by construction. The whole sample is the post Bretton Woods period 1974-2000 and it is divided in nine periods of three years each.

The nominal volatility variable is constructed as the standard deviation of the inflation rate measured by the GDP deflator. The real volatility is obtained as the standard deviation of the growth rate in per capita GDP. In both cases the original data are collected from the World Bank Development Indicators CD-Rom.

The institutional setting is measured by two variables, the degree of political stability and the government effectiveness. The original data belong to Kaufman et al. (2003). These authors have measured those institutions in three different moments during the period 1974-2000. The two institutional variables included are the means of these three different moments. In other words, the institutional setting changes only if the observations included in the ordered probit model are from different countries. The works of Edwards (1996b), Alesina and Wagner (2003) and von Hagen and Zhou (2004) include some institutional measures in their empirical estimations.

As in the previously quoted papers, it is included a variable that quantifies the degree of openness to international trade. The last control set is a group of eight binary variables that account for the fact that each observation belongs to one of the mentioned nine periods.

Regarding the ordinal dependent variable, Levy-Yeyati and Sturzenegger (2002) *de facto* classification of exchange rate regimes is used as the main input. The first thing I do is grouping the crawling peg and the dirty float categories of the original classification into a unique category which identifies the intermediate exchange rate regimes. As the analysis is carried out by three-year periods it is necessary to re-define how to consider that a period has a particular regime. The criterion I adopt is that a period has a pegged (intermediate or floating) exchange rate if at least in two of the three years corresponding to that period, the country has a pegged (intermediate or floating) exchange rate.

5.3. Empirical results

Having done a review of the main characteristics of the ordered probit models and a description of the dataset characteristics and the model to be estimated, we are in conditions to turn to the results of the empirical model. Additionally, it will be necessary to add some observations to clarify issues referring to the way the results should be interpreted.

Table 1 presents the estimated coefficients, its statistical significance and other useful information.

Concerning the individual statistical significance of the explanatory variables it is easy to see in Table 1 that all the included variables are statistically significant at the usual levels, with the only exception of one binary variable which identifies the period 1998-2000. Robust Standard Errors are computed making use of the fact that any observation can be clustered using the country ID.

Table 1. Results of the ordered probit model.

Dependent Variable: Flexibility in the Exchange Rate Regime (FERR)	Coefficients (Robust Std. Err.)	z Statistic
Real Volatility**	-0.0449519 (0.0207763)	-2.16
Nominal Volatility**	0.0042148 (0.0017259)	2.44
Political Stability***	-0.5020051 (0.1443042)	-3.48
Govern Effectiveness***	0.8161344 (0.1460501)	5.59
Trade Openness***	-0.0126962 (0.0026239)	-4.84
Dummy 1974-1976***	-0.9901483	-4.71
Dummy 1977-1979***	-0.7847758	-3.88
Dummy 1980-1982***	-0.6475722	-3.56
Dummy 1983-1985***	-0.5846795	-3.73
Dummy 1986-1988***	-0.616417	-4.11
Dummy 1989-1991*	-0.3033563	-1.94
Dummy 1992-1994***	-0.4706793	-3.45
Dummy 1995-1997	Omitted category	
Dummy 1998-2000	-0.1007945	-0.98
cut 1	-1.10333 (0.2361904)	Ancillary
cut2	-0.4804028 (0.2310021)	Parameters
Total Observations	758	
Number of Countries	131	
Pseudo R²	0.1645	
Wald chi²(13)	98.66 (0.0000)	
log pseudo likelihood (iteration 0)	-722.36156	
log pseudo likelihood (iteration 4)	-603.49748	

As it was mentioned, in ordered probit models it is not possible to obtain simple interpretations of the estimated coefficients. By looking at their signs it is only possible to know the signs of the changes in the probabilities of the first and the last categories (i.e. fixed regimes and flexible regimes) when some explanatory variable is changing (see equations (31) and (33)). But it is not possible to make conclusions about the sign of the changes in the probability of the intermediate categories (in this case, there is only one intermediate category: *de facto* intermediate regimes).

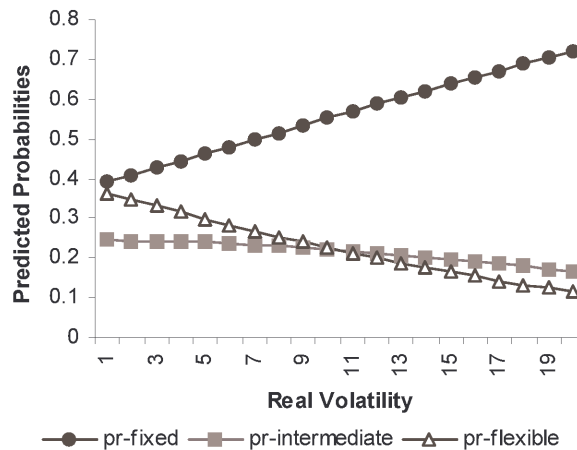
With these considerations in mind, it is possible to draw conclusions with respect to the variables that measure the trade-off between nominal and real volatility. The first result is that the

coefficients of the nominal volatility and the real volatility variables have opposite signs. If this were not the case, then it is not feasible that a trade-off between these variables could exist.

With regard to the real volatility variable and considering equation (33), it can be said that the higher the real volatility of the economy is, the lower the probability of a flexible exchange rate regime will be. Conversely, and according to equation (31), the higher the real volatility is, the higher the probability of a pegged regime will be.

The exact magnitude of these marginal effects are complex to compute (Greene, 2000). However, the empirical results can be extended by means of an analysis in terms of predicted probabilities as it is suggested by Long (1997). The intuitive idea is that the predicted probabilities of each ordinal outcome can be plotted by changing the values of one of the explanatory variables and holding the other variables constant at some level. The usual practice is to evaluate the model in the sample means of each explanatory variable. The predicted probabilities computed for different values of the real volatility are shown in Graph 2. The rest of the control variables are set in their sample means. It is assumed that the period is 1995-1997 (i.e. previous to Asian crisis).

Graph 2. Predicted Probabilities due to changes in real volatility.

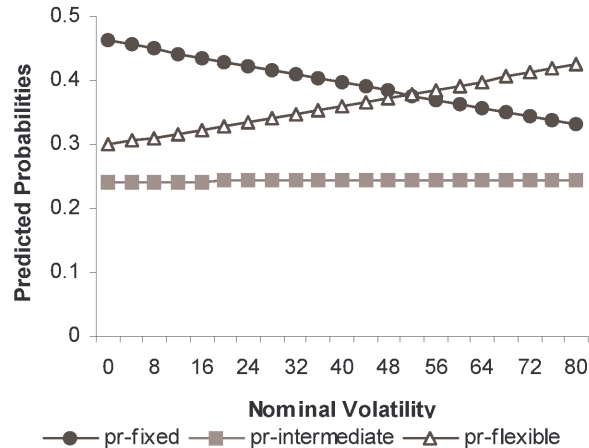


It is necessary to note that the way in which this graph looks depends not only on the real volatility variable but also on the rest of the variables of the model which are held constant. The fact that the model systematically predicts a fixed exchange regime as the most probable outcome does not mean that real volatility is not an important issue. This is a typical result of this family of models and it is related to the fact that 59 percent of the observations included in the whole sample have a fixed exchange rate regime. The key aspect is considering the way the predicted probabilities for each outcome changes when it is increased the value of the variable that measures the real volatility. In this sense, Graph 2 reinforces our previous conclusion. An additional result obtained here is that the change in the probability of an intermediate regime is not seriously affected by the volatility of the real side of the economy.

The same type of analysis could be done for the nominal volatility variable. The results in this case have the opposite signs. If it is increased the nominal volatility of the economy, then it is higher (lower) the probability of a floating (pegged) exchange rate system. As in the case of the

real volatility variable, in Graph 3 is presented an analysis for the predicted probabilities of each category.

Graph 3. Predicted probabilities due to changes in nominal volatility.



As in the previous case, we must be careful in interpreting results. The important result is that the predicted probability for a flexible exchange rate increases with the nominal volatility variable (just the opposite is true for a parity). The categorical outcome which identifies an intermediate exchange rate system is virtually no sensitive to movements in nominal volatility.

Combining Graph 2 and Graph 3 it can be obtained an appealing conclusion: the levels of nominal and real volatility do not influence the probability the policymaker has of selecting an intermediate regime. Of course this is only valid if all the country characteristics are very similar to the sample mean characteristics.

All the results up to now are related to the interpretation in terms of the categorical outcomes, which is the typical way of interpreting results in this family of models. But it also exists another way in which the results of the order probit model can be viewed. This way is related to the interpretation in terms of a latent variable. According to Long (1997), when the idea of a continuous latent variable makes substantive sense, simple interpretations of the estimated coefficients are possible by rescaling the latent variable to a unit variance and computing y^* -standardized coefficients.

As it was shown in the model of section 4, the idea of continuousness of flexibility in the exchange rate regime has, effectively, a clear sense. Then, it will be possible to check the theoretical sings of expressions (17) and (18) through the empirical model. But there is a significant difference between the theoretical and the empirical model. In the empirical model, the real and nominal volatility variables are included. In the theoretical model, the partial changes in the degree of flexibility of the exchange rate regime are obtained when *what effectively changes* is the importance the policymaker gives to the nominal volatility and real volatility objectives (see equations (17) an (18)).

As it was previously said, it is assumed that the effective nominal and real volatility levels observed in the data are inverse proxies of the parameters that measures the importance given to the nominal and real volatility objectives. This assumption allows us to conclude that the

empirical ordered probit model predicts the same result than the theoretical model of section 4. The reason for such a conclusion is related to the sign of the following expression:

$$(34) \quad \frac{\partial y^*}{\partial x_k} = \beta_k$$

where β_k is the coefficient associated to a particular explanatory variable in the “true” latent variable model. But in this model (which cannot be estimated because of the information structure that the researcher observes), the sign of β_k is the same sign as the estimated coefficient sign (for the k variable) of the ordered probit model.

Thus, the final way to make an interpretation in terms of the latent variable (i.e. the degree of flexibility in the exchange rate regime) is as follows: an increase in the importance of the nominal volatility objective in the policymaker loss function -which is measured by a reduction in the level of the nominal volatility effectively observed in the data-, will reduce the desired degree of flexibility in the exchange rate system. Conversely, an increase in the importance of the real volatility objective in the policymaker loss function -which is measured by a reduction in the level of the real volatility effectively observed in the data- will increase the desired degree of flexibility in the exchange rate system. These types of conclusions show the importance of making use of this econometric methodology.

Concerning the control variables it can be seen in Table 1 that it is highly relevant the role of the institutional setting. The first institution is the political stability that a particular country has. The sign for this variable is negative. Thus, it can be concluded that an increase in the political stability reduces the policymaker probability to select a flexible exchange rate system, and increases the probability of a fixed regime. The same result is found in Edwards (1996b): more politically unstable countries have a lower probability of selecting a pegged exchange rate system. The argument offered by Edwards is that the higher the political insatiability is, the higher the cost of abandoning the peg will be and thus, it is reduced the *ex ante* probability of selecting a fixed regime. Alesina and Wagner (2003) have found the same result with a traditional probit model.

The second institution is the degree of government effectiveness. In this case, the result is just the opposite to that found for the political stability variable: the higher the government effectiveness is, the higher the probability of a floating exchange rate regime will be. An attractive interpretation of this result is that good governments have higher credibility and so the economy has a lower inflationary bias. Then, for “effective” governments to have flexibility does not generate a high cost in terms of credibility.

The last explanatory variable is the trade openness and its sign is negative. This means that the probability of a pegging regime is higher for more opened countries. Again, this result is in line with the works of Edwards (1996b) and Alesina and Wagner (2003).

6. Conclusions

If the real world were not full of trade barriers, market imperfections or macroeconomic risks, then it would be difficult to interpret the purpose of this paper. The fact that these issues are actually significant implies that some distance should be taken from the model that is often used as a benchmark in international macroeconomics. Since neutrality is one of the most suggestive results of the benchmark model, we may start to consider the exchange rate regime in a non-

neutral sense. In this paper it is shown that the underlying theoretical discussion about the regime neutrality could be re-interpreted and that this discussion has close connections with the purchasing power parity puzzle and the exchange rate disconnect puzzle (Obstfeld y Rogoff, 2000).

Dealing with the idea of non-neutrality entails to consider the literature about the exchange rate regime selection. In this point, the present study focuses on the dilemma existing between nominal volatility and real volatility. Even when there are some few papers on the so-called "new open economy macroeconomics" which try to incorporate a role for the exchange rate regime, I choose to analyze the model of Devereux and Lane (2003) because it explicitly includes the possibility of the before mentioned trade-off. This allows me to conclude that the old ideas about the regime selection could be revised in the light of the most recent advances in the way of modeling in international macroeconomics. In the Devereux and Lane model the existence of a nominal-real volatility trade-off depends on the assumption that there exists a delayed pass-through from import prices to exchange rates.

I work on a model to investigate the way a rational policymaker acts when it is incorporated the nominal-real volatility trade-off. The result of the model is that the policymaker does not set the degree of flexibility in the exchange rate regime that allows to obtain the lowest level of nominal volatility. This is because its optimal response is to accept some level of nominal volatility and real volatility to reach the minimum social loss.

Turning to the empirical part of this paper, there are several issues to be highlighted. One of the most remarkable of them, is that the empirical results are obtained from an econometrical methodology which fully employs all the available information of an exchange rate classification: ordered probit model. This is because different categories in an exchange rate regime classification could be ranked according to the degree of flexibility that a particular regime has. The use of ordered probit models is a clear methodological improvement in relation to other previous empirical studies on this field.

The central empirical result of the paper is that it effectively exists a trade off between nominal and real volatility. Both volatility variables are taken into account by the policymaker who has to select a particular policy for the nominal exchange rate. Additionally, the possibility of making interpretations in terms of the true latent variable model tells us that: i) an increase in the importance of the nominal volatility objective in the policymaker loss function, will reduce the desired degree of flexibility in the exchange rate system; and ii) an increase in the importance of the real volatility objective in the policymaker loss function, will increase the desired degree of flexibility in the exchange rate system. These results are the same as those obtained in the theoretical model and highlight the importance of making use of this econometric methodology.

Another appealing result is that even if there were big changes in either nominal or real volatility, the predicted probabilities of selecting an intermediate exchange rate system would virtually not change.

With respect to the control variables, it can be mentioned that all of them are statistically significant and their signs are in line with the results of other works which use more traditional econometric methodologies. The most interesting result is related to the variables that measure the institutional background. It is found that the more unstable a county is, the higher the probability of fixing the nominal exchange rate will be. Additionally, the higher the effectiveness that a government has, the higher the probability of selecting a flexible regime will be. This is

because "effective" governments tend to have lower credibility problems, and thus they are less worried about establishing a reputation.

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