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Firms, International Money and Prices: a Survey of the Literature

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ABSTRACT

Sluggish price adjustments with respect to exchange rate shocks take essentially two forms. Firstly, prices do not adjust completely to neutralize the effects of nominal exchange rate shocks. Secondly, price adjustments after exchange rate shocks only take place in discrete time intervals, in other words they are discontinuous. These two features of price adjustments form our definition of international price rigidities. In this paper we shall present a survey of the empirical and theoretical literature on international price rigidities. We provide the underlying intuition of the theoretical research and present a brief summary of the empirical findings.

I. INTRODUCTION

In the international monetary economics literature, there exists a long-standing debate as concerns the effectiveness of the exchange rate instrument to correct for current account imbalances and stabilisation purposes. Conventional wisdom regarding the neutrality of exchange rate policies is not justified by the empirical regularities. A common observation is that nominal exchange rates are much more volatile in comparison to aggregate or firm level prices in an economy providing scope for effective use of exchange rates as monetary policy tools.

There are four very closely related concepts in the handbook of exchange rates and prices: The law of one price, the purchasing power parity, the exchange rate pass-through and the pricing-to-market¹.

The law of one price (LOP) implies an identical price of an identical product across countries in the absence of distribution –, resale –, transaction – or transportation costs. In this outset the exchange rate is the simple conversion operator. The LOP is commonly accepted as the touchstone for the degree of market integration of a particular product. If the LOP can be extended to n- goods in economies engaging in trade we can conveniently refer to the purchasing power parity (PPP). There is extensive empirical evidence that exchange rate changes are not necessarily followed by price adjustments to restore PPP and often it requires long time periods for PPP to be met again. If the nominal exchange rate changes have real effects on the economies, one can forcefully defend independent exchange rate policies.

The exchange rate pass-through (EPT) refers to the destination currency import price changes with respect to a one percent change in the exchange rate between exporting and importing countries. The relationship between import prices and exchange rates is crucial in the sense that devaluation is expected to improve the short-run competitive position of a country that observes its currency depreciating. If an exchange rate instrument has at least a short-run impact on a country's competitiveness, an incomplete EPT is a partial explanation for the famous J-curve result in international trade. Empirical studies conducted so far give strong support for incomplete EPT.

The fourth concept captures microeconomic foundations of price adjustments with respect to exchange rate changes. The pricing-to-market (PTM) refers to the strategic pricing behaviour of firms

engaged in international trade. Some multinational firms may find it in their strategic interest not to reflect exchange rate swings in their local currency prices. If the future prospects are positive multinational firms may allow fluctuations in their profit margins. This may be due to their interest in protecting their market share or due to the existence of the sunk cost and exchange rate uncertainty. PTM explicitly focuses on the international price discrimination of multinational firms in a domestic market. Consequently, LOP is often violated via firm specific pricing decisions².

Although exchange rate pass-through and pricing-to-market have been recognized a long time ago, they only gained attention after the publication of the seminal papers of Krugman (1986) and Dornbusch (1987) noting a less than proportional fall of US domestic prices with respect to an appreciation of the US dollar in the early 1980's, complemented by an insufficient adjustment in the foreign prices³. Later on, several empirical studies verified incomplete pass-through (EPT) and pricing-to-market (PTM) as common evidence in different international goods markets. Although there are numerous conflicting reports about the level and the stability of the pass-through relationship, it is commonly accepted that there is no one-to-one relationship between the changes in exchange rates and price adjustments.

In this paper we aim to provide a survey of some partial equilibrium models dealing with two different aspects of international price rigidities. First of all, prices do not adjust continuously with respect to changes in the exchange rates. Secondly, even if the adjustment occurs, it is often incomplete with respect to the exchange rate changes. These two odd features of prices are which we review in this paper. We shall refer to the incompleteness and/or discontinuity of price adjustments as “the international price rigidities after exchange rate shocks”.

Bulk of the literature focuses on the incomplete price adjustments. Both static and dynamic aspects of incomplete price adjustments are explored in ongoing research. Static aspects of pricing analysis incorporate strategic behaviour as suggested by Bulow et al. (1985) in imperfectly competitive markets with product differentiation. Dynamic analyses incorporate competition for market share or sunk costs and enhance our understanding of price adjustment of individual firms.

Discontinuity feature of the price adjustments gained only limited attention within the international context although there exists ample

evidence that nominal price changes occur only in discrete jumps⁴. The arguments used to support this position rely on the existence of some adjustment costs, more popularly on the menu costs⁵.

Recent research in international macroeconomics attempts to capture these commonly observed features of international prices derived from microfoundations. As Betts and Devereux (2000) note pricing-to-market plays a crucial role in the exchange rate determination and international business cycles. The presence of pricing-to-market limits the role of exchange rate policies to increase or decrease aggregate demand in a certain country. A successful exchange rate policy potentially requires larger shocks to fundamentals thereby increasing the volatility of exchange rates. Secondly, an aggregate pricing-to-market means departure from the PPP. Therefore it constrains the comovements of consumption across countries whereas increasing the comovements of output across countries. Incorporation of microfoundations for international price stickiness in the general equilibrium analysis proves to be crucial. However, general equilibrium models are beyond the scope of this survey paper⁶.

The paper is organized as follows. Section II presents short-term models of incomplete price adjustments. Section III surveys the dynamic aspects of incomplete price adjustment and its impact on market structure. Section IV discusses briefly the discontinuity aspects of international price rigidities. Section V summarizes the empirical findings on international price rigidities, both for incompleteness and discontinuity aspects. Finally, section VI concludes.

II. INCOMPLETE PRICE CHANGES: STATIC APPROACHES

Multinational firms usually take exchange rate fluctuations seriously since exchange rate swings directly affect profit margins. Therefore exchange rate shocks influence pricing, output and investment decisions of individual firms⁷.

In this section, we shall present a survey of static models. In static settings, firms are concerned with period-by-period change in the profitability of their business with respect to exchange rate shocks. Therefore the level of economic exposure to international shocks determines the size and timing of a firm's price change and strategic pricing across firms⁸. Elements of imperfect competition, such as

product differentiation, oligopolistic competition and vertical relationships in multinational production and trading activities shed some light on the pricing process in international markets.

A. Elasticity Approach

We can easily relate the concept of pass-through to the demand and supply elasticities of exports and imports. We start with the definitions provided by Menon (1995). The demand function for an imported good can be written as:

$$y_D = D(p_D) \quad (1)$$

whereas we can write the supply function for the same good as being:

$$y_S = S(p_F / e) \quad (2)$$

y_D represents the quantity demanded, y_S the quantity supplied and e the nominal exchange rate. Differentiation of the above expressions with respect to prices and solving for the equilibrium condition yields⁹:

$$\left(\frac{y_D}{p_D \epsilon_S} \right) \left(\partial p_D - \frac{p_D}{e \partial e} \right) = \frac{y_D}{p_D} \epsilon_D \partial p_D \quad (3)$$

simplifying the expression results in:

$$\frac{\partial p_D}{\partial e} \frac{e}{p_D} = \frac{1}{(1 - \epsilon_D \epsilon_S)} \quad (4)$$

This equation has a simple interpretation. The change in the domestic price is a function of demand and supply elasticities for imports. If the demand and (or) supply for imports are perfectly elastic, the domestic price response will always be in line with exchange rate changes. In other words, exchange rate pass-through will be complete. This is not a realistic result. There is nothing inherent in the analysis that can capture the timing of price response, market structures as institutions and underlying quantity response of the firms. Further we will look at other tools of analysis developed by different scholars, which provided an attempt to

understand the underlying characteristics of the pricing-to-market phenomenon.

B. Market Structure and Product Differentiation

1. Quantity Competition

The elasticity approach is not sufficient to account for incomplete price responses to exchange rate shocks. Product differentiation and oligopolistic competition come as natural candidates to explain the violation of the Law of One Price in the goods markets. In an important paper Dornbusch (1987) provided a straightforward explanation why oligopolistic competition and product differentiation may lead to incomplete adjustment of prices¹⁰.

Due to the simplicity and intuitive nature of its results, we shall present a version of the Dornbusch model. In a n-firm model with constant marginal cost technology-, and linear demand functions, domestic and foreign firms engage in a quantity competition with differentiated products. We can write the profit function for the domestic firms as being:

$$\Pi_D = (p_D - c_D(y_{DD}, y_{DF}))y_{DD} \quad (5)$$

and the foreign firms profit function is represented as:

$$\Pi_F = (p_D - ec_F(y_{FD}, y_{FF}))y_{FD} \quad (6)$$

where p stands for prices, y stands for output and e for the nominal exchange rate. Furthermore, subscript D is for a domestic and subscript F is for a foreign country¹¹. For the sake of simplicity, assume that the firms use the same constant marginal cost technology to produce the final good (i.e. $c_D = c_F$). Secondly, it is assumed that markets are segmented, meaning that the supply responses to demand shocks in, say, the domestic market, has no implications on the supply response in the foreign market. And thirdly we assume a linear demand function represented as $Y_D = a - bp_D$, so that we can write the total supply in the domestic market as $Y_D = n_D y_{DD} + n_F y_{FD}$, where $N = n_D + n_F$ represents the total number of firms active in the domestic market.

We assume that the reaction functions of the Cournot competition are downward sloping. These best response functions represent the response of the firms with respect to their opponent's strategy. In most cases we have downward sloping reaction functions in the Cournot Competition with linear demand and cost specifications. This implies that firms' actions are strategic substitutes (see Bulow, Geanakoplos and Klemperer (1985))¹².

Taking the first order conditions to calculate the equilibrium level of prices in the domestic market leads to the following price expression:

$$p_D = \frac{1}{1+N} \left(n_D c_D + n_F e c_F + \frac{a}{b} \right) \quad (7)$$

where $N = n_D + n_F$. We can write the price elasticities with respect to exchange rates:

$$\varepsilon = \frac{\partial p_D}{\partial e} \frac{e}{p_D} = \left[\frac{n_F}{(N+1)} \frac{e c_F}{p_D} \right] \quad (8)$$

which shows that under the Cournot set-up the prices are explicitly dependent on the number of firms in the domestic market. An increase of the number of the foreign firms (large market power of the foreign firms in the domestic market) will tend to push-up the prices in line with the exchange rate depreciation. Hence, under perfect competition this relation tends to be complete and exchange rate changes are neutralized by the adjustments in prices. Naturally, the weaker competition on the side of the foreign firms operating in the domestic country tends to generate less than proportional price adjustment with respect to exchange rate shocks.

The price to marginal cost relation (represented by the second term on the left hand side of the expression) allows us to derive an interesting conclusion. The more competitive the foreign firms (smaller mark-up) the higher the domestic price adjustment will be.

Thus, the simple Cournot model of Dornbusch is capable of accounting for the incomplete domestic price adjustments with respect to exchange rate shocks as a function of both the concentration and the share of trade. An interesting aspect of quantity competition analysis is its account of incomplete adjustment of prices without any reliance on product differentiation. Naturally,

price adjustments in the opposite direction occur in the foreign country¹³.

2. Price Competition with Product Differentiation

Dornbusch (1987) offered an alternative price competition model using Salop's spatial competition framework. In this set-up domestic and foreign firms are located equidistantly and alternating on a circle¹⁴. The model implies a two-stage game. In the first stage firms decide to enter the market. In the second stage they compete in prices. The entry decision depends on the disutility of consumers per unit of distance, which in fact represents the level of product differentiation, the market size and the fixed costs the firms incur when they enter the market. Thus, the equilibrium number of entrants is determined endogenously, when the size of the market is given.

Next, Dornbusch (1987) derives the elasticities with respect to exchange rate shocks. Foreign firms cannot perfectly adjust their prices with respect to exchange rate shocks. Full adjustment of prices would induce them to loose their market shares if they produce close substitutes to domestically produced products. Yet, the Dornbusch model fails to account for long-term implications of exchange rate shocks, in other words entry and exit is excluded, since the model implicitly relies on the assumption that domestic and foreign firms alternate around the unitary circle. In fact Salop's model is designed to account for entry and exit decisions of the firms. The assumption that firms alternate around the circle does not allow one to address issues of market structure. We will come back to an extension of the Salop model when we investigate dynamic models and market structure changes¹⁵.

3. Input Price Shocks

Input prices can play a crucial role in explaining the price stickiness at the final goods level. A simple illustrative example goes as follows. Assume a devaluation that automatically improves the competitiveness of the firms located in the domestic country defined in terms of domestic currency. The foreign firm's prices defined in terms of the domestic currency will go up, whereas domestic prices do not change. In the foreign country, however, there will be a change in the opposite direction. A domestic firm's prices defined in

terms of the domestic currency will be less, whereas the foreign firms' prices in their own country *ceteris paribus* do not change. This represents the direct effect of devaluation as discussed in the section presenting models of quantity competition. On the other hand, trade integration is certainly relevant for inputs as well. Primary and intermediate goods play a crucial role in total trade transactions. Thus a devaluation of the domestic currency is likely to increase the production costs of the domestic firms, when part of the inputs are imported from abroad. Importing inputs will be more expensive and the costs of production of the final commodity will increase in line with the exchange rate change. This clearly represents the indirect effects of exchange rate shocks and these offsetting effects have strong policy implications for exchange rate pass-through and exchange rate policies.

Here, there are two empirical facts that are worth the mention. Firstly, empirical studies have well documented the fact that some primary and intermediate goods prices do not completely adjust to nominal exchange rate shocks¹⁶. This is particularly interesting for primary goods, which are usually characterized by their homogeneous nature. Secondly, empirical research shows the substantial impact of input price effects due to exchange rate shocks on the final good prices¹⁷.

Knetter (1993), Athukorala and Menon (1994), and Campa and Goldberg ((1995), (1997)) give a partial account of the relevance of these input price shocks. A recent study by Aksoy and Riyanto (2000) developed a two stage game model wherein different institutional setups, in other words vertical integration and vertical separation, and strategic interaction among the firms matter. A vertically integrated firm, or in other words, a firm engaged in the production of both inputs and final goods, will have a strategic advantage in deciding the input prices it will charge as higher strategic input pricing may increase its rivals' costs. In line with certain conclusions reached in the strategic trade literature regarding vertically related markets, exchange rate changes will influence the pricing decisions in a similar way¹⁸. When the foreign market is characterized by vertically integrated firms and the domestic market is not, an exchange rate shock is likely to lead to a higher level of pass-through in the final goods market. This arises due to the market power of the foreign firm in the inputs market that makes the adjustment of prices in the final goods market straightforward.

III. INCOMPLETE PRICE CHANGES: DYNAMIC APPROACHES

The static literature is partially capable of accounting for incomplete price adjustments in the final goods markets. Although they provide intuitive explanations for incomplete price adjustments what is likely to be missed is how price adjustments take place over time and whether incompleteness is a persistent / permanent fact. Exchange rate expectations are neglected and firms pricing decisions are abstracted from time. Its results are dependent on the nature of the competition, assumptions about the strategic interaction between competing firms and the shape of the demand and cost functions. Naturally, static analysis does not take into consideration eventual changes in the market structure due to a nominal shock. Its underlying assumption is that in the long-run macroeconomic aggregates are not affected by monetary shocks. However, recent research proved that the inherent dynamics of the pricing process are crucial. Here, firms' interest lies in the expected value of the firm rather than on the period-by-period profits or revenues where the firm's value is measured as the present discounted value of expected future cash flows.

Essentially, a simple modification in the analysis to capture dynamics can lead to an interesting and very powerful result. If a shock on the nominal exchange rates can trigger persistent and even permanent effects on the trading relationships (and hence on the real economy) this brings one essentially at odds with the idea of long-term neutrality of monetary shocks which underlies all mainstream (New Keynesian or a Real Business Cycle) macroeconomic models. The question then becomes: May an exchange rate shock cause a change in the market structure?

The answer is yes. Incorporation of sunk costs in a dynamic framework establishes this result. In the following sections we will provide an overview of the literature capturing pricing dynamics after an exchange rate shock. We will divide the literature into supply- and demand side analysis. These models are what we will turn to in the following subsections.

A. Supply Side Analysis

If exchange rate shocks trigger entry and exit on the side of the internationally active trade firms in a certain domestic market, we are immediately confronted with market structure changes. There are two

lines of research with sunk cost arguments: The beachhead model and a model of circular competition. We explain first the beachhead model.

1. The Beachhead Model

Hysteresis literature captures the dynamic implications that exchange rate shocks may have on the market structure. Temporary exchange rate shocks can have permanent effects via its influence on the market structure. According to Baldwin (1988) a firm incurs some fixed costs when it enters in a particular export market (costs of marketing, distribution networks, brand name establishment and so on). These costs are sunk, such that they are not recoverable once the firm has entered the market. However, by entering the market, firms anticipate their expected discounted flow of net profits at least to cover these sunk costs in the future¹⁹. Put differently, sunk costs determine the number of firms acting in the market. On the other hand, firms usually incur a recurrent fixed cost in order to maintain their gained market shares. (for instance, costs of regular advertisement, extension of distribution networks etc.) Such maintenance costs directly affect the level of profits of the firms in the domestic market.

A change in the exchange rate may lead to foreign firms changing their behaviour in the domestic market. Foreign firms may be reluctant to leave the market even if their operating profits become negative due to, say, devaluation, because of the sunk costs already incurred. This decision will be explicitly dependent on the perception of the nature of the shock. The size and persistence of the exchange rate shock is the key to the exit /stay decision. Alternatively, since re-entry includes a regeneration of sunk costs, firms may take this into consideration before they decide to leave the domestic market.

Thus, this model has the feature of being able to account for a pricing-to-market range where the market structure will not be affected and the import prices will be less responsive (temporary pricing-to-market effects) as well as for permanent changes in the market structure (permanent exit and entry effects)²⁰.

Let us briefly present the model. Using a slightly modified version of the Spence and Dixit and Stiglitz (S-D-S) framework, Baldwin (1988) assumes perfect foresight and therefore a fully predictable deterministic exchange rate path, whereas Baldwin and Krugman (1989) allow for more realistic stochastic behavior of exchange rates.

We focus on the Baldwin's version (1988) that will serve as the benchmark framework. Let us express the discounted flow of future profits gross of sunk cost for the domestic firm as a case in which where firms produce a variety of a particular good y and engage in quantity competition:

$$\Pi_D = \left[\sum_{t=0}^{\infty} (R^t p_D(m, y_D) y_D - c_D y_D - F) \right] - S \quad (9)$$

and for the foreign firm:

$$\Pi_F = \left[\sum_{t=0}^{\infty} (R^t p_D(m, y_F) y_F - c_F y_F - F) \right] - S \quad (10)$$

where parameter F represents the recurrent fixed costs to be paid at every period. S represents the sunk costs incurred when firms decided to enter the market at $t=1$. Note that S and F are assumed to be equal across firms and varieties, but $S > F$. Let us denote $R^t = \frac{1}{1+r}$, with r being the constant market discount factor and e as the nominal exchange rate²¹. The variable m represents the total number of varieties²². The implication of the S-D-S model is that the inverse demand functions are identical across firms, although they are for a different variety.

Equations (9) and (10) indicate firms' decision rule to enter the domestic market. They anticipate covering at least the sunk cost they incurred, once they decide to enter the domestic market. In other words, they calculate the expected discounted flow of net profits to be at least equal to S . Therefore, we can derive the entry and exit conditions of the domestic and foreign firms from the discounted reduced form profits (ignoring the integer problem) and write:

$$\text{Entry: } R^t * O\Pi_D > F \text{ and } R^t * O\Pi_F > F \quad (11)$$

$$\text{Exit: } R^t * O\Pi_D < 0 \text{ and } R^t * O\Pi_F < 0 \quad (12)$$

where $O\Pi$ represents the optimal profits from the first order conditions. Note that (11) represents entry conditions for domestic and foreign firms and (12) the exit conditions²³. The gap between the exit- and entry conditions clearly provides the explanation for the

hysteresis result of the Baldwin model. In this set-up, the firm number can change in the period-by-period equilibria.

An exchange rate shock typically drives firms away from the symmetric equilibrium. In this case, large and small devaluations have different implications for market structure. A small devaluation does not change the market structure. Firms stay in the market even if they accumulate losses during the deviation period of the exchange rate from its PPP level. In order to protect their market shares, these firms price to market, which is calculated from the price elasticities of exchange rates. Baldwin shows that under small devaluations there will be no decrease in the varieties. When the exchange rate returns to its initial value, prices adjust fully and pre-shock equilibrium is re-established.

In case of large devaluations, some firms will find it profitable rather to leave the market. Thus, due to a decrease in the variety, less than proportional price adjustment will not be restored when the exchange rate returns to its initial level. Price levels and trade volumes will change irreversibly.

Dixit (1989) and Baldwin and Krugman (1989) extended Baldwin's framework by relaxing the deterministic exchange rate path. Baldwin and Krugman (1989) model the exchange rate as an i.i.d. random variable. More interestingly, the entry-exit decisions (and therefore also the market structure) are allowed to give feedback to the exchange rate. Their basic conclusion is that when a large exchange rate shock provokes sufficiently large capital inflows or outflows in a domestic country, the exchange rate cannot return to its initial value. This result is the outcome of entry and exit decisions and causes a structural break in the equilibrium exchange rate.

Dixit (1989) models exchange rates as following a random walk²⁴. His conclusions are in line with those of Baldwin and Krugman. However, he also relaxes the assumption of invariant sunk costs. With asymmetric sunk costs across firms he finds that those firms with the smallest sunk cost will be the first to enter and the first to leave. If the currency starts to appreciate foreign firms with relatively small sunk costs will start to enter. If the exchange rate reverts to establish its PPP level, the firms with smaller sunk entry costs will exit, and those having invested a larger sum in order to enter, will stay in the domestic market and will price to market²⁵.

Baldwin and Lyons (1994) analyzed the long-term effects of exchange rate shocks at the cross-section of Dornbusch's overshoot-

ing model and the sunk cost argument. Their results confirm the previous literature. Furthermore, the application of the Dornbusch model allows them to derive some tentative policy conclusions. They argue that given that prices are sticky, a monetary shock will translate to a greater likelihood of hysteresis. This is a challenge to Dornbusch's model that foresees a long-term neutrality of (nominal) policy-induced shocks.

Another contribution to the hysteresis literature is made by Lin and Tseng (1993). In their model they look at the permanent impact of the devaluations on the current account via macroeconomic decision variables such as consumption and investment. Effects of the exchange rate on the labour market are also analyzed. They combine the Dixit-Stiglitz model (fixed mark-up over constant marginal cost) in an intertemporal maximization framework with the sunk-cost argument of Baldwin and find that devaluation would firstly decrease the sunk and maintenance costs of a foreign firm measured in the foreign currency. This would make the entrance of firms into the domestic market cheaper and would lead to an increase in investment so that individuals should instantaneously and permanently decrease their consumption in order to accommodate the new entrants or new varieties, which will decrease labour demand. This puts pressure on real wages, and therefore domestic real wages decrease. This apparently constitutes a boost in the overall intertemporal profits of the incumbent firm. In the long-run foreign asset stock would be reduced so that the current account deteriorates.

2. Sunk Costs and Circular Aspects

Aksoy and Lustig (1998) use a modified version of the Salop model for spatial competition. As mentioned earlier, Dornbusch's (1987) account of Salop's model does not cover entry and exit decisions. In fact, Salop's model is designed for this purpose. Again the existence of sunk entry costs is the key for understanding the hysteresis result. A foreign homogeneous good producer will be more vulnerable to devaluations than a firm producing a highly differentiated brand, where consumers buy only one brand of a particular product. Aksoy and Lustig (1998) identify the foreign firm which is due to exit after an exchange rate shock and are able to show that exchange rate triggered price increases are more likely to occur than exchange rate triggered price decreases. Entry requires high sunk costs, whereas exit is either costless or less costly.

Both types of supply side analysis shed some light on some recent observations. As Friberg (1999) notes following the Korean exchange rate crisis Volvo took the opportunity to buy part of a Korean firm Samsung hence strengthened its position. Similarly, General Motors, Ford, P&G and Shell, all were looking Korean firms to purchase. As the sunk costs approaches to nil (in terms of domestic currency), it becomes easier for multinational firms to enter a country either for trading or investment purposes. Most importantly, a change in the market structure, therefore a change in the production process, triggers a violation of long run neutrality of a nominal variable, namely exchange rates.

B. Demand Side Analysis

Demand side analysis is a complement to supply side analysis. As Froot and Klemperer ((1989) p.638) put it, in both types of dynamic models, firms can make initial investments in foreign markets that give them the opportunity to earn future profits. In supply side models these investments take the form of sales infrastructure, whereas demand side models investments purchase consumer allegiance. Both of these can be interpreted as firm specific investments in either invisible assets or future demands.

Demand side analysis results are independent of entry and exit decisions and exchange rate uncertainty. Hence, these models do not imply hysteresis but confirm pricing-to-market result from the static theory.

1. Competition for Market Share

Firms' future demands and profits are dependent on their current market shares. Brand loyalty of consumers is a common phenomenon. Switching costs, transaction costs of switching suppliers or search costs may induce consumers to consume the same brand of a product. Due to the existence of such rigidities, past market shares would matter when firms decide on their pricing strategies. As a consequence, any expected change in the exchange rate will influence the value of current market share and thus will affect the pricing behaviour of firms. Froot and Klemperer (1989) address this idea in a two period oligopolistic competition setting with perfect capital mobility in a domestic market.

In the case of appreciation of the domestic currency their findings suggest that the foreign firms price more aggressively in the domestic market in order to gain larger market share, if the price of the domestic currency is expected to stay permanently at a higher level. If exchange rate change is perceived to be temporary, foreign firms will behave less aggressively. This result hinges on the cost- and real interest effects. The cost effect is the first period decrease (here, domestic currency appreciates) of foreign firms' production costs. This tends to decrease the prices of the foreign firms in the domestic market. On the other hand, the real interest effect can be set out as follows: a temporary appreciation makes future domestic currency profits of the foreign firm relatively less valuable than its current profits (defined in domestic currency). This induces the foreign firm to increase its prices. The relative magnitude of these two opposing effects and the perception of the nature of the exchange rate shock determine the prices in the domestic market. The result is independent from the type of competition and specific assumptions about the model. However, potential perverse reactions of prices are closely linked with capital mobility. In this study the exchange rate path is modelled as a deterministic path and expectations are not formed endogenously²⁶. Obviously, these assumptions are quite restrictive. Nevertheless, the model provides interesting insights into the question.

Tivig (1996) provides an extension to the work of Froot and Klemperer. She argues that the microeconomic foundations of the J-curve hinges on the intertemporal maximization problem. In a two-period model of duopolistic competition with differentiated products and constant marginal costs she relaxes the assumption of perfect capital mobility. Tivig finds, regardless of the degree of capital mobility, possibility of 'perverse' price reactions to changes in the exchange rates. The reason for this finding is the intertemporal profit maximization hypothesis itself. With complementary demands duopolists are not forced to operate each period in the elastic region of their demand functions, which generates the potential perverse outcome. In this framework, a first period perverse reaction is possible. In the second period this can be corrected.

Broadly speaking, demand side analysis does not necessarily argue for a permanent impact of nominal exchange rates changes. In this sense this type of analysis can be grouped together with static analysis of PTM and EPT.

IV. DISCONTINUOUS PRICE CHANGES: MENU COSTS

A fundamental observation that underlies the New-Keynesian analysis is that economic decisions are often characterized by periods of an inactive state that is followed by a change in prices. Price adjustments do not follow nominal changes immediately (in other words, these are discontinuous). Current research on price dynamics suggests that firms apply a simple price change rule in which real (unobserved) prices fluctuate between two predetermined bounds. Firms take an action if and only if real prices reach one of these bounds and we observe price changes. According to (among others) Sheshinski and Weiss (1983) these bounds are determined by the price adjustment costs firms face. This type of linear or fixed adjustment costs is often referred to as menu costs. A precise description of the menu costs is not provided in the literature. However, one can think of menu costs as Fluet and Phaneuf (1997) put:

“...in response to small shifts in demand, imperfectly competitive firms do not adjust their prices, because, starting from the profit maximizing price-quantity combination, the gains in profits from small changes in prices are only second-order.”

According to the literature, these costs basically represent the administrative and executive costs of changing the prices²⁷.

The commonly applied methodology that analyses infrequent price adjustment in the dynamic context is borrowed from the inventory models, the so-called *sS* policies²⁸. In this framework, timing of price changes is endogenously determined. However, the main difficulty lies in the empirical applications, since price adjustment costs are unobservable.

Theoretically, the incorporation of the menu costs in the dynamic setting is quite similar to the incorporation of the sunk costs in the analysis of price stickiness. The main difference lies in the research scope. The sunk cost argument provides the intuition to understand the market structure changes, in other words, permanent incomplete price adjustments. The menu cost argument becomes useful in understanding the discontinuity of price changes after exchange rate shocks.

However, the applications of *sS* economies to the observed price rigidities in the international economic environment had to wait for rather a long time. To our knowledge the first (and only) attempt of

such an application is given by Delgado (1991) within a dynamic programming framework. He derives a formal rule for the pricing policies of the multinational firms active in a domestic market. In his model, exchange rates follow a geometric Brownian motion with drift, which plausibly resembles reality. Rather than applying fixed menu costs he uses increasing menu costs. Menu costs largely result from the increased advertising that firms have to incur to retain their lost consumers²⁹. Foreign firms maximize the net discounted value of flow profits minus menu costs. More formally, the firm solves the following value function (V) of the international business as a function of the product prices (P) and the nominal exchange rate (S):

$$V(S, P) = \max_{P_t} E \left(\int_0^{\infty} e^{-\beta t} \Pi_t dt - [I(dP_t > 0)u - I(dP_t < 0)Y] dP_t \right) \quad (13)$$

where P_t represents the flow profits quoted in local currency, I the index function of changing the prices, u the cost of increasing the price and d the cost of decreasing the price, which are dependent on the size of the price change (see Delgado (1991)). Briefly said, the firm's problem is to maximize the expected value of the discounted flow of net profits over the menu costs it faces in each period. When the net profit flow over the infinite time horizon exceeds the costs of changing the prices, the firm would be willing to change its prices. Solution with optimal stopping suggests the existence of bounds of inaction within which prices remain unchanged. In such an analysis, analytical solutions are in general difficult to obtain. Therefore, Delgado assesses the impact of exchange rate shocks on prices in the presence of menu costs with numerical analysis. Comparative dynamics with plausible parameter specifications imply that firms will change their prices if and only if the real price reaches the bounds of inaction that is determined by the menu costs and exchange rate variability. However, once the bound of inaction is reached, adjustment will be complete, a result that is not in line with the empirical regularity of incomplete price adjustments.

V. EMPIRICAL EVIDENCE

Substantial research has been devoted to the issue of price adjustments with respect to exchange rate changes. Generally, empirical

findings on pricing-to-market and exchange rate pass-through show that exchange rate induced price discrimination in international markets is crucial in almost all manufacturing markets. Therefore, empirical research largely favors the argument that the international goods markets are segmented³⁰.

A. Summary of Empirical Evidence

Table 1 provides a selection of recent empirical evidence in the literature.

TABLE 1
A Selection of Empirical Studies

<i>Author(s) and Year</i>	<i>Countries</i>	<i>Data</i>	<i>Method</i>	<i>Main Findings</i>
Mann (1986)	US	1977:1-1985:2 7 exports and 9 imports industries	OLS	Strong export mark-up decline after an increase in the dollar Asymmetry in EPT
Baldwin (1988)	US	1967:1-1987:2 aggregate import prices	OLS	Structural break Hysteresis Mark-up decline as a result of entry
Fischer (1989)	Japanese, German exports to the US	Cross section 1984 to 1986 2 digit industries	Spearman statistic	PTM Export mark-up decline after an increase in the dollar
Hooper and Mann (1989)	US	1973:1-1988:2 aggregate import prices	OLS	EPT varying from 60% to 74%
Feenstra (1989)	US	1974:1-1987:4 motor cars, trucks imports prices	Ols	EPT varying from 63% to 89%
Kim (1990)	US	1968:1-1986:4 import prices	OLS, Varying parameters	Incomplete EPT
Marston (1990)	Japan	1980:1-1988:4 4 digit industries	OLS	PTM common across sectors
Kim (1991)	US, Japan, Germany	1974:1-1989:4 aggregate prices	VAR	Incomplete EPT

Kasa (1992)	US Canada	1978:1-1987:12 7 digit industries imports	SUR	Incomplete EPT Substantial variation
Ghosh and Wolf (1994)	UK	1973:1-1990:12 The Economist	OLS, probit	Presence of the PTM, Menu costs matter
Knetter (1993)	US, UK, Japan, Germany	1973-1987 7 digit industries	OLS	No significant mark-up adjustment Incomplete EPT
Gron and Swenson (1996)	US, Japan	1984-1993 automobiles	Instrumental variables	Account for the local production Presence of PTM
Feenstra et al. (1996)	Canada, France, Germany, Japan, Sweden, UK, Switzerland, US, Norway, Finland, Austria, Israel	1970-1988 automobiles	OLS Allowance for dynamic adjustment patterns	Different level of EPT Norway, US: very low Israel: very high
Roberts and Tybout (1997)	Colombia	1981-1989 plant level	Dynamic probit model	Relevance of sunk costs in the decision to export
Goldberg and Knetter (1999)	Germany, US	1975-1987 German beers US linerboard	OLS Residual demand	Beer: US elastic demand Linerboard: Japan flat, Australia steep demand

1. Incompleteness of Price Changes

Table 1 provides a summary of empirical evidence in the literature. Main results from the literature can be summarized as follows. (See also Menon (1995)).

Pass-through: degree and dynamics

Incomplete pass-through is a common and pervasive phenomenon in the studies surveyed. Only 6 studies report complete or near complete pass-through across countries in different goods markets.

Pass-through across countries

Pass-through is significantly different across countries. Note that these studies opt for different methodologies, which makes the comparison much harder. Therefore, in the following we will refer to the study of Knetter (1993) wherein he applies the same econometric methodology across countries, which will ease the task.

Pass-through across studies for a given country

There are conflicting reports across studies as concerns the size of the pass-through for a given country, which is fairly natural due to the choice of the methodology and data.

Pass-through across products

This is a direct test of the pricing-to-market. Studies report a strongly divergent level of pass-through across countries in different goods markets. International price discrimination is common.

Stability of pass-through relationship

There are numerous conflicting reports regarding the persistence and level of the pass-through relationship.

Knetter (1993) uses the term “local currency price stability” when he compares price discrimination practices in the cross-country context using data for seven-digit industries for the period of 1973-1987³¹. The term aims to define the decline of the foreign producers' (exporters') mark-ups when they are confronted with a depreciating domestic currency. Apparently, Japanese, German and British export industries exhibit more local currency price stability than the US exports industries in the study. However, he finds in general that, industry effects tend to dominate source country effects in terms of price discriminatory behavior of firms. Secondly, destination specific mark-up changes are very similar across destination markets. The degree of local currency price stability is nearly identical across destination markets for a particular good, which generates doubt regarding the belief about the existence of systematic discrimination across countries. The third finding rejects the hypothesis of an identical mark-up decline in all industries within a given destination country. Thus price adjustment exercise has a strongly heterogeneous nature across industries within a given country.

The common explanation for the presence of pricing-to-market found in most of the studies is the mark-up adjustment in different industries. As Goldberg and Knetter (1999) put it the existence of exchange rate induced, destination specific, variation in mark-ups implies that price cannot equal marginal cost on shipments to all destinations. The finding of price discrimination in the PTM literature allows rejection of the null hypothesis of integrated world markets.

Relevance of Sunk Costs

In line with the theoretical research Roberts and Tybout (1997) show that sunk costs play a crucial role in the decision to export with the use of Colombian plant level panel data over the period 1981-89. Their empirical findings suggest that theoretical sunk costs literature are relevant as the firms decisions to export are significantly affected by the firms prior relevant export-market experiments.

2. Discontinuity of Price Changes

Only a few studies analyzed discontinuous price adjustments related to menu costs. One has to remember that conducting an empirical study to measure the level of pricing-to-market is not necessarily reliable, unless there is data at the most disaggregated level. The main difficulty of analysing firm specific pricing rules is data availability. Firstly, data should contain information of a single homogeneous good. Any composite price index blurs analysis of pricing behavior. Secondly, in order to be able to pass fair judgement on the individual firms' pricing decisions one needs high frequency price data (say, weekly or monthly data). Low frequency data hides all information about in-between price adjustment exercises. An exception is the study of Ghosh and Wolf (1994) in which they use cover price data of the journal *The Economist*. A probit analysis with a relevant proxy for menu costs (deviations from the Law of One Price) led them to conclude that when menu costs are present, statistically significant findings of the pricing-to-market behavior may be spurious.

VI. CONCLUDING REMARKS

The issue of incomplete and discontinuous adjustment of prices to exchange rate changes is not a new one. However, this phenomenon only gained attention after the seminal writings of Krugman (1986) and Dornbusch (1987), which noted the significant impact of exchange rate shocks on trade volumes and several scholars reported discontinuous and disproportionate adjustment of prices. Recent theoretical and empirical research devoted its attention to firm level pricing behavior after exchange rate shocks underlying the incomplete pass-through and the failure of the law of one price results in different goods markets.

There are two main streams of analysis that evaluate the exchange rate induced incomplete price adjustments in international economics. Static theoretical research pins down the importance of price differentiation, market size and type of competition. Dynamic analysis on the other hand introduces elements of sunk costs, which allows accounting for the stylised facts of hysteresis in import volumes and price levels. The discontinuity feature, however, received relative less attention in the international context.

Empirical evidence confirms pricing-to-market as a common strategic behavior of firms. This obviously implies that the markets are segmented in international trade activities. However, one should be cautious in evaluating the results when menu costs are present.

Finally, recent research in the line of New Keynesian international macroeconomics aims to provide microfoundations for international price stickiness following exchange rate shocks. However, these microfoundations heavily rely on the incompleteness feature of price adjustments. To our knowledge discontinuity feature is not explicitly taken into account in modelling.

NOTES

1. For an excellent analysis of exchange rates and prices see Goldberg and Knetter (1997). For a detailed account of PPP failure see Rogoff (1996).
2. In order to provide a secure profits firms usually engage in hedging activities. A detailed discussion of these issues is provided by Friberg (1999).
3. See Branson (1972) writings after Smithsonian realignments.
4. See for example Cecchetti (1986) or Lach and Tsiddon (1992) for evidence in domestic inflationary environments and Gosh and Wolf (1994) for an application in the international context.
5. Blinder *et al.* (1998) provide with valuable insider information regarding the firm specific pricing decisions in a domestic market. Although international dimensions are neglected and direct questions about strategic interaction and collusion are omitted from the survey (in order to provide as many responses as possible) it is interesting to note that the survey outcome suggest that coordination failures, (i.e. firms holding back on price changes waiting for other firms to go first) appears as the most important element in pricing decisions. Costly price adjustment is seen to be rather unimportant.
6. For these recently expanding literature see for example Obstfeld and Rogoff ((1995), (1998), (2000)), Betts and Devereux (1996).
7. For several anecdotal evidence covering incompleteness feature of international prices, see Friberg (1999).
8. According to Friberg (1999) economic exposure is defined as the sensitivity in the value of the firm to exchange rate surprises. Firm's value is measured as the present discounted value of expected future cash flows. In static terms the focus is on the period by period profits or revenues.
9. Defining elasticity of demand as being $\epsilon_D = \frac{\partial D}{\partial P_D} \frac{P_D}{y_D}$ and elasticity of supply as being $\epsilon_S = \frac{\partial S}{\partial P_F} P_D (P_D e)$ (See Menon (1995)).
10. Baniak and Philips (1995), Kirman and Philips (1996) and Hens et al. (1999) provide a similar model in the general framework.
11. In other words, y_{DD} stands for the domestic firm's output for the domestic market and y_{DF} stands for the domestic firm's output for the foreign market and so on.
12. A final good is said to be a strategic substitute (strategic complement) if a more aggressive strategy by a player, e.g. a higher quantity, decreases (increases) the oppo-

nent's marginal profitability. More formally, we can express the strategic substitutability and complementarity as the second order partial derivatives with respect to the rival's strategic variable. For instance, for a foreign firm in the domestic final

good market strategic substitutability can be written as $\frac{\partial^2 \Pi_H}{\partial y_{HH} \partial y_{FH}} < 0$. Alternatively,

suppose we have $\frac{\partial^2 \Pi_H}{\partial y_{HH} \partial y_{FH}} > 0$ we encounter strategic complementarity. For the

foreign firm in the domestic market we write $\frac{\partial^2 \Pi_F}{\partial y_{FH} \partial y_{HH}} < 0$ for strategic substitutes

and $\frac{\partial^2 \Pi_F}{\partial y_{FH} \partial y_{HH}} < 0$ for strategic complements. The similar reasoning applies for the foreign market.

13. Although some authors have proven that 'perverse' price adjustment can occur under particular extreme set-ups, we will neglect this possibility for tractability reasons. For such analysis see Hens et al. (1991) and Kirman and Philips (1996).
14. The alternating firms assumption is replaced by a clustering of the firms in recent research. See Aksoy and Lustig (1998).
15. For the case of Bertrand competition in differentiated goods see Friberg (1997).
16. See for example Gilbert ((1989), (1991)), Amano and Van Norden (1998) and Cote (1987). Such examples of systematic deviations from the PPP likely suggest pricing-to-market even in these homogeneous markets.
17. See Athukorala and Menon (1994) and Campa and Goldberg (1995) among others.
18. See for example Spencer and Jones ((1991), (1992)).
19. This view was subject to the studies of Baldwin and Krugman (1989), Dixit (1989) and Baldwin and Lyons (1994).
20. Empirical tests of the hysteresis hypothesis are rather rare. See Roberts and Tybout (1998) for an application of the sunk cost idea to the Colombian firm level data. They find firm evidence of the relevance of sunk costs, in order to explain hysteresis in trade volumes and prices.
21. Assume that the second order profit maximization condition is satisfied.
22. In line with Chamberlain's conclusions an increase in the varieties in an industry can be seen to shift demand for each variety downwards making them more elastic.
23. Verify from (9) and (10).
24. In line with the findings of Meese and Rogoff (1983).
25. Ansic and Pugh (1997) conducted an interesting laboratory experiment on the market exit and entry decisions in the presence of sunk costs and exchange rate uncertainty. Their findings support the view that sunk costs play a crucial role in trade activity. It suggests that the band of inaction widens as the variance of exchange rate is high and sunk costs are sufficiently large. A recent study by Campa (1998) argues that sunk costs were crucial in the entry-exit decisions of Spanish manufacturing exporters. He finds that exchange rate uncertainty does not play an important role in entry-exit decisions.
26. For a controversial result of the impact of exchange rate shocks on market shares, see Cabral and Mello (1997). They find that in an asymmetric duopoly framework, temporary exchange rate shocks have a larger impact on market shares than permanent exchange rate shocks.
27. See for instance, Delgado (1993) or Sheshinski and Weiss ((1983), (1993)).
28. Another class of models applied to closed economies stipulate a set time period with fixed nominal prices-the contract period. The researchers then focus on what deter-

mines the length of the pricing contract, the real price behaviour within this contract period and the extent to which further contracts are linked with the earlier ones. In this survey paper we will neglect this type of analysis since this did not find an application area in the international context. For an excellent detailed analysis of *sS* economies consult Sheshinski and Weiss (1993). For a general equilibrium perspective see Danziger (1999).

29. In other words, the firm's adjustment costs increase as a function of the changes in the demand function. This assumption stands at odds with the standard fixed adjustment costs literature, where menu costs represent just the administrative or execution costs of changing the price. In particular, capturing demand elements in the adjustment cost function should cause some strategic complications in his analysis.
30. See Menon (1995) who conducted an excellent survey comprising 46 studies analysing exchange rate pass-through. In these 46 studies the following countries are tested for the exchange rate pass-through: the US, Japan, Australia, Germany, Canada, the UK, Korea, France, the Netherlands, Belgium, Italy, Taiwan, Botswana, Papua New Guinea, Austria, Denmark, Finland, Norway, Spain, Sweden, Switzerland, Indonesia, Malaysia, Singapore and Thailand.
31. Sample data covers the UK, the USA, Germany and Japan.

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