Banco Central de Chile
Documentos de Trabajo

Central Bank of Chile
Working Papers

N° 216

Junio 2003

OPENNESS AND IMPERFECT PASS-THROUGH: IMPLICATIONS FOR THE MONETARY POLICY

Claudio Soto Jorge Selaive

BANCO CENTRAL DE CHILE

CENTRAL BANK OF CHILE

Documentos de Trabajo del Banco Central de Chile
Working Papers of the Central Bank of Chile
Huérfanos 1175, primer piso.
Teléfono: (56-2) 6702475; Fax: (56-2) 6702231

Documento de Trabajo N° 216 | **Working Paper N° 216**

OPENNESS AND IMPERFECT PASS-THROUGH: IMPLICATIONS FOR THE MONETARY POLICY

Claudio Soto
Banco Central de Chile

Jorge Selaive
New York University

Resumen
Este trabajo analiza las implicancias positivas y normativas del grado de apertura de una economía para la transmisión de choques monetarios. Primero, presentamos nueva evidencia empírica sobre la relación entre el grado de apertura de la economía y el coeficiente de traspaso de tipo de cambio a precios. Luego, desarrollamos un modelo de equilibrio general donde los países no se especializan completamente de acuerdo a sus ventajas comparativas. En este marco, mostramos como el hecho que los países no estén completamente especializados hace que el coeficiente de traspaso de tipo del cambio a los precios de bienes importados sea menor que uno. Mientras menos abierto es un país –menos especializado—menor será el coeficiente de traspaso. Finalmente mostramos que a pesar de que este hecho implica un menor grado de ajuste de la demanda a cambios en los precios relativos (*expenditure switching effect*), la asignación que surgiría bajo precios flexibles aún puede ser replicada por medio de una política monetaria que responda exclusivamente a choques domésticos.

Abstract
This paper analyzes the positive and normative implications of the degree of openness of a small economy for the transmission mechanism of monetary shocks. First, we show empirical evidence on the direct relationship between openness and the degree of exchange rate pass-through. Then, we develop a general equilibrium model where countries do not fully specialize according to their comparative advantages. With this framework we show that incomplete specialization makes the pass-through from exchange rate to import prices imperfect. The less open is the country --the less specialized- the lower is the pass-through from exchange rate to import prices. Despite the fact that the pass-through is incomplete and the expenditure switching effect is diminished, the flexible price allocation can still be reached with an inward-oriented monetary policy.

We are grateful to Pierpaolo Benigno for his invaluable advice. We would also like to thank the participants at the Internal Seminar at NYU and LACEA Conference. All remaining errors are, of course, ours.
E-mails: csotog@bcentral.cl; js899@nyu.edu.

1 Introduction

The objective of this paper is to analyze the positive and normative implications of openness for the transmission mechanism of monetary shocks. Our concept of openness differs from the standard assumption in macro models in the New Open Macroeconomics (NOM) tradition and it is more related to the trade literature. We say that an economy is completely open when it is completely specialized in the production of goods for which it has comparative advantages. On the contrary, a country is not completely open if certain amount of resources are allocated in the production of goods for which it has no comparative advantages. The degree of openness depends on how specialized is the country.[1]

We develop a general equilibrium monetary model with oligopolistic competition, where foreign firms interact strategically with domestic firms to determine the equilibrium price of the imported good. In this framework, we show that incomplete specialization breaks down the link between exchange rate and import prices. In this oligopolistic environment, the existence of firms that substitute imports and compete strategically with foreign producers makes domestic marginal cost relevant in the determination of equilibrium import prices. Since domestic marginal costs are not affected by the exchange rate, then the impact of this variable on the equilibrium import prices is dampened. In other words, the pass-through from exchange to import prices is not perfect. Moreover, the degree of openness determines the degree of pass-through. The less open is the country, the lower is the pass-through from exchange rate to import prices. This has important implications for the effect of monetary shocks on terms of trade, and the real exchange rate. In particular, if the country is not completely open, according our definition of openness, then purchasing power parity (PPP) does not longer holds. At the same time, the degree of openness determines the response of the real exchange rate to monetary shocks, and the sign of the correlation between the terms of trade and the exchange rate.

Recent debate on optimal monetary policy in open economies has emphasized the role of limited exchange rate pass-through in defining the right response of monetary policy to foreign shocks. Models that assume perfect pass-through – producer currency price (PCP) models – show that inward looking policies sustain the flexible price allocation and are efficient. On the other hand, models where firms discriminate across markets – price to market (PTM) models – and where the pass-through is limited, show that

[1] We may think that tariffs or other trade barriers prevent complete specialization.

an optimal policy should also react to foreign shocks (Corsetti and Pesenti, 2001a; Devereux and Engel, 2000). In this literature, the optimal monetary policy implies a reduced volatility of the exchange rate.

Key to the results in the PTM literature is the nature of the limited pass-through from exchange rate into import goods prices. Imperfect pass-through in these models is generated by assuming that the local currency price of import goods is fixed. Then, there is no expenditure switching effect. In this context, a flexible exchange rate regime would only introduce noise in the economy, and the flexible price allocation would not be reached by means of monetary policy.

In our case, however, the nature of the imperfect exchange rate pass-through phenomenon is not linked to the source of nominal rigidity in the economy. Because of that, a policy that reacts only to domestic shock is able to replicate the flexible price allocation. Moreover, under such a policy the nominal exchange rate will fluctuate with domestic and foreign real shocks.

Our decentralized equilibrium is not Pareto Optimal due to a set of distortions. First, goods markets are not competitive since there is oligopolistic competition with a finite number of firms. Second, workers have monopoly power and set wages above their marginal disutility. Third, the fact that countries do not fully specialize according to their comparative advantages also introduces a distortion into the model. Thus, potentially there exist incentives for the monetary authority in going beyond replicating the flexible price allocation. We show that when the economy is completely closed the Central Bank may have incentives to deviates from policy rules. However, we also show that those incentives are minimized for intermediate degrees of openness.

Most of the NOM literature have assumed that countries completely specialize in the production of goods. Usually, in these models the degree of openness is measured by the share of foreign goods in the specification of the consumption bundle[2]. In other words, countries with different degrees of openness consume different consumption bundles. In our model, however, households in each country consume *exactly* the same bundle. Openness affects the production sector of the economy, but not preferences.

The imperfect pass-through from exchange rate to import prices is a robust stylized fact (see Engel C. (2001) for a survey). The first papers that formally introduced imperfect pass-through assumed that firms engage in PTM and face costly price adjustments (Devereaux and Engel, 1998). Dynamic version of these models have been developed by Monacelli (1999), and

[2] See Lane P. (2001) for a complete survey of this literature.

Smets and Wouters (2002). Recently, Corsetti and Dedola (2001), following evidence presented by Burnstein, Neves and Rebelo (2000), have developed a model where distribution costs incurred in the delivery of tradable goods generate a gap between the consumer price of import goods and the producer price. Since distribution cost are not affected by the exchange rate, fluctuations in this variable are only partially trespassed into the consumer price. As a result, the exchange rate pass-through is incomplete.

The hypothesis that market structure and local competition may affect the degree of pass-through has its roots in the pioneer work by Dornbush (1987). In the context of NOM models, Tille (2001) relaxes the assumption of complete international sectorial specialization as in our model. However, in his setup countries do not fully specialize in a given type of good but the do specialize in particular brands. Therefore the LOP remains valid at brands level.

The structure of the paper is the following: In section 2 we present some new evidence about the relationship between openness and the degree of pass-through. In section 3 we lay down the model. In sections 4 and 5 we analyze some partial equilibrium implications of the model. Section 6 characterizes the flexible price equilibrium of this economy. In section 7 we discuss different monetary regimes and analyze the short run implication of small monetary shocks. Finally, in section 8 we conclude.

2 Openness and Pass-through: New Evidence

In this section we present new evidence on the relationship between openness and exchange rate pass-through.

Micro-level studies have shown the importance of market structure and the degree of openness in determining the pass-through from exchange rate into import prices (see Kettner and Goldberg, 1997 for a survey). Studies that utilize aggregate data are more scarce and mainly focus on the relationship between nominal devaluation and domestic inflation (Golfajn and Werlang, 2001; De Gregorio, 2000). One of the few exceptions is the recent work by Campa and Goldberg (2002) which specifically focus on the effect of the exchange rate on aggregate import prices. Our empirical approach follows closely these authors.

2.1 Pass-through elasticity

Consider the domestic-currency price of good j imported from a particular country:

$$P_t^{m,j} = \mathcal{E}_t P_t^{x,j}$$

where $\mathcal{E}_t$ is the nominal exchange rate, and $P_t^{x,j}$ is the price charged by the exporter in units of its own currency.[3] The exchange rate pass-through to import price, γ_t^j, is defined as:

$$\gamma^j \equiv \frac{\delta P_t^{m,j}}{\delta \mathcal{E}_t} \frac{\mathcal{E}_t}{P_t^{m,j}} = 1 + \frac{\delta P_t^{x,j}}{\delta \mathcal{E}_t} \frac{\mathcal{E}_t}{P_t^{x,j}}$$

In general, macro-models have assumed that the second term on the RHS of this expression is zero. In other words, it has been assumed that the exporter keeps $P_t^{x,j}$ fixed in response to exchange rate fluctuations. This case corresponds to a case were the exchange rate pass-through is one. However, what micro evidence shows is that $P_t^{x,j}$ also fluctuates with the exchange rate. More precisely, it has been shown that in general $P_t^{x,j}$ falls with $\mathcal{E}_t^j$.

The export price can be decomposed as follows:

$$P_t^{x,j} = \mu^j \left(\mathcal{E}_t, x_t^j \right) C^j \left(\mathcal{E}_t, y_t^j \right)$$

where $\mu^j(\cdot)$ represents the markup and $C^j(\cdot)$ is the marginal cost. In principle both the markup and the marginal cost depend on the exchange rate. Vectors x_t^j, and y_t^j summarize all other variables that affect μ^j and C^j, respectively.

There are different reasons why the exchange rate influences the local-currency export price. The marginal cost could be affected by the exchange rate because of the existence of imported inputs. The markup, on the other hand, may be affected by the exchange rate because of strategic reasons concerning the maximization problem faced by the firm. In particular, if the optimal markup depends on the market share of the firm and this, in turn, depends on the relative price of good j, then the exchange rate would affect the markup. This is our hypothesis.

If we consider these effects of the exchange rate on the markup and the marginal cost, then the pass-through elasticity would be given by

$$\gamma^j = 1 + \omega^j + \eta^j \leq 1$$

[3] We assume that good j is imported from a single country. If the good is imported from many different countries then $P_t^{x,j}$ would be a price index and $\mathcal{E}_t^j$ would be the price of a baskett of currencies.

where $\omega^j \leq 0$ is the exporters' markup elasticity with respect to the exchange rate and $\eta^j \leq 0$ is the elasticity of the marginal cost with respect to the exchange rate.

2.2 Empirical evidence

Our approach follows closely the empirical approach utilized recently by Campa and Goldberg (2002). In the first place we estimate short run pass-through elasticities for a set of countries. Then, we regress the pass-through estimates against a set of macro variables. Our main objective is to evaluate the importance of openness in affecting the degree of pass-through. Therefore, we explicitly incorporate different measures of openness as regressors. Our sample consist of quarterly data for 35 countries, including not only industrial countries but also developing countries from Africa, Asia and Latin-America.

The basic specification for the equation that characterizes the price of import goods is the following:

$$p_t^m = \gamma e_t + \varepsilon_t \tag{1}$$

where p_t^m and e_t are the natural logarithm of the import price and the nominal exchange rate.[4]

The data we utilize is the following: For import prices we consider the unitary value of import from the IFS (series *75..dzf*), expressed in domestic currency. The exchange rate is the nominal effective exchange rate, also from the IFS (series *nec*). The data is quarterly for different periods between 1975:1 and 2001:4. We consider only countries for which at least 25 observations were available during this period. After applying this criterion a sample of 35 countries remained in the data set.

Equation (1) is estimated in first differences with the addition of lagged exchange rate and import price to allow for gradual adjustment and to

[4] Campa and Goldberg criticize this specification. They argue that a correct specification should include, additionally, controls to capture exporters' costs associated with local inputs, and demand conditions in the destination market -others than the ones related with the exchange rate. Unfortunately the data required to include such controls is not readily available but only for a small sample of countries (the 25 industrilized countries that Campa and Goldberg include in their regressions). Therefore, in order to increase the sample of countries we did not include such additional controls.

Under our specification the results would be biased only in the case that the cost of local inputs and demand conditions in the destination market were correlated with the exchange rate. However, we think that there are good reasons to assume that the nominal effective exchange rate is not correlated with these variables.

control for seasonality:[5]

$$\Delta p_t^m = \gamma \Delta e_t + \sum_{i=1}^{4} \alpha_i e_{t-i} + \sum_{i=1}^{4} \beta_i p_{t-i}^m + \upsilon_t \tag{2}$$

Notice that in (2) the pass-through elasticity is constant. Some authors claimed that this elasticity has changed over time (Taylor, 2000) or that it is correlated with the business cycle. In our approach, thus, γ corresponds to the average pass-through elasticity for the all period.

The results of the pass-through estimation for 35 countries are summarized in table 1. For comparison, we also present the estimates in Campa and Goldberg.

For most of the countries, both the hypothesis of zero pass-through (LCP) and perfect pass-through (PCP) can be rejected with 95% confidence. The hypothesis of zero pass-through is rejected for 28 of the 35 countries. At the same time, for only 2 cases the full pass-through hypothesis could not be rejected.

The average pass-through elasticity for our sample of countries is 0.5 with a standard deviation of 0.27.

Since we are interested in the relationship between openness and pass-through through its effect of the mark-up exposure to exchange fluctuation, ideally we would like to have an estimate of ω. However, it is clear from equation (1) that it is not possible to identify ω and η separately.

We could obtain a very rough idea of the range of values of η based on imported input share data. Campa and Goldberg (1997) computed imported input shares for 4 industrialized countries (US, UK, Canada and Japan). Their figures range from 0.041 (Japan, 1993) up to 0.217 (UK, 1993). Base on this data we may claim that any value of γ below 0.8 would correspond to $\omega < 0$.[6]

[5] Co-integration test were performed and the null of no cointegration could not be rejected for all countries.

[6] Notice that in order to properly identify η for a particular countr i we must realy on data about the cost structure of all countries from which that particular country imports, including not only domestic labor cost (as in Campa and Goldberg, 2002) but also considering imported input from country i.

Table 1
Short-run exchange rate pass-through into import price

Country	$\widehat{\gamma}$	CG^a	CG^b	Country	$\widehat{\gamma}$	CG^a	CG^b
Australia	$0.62^{+,*}$	0.55	0.55	Malasya	-0.04*	n.a.	n.a.
Belgium	$0.70^{+,*}$	0.16	0.66	Morocco	0.60	n.a.	n.a.
Canada	$0.66^{+,*}$	0.65	0.70	Norway	$0.52^{+,*}$	0.51	0.38
Chile	$0.53^{+,*}$	n.a.	n.a.	Netherlands	$0.90^{+,*}$	0.75	0.74
Colombia	$0.28^{+,*}$	n.a.	n.a.	New Zealand	$0.66^{+,*}$	0.47	0.58
C. Ivoire	0.53*	n.a.	n.a.	Pakistan	-0.10*	n.a.	n.a.
Cyprus	0.02	n.a.	n.a.	Poland	$0.51^{+,*}$	0.50	0.50
Denmark	$0.91^{+,*}$	0.56	0.70	Portugal	$0.53^{+,*}$	0.60	0.56
Finland	$0.41^{+,*}$	0.69	0.59	S. Africa	$0.20^{+,*}$	n.a.	n.a.
France	$0.61^{+,*}$	0.53	0.56	Spain	$0.72^{+,*}$	0.66	0.73
Germany	$0.57^{+,*}$	0.59	0.50	Sweden	$0.47^{+,*}$	0.67	0.68
Greece	$0.70^{+,*}$	0.40	0.30	Switzerland	$0.74^{+,*}$	0.67	0.60
Hungary	$0.58^{+,*}$	0.58	0.46	T. Tobago	0.06	n.a.	n.a.
Ireland	$0.73^{+,*}$	0.79	0.80	Tunisia	0.11*	n.a.	n.a.
Israel	$0.78^{+,*}$	n.a	n.a.	U. K.	$0.37^{+,*}$	0.39	0.31
Italy	$0.71^{+,*}$	0.67	0.75	U. S.	$0.17^{+,*}$	0.26	0.18
Japan	$0.82^{+,*}$	0.88	0.84	Venezuela	$0.44^{+,*}$	n.a.	n.a.
Malawi	0.55*	n.a.	n.a.				

Note: $+, *$ significantly different from zero or one at 5 percent level
CG^a: Campa and Goldberg estimates (table 1 main text)
CG^a Campa and Goldberg estimates (table 1 appendix)

To address the effect of openness on the degree of pass-through we run second stage cross-section regressions over the pass-through coefficients estimated before. The specification is the following:

$$\widehat{\gamma}_i = c + ax_i + \epsilon_i \tag{3}$$

where x_i is a vector containing exogenous variables. This vector includes, as regressors, country-specific inflation, inflation volatility, and nominal exchange rate volatility. We consider three different measures of openness: (i) OPEN, which corresponds to the imports/GDP ratio, constructed utilizing data from the IFS; (ii) DUTIES, which measures import duties as a percentage of imports, from the WDI (based on data from the GFS), and finally (iii) TARIFF, which corresponds to the own-import weighted tariff rates on intermediate inputs and capital goods, from Barro and Lee (based on UNCTAD data).[7] Also, as Campa and Goldberg, we include real GDP as a proxy for country size. Like the openness, this measure is meant to capture the extent to which local competitors are large in number relative to foreign firms, which could affect the degree of pass-through.

The regressions use weighted least squares, where the weights are the inverse of the standard error of the estimated pass-through. Under this approach noisy estimates from the first stage receive less weight in the second stage regression.

Table 2 summarizes the results under different specifications for equation (3).

Table 2

	1	2	3	4	5	6	7	8
C	0.37*	0.20*	0.32*	0.18*	0.57*	0.44*	0.54*	0.38*
	0.10	0.11	0.09	0.11	0.06	0.09	0.06	0.10
OPEN	0.58	0.60*	0.61	0.53				
	0.31	0.30	0.32	0.31				
DUTIES					-1.39	-1.30*	-1.64*	-1.49*
					0.84	0.69	0.70	0.68
infl	-0.00				-0.00			
	0.00				0.00			
vol. infl.		0.20		0.21		0.17		0.21
		0.11		0.11		0.11		0.11
vol. ee			0.02	0.05			0.09	0.11
			0.07	0.07			0.07	0.07
R^2 adj.	0.59	0.61	0.58	0.61	0.58	0.61	0.60	0.63
# obs.	35	35	35	35	35	35	35	35

Note: *significantly different from 0 at 5% level

[7] See Edwards (1998) for a discussion on different measures of openness and their drawbacks.

Table 2 (cont.)

	9	10	11	12	13	14	15	16
C	0.51*	0.46*	0.50*	0.49*	0.61*	0.37*	0.51*	0.34*
	0.06	0.11	0.06	0.06	0.06	0.08	0.05	0.09
TARIFF	-1.38*	-0.74*	-1.26*	-1.41*				
	0.45	0.34	0.36	0.44				
RGDP					-0.10*	-0.08*	-0.07*	-0.08*
					0.04	0.04	0.04	0.04
infl	0.01				-0.01*			
	0.01				0.00			
vol. infl.		0.14		0.16		0.22*		0.24*
		0.12		0.12		0.10		0.11
vol. ee			0.26	0.28*			0.02	0.05
			0.14	0.14			0.07	0.07
R^2 adj.	0.61	0.59	0.63	0.64	0.62	0.63	0.58	0.62
# obs.	29	29	29	29	35	35	35	35

Note: *significantly different from 0 at 5 percent level

For all different specifications our alternative measures of openness are significantly different from zero. In all cases, more openness (lower import duties, lower tariffs) implies a higher pass-through elasticity More importantly, of all variables meant to capture openness the variable TARIFF is the one that presents the highest t-test. This variable measures trade distortions that may exist to protect sector in which import substitution exists. The inflation rate is significant only when real GDP is included. Inflation volatility, on the other hand, seems to be more important in affecting the pass-through. Real GDP is statistically significant and present the expected sign. Contrary to the results of Campa and Goldberg, exchange rate volatility does not affect in a statistically significant way the degree of pass-through in our estimates.

2.3 Further evidence

Other evidence confirm the positive relationship between the degree of openness of the economy and the exchange rate pass-through into both the price of import goods and inflation.

For a group of industrialized countries McCarthy (2000) estimate VARs and concludes that the exchange rate pass-through to domestic inflation is larger in countries with larger import shares. Campa and Gonzalez (2002) focus on the differences in exchange rate pass-through to import prices in the Euro area. They conclude that those differences are primarily explained by differences in the degree of openness to non-euro countries.

A more comprehensive study by Goldfajn and Wagner (2001) shows that openness has a positive impact on the estimated coefficient of the exchange rate in an inflation regression for a panel of countries.

Indirect evidence based on stock markets is presented by Bodnar and Gentry (1993) and Friberg and Nydahl (1999). Bodnar and Gentry find that the value of firms in more open economies is more influenced by the exchange rate than in more closed economies. Similarly, Friberg and Nydahl find a positive and statistically significant relationship between exchange rate exposure and openness for the OECD countries.

3 The Model

There are two countries: *Domestic* country (d) and *Foreign* country (f). Each country is populated by a large number of consumers with identical preferences, indexed by $j \in [0, 1]$. Consumers in each country live infinitely and consume two types of *traded* goods: a and b.

Countries are *incompletely specialized* in the production of one of the two traded goods. The Domestic country has comparative advantages in good a and produces this type of good for both domestic consumption and exports. However, this country also produces some amount of good b for local consumption. The Foreign country, on the other hand, produces good b for local consumption and exports, and it also produces a certain amount of good a.[8]

The degree of openness of each country is measured by the fraction of foreign (domestic) firms selling the import good. The degree of openness of the Domestic country is given by the fraction $0 \leq \gamma \leq 1$ of firms selling good b that are foreign. Analogously, the degree of openness of the Foreign country in given by the fraction $0 \leq \gamma^* \leq 1$ of firms selling good a that are domestic firms.

[8] Notice that this is a very extreme form of import substitution: Countries produce domestically *exactly* the same good they import. Alternatively, we could assume that countries produce *close substitutes* of the goods they import. In either case, the key element is whether or not there is strategic interaction between domestic and foreign firms. As we will see below, our extreme assumption allows us to obtain close form solutions for the equilibrium prices.

When $\gamma = 0$ the Domestic country does not import from the Foreign economy and produces both types of goods. This corresponds to a closed economy case. If $\gamma = 1$ then the domestic economy is completely specialized in the production of good a. In this case we will say that the economy is *completely open*. This case corresponds to most of the models in the NOM literature where a Home country specializes in the production of home goods.

3.1 Household's Problem

There is a continuum of households indexed in the interval $[0, 1]$. Household j's preferences are given by the following lifetime expected utility:

$$U_0^j = E_0 \left\{ \sum_{t=0}^{\infty} \beta^t \left(\log C_t^j + \chi \log \frac{M_t^j}{P_t} - \zeta_t l_t^j \right) \right\} \tag{4}$$

where l_t^j represents labor effort, M_t^j / P_t are real balances, ζ_t is a withe noise stochastic process with mean 1 that corresponds to a shock to labor effort disutility, and C_t^j is a consumption index that includes two types of traded goods, a and b, and is defined as:

$$C_t^j = C_{a,t}^{j1/2} C_{b,t}^{j1/2}$$

Household j's demands for each type of good are given by

$$C_{a,t}^j = \frac{1}{2} \left(\frac{P_{a,t}}{P_t} \right)^{-1} C_t^j, \quad C_{b,t}^j = \frac{1}{2} \left(\frac{P_{b,t}}{P_t} \right)^{-1} C_t^j \tag{5}$$

where the corresponding aggregate price index P_t is

$$P_t = 2 P_{a,t}^{1/2} P_{b,t}^{1/2}$$

In this economy, asset markets are complete: There are complete, contingent one-period bonds denominated in the domestic currency. Let $B_t^j(s_{t+1})$ denote the domestic consumer's holding of a bond purchased in period t with payoffs contingent in some particular state s_{t+1} at $t+1$. One unit of this bond pays one unit of the home currency in period $t+1$ if the particular state s_{t+1} occurs and 0 otherwise. Let $q(s_{t+1} \mid s^t)$ denote the price of one unit of that bond in period t and history s^t. Household j maximize utility subject to the sequence of budget constraints,

$$\frac{M_t^j}{P_t} + \sum_{s_{t+1}} q(s_{t+1} \mid s^t) \frac{B_t^j(s_{t+1})}{P_t} \leq \frac{M_{t-1}^j}{P_t} + \frac{B_{t-1}^j}{P_t} + \frac{T_t^j}{P_t} + \frac{W_t^j}{P_t} l_t^j + \frac{\Pi_t^j}{P_t} - \frac{P_{a,t}}{P_t} C_{a,t}^j - \frac{P_{b,t}}{P_t} C_{b,t}^j \tag{6}$$

where T_t^j are net transfers from the government, W_t^j is the nominal wage rate, and Π_t^j are profits received from firms.

The government budget constraint in the domestic country is given by:

$$\int_0^1 M_t^j dj - \int_0^1 M_{t-1}^j dj - \int_0^1 T_t^j dj = 0 \tag{7}$$

3.2 Consumer Optimization

From the first order conditions for the consumers problem for each possible realization of the state s, and adding up over those different states we obtain the following relations:

$$\frac{1}{P_t C_t^j} = (1 + i_{t+1}) E_t \left(\frac{1}{P_{t+1} C_{t+1}^j} \right), \tag{8}$$

$$\chi \left(\frac{M_t^j}{P_t} \right)^{-1} C_t^j = \frac{i_{t+1}}{1 + i_{t+1}} \tag{9}$$

where E_t is the expectation operator conditional on the information set at time t and i_{t+1} is the risk free interest rate. Expression (8) is the Euler equation. Equation (9) corresponds to the money demand. It shows that at the optimum the marginal rate of substitution between real money balances and consumption must equate the marginal cost of holding an extra unit of real balances one period.

In equilibrium the risk free interest rate satisfies,

$$1 + i_{t+1} = \frac{1}{\sum_{s^{t+1}} q(s^{t+1} \mid s^t)}.$$

It is easy to show that with complete asset market there is perfect risk sharing between domestic and foreign consumption. In other words, the ratio between marginal utilities of consumption of both countries is proportional to the real exchange rate:

$$e_t = \omega \frac{C_t^j}{C_t^{j*}} \tag{10}$$

where the real exchange rate is defined as $e_t = \frac{\mathcal{E}_t P_t^*}{P_t}$, and where ω is just a constant. From (10), we can see that relative consumption across countries is proportional to the real exchange rate. If the law of one price (LOP) holds, then the previous condition implies that there is full risk sharing across countries. However, as we will see below in our model LOP does not hold, and there is no full risk sharing.

3.3 Technology and Labor Demand

We can distinguish three different types of domestic firms. One type of firms produce good a only for the domestic market; A second type of firms produces this type of good to export to the foreign country; Finally a third group of firms produce good b for the domestic market. This last group of firms substitute imports and compete with foreign producers that also sell good b domestically.

Let $Y_{i,t}(m)$ denote total output of good type i produced by a domestic firm selling to market m, for $i = a, b$ and $m = d, f$. The firm combines differentiated labor inputs from all domestic households to produce output. The production function is the following:

$$Y_{i,t}(m) = \alpha_i \left(\int_0^1 l_{i,t}^j(m)^{\frac{\phi-1}{\phi}} dj \right)^{\frac{\phi}{\phi-1}}, \tag{11}$$

where $l_{i,t}^j(m)$ represents labor input from household j. Parameter ϕ is the elasticity of substitution among different types of labor inputs, which we assume is the same across sectors and across countries, and α_i is a non-stochastic productivity parameter idiosyncratic to sector i.

Given the previous technology, cost minimization by the firm yields the following demand for labor of type j:

$$l_{i,t}^j(m) = \left(\frac{W_t^j}{W_t} \right)^{-\phi} \frac{Y_{i,t}(m)}{\alpha_i},$$

where $W_t(j)$ is the price of household's j labor and where the wage index, W_t, is defined as:

$$W_t = \left(\int_0^1 W_t^{j\,1-\phi} dj \right)^{\frac{1}{1-\phi}}$$

Let $N_{i,m}$ denote the number of domestic firms producing good i and selling to market m. The total demand for the labor input supplied by household j, by all domestic firms is given by,

$$l_{i,t}^j = \sum_{i=a,b} \sum_{m=d,f} \left(\frac{W_t^j}{W_t} \right)^{-\phi} N_{i,m} \left(\frac{Y_{i,t}(m)}{\alpha_i} \right). \tag{12}$$

Analogously, in the Foreign country total labor demand is given by,

$$l_{i,t}^{j*} = \sum_{i=a,b} \sum_{m=d,f} \left(\frac{W_t^{j*}}{W_t^*} \right)^{-\phi} N_{i,m}^* \left(\frac{Y_{i,t}^*(m)}{\alpha_i^*} \right), \tag{13}$$

where $N^*_{i,m}$ denotes the number of foreign firms producing good i and selling to market m, and α^*_i is a non-stochastic productivity parameter idiosyncratic to sector i in the foreign country.

We assume that the Domestic country has comparative advantages over the Foreign country in the production of good a. In other words, we assume that the productivity parameters satisfy:

$$\frac{\alpha_a}{\alpha^*_a} \geq \frac{\alpha_b}{\alpha^*_b}$$

3.4 Wage Setting

Price stickiness is induced in the model by assuming that workers and firms agree on the nominal wage before the realization of any shock. Domestic household j chooses an optimal wage rate by maximizing (4) subject to the budget constraint (6) and total labor demand (12). The first order condition for the optimal wage contract yields:

$$W^j_t = \Phi_W \frac{E_{t-1}\left\{\zeta_t l^j_t\right\}}{E_{t-1}\left\{\frac{1}{P_t C^j_t} l^j_t\right\}} \tag{14}$$

where $\Phi_W \equiv \frac{\phi}{\phi - 1}$.

Because of workers monopoly power, the wage rate is set with a markup Φ_W over the expected utility cost of labor effort, expressed in units of domestic currency. Having set wage rate optimally workers stand ready to provide any amount of labor to firms at the ongoing rate, as long as the real wage is above the marginal disutility of labor. We restrict the size of shocks such that this is always the case.

3.5 Firms' optimization

In each market a *finite* number of firms compete in an oligopolistic fashion. We assume that competition among firms is *Cournot*.[9] Each period a firm must decide how much to produce of a certain good subject to the demand for that good, taking as given the production of all other competitors.

[9] This assumption is not fundamental for our results. It allows us to obtain close form solutions for the equilibrium prices. Assuming other forms of oligopolistic competition with domestic firms interacting strategically with foreign firms would not change our main results.

We also assume that a particular firm produces only one type of good for one particular market. Therefore, firms producing good a for domestic consumption are different than firms exporting this good abroad.

Let $Y_{i,t}(d)$ denote the quantity produced by a domestic firm selling good i in the domestic market ($i = a, b$). The problem for this firm is to choose $Y_{i,t}(d)$ in order to maximize profits:

$$\max_{Y_{i,t}(d)} P_{i,t}Y_{i,t}(d) - W_t \frac{Y_{i,t}(d)}{\alpha_i}, \tag{15}$$

subject to the domestic demand for good i (5).[10] From the first order condition we obtain the following expression:

$$Y_{i,t}(d) = \left(\frac{P_{i,t} - \frac{W_t}{\alpha_i}}{P_{i,t}} \right) C_{i,t}. \tag{16}$$

This expression defines the *reaction function* of the firm. For a given price, this reaction function implies a negative relationship between the market share of the firm and its marginal cost. In other words, the less competitive is the firm the lower is its market share.

A domestic firm that exports good a chooses $Y_{a,t}(f)$ in order to maximize its domestic currency profits:

$$\max_{Y_{a,t}(f)} \mathcal{E}_t P^*_{a,t} Y_{a,t}(f) - W_t \frac{Y_{a,t}(f)}{\alpha_a}$$

subject to the foreign demand for the good and taking as given output from other competitors. The first order condition for this problem is the following:

$$Y_{a,t}(f) = \left(\frac{\mathcal{E}_t P^*_{a,t} - \frac{W_t}{\alpha_a}}{\mathcal{E}_t P^*_{a,t}} \right) C^*_{a,t}$$

To solve for the equilibrium price in each market we look for the fixed point of each one of the reaction functions obtained from the first order conditions.

[10] Here we use the fact that in a symmetric equilibrium, households will set optimally the same wage and $W_t^j = W_t$. In this case, the quantity demanded of each type of labor by a firm is the same, $l_{i,t}(j, m) = l_{i,t}(m) = Y_{i,t}(m)/\alpha_{i,t}$.

3.6 Market Clearing

For simplicity we assume that a number $N > 1$ of firms sell good a in the domestic country and the same number N of firms sell good b. Analogously, the number of firms that sells goods a and b in the foreign economy is N^*.[11].

Notice that by assumption domestic firms producing good b are less productive than foreign's. In order to support an equilibrium with firms with productivity coexisting we must assume that the entry cost is also differentiated. In particular, we have to assume that foreign firms that export good b must pay a higher entry cost than domestic producers.[12]

Goods market equilibrium: Since the Domestic country is specialized in the production of good a, all firms selling that good locally are domestic firms. Then, we have that $N_{a,d} = N$. The market clearing condition implies:

$$C_{a,t} = NY_{a,t}(d).$$

For the case of good b a fraction γ of the N firms selling this good domestically are foreign firms. The remaining $(1-\gamma)N$ firms are domestic. In terms of our previous notation, we have that $N^*_{b,d} = \gamma N$ and $N_{b,d} = (1-\gamma)N$. The market clearing condition in this case is the following,

$$C_{b,t} = \left((1-\gamma)Y_{b,t}(d) + \gamma Y^*_{b,t}(d)\right) N$$

Analogously, market clearing condition for goods a and b in the foreign market are the following:

$$C^*_{a,t} = \left(\gamma^* Y_{a,t}(f) + (1-\gamma^*)Y^*_{a,t}(f)\right) N^*$$
$$C^*_{b,t} = N^* Y^*_{b,t}(f)$$

[11] Clearly, in order to justify a finite number of firms in each market we would need to introduce an entry costs.

[12] There is wide evidence that firms wishing to export not only face variable costs , but also face some fixed costs that do not vary with export volume (see Roberts and Tybout (1997)). For example, a firm must inform foreign buyers about its product and learn about the foreign market. It must then research the foreign regulatory environment and adapt its product to ensure that it conforms to foreign standards. An exporting firm must also set up new distribution channels in the foreign country and conform to all the shipping rules specified by the foreign customs agency. Although some of these costs can not be avoided, others are often manipulated by governments in order to erect non-tariff barriers to trade. Regardless of their origin, these costs are most appropriately modeled as independent of the firm's export volume decision.

Labor market equilibrium. In a symmetric equilibrium all households set optimally the same wage rate W_t. Then, from expression (12) and from the assumption that workers satisfy demand at the ongoing wage rate we obtain he following labor market clearing conditions:

$$l_t = N\frac{Y_{a,t}(d)}{\alpha_a} + \gamma^* N^* \frac{Y_{a,t}(f)}{\alpha_a} + (1-\gamma)N\frac{Y_{b,t}(d)}{\alpha_b}, \tag{17}$$

$$l_t^* = (1-\gamma^*)N^*\frac{Y_{a,t}^*(f)}{\alpha_a^*} + N^*\frac{Y_{b,t}^*(f)}{\alpha_b^*} + \gamma N\frac{Y_{b,t}^*(d)}{\alpha_b^*}, \tag{18}$$

where we have replaced in (12) the corresponding number of firms producing for each market.

3.7 Monetary Policy

We assume that the government affects the stock of monetary assets by controlling the short term interest rate i_t. In order to characterize monetary policy we follow Corsetti and Pesenti (2001), and define a variable μ_t that satisfies:

$$\frac{1}{\mu_t} = (1+i_t)\, E_t\left(\frac{1}{\mu_{t+1}}\right) \tag{19}$$

Given the path μ_t there is a corresponding sequence for the nominal interest rate. From the Euler equation, we can also see that in equilibrium $\mu_t = P_t C_t$ satisfies the monetary rule. In other words, the monetary authority controls nominal expenditure.

3.8 Equilibrium

An *equilibrium* for this economy is a the sequence $\{P_{a,t},\ P_{b,t},\ P_{a,t}^*,\ P_{b,t}^*,$ $C_{a,t},\ C_{b,t},\ C_{a,t}^*,\ C_{b,t}^*,\ l_{a,t},\ l_{b,t},\ l_{a,t}^*,\ l_{b,t}^*\}$ such that: (i) Consumer allocations solve the consumer's problem; (ii) the price of final goods solve the firm's maximization problem; (iii) market clearing condition hold; and (iv) the money supply process and transfers satisfy (7) and (19).

From the first order condition for the firms and the goods market clearing conditions we obtain the following equilibrium domestic prices:

$$P_{a,t} = \Phi_N \frac{W_t}{\alpha_a} \tag{20}$$

$$P_{b,t} = \Phi_N \left((1-\gamma)\frac{W_t}{\alpha_b} + \gamma \mathcal{E}_t \frac{W_t^*}{\alpha_b^*}\right) \tag{21}$$

where $\Phi_N \equiv \frac{N}{N-1}$ reflects the distortion created by the oligopolistic competition.

Analogously, equilibrium prices in the foreign economy are given by the following expressions:

$$P^*_{a,t} = \Phi^*_N \left(\gamma^* \frac{1}{\mathcal{E}_t} \frac{W_t}{\alpha_a} + (1-\gamma^*) \frac{W^*_t}{\alpha^*_a} \right) \tag{22}$$

$$P^*_{b,t} = \Phi^*_N \frac{W^*_t}{\alpha^*_b} \tag{23}$$

The equilibrium price in each market depends on the degree of competition and the average marginal cost of the firms participating in it. The degree of competition is determined by the total number of firms selling each type of goods on each market. The larger is the number of firms the more competitive is the market and the lower is the bridge between the average marginal cost and the price.

Since all firms selling good a in the Domestic country are alike, the average marginal cost is just the marginal cost of the representative firm. The average marginal cost in the domestic market for good b, in turn, is a linear combination of domestic and foreign costs with a weight given by the fraction of each type of firms in the market. If the country is completely open ($\gamma = 1$) then the price of import goods is just a function of the marginal cost of foreign producers, expressed in domestic currency. In this case, fluctuations in the nominal exchange rate are fully transmitted to the price of the good. In other words, the model collapses to a standard PCP model (Obstfeld and Rogoff (1998, 2000)) were good a would correspond to a Home good and good b to a Foreign good.

If the country is partially open ($\gamma < 1$) then the marginal cost of domestic firms also influences the price of the import good. In this case, exchange rate fluctuations are not fully transmitted to the price. We will come back to this point when discussing the incomplete pass-through from exchange rate to import price.

Table 3 presents all equations that characterize the short-run (sticky wages) equilibrium in this economy. Unfortunately, it is not possible to obtain a closed-form solution for consumption and labor. In section 4 and 5 we discuss some partial equilibrium implications of the model. In section 6 below we perform some monetary policy analysis. .

4 Markups and Market Shares

Before analyzing the effect of nominal shocks on the real exchange rate and the terms of trade, it is illustrating to characterize the equilibrium markups and market shares for different types of firms.

Markups for each one of the three types of firms operating in the domestic market are given by:

$$
\begin{aligned}
\Phi_{a,t}(d) &\equiv \frac{P_{a,t}}{W_t}\alpha_a = \Phi_N \\
\Phi_{b,t}(d) &\equiv \frac{P_{b,t}}{W_t}\alpha_b = \Phi_N \left(1-\gamma+\gamma\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*}\right) \\
\Phi_{b,t}^*(d) &\equiv \frac{P_{b,t}}{\mathcal{E}_t W_t^*}\alpha_b^* = \Phi_N \left(\gamma+(1-\gamma)\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_b^*}{\alpha_b}\right)
\end{aligned}
$$

The markup for firms selling a domestically is constant and depends only on the degree of competition in the market. For the case of the two types of firms selling b domestically the markup is a function of the exchange rate and the relative *unitary labor cost (ulc)*.

Keeping everything else constant, a nominal depreciation raises the markup for a domestic firm that substitute imports, and reduces the markup of a foreign firm selling b domestically. This result does not hinge on changes in individual firm's cost schedules (wages are constant in the short run), but the result of the strategic interaction of firms that are affected in an asymmetric way by changes in the exchange rate.

The market share of each type of firm is directly related with its markup:

$$
\begin{aligned}
\frac{Y_{a,t}(d)}{C_{a,t}} &= 1-\frac{1}{\Phi_{a,t}(d)}, \\
\frac{Y_{b,t}(d)}{C_{b,t}} &= 1-\frac{1}{\Phi_{b,t}(d)}, \\
\frac{Y_{b,t}^*(d)}{C_{b,t}} &= 1-\frac{1}{\Phi_{b,t}^*(d)}.
\end{aligned}
$$

Thus, a nominal devaluation will increase the market share of domestic firm and reduce the participation of foreign companies in market b. Then, expansive policies will have a double effect on employment in this sector. On the one hand, such policy raises overall demand in general, and the demand for good b in particular. By itself this effect increases labor in sector b. But at the same time, domestic firms expand their participation in the market, which reinforces the increase in labor demand in that sector.

Notice that without any further restriction it could be possible that for certain realizations of the shocks the market share on one of these firms falls below zero. To avoid this situation we impose certain restrictions on the shocks and the parameters of the model. In particular, we assume that following inequality is always satisfied:

$$\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*} \geq 1 - \frac{1}{\gamma N}$$

For a given ratio of nominal wages, if the domestic market is very competitive (large N) then the difference between domestic productivity and foreign productivity in sector b can not be to large (α_b/α_b^* not to low)

Analogously, we impose the following restriction on the productivity shocks in sector a abroad

$$\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_a^*}{\alpha_a} \geq 1 - \frac{1}{\gamma^* N^*}$$

With these two restrictions it is easy to show that market shares of both types of firms are a decreasing function of γ. More openness implies that both the fraction of foreign firms in the domestic market for good b and the fraction of domestic firms in the foreign market for good a, increase. Therefore, existing firms in either market must compete with more productive firms, and their market shares must fall.

5 Imperfect Pass-Through, Real Exchange Rate and Terms of Trade Under Sticky Wages

The main feature of the model is the existence of market segmentation. Thus, two foreign firms with the same cost structure charge different prices depending on where they sell -domestic or foreign market. The only case where the price of a good is the same in both countries is when domestic cost and foreign cost are equal and the number of firms operating in each market is the same. For the case of good b we have that,

$$\frac{\mathcal{E}_t P_{b,t}^*}{P_{b,t}} = \frac{\Phi_N^*}{\Phi_N}\frac{\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*}}{(1-\gamma)+\gamma\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*}}$$

A second feature of this model with incomplete specialization is the existence of an incomplete pass-through from the nominal exchange rate to the price of import goods. In the domestic country, the pass-through elasticity is given by

$$\frac{\partial P_{b,t}}{\partial \mathcal{E}_t}\frac{\mathcal{E}_t}{P_{b,t}} = \frac{1}{1+\frac{1-\gamma}{\gamma}\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_b^*}{\alpha_b}} \leq 1$$

Is easy to see that the pass-through will be complete only when γ is one. On the other hand, as long as there is some participation of domestic producers in sector b the pass-through will be lower than one. The key element explaining this result is the fact that domestic wages, which are nor affected by the exchange rate, are relevant in determining the equilibrium import price.

The pass-through elasticity in our model with oligopolistic competition is remarkably similar to the one obtained by Corsetti and Dedola (2002) in a setup with distribution costs. In their case, the existence of such costs -that depend on the price of non-traded good and are not affected by the exchange rate- precludes foreign firms from trespassing completely all changes in their cost.

As in Corsetti and Deldola our pass-through elasticity also depends on the relative unitary labor cost. The higher is the domestic unitary labor cost relative to foreign' *ucl* the lower is the pass-through. For a given γ, high domestic *ulc* relative to foreign *ulc* implies that domestic cost are more important in the determination of the equilibrium price in this sector. Thus, exchange rate fluctuations will have a lower impact.

Notice that in general, violations of the relative LOP not necessarily imply incomplete pass-through. Models with shipping cost, for example, exhibit departures from the LOP but a perfect pass-through from exchange rate to import prices.

The imperfect pass-through from exchange rate to import prices will have important consequences on both the real exchange rate and the terms of trade.

Define the real exchange rate e_t, as

$$e_t \equiv \frac{\mathcal{E}_t P_t^*}{P_t} = \frac{\Phi_N^*}{\Phi_N}\left(\frac{\gamma^* + (1-\gamma^*)\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_a}{\alpha_a^*}}{\gamma + (1-\gamma)\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_b^*}{\alpha_b}}\right)^{\frac{1}{2}} \tag{24}$$

From the previous definition it is easy to show that under sticky wages, and for γ and γ^* different than one, a nominal depreciation *unambiguously* depreciates the real exchange rate.

It is important to note here that all fluctuations in the real exchange rate corresponds to fluctuations in the relative price of traded goods (as compared with fluctuations arising from changes in the relative price of non traded goods). Chari, Kehoe and McGrattan (2001) present evidence that fluctuations in the price of non-traded goods across countries account for none of the volatility of the real exchange rate. This evidence is consistent with our formulation for the real exchange rate. In general, this will be also true for any model where the law of one price does not hold.

If both countries are completely open ($\gamma = \gamma^* = 1$) then nominal shocks have no effect since the real exchange rate is constant. On the other hand, as γ and γ^* approach to 0 nominal shocks tend to be fully transmitted into the RER. Hence, for a given degree of openness abroad, the *more closed* and *less specialized* is the domestic economy, the *more sensible* is the real exchange rate to nominal exchange rate fluctuations. As γ decreases, the domestic price level tends to be isolated from foreign nominal shocks. In this case, fluctuations in the nominal exchange rate are not compensated by movement in P_t. Instead, they are translated into real exchange rate fluctuations.

In this context, if the monetary authority wants to reduce the real exchange volatility, it will be more prone to intervene and reduce the nominal variability in relatively closed and open economies (with a high γ but small γ^*). Firms from small economies will tend to be marginal in the determination of foreign prices. In other words, we might think of small economies as ones facing low γ^*. This result is consistent with empirical evidence presented by Hau (1999) who find that the volatility of the real exchange rate is negatively correlated with the degree of openness measured by the ratio of imports to GDP.

Lets consider the impact of nominal exchange rate fluctuations on the terms of trade. Following the convention, terms of trade (TOT_t) are defined as the relative price of import goods to export goods in terms of domestic currency:

$$TOT_t \equiv \frac{P_{b,t}}{\mathcal{E}_t P^*_{a,t}} = \frac{\Phi_N}{\Phi^*_N} \left(\frac{\gamma + (1-\gamma)\,\frac{W_t}{\mathcal{E}_t W^*_t} \frac{\alpha^*_b}{\alpha_b}}{\gamma^* + (1-\gamma^*)\,\frac{\mathcal{E}_t W^*_t}{W_t} \frac{\alpha_a}{\alpha^*_a}} \right) \frac{\mathcal{E}_t W^*_t}{W_t} \frac{\alpha_a}{\alpha^*_b}$$

According to this definition, a fall in TOT_t corresponds to an improvement in the terms of trade. In contrast with the real exchange rate, here a nominal devaluation has an ambiguous effect. In fact, the response of the terms of trade will depend on the degree of openness in both economies.

Proposition 1 *If* $\gamma > \left(1 + \frac{\gamma^*}{1-\gamma^*} \frac{\alpha_a^* \alpha_b}{\alpha_b^* \alpha_a}\right)^{-1}$ *then a nominal depreciation worsens the terms of trade.*

If γ is large enough, then the price of the imported good in the domestic country is largely determined by foreign producers. At the same time, if γ^* large then the foreign currency price of domestic exports is determined by domestic costs. In this context, a nominal devaluation increases the domestic currency price of import goods without affecting the domestic currency price of exports. However, if γ is smaller than the threshold defined in the previous proposition, a nominal devaluation improves the terms of trade. This is an important property of our model. Typically, PTM-LCP models predict a negative correlation between the terms of trade and the nominal exchange rate (*improvement*). On the other hand, PCP models predict that the correlation between these two variables is one (*worsening*).

6 Flexible price equilibrium

In a flexible price scenario wages are set after the realization of the shocks. In this case, the optimal wage rate is given by,

$$W_t = \Phi_W \zeta_t \mu_t$$

Clearly, a negative real shock (an increase ζ_t) and/or a expansionary monetary shock will rise the nominal wage.

Analogously, the equilibrium level for the real exchange rate is given by

$$e_t^{flex} = \frac{\Phi_N^*}{\Phi_N} \left(\frac{\gamma^* + (1-\gamma^*) \frac{\zeta_t^*}{\zeta_t} \frac{\alpha_a}{\alpha_a^*}}{\gamma + (1-\gamma) \frac{\zeta_t}{\zeta_t^*} \frac{\alpha_b^*}{\alpha_b}} \right)^{\frac{1}{2}} \tag{25}$$

In general, the real exchange rate will divert from 1. This implies that even under flexible prices there is no full risk sharing in consumption across countries. In general, a positive real shocks (a fall in ζ_t) will depreciate the equilibrium real exchange rate by making domestic labor relatively cheaper with respect to the foreign one. At the same time, for any given γ^* the relationship between openness and real exchange rate is ambiguous. A more open economy will have a more depreciated real exchange rate only if $\zeta_t > \zeta_t^*/\alpha$.

The equilibrium level for the terms of trade in the long run is given by,

$$TOT_t^{flex} = \frac{\Phi_N}{\Phi_N^*} \left(\frac{\frac{\alpha_b^*}{\alpha_b} \frac{\zeta_t}{\zeta_t^*} - \gamma \left(\frac{\alpha_b^*}{\alpha_b} \frac{\zeta_t}{\zeta_t^*} - 1 \right)}{\frac{\alpha_a}{\alpha_a^*} \frac{\zeta_t^*}{\zeta_t} - \gamma^* \left(\frac{\alpha_a}{\alpha_a^*} \frac{\zeta_t^*}{\zeta_t} - 1 \right)} \right) \frac{\zeta_t^*}{\zeta_t} \frac{\alpha_a}{\alpha_b^*} \tag{26}$$

Basically, the more productive is a country in the good in which it has comparative advantages, the worse are its terms of trade in equilibrium. At the same time, the more open is an economy the lower are its terms of trade in equilibrium.

7 Monetary Regimes

In this section we consider two different monetary rules and we analyze the incentives the central bank has to pursue a discretionary policy. In the first regime, the central bank adjusts the monetary stance in response to foreign monetary innovations. This regime can be interpreted as a managed exchange rate regime. In the second regime the central bank reacts only to domestic real shocks. The exchange rate, in this case, will fluctuate together with domestic and foreign real shocks.

7.1 Managed exchange rate

Consider a rule for the domestic monetary policy, where the domestic monetary policy stance is set proportional to the foreign monetary stance:

$$\mu_t = \delta_t \mu_t^*$$

Clearly, this rule implies that the nominal exchange rate is fixed at a particular level δ_t:

$$\mathcal{E}_t = \delta_t \tag{27}$$

In the context of a PTM framework, Engel (2002) proposed such a rule in order to deliver full consumption risk sharing across countries. In his particular framework he proposed to set, ex-post, $\mathcal{E}_t = \frac{P_t}{P_t^*}$. The monetary authority is able to do this because in the PTM framework prices are predetermined.

In our case, it is not possible to have full risk sharing unless the number of firms in both countries is the same, $N = N^*$, and the relative productivity satisfy $\frac{\alpha_a}{\alpha_a^*} = \frac{\alpha_b}{\alpha_b^*} = 1$. If that is the case, then full risk sharing could be reached if the central bank chooses $\delta_t = \frac{W_t}{W_t^*}$. As in the PTM model, this is possible because nominal wages are predetermined.

Notice that under this regime domestic and foreign consumption satisfy

$$C_t = C_t^* = \frac{1}{2}\frac{1}{\Phi_N}\left(\alpha_a^*\alpha_b^*\right)^{\frac{1}{2}}\frac{\mu_t^*}{W_t^*}$$

Thus, the precise allocation will depend on the policy followed by the monetary authority abroad. However, this allocation does not depend on the degree of openness or the pass-through.

An important drawback of this policy is that domestic nominal magnitudes are undetermined. Any wage set by workers will be validated ex-post by the central bank in order to keep the rule. Again, this is independent of the pass-through and it is the result of the wage setting in the model.

7.2 Inward policy rule

Consider now the following policy rule for both countries:

$$\mu_t = \frac{\Psi}{\zeta_t} \qquad \mu_t^* = \frac{\Psi^*}{\zeta_t^*} \tag{28}$$

where Ψ and Ψ^* are two parameters.

This rule has been put forward by Corsetti and Pessenti (2001b). Under this rule the central bank moves the monetary stance in a pro-cyclical way: it expands nominal expenditure in response to a positive productivity shock (low ζ_t) and contract nominal expenditure when productivity is low (high ζ_t). Notice that this policy rule is an inward-looking rule. The central bank does not adjust the monetary stance in response to any foreign innovation.

It is easy to show that if monetary authorities in both countries follow this inward-looking rule then the equilibrium outcome coincides with the outcome that would result if wages were flexible. To see this, just replace (28) into the wage equations (39) and (40). Under this rule the nominal exchange rate is given by,

$$\mathcal{E}_t = \frac{\zeta_t^*}{\zeta_t}$$

Therefore, the volatility of this variable will depend exclusively on the correlation between domestic and foreign real shocks.

It is important to remark that this result is in sharp contrast with some results in previous model for open economies with imperfect pass-through (Devereux and Engel 2000, Engel 2002). In general, the source of nominal stickiness and the reason why the pass-through is incomplete in those models coincide: after a shock firms can not adjust their export prices. This is way the flexible price allocation in those models can not be reached. In our case, imperfect pass-through arise independently form the source of stickiness. Then, even in a context of imperfect pass-through the flexible price allocation can be reached with the proper monetary policy.

7.3 Inflationary bias under discretion

We just saw that if both domestic and foreign central banks follow and inward-looking monetary rule then the equilibrium outcome coincides with the flexible price allocation. In this sub-section we analyze whether the central bank has incentives to deviate in the short run from that particular rule -or any other rule-. In other words, we analyze whether the central bank has incentives to pursue a discretionary monetary policy.

In an open economy it is not obvious that an expansive monetary shock increases welfare. One the one hand, because of monopolistic distortions in both labor market and goods markets, the nominal wage and the price of goods exceed labor marginal disutility and marginal cost, respectively.[13] Therefore, output and consumption of domestic goods are suboptimally low. In presence of nominal rigidities a small expansive monetary shock may rise output and consumption of domestic goods. On the other hand, an expansive monetary shock induces a nominal depreciation that may worsen the terms of trade, and reduce the purchasing power of domestic agent's income.

Suppose the economy starts at the steady-state. We characterized such a steady-state by assuming that disutility and monetary shocks satisfy: $\zeta = \zeta^*$, and $\mu = \mu^*$. If a monetary shock that boosts demand increases welfare, then under discretion the central bank will be biased towards pursuing an expansive policy. In other words there would exist an inflationary bias in the policy.

To simplify the exposition make some assumptions. In particular we assume that $\frac{\alpha_b^*}{\alpha_b} = \frac{\alpha_a^*}{\alpha_a} = 1$. We also assume that the steady-state markup in each market for each country are the same, and that the degree of openness of each economy are symmetric. These assumption just alter certain threshold parameters defined below but do not change qualitatively the results.

As a welfare criteria we utilize the non-monetary utility of the representative households, defined as $\widetilde{U}_t = \log C_t - \zeta l_t$. Differentiating this expression around the steady-state we obtain,

$$d\widetilde{U}_t = \widehat{C}_t - \zeta \overline{l} \widehat{l}_t \tag{29}$$

where $\overline{l} = \frac{1}{\zeta \Phi_N \Phi_W}$ is the steady state level of labor and where $\widehat{C}_t$ and $\widehat{l}_t$ are the log-linear deviation of consumption and labor with respect to their steady-state level, respectively.

[13] Notice that real wages could be suboptimally to high or to low. If $\Phi_N > \Phi_W$ then real wages are suboptimally low.

Under the previous assumptions the log-deviation of consumption is given by the following expression:

$$\widehat{C}_t = \widehat{\mu}_t - \frac{1}{2}\gamma\widehat{\mathcal{E}}_t \tag{30}$$

where $\widehat{\mathcal{E}}_t = \widehat{\mu}_t - \widehat{\mu}_t^*$. Here, we have utilized the fact that in the short run wages are fixed and, therefore, their log-deviations from the steady state are zero.

A positive monetary shock as a direct impact on consumption by expanding aggregate demand. However, a monetary shock also produces a nominal depreciation that moves demand away from domestically produced goods – expenditure switching effect – . This effect is larger the more open is the economy. In the limiting case, when $\gamma = 1$ the elasticity of consumption with respect to a domestic monetary shocks is equal to 1/2. In this case, domestic consumption will also respond to foreign monetary shocks with the same elasticity. On the other extreme, when $\gamma \longrightarrow 0$, consumption responds only to domestic monetary shocks with an elasticity equal to 1. In this case there is no expenditure switching effect and fluctuations in the nominal exchange rate have no impact on domestic consumption.

The log-linear version of domestic labor can be expressed as follows:

$$\widehat{l}_t = (N-2)(1-\gamma)\gamma\widehat{\mathcal{E}}_t + \widehat{\mu}_t \tag{31}$$

There are two effect of a monetary shock on labor: (i) An expansive monetary shock boost aggregate demand, and as a result output and labor in all sectors rise. (ii) At the same time, the nominal depreciation of the exchange rate, associated with the monetary expansion, changes the relative participation of domestic and foreign firms in each market. In this case, the effect monetary shock is a non-linear function of γ. If γ is large then the elasticity of the markup of domestic firms with respect to the exchange rate is also large. Then the market share of domestic firms is very sensible to changes in the nominal exchange rate. However, a large γ also means that the proportion of domestic firms producing good b is low. Therefore, the expansion in employment is not so large.

The next proposition characterizes and summarizes the impact of a domestic monetary shock on domestic welfare. Let us first define the following threshold parameter: $\Gamma = \frac{(N-2)+\Phi_W\Phi_N}{4(N-2)^{1/2}(\Phi_W\Phi_N-1)^{1/2}}$.

Proposition 2 *(a) If* $\frac{1}{\Phi_N}\frac{1}{\Phi_W} < \frac{1}{2}$ *and* $\Gamma < 1$ *then for any* γ *an expansive monetary shock* increases *domestic welfare.*

(b) If $\frac{1}{\Phi_N}\frac{1}{\Phi_W} < \frac{1}{2}$ *and* $\Gamma > 1$ *then there exist two values* $\underline{\gamma}, \overline{\gamma} \in (0,1)$ *with* $\underline{\gamma} < \overline{\gamma}$ *such that for any* $\gamma \in \left(\underline{\gamma}, \overline{\gamma}\right)$ *an expansive monetary shock* decreases *domestic welfare.*

(c) For N, ϕ *large enough such that* $\frac{1}{\Phi_N}\frac{1}{\Phi_W} > \frac{1}{2}$ *then there exists a unique* $\widetilde{\gamma} \in (0,1)$ *such that for any* $\gamma < \widetilde{\gamma}$ *an expansive monetary shock* increases *domestic welfare.*

When both economies are fully specialized the exchange rate pass-through is complete and the gains, in terms of welfare, associated with a monetary shock are 1/2. However, a monetary shock also raises labor effort. When both economies are fully specialized the disutility associated with this increase in labor effort is $\frac{1}{\Phi_N}\frac{1}{\Phi_W}$. Then if $\frac{1}{\Phi_N}\frac{1}{\Phi_W} > \frac{1}{2}$ and economies are fully specialized then a monetary shock unambiguously lowers welfare. In this case Φ_N and Φ_W are relatively low which means that the economy is operating close to the level of employment that is socially optimal. Then, if the economy is completely specialized a monetary expansion lowers welfare. The opposite is true when $\frac{1}{\Phi_N}\frac{1}{\Phi_W} < \frac{1}{2}$. In this case, goods and labor markets distortions are large. Then policies that boost aggregate demand move the economy closer to the efficient production with lower real wages and more output and employment. This is a well known result from the analysis of Blanchard and Kiyotaki (1987) among others.

When γ decreases the response of consumption to a given monetary shock rises. On the other hand, the magnitude of the response of labor – and the associated labor effort disutility – first rises and then it falls. In the limit case when $\gamma \to 0$ a monetary shock unambiguously increases welfare. This is consistent with the results in Betts and Devereux (2000) who find that the degree of pass-through is crucial to pin down the effect of a depreciation of the exchange on domestic and foreign welfare.[14] For intermediate values of γ the impact of an expansive shock is ambiguous. For example, in case *(b)* above either when the economy is very open or very close, domestic welfare will increase following a monetary expansion. On the other hand, when there are intermediate degrees of openness, monetary shocks may decrease welfare in the line of Corsetti and Pesenti (2001b).

[14] These authors, by the assumption of perfect PTM, predict that a country terms of trade improve when its currency depreciates. By the structure of our model, perfect PTM ($\gamma = 0$) cannot be addressed but as a closed-economy solution

8 Conclusions

In this paper we analyze the positive and normative implications of openness for the transmission mechanism of monetary shocks. We develop a general equilibrium monetary model where countries do not fully specialize according to their comparative advantages. The degree of openness determines how specialized is the country. With this framework we show that incomplete specialization, in an oligopolistic environment, makes the pass-through from exchange rate to import prices imperfect. The less open is the country, the lower is the pass-through from exchange rate to import prices. As a result, purchasing power parity (PPP) does not longer holds and real exchange rate fluctuations in response to monetary shocks depend on the degree of openness of the country. At the same time, the correlation between the terms of trade and the exchange rate can be positive or negative depending also on the degree of openness of the country and its trade partners.

We analyze two alternative monetary regimes and investigate whether the monetary authority has incentives to deviate from policy rules. We show that even in the presence of imperfect exchange rate pass-through, an inward-looking monetary policy can replicate the flexible price allocation. At the same time, we show that for intermediate degrees of openness the incentives to pursue a discretionary expansive monetary policy are reduced.

Table 3: Flexible Price Equilibrium Allocation

$$W_t = \Phi_W \zeta_t \mu_t \tag{32}$$

$$W_t^* = \Phi_W \zeta_t^* \mu_t^* \tag{33}$$

$$\mathcal{E}_t = \frac{\mu_t}{\mu_t^*} \tag{34}$$

$$l_t = \frac{1}{2}\frac{1}{\zeta_t \Phi_W}\frac{1}{\Phi_N}\left(1 + \gamma^* \frac{1 + (1-\gamma^*)N\left(\frac{\zeta_t^*}{\zeta_t}\frac{\alpha_a}{\alpha_a^*} - 1\right)}{\left(1 - \gamma^* + \gamma^*\left(\frac{\zeta_t^*}{\zeta_t}\frac{\alpha_a}{\alpha_a^*}\right)\right)^2} + (1-\gamma)\frac{1 + \gamma N\left(\frac{\zeta_t^*}{\zeta_t}\frac{\alpha_b}{\alpha_b^*} - 1\right)}{\left(1 - \gamma + \gamma\left(\frac{\zeta_t^*}{\zeta_t}\frac{\alpha_b}{\alpha_b^*}\right)\right)^2}\right) \tag{35}$$

$$l_t^* = \frac{1}{2}\frac{1}{\zeta_t^* \Phi_W}\frac{1}{\Phi_N}\left(1 + (1-\gamma^*) \frac{1 + \gamma^* N\left(\frac{\zeta_t}{\zeta_t^*}\frac{\alpha_a}{\alpha_a^*} - 1\right)}{\left((1 - \gamma^*)\left(\frac{\zeta_t}{\zeta_t^*}\frac{\alpha_a}{\alpha_a^*}\right) + \gamma^*\right)^2} + \gamma\frac{1 + \gamma N\left(\frac{\zeta_t}{\zeta_t^*}\frac{\alpha_{b,t}}{\alpha_{b,t}^*} - 1\right)}{\left((1 - \gamma)\left(\frac{\zeta_t}{\zeta_t^*}\frac{\alpha_{b,t}}{\alpha_{b,t}^*}\right) + \gamma\right)^2}\right) \tag{36}$$

$$C_t = \frac{1}{2}\frac{1}{\zeta_t \Phi_W}\frac{1}{\Phi_N}\left(\frac{\alpha_a \alpha_b}{1 - \gamma + \gamma \frac{\zeta_t^*}{\zeta_t}\frac{\alpha_b}{\alpha_b^*}}\right)^{1/2} \tag{37}$$

$$C_t^* = \frac{1}{2}\frac{1}{\zeta_t^* \Phi_W}\frac{1}{\Phi_N}\left(\frac{\alpha_a^* \alpha_b^*}{(1 - \gamma^*)\frac{\zeta_t}{\zeta_t^*}\frac{\alpha_a}{\alpha_a^*} + \gamma^*}\right)^{1/2} \tag{38}$$

Table 4: Short-Run Equilibrium Allocation

$$W_t = \Phi_W \frac{E_{t-1}\left\{\zeta_t l_t\right\}}{E_{t-1}\left\{\frac{l_t}{\mu_t}\right\}} \tag{39}$$

$$W_t^* = \Phi_W \frac{E_{t-1}\left\{\zeta_t^* l_t^*\right\}}{E_{t-1}\left\{\frac{l_t^*}{\mu_t^*}\right\}} \tag{40}$$

$$\mathcal{E}_t = \frac{\mu_t}{\mu_t^*} \tag{41}$$

$$l_t = \frac{1}{2}\frac{\mu_t}{W_t}\frac{1}{\Phi_N}\left(1+\gamma^*\frac{1+(1-\gamma^*)N^*\left(\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_a}{\alpha_a^*}-1\right)}{\left(\gamma^*+(1-\gamma^*)\left(\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_a}{\alpha_a^*}\right)\right)^2} + (1-\gamma)\frac{1+\gamma N\left(\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*}-1\right)}{\left(1-\gamma+\gamma\left(\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*}\right)\right)^2}\right) \tag{42}$$

$$l_t^* = \frac{1}{2}\frac{1}{\zeta_t^*\Phi_W}\frac{1}{\Phi_N}\left(1+(1-\gamma^*)\frac{1+\gamma^* N\left(\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_a}{\alpha_a^*}-1\right)}{\left((1-\gamma^*)\left(\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_a}{\alpha_a^*}\right)+\gamma^*\right)^2} + \gamma\frac{1+\gamma N\left(\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_b}{\alpha_b^*}-1\right)}{\left((1-\gamma)\left(\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_b}{\alpha_b^*}\right)+\gamma\right)^2}\right) \tag{43}$$

$$C_t = \frac{1}{2}\frac{1}{\Phi_N}\left(\frac{\alpha_a\alpha_b}{\left(1-\gamma+\gamma\frac{\mathcal{E}_t W_t^*}{W_t}\frac{\alpha_b}{\alpha_b^*}\right)}\right)^{\frac{1}{2}}\frac{\mu_t}{W_t} \tag{44}$$

$$C_t^* = \frac{1}{2}\frac{1}{\Phi_N}\left(\frac{\alpha_a^*\alpha_b^*}{\left((1-\gamma^*)\frac{W_t}{\mathcal{E}_t W_t^*}\frac{\alpha_a}{\alpha_a^*}+\gamma^*\right)}\right)^{\frac{1}{2}}\frac{\mu_t^*}{W_t^*} \tag{45}$$

References

[1] Benigno, Gianluca. and Pierpaolo Benigno (2000), "Price Stability as a Nash Equilibrium in Monetary Open -Economy Models," Mimeo, New York University.

[2] Betts, Caroline and Michael Devereux (1996), "The Exchange Rate in a Model of Pricing to Market," *European Economic Review*, 40, pp. 1007-1021.

[3] Betts, Caroline and Michael Devereux (2000), "Exchange Rate Dynamics in a Model of Pricing to Market," *Journal of International Economics, 50,* pp. *215-244.*

[4] Blanchard, Olivier and Nobuhiro Kiyotaki (1987), "Monopolistic Competition and the Effects of Aggregate Demand," *American Economic Review,* 77, pp 647-666.

[5] Bodnar and Gentry (1993), "Exchange Rate Exposure and Industry Characteristics: Evidence from Canada, Japan and USA," *Journal of International Money and Finance* 12, pp. 29-45.

[6] Burnstein A, J. Neves, and S. Rebelo (2000), "Distribution Costs and Real Exchange Rate Dynamics Exchange-Rate-Based-Stabilizations," NBER Working Paper #7862

[7] Campa, Jose and Linda Goldberg (2002), "Exchange Rate Pass-Though into Import Prices: A Macro or Micro Phenomenon?," NBER Working Paper #8934.

[8] Chari, V.V., Patrick J. Kehoe and Ellen R. McGrattan (2002), "Can Sticky Prices Explain the Persistence and Volatility of Real Exchange Rate," Review of Economic Studies, 69, pp. 533-63.

[9] Corsetti, Giancarlo and Dedola, Luca (2001), "Macroeconomics of International Price Discrimination," European Central Bank Working Paper #176

[10] Corsetti, Giancarlo and Paolo Pesenti (2001a), "Welfare and Macroeconomic Interdependence," *Quarterly Journal of Economics*, 116, pp. 421-45

[11] Corsetti, Giancarlo and Paolo Pesenti (2001b), "International Dimensions of Optimal Monetary Policy," NBER Working Paper #8230.

[12] Devereux, Michael and Charles Engel (1998), "Fixed vs. Floating Exchange Rates: How Price Setting Affects the Optimal Choice of Exchange-Rate Regime," NBER Working Paper #6867.

[13] Devereux, Michael and Charles Engel (2000), "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility," NBER Working Paper #7665.

[14] Dornbusch, Robert (1987), "Exchange Rate and Prices," *American Economic Review*, 77, pp 93-106.

[15] Edwards, Sebastian (1998), "Openness, Productivity and Growth: What Do We Really Know?," *EconomicJournal*, 108, pp. 383-398.

[16] Engel, Charles (2000), "Local-Currency Pricing and the Choice of Exchange Rate Regime," *European Economic Review*, 44, pp. 1149-1472.

[17] Engel, Charles (2002), "Expenditure Switching and Exchange Rate Policy," NBER Working Paper #9016

[18] Friberg, Richard and Stefan Nydahl (1999), "Openness and the Exchange Rate Exposure of Natioanl Stock Markets," *International Journal of Finance and Economics*, 4, pp. 55-62.

[19] Goldberg, Pinelopi and Michael Knetter (1997), "Goods Prices and Exchange Rate: What Have We Learned?," *Journal of Economic Literature* 35, pp. 1243-1272.

[20] Goldfajn , Ilan and Sergio Werlang (2001), "The Pass-through from Depreciation to Inflation: A Panel Study," PUC-Rio. Working paper No 423.

[21] Hau, Harald (1999). "Real Exchange Rate Volatility and Economic Openness: Theory and Evidence," *Journal of Money, Credit and Banking*, 34, pp 611-630.

[22] Lane, Phillips. (2001), "The New Open Economy Macroeconomics: A survey," *Journal of International Economics*, 54, pp. 235 – 266.

[23] McCarthy, Jonathan (2000), "Pass-Through of Exchange Rates and Import Prices to Domestic Inflation in Some Industrialized Economies, " Federal Reserve Bank of New Yor, Staff Report #3.

[24] Obstfeld, Maurice and Kenneth Rogoff (1995), "Exchange Rate Dynamics Redux," *Journal of Political Economy*, 103, pp 624-60.

[25] Obstfeld, Maurice and Kenneth Rogoff (1998), "Risk and Exchange Rates," NBER Working Paper #6694.

[26] Obstfeld, Maurice and Kenneth Rogoff (2000), "New Direction for Stochastic Open Economy Models," NBER Working Paper #7313.

[27] Roberts, Marks and James Tybout (1997), "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs," *American Economic Review*, 87, pp. 545-564

[28] Tille, Cedric (2001). "On the Distributional Effects of Exchange Rate Fluctuations," Federal Reserve Bank of New York, Staff Report #146.

Appendix

Proof. Proposition 2.

The change in welfare (29) can be written as follows:

$$d\widetilde{U}_t = \Omega(\gamma)\,\widehat{\mu}_t$$

where $\Omega(\gamma) = 1 - \frac{1}{\Phi_W \Phi_N} - \frac{1}{2}\gamma - \frac{1}{\Phi_W \Phi_N}(N-2)\,\gamma(1-\gamma)$, and where have used the fact that $\widehat{\mathcal{E}}_t = \widehat{\mu}_t$.

Function $\Omega(\gamma)$ is of second order in γ. Notice that since $\Phi_W,\ \Phi_N > 1$ then $\Omega(0) > 0$. In other words, if both economies are completely closed then there are incentives to surprise agents and pursue an expansive monetary policy. We are interested in analyzing how those incentives vary when the degree of openness changes. Observe that when both economies are completely open $\Omega(1) = \frac{1}{2} - \frac{1}{\Phi_W \Phi_N} \lesseqgtr 0$. Then, we can differentiate two cases: (i) $\frac{1}{2} > \frac{1}{\Phi_W \Phi_N}$; and (ii) $\frac{1}{2} < \frac{1}{\Phi_W \Phi_N}$.

Consider first part (c) in proposition 2, where $\frac{1}{2} < \frac{1}{\Phi_W \Phi_N}$. This implies that $\Omega(1) < 0$. Since $\Omega(\gamma)$ is of second order and $\Omega(0) > 0$, then there must exist an $\widetilde{\gamma} \in (0,1)$ such that $\forall \gamma < \widetilde{\gamma}$, $\Omega(\gamma) > 0$.

Consider next parts (a) and (b) in proposition 2. In both cases we have that $\frac{1}{2} > \frac{1}{\Phi_W \Phi_N}$. This implies that $\Omega(1) > 0$. Then, the function $\Omega(\gamma)$ can have zero, one, or two roots between 0 and 1. It is easy to see that if $\frac{(N-2)+\Phi_W \Phi_N}{4(N-2)^{1/2}(\Phi_W \Phi_N - 1)^{1/2}} > 1$ then there are two roots. If $\frac{(N-2)+\Phi_W \Phi_N}{4(N-2)^{1/2}(\Phi_W \Phi_N - 1)^{1/2}} < 1$ then there are no real roots. Finally, when $\frac{(N-2)+\Phi_W \Phi_N}{4(N-2)^{1/2}(\Phi_W \Phi_N - 1)^{1/2}} = 1$ there is only one root. ■

Documentos de Trabajo Banco Central de Chile	Working Papers Central Bank of Chile
NÚMEROS ANTERIORES	PAST ISSUES

La serie de Documentos de Trabajo en versión PDF puede obtenerse gratis en la dirección electrónica: http://www.bcentral.cl/Estudios/DTBC/doctrab.htm. Existe la posibilidad de solicitar una copia impresa con un costo de $500 si es dentro de Chile y US$12 si es para fuera de Chile. Las solicitudes se pueden hacer por fax: (56-2) 6702231 o a través de correo electrónico: bcch@bcentral.cl.

Working Papers in PDF format can be downloaded free of charge from: http://www.bcentral.cl/Estudios/DTBC/doctrab.htm. Printed versions can be ordered individually for US$12 per copy (for orders inside Chile the charge is Ch$500.) Orders can be placed by fax: (56-2) 6702231 or e-mail: bcch@bcentral.cl.

DTBC-215 Junio 2003
Purchasing Power Parity in an Emerging Market Economy: A Long-Span Study for Chile
César Calderón y Roberto Duncan

DTBC-214 Junio 2003
Non-traded Goods and Monetary Policy Trade-Offs in a Small Open Economy
Claudio Soto

DTBC-213 Junio 2003
Do Free Trade Agreements Enhance the Transmission of Shocks Across Countries?
César Calderón

DTBC-212 Junio 2003
Crisis Financieras Internacionales, Prestamista de Última Instancia y Nueva Arquitectura Financiera Internacional
Esteban Jadresic, Klaus Schmidt-Hebbel y Rodrigo Valdés

DTBC-211 Mayo 2003
Reserves over the Transitions to Floating and to Inflation Targeting: Lessons from the Developed World
Fernando Aportela, Francisco Gallego y Pablo García

DTBC-210 Mayo 2003
Trade Reforms and Manufacturing Industry in Chile
Roberto Alvarez y Rodrigo Fuentes

DTBC-209 Mayo 2003
Corporate Governance in Chile
Manuel R. Agosin y Ernesto Pastén H.

DTBC-208 Abril 2003
Indicadores Líderes del IMACEC
Luis Firinguetti y Hernán Rubio

DTBC-207 Marzo 2003
El Embrague Financiero: Un Mecanismo Alternativo de Amplificación Bancaria
Elías Albagli

DTBC-206 Marzo 2003
Efectos de las Intervenciones en el Mercado Cambiario: el Caso de Chile
Matías Tapia y Andrea Tokman

DTBC-205 Marzo 2003
Policy Evaluation and Empirical Growth Research
Steven N. Durlauf

DTBC-204 Marzo 2003
Growth and Adjustment in Chile: A Look at the 1990s
Vittorio Corbo y José A. Tessada

DTBC-203 Febrero 2003
Microeconomic Effects of Capital Controls: The Chilean Experience during the 1990s
Francisco A. Gallego y F. Leonardo Hernández

DTBC-202 Febrero 2003
Building Confidence Intervals for the Band-Pass and Hodrick-Prescott Filters: An Application using Bootstrapping
Francisco A. Gallego y Christian A. Johnson

DTBC-201 Febrero 2003
Dinero e Inflación: ¿En qué Estamos?
José De Gregorio

DTBC-200 Febrero 2003
Exploring the Implications of Official Dollarization on Macroeconomic Volatility
Roberto Duncan