Trade Flows, Prices, and The Exchange Rate Regime[*]

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December 2000

Abstract

This paper examines the relationship between the exchange rate regime and trade flows using a general equilibrium model based on Bacchetta and van Wincoop (AER, 2000). We show that in general the link between trade and the exchange rate regime is ambiguous and that it depends in particular on the nature of macroeconomic shocks and consumer preferences. A critical aspect is the pricing strategy adopted by monopolistically competitive firms. Trade is more likely to be affected by the exchange rate regime if firms price in buyers' currency, or price to market (PTM), than if they price in producers' currency (PCP). We show, however, that PCP is not an equilibrium under reasonable parameters when international capital markets are not available. In contrast, when markets become more complete, firms tend to switch to PCP.

JEL Classification: F31, F33, F41

[*] Paper written for the Bank of Canada conference on Revisiting the Case for Flexible Exchange Rates, November 2-3, 2000. We would like to thank Monique Ebell and Alexander Mihailov for comments on an earlier draft.

1. Introduction

It is commonly held that trade flows are enhanced if a country switches from a floating to a fixed exchange rate. This is one of the main motivations for exchange rate stabilization in regional trade blocks, such as the European Union. The argument is that exchange rate volatility increases the risk of buying and selling in foreign countries. While this explanation based on risk aversion has intuitive appeal, its validity needs to be examined in a consistent framework. In particular, one needs to consider the overall macroeconomic uncertainty faced by firms and households and how this is affected by the choice of exchange rate system. In this paper we will do so within the context of a simple two-country general equilibrium setup, since it is not sufficient to analyze single individual firms or consumers to understand aggregate trade.

Most of the international macroeconomics models are not suited to analyze these issues. For example, in the standard macroeconomic models of the Mundell-Fleming type, the impact of exchange rate risk cannot be analyzed since the aggregate behavioral equations are ad hoc and individual decisions are not modeled. There is also a literature that examines individual firms facing exogenous exchange rate fluctuations. But this partial equilibrium approach is not adequate since it does not consider the overall macroeconomic risks that affect firms and households and that also affect the exchange rate itself.[1]

The extent to which exchange rate fluctuations affect firms depends crucially on their pricing strategy. When exporters set prices in their home currency they are not directly affected by the nominal exchange rate through the price received for their goods. We will call this case PCP for Producer Currency Pricing. Nevertheless, this strategy is not widely used in practice. It would imply that prices in local currency move one-to-one with the nominal exchange rate (i.e., that the law of one price holds). Most empirical evidence shows that the pass-through from exchange rate to prices is gradual and incomplete (see, for example, Goldberg and Knetter, 1997, for a survey) so that Purchasing Power Parity (PPP) and the law of one price do not hold. An explanation for this evidence is that exporters can discriminate across markets

1. See Côté (1994) for a review of the literature.

and price in local currency, i.e., they adopt a strategy of Pricing To Market or PTM.[2] Although the pricing strategy is a microeconomic decision, it has substantial macroeconomic implications. In this paper we examine how the pricing strategy affects the link between trade and the exchange rate regime. We will also investigate the optimality of the two pricing strategies (PCP and PTM) within the context of the model.

We consider the impact of macroeconomic risks on uncertainty about labor costs and demand that firms face, and how this is affected by the choice of exchange rate system. A partial equilibrium approach, whereby the impact of exchange rate risk is considered in isolation, is useful only if the nominal exchange rate is uncorrelated with macroeconomic shocks, such as monetary, fiscal and productivity shocks. Although exchange rates are highly volatile and seemingly unrelated to fundamental variables in the very short run, empirical evidence shows significant correlations between exchange rates and fundamentals in the medium run. Thus, we take the view that fundamental macroeconomic shocks affect demand and labor costs that firms face both through their impact on the exchange rate and through other channels. Therefore, instead of investigating the impact of exchange rate per se, we study the impact of the exchange rate regime on the certainty equivalent of firm profits. The exchange rate regime matters to the extent that it affects the impact of macroeconomic shocks (monetary, fiscal and productivity) on demand and costs faced by firms.

Trade will be lower under a flexible exchange rate regime only if switching to such a regime reduces the certainty equivalent of profits when exporting to foreign markets relative to selling in the home market. This is not necessarily the case and the opposite may be true, e.g., selling in the foreign market can provide more risk diversification than selling in the home market.

In this paper, we rely on developments in the New Open Economy Macroeconomics literature, characterized by general equilibrium models with optimizing firms and consumers, combined with price rigidities.[3] More specifically, we present a model based on Bacchetta and van Wincoop (2000b) (henceforth BW). In this framework, exporting firms need to set prices

2. Notice that in theory exporters could price to market in their own currency. We do not consider this case in this paper and assume that pricing to market is always done in local currency.

3. This growing literature started with Obstfeld and Rogoff (1995) who assume PCP and no uncertainty. Betts and Devereux (1996, 2000) extend it to PTM, while Obstfeld and Rogoff (1998) and Bacchetta and van Wincoop (2000b) introduce uncertainty under PCP and PTM respectively. This literature typically does not look at trade flows.

before macroeconomic risks are resolved. If firms find it very risky to sell in foreign markets, they will include a risk premium and charge a higher price that will discourage foreign consumers and thus reduce trade. On the other hand, if selling in foreign markets under a flexible exchange rate provides risk diversification, exporters will set a lower price so that trade is larger.[4]

While the BW framework makes several strongly simplifying assumptions, it provides a tractable framework in which quite general results can be derived. In particular, we can draw the following conclusions:

- The pricing strategy (PCP versus PTM) matters for the sensitivity of trade to the exchange rate regime.

- Trade is more likely to be affected under PTM. The impact of the exchange regime, however, is ambiguous due to general equilibrium mechanisms.

- The existence of asset markets - such as a forward market or even complete markets - does not eliminate the sensitivity of trade to the exchange rate under PTM, although it may reduce it.

- In the absence of international asset trade, all firms choose the PTM pricing strategy.

- As international financial markets become more integrated, more firms adopt the PCP pricing strategy.

The rest of the paper is organized as follows. In the next section we present the basic intuition behind the link between pricing and trade flows, as well as the pricing decision under PTM. In Section 3, we briefly describe how general equilibrium considerations affect the relationship between trade and the exchange rate regime. In Section 4, we determine what the optimal pricing strategy is, i.e., under what conditions PTM or PCP are equilibria when firms can choose their strategy. Finally, Section 5 offers concluding remarks.

4. We abstract from transportation costs. While they affect the level of trade, they do not have a significant impact on the sensitivity of trade to the exchange rate regime in a symmetric model like ours. See Sercu and Uppal (2000) for a general equilibrium model where these costs matter.

2. Preliminary Concepts

Before describing the full structure of the general equilibrium model, we present two basic ingredients of the analysis at a more intuitive level. We first look at the link between the pricing strategy and trade and then examine the price setting criteria for firms.

2.1 Trade Flows and the Role of Prices

We first take an aggregate perspective on trade. Assume that there are only two countries (home and foreign) and that domestic goods are different from foreign goods. A standard measure of total trade is the sum of exports and imports divided by GDP. For convenience in this section we consider only imports and assume that the nominal value of imports IM is given by:

$$IM = p_F \cdot \Phi\left(\frac{p_F}{p_H}\right) \cdot \frac{Y}{P} \tag{1}$$

where p_F (p_H) is the price of imported (domestic) goods in the home country and P is the home consumer price index. Figure 1 illustrates our notation for the pricing of goods. Since consumers purchase both domestic and foreign goods, P is a function of both goods prices. Thus we can write $P(p_F, p_H)$, which is homogeneous of degree one in both prices. Moreover, Φ is a function that depends negatively on the relative price between imported and domestic goods; and Y is nominal GDP which is assumed equal in equilibrium to nominal income. Trade can thus be measured by:

$$\frac{IM}{Y} = \frac{p_F \cdot \Phi\left(\frac{p_F}{p_H}\right)}{P(p_F, p_H)} \equiv \Psi(p_F, p_H) \tag{2}$$

The impact of exchange rate fluctuations depends on the pricing strategy and more generally on the degree of pass-through of the exchange rate to prices. Two extreme cases can be considered. First, assume that foreign exporters set the price p_F in the domestic currency of the importing country and that they can price discriminate across national borders, i.e., that we have PTM or pricing to market in local currency for all goods. In that case, domestic importers are not directly affected by exchange rate movements. The only way exchange rate volatility can affect trade is through the pricing of goods, i.e., the differences between p and p_F. The higher the price charged in the foreign market relative to the home market (higher p_F / p_H), the lower the level of trade.[5]

The second extreme case occurs when all imports are priced in the exporters' currency and when exporters cannot discriminate between the domestic and the foreign market. This is the PCP case, where $p_F = S \cdot p_F^*$, with S being the nominal exchange rate (domestic per foreign currency) and p_F^* the pre-set price in the foreign market in foreign currency (which implies that in this case p_F fluctuates with S). Trade can be written as:

$$\frac{IM}{Y} = \frac{Sp_F^* \cdot \Phi\left(\frac{Sp_F^*}{p_H}\right)}{P\left(Sp_F^*, p_H\right)} \equiv \Psi\left(Sp_F^*, p_H\right) \tag{3}$$

In this case, we first see that trade fluctuates with the exchange rate so that we have to consider a measure of average or expected trade. Second, when countries are fully symmetric so that the prices of goods in domestic markets (home and foreign) are equal, i.e., $p_H = p_F^*$, the trade level only depends on the exchange rate. The level at which firms set prices is irrelevant. In a symmetric setup, where S and $1/S$ have the same distribution, it is easily verified that the expected level of trade is independent of exchange rate volatility. Intuitively, a currency appreciation makes foreign goods cheaper, while a depreciation makes domestic goods cheaper. If both goods matter in a similar way to consumers the effect will be symmetric and an increase in the variance of the nominal exchange rate will not affect expected trade. This contrasts with the PTM case, where the level of trade can differ across

5. Notice that for the price ratio p_F / p_H to have the expected negative result on imports, the real demand for imports must be sufficiently price elastic, in a way similar to the Marshall-Lerner condition.

exchange rate systems, dependent on the effect of the exchange rate regime on p_F / p_H. The pricing strategy therefore affects the sensitivity of trade to the exchange rate system. In most of the paper we will focus on the PTM case since the effect of the exchange rate system on trade is non-trivial and depends on the level at which firms pre-set prices in the home and foreign markets.

An important dimension to consider is the presence of asset markets and the extent to which exporters and importers can hedge the exchange rate risk. It is obvious that if the exchange rate is the only source of risk and a forward market exists, agents in symmetric countries can fully hedge their exposure. In other situations, however, it may not be desirable or feasible to fully hedge exchange rate risk. In Section 3, we first examine the behavior of producers and consumers in a general equilibrium framework when no international asset market is available and then discuss the impact of international asset trade. Before we consider the full model, however, we describe in general terms what determines the degree of pricing discrimination of exporters under PTM.

2.2 Optimal Price Setting

A crucial channel for the impact of the exchange rate regime is the behavior of firms, in particular their optimal price setting. To gain intuition, we examine optimum price setting by a single firm that prices in the currency of its customers. We also relate our analysis to the previous literature.

Consider a firm setting prices in advance and able to discriminate between the domestic p_H and the foreign price p_H^* in foreign currency. Markets are segmented, so that consumers cannot arbitrage price differentials. The foreign price expressed in domestic currency is Sp_H^*. The firm faces real demands $c(p_H / p_F, x)$ and $c^*\left(p_H^* / p_F^*, x^*\right)$ at home and abroad, where x and x^* represent aggregate factors affecting consumption demand. For convenience, assume that the demand functions have the same constant price-elasticity μ and that μ > 1. Finally, the firm has a linear production function, using $1/a$ quantity of labor per unit of output, independently of whether it is sold at home or abroad. It pays a nominal wage rate w. Profits are simply:

$$\Pi = p_H c + S p_H^* c^* - \frac{w}{a}\left(c + c^*\right) \qquad (4)$$

Without uncertainty, the optimal price rule with a constant markup is well known:

$$p_H = \frac{\mu}{\mu - 1}\frac{w}{a} \qquad (5)$$

If S is normalized to 1, it is obvious that $p_H^* = p_H$.

Giovannini (1988) introduces exchange rate uncertainty in this framework and assumes that the firm maximizes expected profits. The exchange rate is the only element of uncertainty facing the firm. In this case, the optimal domestic price is still given by (5), and the foreign price is:

$$p_H^* = \frac{\mu}{\mu - 1}\frac{w}{a}\frac{1}{E(S)} \qquad (6)$$

Exchange rate uncertainty has no impact on prices. Only its expected value matters. There is no ex-ante price discrimination: $p_H = E\left(S p_H^*\right)$. A crucial assumption for this result is risk neutrality as firms only care about expected profits.

If firms are risk averse, exchange rate uncertainty matters and would lead to a price that is higher in the foreign market, as first shown by Baron (1976). This reduces the level of trade.[6] However, many authors have shown that trade remains unaffected by exchange rate risk when firms have access to a forward market and the forward discount is zero.[7] In that case (6) still holds.

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6. Hooper and Kohlhagen (1978) consider a somewhat different setup, with both importers and exporters bearing part of the exchange rate risk. When exporters bear most of the risk, exchange rate uncertainty raises the export price and thus reduces trade. When importers bear most of the risk, exchange rate uncertainty reduces import demand (and therefore trade), and lowers the import price. In general, the price effect is therefore ambiguous, but the trade effect is unambiguously negative.

7. See Ethier (1973), Baron (1976), Viaene and de Vries (1992) and Feenstra and Kendall (1991).

An important hypothesis underlying all these papers is that the exchange rate is the only source of uncertainty.[8] However, firms typically face other sources of risk that are potentially correlated with exchange rate fluctuations. If we take the view that exchange rate changes are related to fundamentals, then the same variables that drive fluctuations in the exchange rate are also responsible for uncertainty about the wage rate w, the aggregate demand factors x and x^*, and the technology parameter a. Thus, in order to understand the implications of different exchange rate regimes for price setting and trade flows, we need to compare the overall macroeconomic risks faced by firms under different monetary systems.

In a general equilibrium setting, the firm maximizes the market value of profits $E(q\Pi)$, where q represents the pricing-kernel. It is the value that firms' owners attach to marginal revenue in different states of the world.[9] The pricing-kernel is proportional to the marginal utility of consumption of the firm's owners, which we denote u_c. This implies that the firm will act as being risk averse when setting prices. When all macroeconomic variables are stochastic, optimal prices are:

$$p_H = \frac{\mu}{\mu - 1} \frac{E(u_c cw/a)}{E(u_c c)} \tag{7}$$

$$p_H^* = \frac{\mu}{\mu - 1} \frac{E(u_c c^* w/a)}{E(u_c S c^*)} \tag{8}$$

Prices are still equal to a standard markup over unit cost.[10] The latter is now written as the certainty equivalent of total labor cost, divided by the certainty equivalent of sales. Equations (7) and (8) show that ex-ante price discrimination can go in either direction, dependent on the nature of the uncertainty. In the following sections we develop a full model that determines the behavior of the variables in (7) and (8).

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8. Adam-Mueller (1997) includes both revenue and exchange rate uncertainty.

9. The pricing-kernel corresponds to the price of state-contingent claims if they are traded (which is not required for the pricing-kernel to exist).

10. Notice that these equations are similar to those found in dynamic general equilibrium models with PTM, such as Betts and Devereux (2000), Chari, Kehoe and McGrattan (2000) and Kollmann (1997).

Introducing a forward market does not change the optimum price equations (7) and (8). When firms take a hedge position of quantity b, we have to add the net profit $b(F\text{-}S)$ to (4), where F is the forward rate. This additive term does not affect pricing rules, but affects the stochastic properties of c, c^*, S, and w (thus, the equilibrium prices do change). The same is the case when adding other internationally traded securities. This again shows that a general equilibrium approach is unavoidable.

3. A General Equilibrium Model

In this section we describe - without presenting the technical details - a general equilibrium model based on BW when no asset markets are available. We present the main insights that can be drawn from such a context. The main ingredients of the model are:

- There are two countries. The economic structure and the distribution of shocks are fully symmetric, while shock realizations usually differ across countries. There are both productivity and monetary shocks.

- There is monopolistic competition, à la Dixit-Stiglitz. Consumers in each country value both domestically and foreign produced goods. Thus, there is two-way trade.

- It is a monetary model, with money introduced through a cash-in-advance constraint. The equilibrium nominal exchange rate S depends on the ratio of money supplies, M and M^* which have a jointly symmetric distribution. When money supplies are perfectly correlated, the exchange rate is fixed.

- Individuals consume and supply labor. They maximize expected utility $EU(c,l)$, where c is total consumption and l is leisure.

- Producers set prices before knowing the realization shocks. The amount sold is determined by demand. Each good is produced with one unit of labor. The wage rate is flexible, so that the labor market is always in equilibrium.

- Producers have two potential pricing strategies, PCP or PTM. It is only with this second strategy that exchange rate risk can have a direct effect on trade.

Figure 1 shows the basic structure of the general equilibrium model, abstracting from the monetary sector. Domestic firms are held exclusively by domestic consumers and hire exclusively domestic workers. The only international interaction is the sale of goods in foreign markets.

Given the monopolistic competition assumption, BW show that the various demands relevant for the home country are (for a single good *i*):

$$\begin{aligned} &\text{Domestic demand} \qquad c_H(i) = \frac{1}{2}\left(\frac{p_H(i)}{P}\right)^{-\mu}\frac{M}{P} \\ &\text{Exports} \qquad c_H^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{-\mu}\frac{M^*}{P^*} \qquad (9) \\ &\text{Imports} \qquad c_F(i) = \frac{1}{2}\left(\frac{p_F(i)}{P}\right)^{-\mu}\frac{M}{P} \end{aligned}$$

where μ is the elasticity of substitution between goods. Defining trade as the sum of exports plus imports, divided by GDP, it can be shown that we have:

$$Trade = \frac{\text{exports} + \text{imports}}{GDP} = \frac{Sp_H^* c_H^* + p_F c_F}{Y} = \frac{2}{1 + \left(p_H / p_F\right)^{1-\mu}} \qquad (10)$$

where we use the fact that, in equilibrium, quantities are the same for all firms.[11] As illustrated in Section 2, the measure of trade can be fully determined by relative prices. Equation (10) is even simpler than equation (2), given the model's assumptions, in particular symmetry. In the

11. Trade under PCP is analyzed by Bacchetta and van Wincoop (1998).

PTM case, firms set directly p_H and p_F, so that one needs to look at the optimal pricing decision. When $p_H = p_F$, our trade measure is equal to one (given symmetry the same quantity of foreign and domestic goods is consumed). In the PCP case, we have $p_F = S \cdot p_F^*$ and by symmetry $p_F^* = p_H$. Thus, for PCP equation (10) can be written as:

$$Trade = \frac{2}{1 + S^{1-\mu}} \tag{11}$$

which is simpler than (3). It is easy to show that expected trade is not affected by volatility when the exchange rate depends on the ratio of M and M^*, which have a jointly symmetric distribution.

Let us now examine the pricing discrimination decision under PTM. In this case, BW show that the nominal exchange rate is simply given by $S = M/M^*$. Since prices are preset in local currency, PPP does usually not hold ex post; i.e., $P \neq SP^*$.

As explained in Section 2.2, domestic firm i sets prices $p_H(i)$ and $p_H^*(\mathrm{i})$ to maximize the market value of profits $E(u_c \Pi(i))$; quantities in each market are given by (9). In the benchmark model considered by BW, the certainty equivalent of sales is the same when selling in the home market as when selling in the foreign market. More precisely, domestic sales are proportional to the domestic money supply M, while the value of foreign sales is proportional to SM^*. Since $M = SM^*$, these are equal. One might have expected that the exporter faces a loss in the foreign market when the foreign currency depreciates (S drops). But this is offset by higher demand from abroad if the foreign currency depreciation is the result of a foreign monetary expansion (M^* rises). If the foreign currency depreciation is the result of a domestic monetary contraction, revenue from sales drops the same in the home market as in the foreign market, so in a relative sense there is again no loss from selling in the foreign market.

Therefore, it is only the difference in the certainty equivalent of costs that matters. The price ratio is then given by:

$$\frac{p_H}{p_F} = \frac{Eu_c wM/a}{Eu_c wM^*/a} \tag{12}$$

using the fact that $p_H^* = p_F$ in the symmetric equilibrium. With a fixed exchange rate, $M = M^*$, so that the price ratio is equal to one (and hence the trade measure is equal to one). When the exchange rate is flexible, BW show that the price ratio can be either larger or smaller than one so that trade can be either larger or smaller.

Trade will be lower in a flexible exchange rate regime when selling in the foreign market brings less risk diversification than selling in the domestic market. This is the case for example when:

- Money supply is positively correlated with productivity shocks a (e.g., to stabilize employment). Then, the certainty equivalent of labor costs is lower in the domestic market since M/a is less variable then M^*/a.

- Consumption and leisure are substitutes in the utility of consumers. The wage rate is more correlated with domestic demand shocks than with foreign demand shocks, which makes the total wage bill more volatile in the home market and by itself makes the foreign market more attractive, leading to higher trade under a float. On the other hand, under domestic demand shocks the wage bill is high exactly when firms can well afford to pay them (more formally u_c is low). When selling in the foreign market it is possible that the wage bill is high exactly when firms' revenues are low. This happens when there is a domestic monetary contraction, combined with a foreign monetary expansion. This by itself leads to lower trade under a float. When consumption and leisure are substitutes, the wage rate is less pro-cyclical, weakening the first channel and leading to lower trade under a float.

BW also present conditions under which trade is unaffected by the exchange rate regime. This is the case when utility is separable between consumption and leisure and monetary and productivity shocks are independent. In that case the certainty equivalent of costs is the same whether producers sell at home or abroad.

Finally, BW show that the direction in which the exchange rate system affects trade remains the same once we introduce international asset trade. Although international asset trade, even the extreme of complete Arrow-Debreu markets, can reduce the magnitude by which the exchange rate regime affects trade, it cannot eliminate the impact of the exchange rate regime on trade. Intuitively, this is the case because international financial markets cannot eliminate the difference between foreign demand and domestic demand as a function of the underlying shocks. For example, under complete financial markets the ratio of marginal utilities from domestic and foreign consumption is equal to the real exchange rate, which varies one for one with the nominal exchange rate.

4. But What Is the Optimal Pricing Strategy?

The pricing strategy adopted by firms has important macroeconomic implications. We already saw that the impact of exchange rate volatility on trade depends on the two pricing strategies considered, PCP and PTM. The model also implies more exchange rate volatility under PTM pricing than PCP pricing.[12] With PTM pricing the exchange rate is $S = M/M^*$, while in the PCP case we have $S = \left(M/M^*\right)^{\frac{1}{\mu}}$. Finally, Devereux and Engel (2000) show that the pricing strategy (PCP versus PTM) plays a key role in determining the optimality of different exchange rate systems.

This leads to the question which of these two pricing-strategies is more empirically relevant. The shortcoming of PCP is that it implies a constant real exchange rate. It has been well documented that real exchange rates are very volatile and highly correlated with nominal exchange rates. For identical traded goods the law of one price is grossly violated and relative prices are closely correlated with the nominal exchange rate (e.g. Engel [1993]). This fits very well the implications of PTM pricing. The exchange rate pass-through literature is insightful as well. Under PCP there is full exchange rate pass-through to import prices, while under PTM there is no pass-through. The empirical evidence, reviewed in Goldberg and Knetter (1997), suggest that pass-through from exchange rates to prices, while varying across countries and industries, is on average no more than 50%. The evidence in Engel (1999) suggests that at the level of consumer prices there is almost no pass-through at all. At the

12. Betts and Devereux (1996) make the same point.

consumer level relative non-tradable prices across countries behave very similarly as relative tradable prices.

Even though it seems that the PTM assumption is more appropriate, an important question is whether this pricing strategy is consistent with the underlying microeconomic model used. In the New Open Economy Macroeconomics literature, this question is never asked and the pricing strategy is assumed a priori. The PCP strategy can be justified if price differences between foreign and domestic goods can be arbitraged at no cost. But arbitrage is often very costly, and even impossible when firms have exclusive rights to distribute their products in different countries. The pricing decision is therefore one that needs to be made by the firm. The question is whether exporters prefer PTM or PCP. We need to determine within the context of the model whether either of these pricing strategies is an equilibrium. For example, if all exporters apply PTM, is it optimal for a marginal firm to do the same? Mixed strategies, whereby some firms choose PTM while others choose PCP, may also be an equilibrium. It is important to address these questions both for internal consistency reasons in the context of the models used and to understand what determines the optimal pricing strategy under different conditions. Our current research (Bacchetta and van Wincoop, 2000c) examines these issues and we report on some of the results.

Consider an individual firm *i* in the environment described in Section 3, where all other firms choose PTM. Firm *i* will compare the market value of its profits under both PTM and PCP strategies.[13] If PTM gives higher profits, there is no incentive to deviate from that equilibrium, so that PTM is a pricing strategy that is consistent with firms' optimal behavior. Is there an incentive for an individual firm to deviate from PTM? Let us focus on exports only and remember that the certainty equivalent of profits is equal to the certainty equivalent of sales minus costs. On the cost side firms prefer PTM as it gives less variable quantities and therefore labor costs. The reason is mainly that foreign consumer demand under PTM is not directly affected by the nominal exchange rate. Therefore, there might be a deviation from PTM only if the certainty equivalent of sales can be higher under PCP. Under PTM, the certainty equivalent of firm *i*'s exports $X(i)$ is:

13. In general, other pricing strategies are feasible, such as pricing to market in producers' currency, but we abstract from them in this paper.

$$Eu_c X(i) = Eu_c S p_H^*(i) c^*(i) = \frac{1}{2}\left(\frac{p_H^*(i)}{P^*}\right)^{1-\mu} Eu_c S M^* \tag{13}$$

while under PCP they are:

$$Eu_c \tilde{X}(i) = Eu_c \tilde{p}_H(i) \tilde{c}^*(i) = \frac{1}{2}\left(\frac{\tilde{p}_H(i)}{P^*}\right)^{1-\mu} Eu_c S^{\mu} M^* \tag{14}$$

Where ~ denotes variables under PCP and where we use the fact that under PCP there is a single price for home producers ($\tilde{p}_H = \tilde{p}_H^*$). Under PCP, export sales are more sensitive to the exchange rate, since $\tilde{c}^*(i)$ depends directly on S and the price elasticity μ is larger than one. The higher variability of sales under PCP can however be compensated by the fact that the marginal valuation factor u_c may fluctuate inversely to the nominal exchange rate. Intuitively, when M drops and the marginal utility from domestic consumption is high, the revenue from exports is high under PCP because the currency depreciation increases foreign demand. This makes the PCP strategy more attractive. Thus, there are cases where a firm will deviate from the PTM strategy because PCP provides a better risk diversification. In general, however, it is not clear when firms would deviate from PTM and PCP pricing. This depends in particular on μ and the concavity of the utility function with respect to consumption.

Similar reasoning can be conducted when all the other firms use PCP. In this case, it is also possible to show that the optimal pricing behavior is ambiguous and depends on the parameters. An interesting question is whether there are circumstances (i.e., parameter values) where neither PCP nor PTM are equilibria. In this case, a solution to the optimal pricing strategy is to have a proportion of firms applying PTM, while others apply PCP. Whether such cases exist cannot be determined analytically and numerical simulations must be used.

Another important issue is the role of asset markets. Since the optimal pricing strategy is influenced by risk diversification considerations, different asset market structures may influence the pricing strategy. Here again, the issue is complex and no analytical results are available (yet). Thus, we will need to use simulations.

To get more specific results, we focus on a CES utility function:

$$U(c,l) = V(c,l)^{1-\gamma} \big/ (1-\gamma) \tag{15}$$

where $V(c,l)$ is a CES index with ε the elasticity of substitution between consumption and leisure. Consumption and leisure are complements, separable, or substitutes, dependent on whether $\varepsilon\gamma$ is respectively smaller than, equal to, or larger than 1. In the separable case, it can be shown that the certainty equivalent of export sales is higher under PCP when $\mu > \gamma$. Since the certainty equivalent of labor costs is lower under PTM, we need situations where μ is clearly higher than γ to have PCP preferred by the marginal firm. Notice that if the marginal firm does prefer PCP, it only tells us that PTM adopted by all firms is not an equilibrium. It does not tell us that PCP is an equilibrium.

Table 1: Optimal pricing strategy when other firms choose PTM
(separable preferences and no international asset trade)

	γ			
μ	0.9	1.1	2	5
2	PCP	PTM	PTM	PTM
5	PCP	PCP	PTM	PTM
10	PCP	PCP	PTM	PTM
50	PCP	PCP	PCP	PTM

Table 1 presents simulation results under different values of γ and in the separable case ($\varepsilon\gamma$ = 1). [14] It shows that depending on parameters, either PTM or PCP is preferred. However, for

14. We assume that M and M^* can take on 11 equidistant values, with mean 0.5, standard deviation 0.075, and correlation 0.5. A final assumption is that the weight of the CES index is set such that l= 0.5 in the deterministic equilibrium, assuming that time (other than sleep and household chores) is equally divided between work and leisure.

the most plausible values for γ and μ PTM is preferred by the marginal firm and is therefore an equilibrium. Most evidence shows that the rate of relative risk aversion γ is larger than 2 (e.g., Friend and Blume [1975]). Hummels [1999] obtains estimates for μ in the range of 5 to 10.

Simulations can also be conducted when all other firms apply the PCP strategy. Our numerical results show that the marginal firm prefers PTM under all the parameters combinations of Table 1. Thus, PCP is not an equilibrium in this context. This also implies that there are parameter combinations, e.g., when γ is low, where neither PTM nor PCP are equilibria. In these cases, there will be 'mixed' equilibria where a proportion of firms apply PTM, while the other firms apply PCP.[15]

In all these experiments, it is assumed that firms have no access to asset markets and thus cannot hedge. How does the availability of assets influence the optimal pricing decision?[16] We have run the simulations with the parameters of Table 1 under the assumption that all firms have access to complete financial markets.

We find that, for all parameter combinations, a marginal firm prefers PCP when other firms price according to PTM, while the marginal firm prefers PTM when all other firms price according to PCP. This means that neither PTM nor PCP are equilibria. There will be a mixed strategy equilibrium whereby a fraction of firms price according to PTM, while others choose PCP.[17]

To summarize, in the absence of international asset trade, PTM is an equilibrium for most plausible parameter values, while under complete asset markets there will be a mixed strategy equilibrium. Overall, we may therefore conclude that the model's predictions are roughly consistent with empirical evidence. Since there is limited risk sharing (e.g., see Athanasoulis and van Wincoop (2000)), we are far from the complete market situation. The model would

15. Actually, there could be mixed strategies by individual firms or a 'mix' of pure strategy. The two are equivalent since the number of firms is infinite.

16. In a partial equilibrium framework Friberg (1998) shows that PTM is preferred when a forward market is available.

17. For implausible parameters that are not in the table, PTM can be an equilibrium. In particular, when $\gamma\mu < 1$, PTM is an equilibrium under complete asset markets.

then predict that PTM is an equilibrium strategy, which is what is empirically observed. As international financial markets become more integrated, the model would predict that PCP becomes a more attractive pricing strategy.

5. Conclusion

This paper has examined the relationship between nominal exchange rate fluctuations and trade flows. There might be a presumption that more exchange rate volatility increases the riskiness of trade flows, and thus decreases trade flows. However, this presumption is much too simplistic. First, we argue that we cannot analyze exchange rate volatility in isolation, but we need to specify the exchange rate regime. The question therefore becomes whether trade is lower under a floating exchange rate regime. Here, we show that the answer is ambiguous and that it depends on numerous factors, in particular the pricing strategy. Trade is only affected by the exchange rate regime when firms apply PTM. We argue that PTM is more empirically relevant than PCP and for reasonable parameters is indeed an optimal pricing strategy for firms when markets are incomplete. While we have given some examples where trade is lower under a float with PTM, in general it can go either way, depending on preferences and the way monetary policy is conducted under a float.

Some readers might wonder whether this is a sterile theoretical exercise. True, part of our investigation is still at an early stage and more work needs to be done to fully apply it to the real world and to resolve several of the ambiguities. In particular, it would be interesting to conduct empirical studies based on the present framework. This would help determine what aspects of the model should be amended or extended. Overall, however, we strongly believe that the general equilibrium approach presented in this paper is more fruitful than partial equilibrium or ad-hoc models to understand the impact of the exchange rate regime.

One of the advantages of the approach is that welfare conclusions can be drawn. This is done in detail in BW, where we present conditions under which a fixed exchange rate is preferred to a flexible rate. One of the results is that there is no one-to-one relationship between trade and welfare, e.g., a fixed exchange rate regime may increase trade, but lower welfare. So even when the presumption that exchange rate volatility reduces trade is correct, it does not necessarily mean that welfare is lower under a float.

We have also shown that the asset market structure has an important role for the pricing strategy. The model suggests that as financial markets become more integrated, firms are likely to switch more to producer currency pricing, leading to lower real exchange rate fluctuations and a smaller impact of the exchange rate regime on trade. While financial markets affect the pricing strategy of firms, the opposite may be the case as well. The currency denomination of goods trade could affect the currency denomination of asset trade, leading to a potentially interesting simultaneity problem that is beyond the scope of the present paper.

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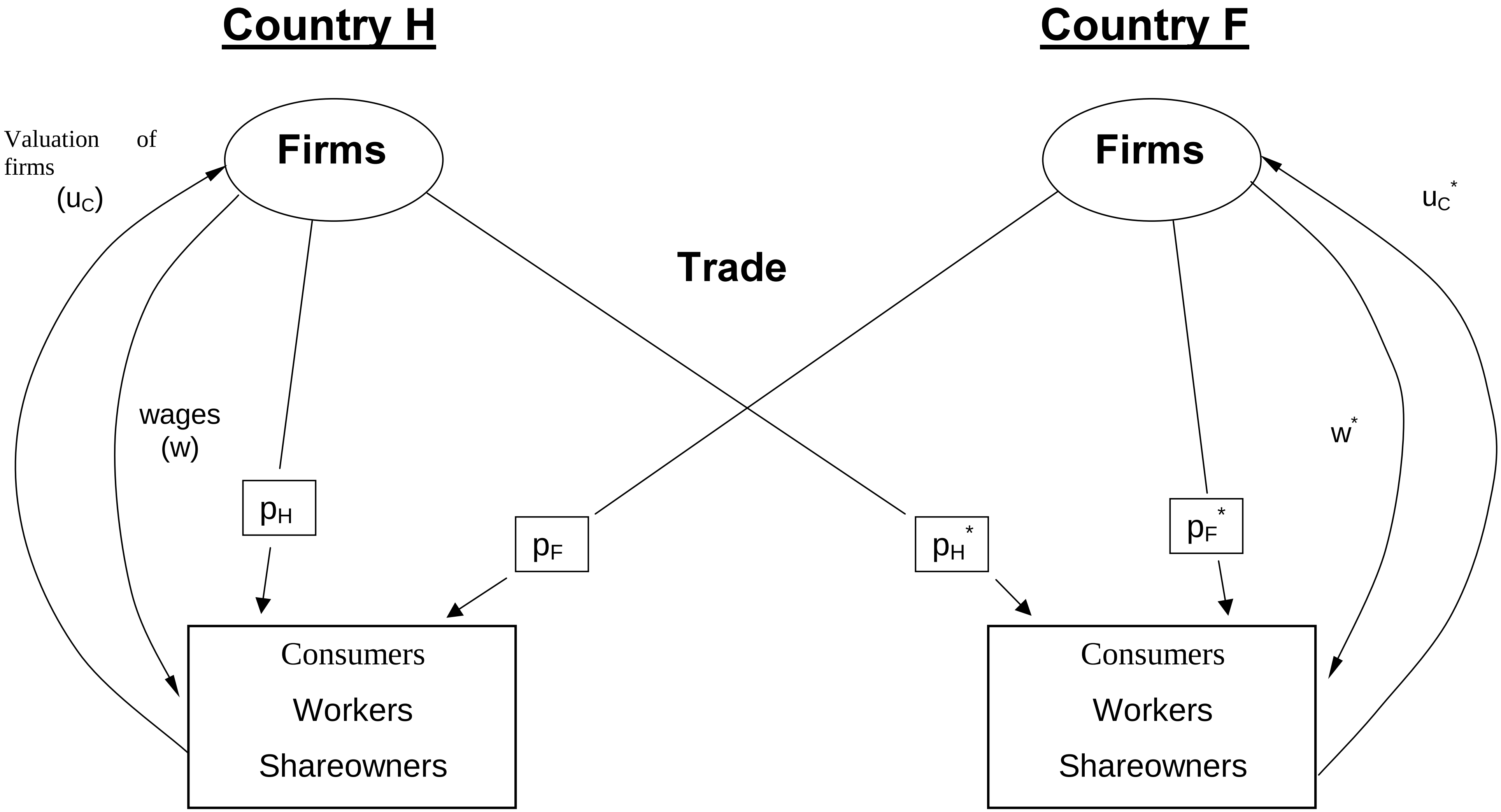
Figure 1



Under PTM: H firms set p_H, p_H^*. In symmetric equilibrium, $p_H = p_F^*$

F firms set p_F, p_F^*. $p_F = p_H^*$

Under PCP: H firms set p_H. Then, $p_H^* = \frac{p_H}{S}$ In symmetric equilibrium, $p_H = p_F^*$

F firms set p_F^*. Then, $p_F = S \cdot p_F^*$