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Department of Economics

Industry Price Adjustment to Exchange Rate Fluctuations in Oligopoly. An Empirical Study of the Pass-through Relationship Determinants in the Spanish Automobile Industry, 1981-1991

Iñigo Herguera

Florence, September 1994

To my family, my twin and to Juan, my father

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Chapter 1

Introduction

In this dissertation proposal I study the implications of some aspects of imperfect competition in the adjustment of import prices to exogenous exchange rate changes. First, form a theoretical perspective I study what role does market structure, strategic behavior and the type of competition played by the firms have on the adjustment of prices, or quantities, to exchange rate fluctuations. In a later chapter I study empirically some of the determinants of the pass-through relationship, i.e. the elasticity of the import price with respect the exogenous exchange rate changes, with industry and company level data. The pass-through relationship has received a lot of attention recently from the theoretical perspective but few studies have been done at disaggregated level of analysis. I chose the automobile market in Spain because it is an industry open to foreign competition, where product differentiation, strategic interaction and cross markets relationships are present. Moreover, it is an industry where company and even product level data has been available. I think that the original part of the work that follows lies in the disaggregation level of the analysis: to test the effects of exchange rate changes on the company and the product level. Prices and mark-ups for each company are affected by exchange rate fluctuations, in the short as well as in the long run. But the price adjustment to exogenous shocks is not clear-cut: the perfect competition models of international trade, like the Heckscher-Ohlin model, do not predict correctly in the short and medium term the behavior of import prices. On the other side, models of imperfect competition predict "too many" conclusions, depending heavily on the hypotheses used in the modeling of strategic rivalry. I review briefly the main results appeared recently in this growing literature linking the theoretical explanations with the empirical evidence that supports them. I propose to study then two aspects that had, to my knowledge, not received enough attention: the expected behavior by the rivals in an oligopolistic industry and the risk aversion on the part of the exporters and their implications for the industry (import) price (or quantity)

adjustment in the short and in the long run when different varieties in trade are introduced. In the last part, I propose to study empirically the determinants of the equilibrium price in the industry taken into account that exchange rate fluctuations can affect the industry equilibrium. I estimate different pass-through elasticities, in the short and in the long-run, and study the mark-up absorption hypothesis at company level data.

In chapter 2, I review the recent literature on the relationship between exchange rates and industry prices. The pass-through relationship started to receive attention in the mid 1980's with an empirical observation: after five years of dollar appreciation (1980-85) the US current account did not seem to adjust and US import prices did not diminish as expected, especially when comparing the price series for the US in a number of manufacturing industries with the same import price series in competing countries. This empirical fact led to *Dornbusch* (1987) and *Mann* (1987) in what can be considered the two seminal papers of this literature to put forward the idea that international markets were imperfectly competitive and that due to this prices and quantities do not adjust as perfectly and fully as the arbitrage-based Purchasing Power Parity doctrine predicts.

I review this literature and its results with an underlying purpose: to relate the theoretical extensions with the empirical regularities found in the literature. The pass-through relationship has been mainly studied from an Industrial Organization (IO) approach, whereby models of imperfect competition have been used. Empirical studies haven been so far few in number, but several contributions to the New Empirical IO make it possible to study the adjustment of prices to exogenous exchange rate changes with an empirical purpose. At the empirical level, one common problem encountered is the lack of good disaggregate (industry or company level) data. Measurement problems, missing periods in the time series, different data construction methodologies and the impossibility of comparing similarly disaggregate data across markets or countries are common difficulties in industry level studies. At any rate, as I shall show here, the empirical regularities shed light on theoretical problems (and validity of the models) and new advances in the econometric field (panel techniques, testing for exogeneity and co-integration analysis) make it possible to study short term dynamics, deviations from equilibrium behavior at the individual firm level, firm's conjectures and types of strategic competition played in the industry.

The issue of the pass-through elasticity has very important macroeconomic implications. When the exchange rate moves the price level of the (say) devaluating

currency country will increase in order for the current account to adjust to equilibrium. The main macroeconomic theory that explained the adjustment of price levels to exchange rates was the monetary approach to the balance of payments. The monetary approach in its most basic form implies the Purchasing Power Parity doctrine. Understood as an equilibrium relationship, rather than as an adjustment mechanism, this implies that the country whose currency is devaluating will experience an increase in the price level that will offset one-to-one the movement in the exchange rate. The final domestic price level will return to its prior equilibrium (denominated in foreign currency terms). The mechanism that makes this adjustment possible is arbitrage in the goods markets. Any price differential of the same good in two different locations, expressed in a common currency, will be exploited by rational consumers and this arbitrage will restore the price to the original level.

One assumption of the Purchasing Power Parity doctrine (PPP) has received strong criticism: that perfect competition holds in the goods markets. *Isard* (1977), *Dunn* (1970) and especially *Dornbusch* (1987), *Baldwin* (1986), *Krugman* (1987) and *Mann* (1987) proposed to introduce imperfect competition models to explain the price adjustment to exchange rate changes with a partial equilibrium approach. The aim was to analyze the microeconomics of the adjustment process (at the industry and the firm level) and see the implications for the macroeconomic (i.e. current account and price level) adjustment. *Dornbusch* (1987) made use of the Cournot oligopoly model to introduce the hypothesis that market share matters, and with the Salop "competition along the circle" model, made relevance of the fact that product differentiation in international trade could impose a different adjustment mechanism to price adjustments.

I review these elements by grouping the extensions, hypothesis and main conclusions reached in two categories: first, *static models* with Cournot or Bertrand competition were used. One common conclusion, as I study in a later chapter, is that depending on the type of competition modeled, the more or less aggressive response expected from the rivals, the types of goods traded, the more or less integrated the markets are assumed to be and depending on the market structure a whole range of possible outcomes is possible. Second, *dynamics* have been introduced in this branch of the literature. If some form of sunk cost is introduced these models lead to one common effect known as hysteresis: the inability of prices and quantities to reflect an underlying exogenous change in a structural parameter of the model (i.e.the exchange rate). Expectations regarding the duration in time of exchange rate changes have also been introduced leading to a different explanation of pass-through behavior and explaining also a puzzle: the "perverse" pass-through (*Giovannini*, 1988).

One common feature of the models used in explaining the pass-through relationship is the possibility for the firms to price discriminate among markets. Since the markets are generally assumed to be segmented, it is possible to charge different prices depending on the elasticity of demand perceived by each firm. But the result of different prices in different locations is not in contradiction with the assumption of perfect competition, as *Knetter* (1989) points out. If no arbitrage is possible, the final equilibrium price in different countries that have different elasticities of demand, will differ as well. Therefore the empirical branch of the pass-through studies has to specify the hypothesis to be tested in such a form as to discriminate between perfect and imperfect competition in the first place. Since such studies should focus on the short-term and data availability is scarce, the new empirical approach to IO offers a good ground to infer the behavior of marginal costs and profit margins when the exchange rate changes. In the last section of the chapter I present recent empirical evidence of the short and the long run behavior of import prices by introducing dynamics in the pricing policy for each firm and with an Error-correction representation different estimates of the short and the long run price adjustments at different levels of aggregation have been obtained.

In chapter 3 I propose a model of imperfect competition to study the behavior of import prices when the exchange rate changes. Existing models predict deviations from the Law of One Price due to concentration and strategic behavior. In this paper I extend some results obtained in the literature in two particular ways: first, by introducing a simple form of uncertainty we can study the comparative statics of the relationship between risk aversion on the part of the firms and its implications for the price adjustment and secondly, by studying different forms of aggressiveness in the expected response of the rivals. As the number of exporters tends to infinity, the industry adjustment tends towards the perfect competition case (i.e. the Law of One Price). The difference between economic exposure and exchange rate risk is briefly explored and in the last section, the invoicing currency of the contract and the role of the strategic variable (prices vs. quantities) are studied.

In chapter 4 I test for the effects of exogenous exchange rate movements on the pricing policies of the firms in a panel data set constructed for the period 1981:I - 1991:IV in the Spanish automobile industry. I test the different pricing behaviors at a very disaggregate level (models of cars imported in each country). I find different responses to exogenous fluctuations in different firms. The overall pass-through effects (the way exchange rate changes are passed into import prices) seems to be in order with what a

Cournot oligopoly model would predict: the pass-through is incomplete. I allow for different responses to exogenous fluctuations depending on three factors that are introduced as individual-specific time-invariant effects: (1) country of origin, (2) company and (3) type of model exported. A reduced form pricing equation is estimated with fixed and random individual effects. The main factor that explains heterogeneity in the pricing equations is the country of origin and, to a lesser extent, the type of model traded, which reflects a measure of product differentiation. In the pooled model the exchange rate and import tariff pass-through elasticities show constancy when the estimation is done with fixed and with random individual effects. 30% of the change in the exchange rate is passed by the German, 24% by Italian and 16% by Japanese exporters into the domestic price in the long run. Import tariff changes are passed more intensely than exchange rate changes are. Italian firms translated 44% and German firms 80% of the change in the real import tariff. These results on the pass-through elasticities are in accordance with other empirical studies done at more aggregrate levels of trade (*Knetter* (1991, 1993), *Kasa* (1992), *Mann* (1991), *Kreinin, Martin and Sheehy* (1987), *Feinberg* (1986, 1989, 1991 and 1992), *Feenstra* (1989) and others), in that the majority of them show pass-through elasticities less than one (in absolute value), and higher tariff than exchange rate pass-through estimations.

The hypotheses of homogeneous pricing equations across individuals, i.e. units, is tested and cannot be rejected for the majority of cases considered, except for the hypotheses of heterogeneous pricing equation intercepts and slopes when the country of origin is included as the individual effect: whereas German firms tend to pass more of the exogenous fluctuations in the exchange rate, Italian firms seem to enjoy less market power in the export market. Mark-up seems to absorb a very important part of the exchange rate fluctuations: each exporting company absorbs in the pooled model 36% of the unit change in the exchange rate but in the mark-up equations greater heterogeneity has been found due to individual time-invariant effects. Mark-up absorption together with incomplete pass-through and the fact that unit (variable) cost differential is not significant in the pricing equations imply together a high degree of pricing to the market policy by the exporters and a relatively small market power for automobile exporters.

Chapter 2

Models of Imperfect Competition Explaining the Pass-through Relationship: a Review

1. Introduction

In this chapter I review the different explanations given in the literature on the behavior of prices and quantities in imperfectly competitive international markets when there is exchange rate uncertainty. I focus especially on the way exchange rate changes are passed through to import domestic prices, i.e. the pass-through relationship, in models that explicitly deal with some form of imperfect competition. In this review I shall mostly use one type of model, that of Cournot oligopolistic competition, and extend it to include problems explained in the literature with different types of models. The pass-through elasticity has also been studied with models of Bertrand competition introducing product differentiation among the goods in trade[1]. The focus here lies in models that deal with quantity competition for two reasons: first, because in international trade the shipping decisions take time to realize and we can think of the firms competing in the medium and long-run, and secondly, because basic results obtained with Bertrand competition and product differentiation do not depart widely from those obtained with Cournot competition.

I shall review this literature and its results with an underlying purpose: to relate the theoretical extensions with the empirical regularities found in the literature. The pass-through relationship has been mainly studied from an Industrial Organization approach, using models of imperfect competition. Empirical studies shed light on a number of empirical regularities found in industry level adjustment. One relevant problem

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[1] as in Giovannini (1989) and Fisher (1991)

encountered is the lack of good disaggregate (industry or company level) data. Measurement problems, missing periods in the time series, different data construction methodologies and the impossibility of comparing similarly disaggregate data across markets or countries are common difficulties in industry level studies. At any rate, as I shall show here, the empirical regularities shed light on theoretical problems (and the validity of the models) and new advances in the econometric field (panel techniques, testing for exogeneity and co-integration analysis) make it possible to study short term dynamics, deviations from equilibrium behavior at the individual firm level, firm's conjectures, heterogeneous behavior of the agents and types of strategic competition played in the industry[2].

The pass-through relationship started to receive attention in the mid 1980's with an empirical observation: after five years of dollar appreciation (1980-85) the US current account did not seem to adjust and US import prices did not diminish as expected, especially when comparing the price series for the US in a number of manufacturing industries with the same import price series in competing countries. This empirical fact led Dornbusch (1987) and Mann (1987), in what can be considered the two seminal papers of this literature, to put forward the idea that international markets were imperfectly competitive and that due to this, prices and quantities do not adjust as perfectly and fully as the arbitrage-based Purchasing Power Parity doctrine predicts.

The issue of the pass-through elasticity has very important macroeconomic implications. When the exchange rate moves the price level of the (say) devaluating currency country will increase in order for the current account to adjust to equilibrium. The main macroeconomic theory that explained the adjustment of price levels to exchange rates was the monetary approach to the balance of payments. The monetary approach in its most basic form implies the Purchasing Power Parity doctrine. Understood as an equilibrium relationship, rather than as an adjustment mechanism, this implies that the country whose currency is devaluating will experience an increase in the price level that will offset one-to-one the movement in the exchange rate. The final domestic price level will return to its prior equilibrium (denominated in foreign currency terms). The mechanism that makes this adjustment possible is arbitrage in the goods markets. Any price differential of the same good in two different locations, expressed in a common currency, will be exploited by rational consumers and this arbitrage will restore the price to the original level.

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[2]for a review on the new empirical approaches, Bresnahan (1987) and Slade (1986)

One assumption of the Purchasing Power Parity doctrine (PPP) has received strong criticism: that perfect competition holds in the goods markets. Isard (1977), Dunn (1970) and especially Dornbusch (1987), Baldwin (1986), Krugman (1987) and Mann (1987) proposed to introduce imperfect competition models to explain the price adjustment to exchange rate changes with a partial equilibrium approach. The aim was to analyze the microeonomics of the adjustment process (at the industry and the firm level) and see the implications for macroeconomic (i.e. current account and price level) adjustment. Dornbusch (1987) made use of the Cournot oligopoly model to introduce the hypothesis that market share matters, and with the Salop "competition along the circle" model, made the point that product differentiation in international trade could impose a different price adjustment mechanism.

In the Industrial Organization (IO) literature different forms of imperfect competition have been proposed to explain different patterns of pricing behavior. We can group these models in two main categories:

1. *demand side factors:* dealing mainly with incomplete arbitrage in international markets, uncertainty, risk aversion, expectations, product differentiation, switching costs on the part of consumers and quality uncertainty that can explain some unresponsiveness of import prices to exchange rate changes

2. *supply side factors*: economies of scale, market structure, sunk costs, capacity constraints, free entry and exit.

I review these elements by grouping the extensions, hypothesis and main conclusions reached in two categories: first, *static models* with Cournot or Bertrand competition were used. Depending on the type of competition modeled, the more or less aggressive response expected from the rivals, the types of goods traded, the assumed degree of market integration and on the market structure a range of possible outcomes is possible. Second, *dynamics* have been introduced in this branch of the literature. If some form of sunk cost is introduced these models lead to one common effect known as hysteresis: the inability of prices and quantities to reflect an underlying exogenous change in a structural parameter of the model (i.e.the exchange rate). Expectations regarding the duration in time of exchange rate changes have also been introduced leading to a different

explanation of pass-through behavior and explaining also a puzzle: the "perverse" pass-through (Giovannini, 1988).

In international trade an important fact to analyze is whether the markets are segmented. If this is so, the firm can charge different prices depending on the elasticity of demand perceived in each market. But the result of different prices in different locations is not in contradiction with the assumption of perfect competition, as *Knetter* (1989) points out. If no arbitrage is possible, the final equilibrium prices in countries that have different elasticities of demandwill differ. Therefore the empirical branch of the pass-through studies has to specify the hypothesis to be tested in such a form as to discriminate between perfect and imperfect competition in the first place. Since such studies should focus on the short-term and data availability is scarce, the new empirical approach to IO offers a good ground to infer the behavior of marginal costs and profit margins when the exchange rate changes.

There are, of course, many important aspects that I ignore in this review. General equilibrium effects will not be dealt with. It is intuitive that exchange rate changes can have significant income effects and cross-market effects that I do not consider here. Another aspect that has important implications is the contractual relations between the producer and the dealer, or distribution network, in the destination market. The invoicing currency of the contracts, partially studied in chapter 3, and the optimal length of the international contract, are all aspects that I do not deal with here.

2. The Law of One Price: Perfect Competition can also Explain Price Discrimination in International Markets

The problem of price (and quantity) adjustment to exchange rate changes received some attention before the mid 1980's. The available theory was the purchasing power parity (PPP) and some authors had tested it in different periods, obtaining in general weak support for it in the short and medium term. But the PPP doctrine is an aggregate theory that stems from the monetary approach to the balance of payments. It was not supposed to be a theory of international price determination at the industry level. There was no explanation of industry price adjustments to exchange rate shocks. In fact, the PPP

doctrine was not even considered to be a theory of price determination, but an aggregate equilibrium relationship, as expressed in the formulation:

$$P_t = k \, e_t \, P_t^*$$ (1)

where e_t is the exchange rate, P_t is the domestic currency denominated price index and P_t^* is the price index denominated in foreign currency. The parameter k stands for barriers to trade and other factors that put a gap between two prices of the same product in two different markets. Including k means expressing the relative version of the PPP; k=1 implies the absolute version of PPP[3]. The relationship in (1) was supposed to be an aggregate relationship. I can express it for the industry level, where there are n goods, indexed by i,and two different countries, k and j, as

$$P_{ik} = k_{ij} \, e_t \, P_{ij}^*$$ (2)

which is the Law of One Price. The price of the same commodity in two different locations should be the same, once both prices are expressed in the same currency. There may be possibly a difference reflecting barriers to trade, as shown by the parameter k. This theory assumes that there is perfect arbitrage in trade.

At the industry level, it is possible to obtain the price discrimination result as the outcome of the optimizing behavior of the exporter in each market. Assume that each exporter faces a different demand schedule in each market of the form[4]

$$x_{it} = x(p_{it} \, e_t)$$ (3)

and faces cost of production, $C(x) = C(\Sigma x_{it})$, where i=1,...,N, t =1,...,T and C is a measure of costs in the exporter's currency. Hence the exporter maximizes the function

$$\Pi_{it} = \sum_{i=1}^{N} p_{it} \, x_{it} - C \left(\sum_{i=1}^{N} x_{it} \right)$$ (4)

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[4]for present purposes the demand may be thought as that faced by a monopoly producer, as the residual demand facing a Cournot oligopolist, or as the demand curve facing the producer of one variety of a differentiated product group.

and from here we can obtain the first order conditions for each market as

$$p_{it} = c_t [\epsilon_{it} / (\epsilon_{it} + 1)] \tag{5}$$

where ϵ_{it} is the elasticity of the demand with respect to the destination currency price (in country i) and c_t is the marginal cost of production. This equation gives the standard optimization result for a producer, i.e. the price in one destination market, market i, is a mark-up over marginal costs (c) that is determined by the elasticities of demand (ϵ_{it}) faced in the market by the exporter. The greater the perceived elasticity of demand, the smaller the mark-up of price over marginal costs. Under perfect competition, the elasticity should be infinite and price should equal marginal cost in the long run equilibrium. In the short run, marginal cost facing each firm might not be equal across firms, or different marginal cost schedules might be different in the various destination markets, resulting in an equilibrium price that equates the highest marginal cost of a firm with positive output. Equilibrium prices in different markets, even if competitive, might differ.

The basic assumption used in deriving this result is that the demand for the good in one market is not related to the demand in any other market. This segmentation of markets, to which I shall come back later, implies no arbitrage in the goods market. As soon as arbitrage is impeded, price discrimination can occur in a perfectly competitive world as well. The implication of equation (5) is an important empirical testable one: exchange rate changes should affect equally all destination markets if perfect competition rules. Any difference in marginal costs can be collected by a fixed individual specific for each firm (or country) term and the slope coefficient, i.e., the pass-through elasticity, should be the same across destinations.

Knetter (1989) distinguishes the competitive from other models at the empirical level, and estimates a combined cross-section and time series model of the form,

$$p_{it} = \rho_t + \lambda_i + \beta_i e_{it} + u_{it} \tag{6}$$

where all variables are expressed in logs, the subscript i refers to the destination country, and t describes the time index. The term ρ_t reflects the time effect in the panel estimation, the term in λ_i reflects the individual or country specific effect of exchange rate changes (e_t) in the domestic import price (p_{it}). If the markets studied were integrated (i.e. not segmented) and perfectly competitive, the joint hypothesis to test perfect competition (and

the relative version of the Law of One Price) is, H_N: $\lambda_i = \beta_{it} = 0$, since no price differential could persist due to the arbitrage hypothesis ($\lambda = 0$), and no change in the producers' price could be provoked by the change in the exchange rate that does not affect all the producers at the same time ($\beta_i = 0$). When imperfect competition is introduced, the country specific effect is allowed to vary since it reflects changes in marginal costs due to changes in the exchange rate. In the empirical estimations, Knetter finds evidence for a "stabilizing effect" of the price changes with respect the local currency price in the destination market in those markets where prices seem to respond to exchange rate changes (as the German market). For the US, Knetter found that prices did not respond significantly to fluctuations in the external value of the US dollar.

3. Motivation : Why Models of Imperfect Competition ? Empirical Studies of Price Adjustment to Exchange Rate Changes

Empirical tests on the Purchasing Power Parity theory (PPP) have led to different results, though in general it is easy to conclude that the PPP relation does not predict well the behavior of import prices in the short and in the medium term. The basic proposition to test is that the real (bilateral) exchange rate $e_t = P/P^*$, should follow a random walk, where P is the domestic country price level and P* is the foreign country price level. Empirically, the proposed estimation equaton is (in logs),

$$e_t = \alpha + \beta \, (P_t/P_t^*) + \varepsilon_t$$

where ε_t satisfies, $E(\varepsilon_t) = 0$ and $E(\varepsilon_t^2) = \sigma_\varepsilon^2$, and α is a shift parameter that reflects the existing barriers to trade and e_t and (P_t/P_t^*) are the logs of the real exchange rate and of the national and foreign price levels, respectively. If the PPP theory holds, we expect $\beta = 1$. The disturbance term, ε_t, is a measure of deviations from the PPP relationship. The equation has been tested with macroeconomic data and there is evidence that the disturbance term of the estimated equation are correlated, which contradicts the PPP hypotheses: due to perfect commodity arbitrage and perfect foresight, deviations from the PPP equilirium relation should have no pattern over time. This has led to some authors, as Dornbusch (1980), to reject the PPP hypotheses. The hypotheses of a random walk in the real exchange rate, or in deviations from the PPP relation, have not been rejected, though, by

other authors (Frenkel, 1981), due probably to the low power of the tests applied. In the majority of cases a correlation pattern in the error term across time is accepted.

One argument proposed to explain the possible correlation patterns of the deviations from the PPP relation is based on the idea of *imperfect substitutes.* If the domestic and the foreign (imported) varieties are imperfect substitutes, any shock to the economy will imply an adjustment of the real exchange rate as well as of the domestic and foreign price levels. Since substitution among the different goods in trade is not perfect, the adjustment of prices and trade volumes will take time and the evolution of the real exchange rate during the adjustment process will not be well predicted by the random walk hypotheses. This explanation suggests, then, that the basic PPP equation might be dynamically misspecified: it does not include the relevant adjustment mechanism in the short run for the exchange rate. For industry level data, this argument is crucial in any estimation of the pass-through relationship and I shall come back to it later in more depth.

Another argument proposed to explain the correlation of the deviations over time is based on the idea of exploiting the *contemporaneous correlation* in the deviations from PPP across the different units (countries). The idea is that using only bilateral exchange rates ignores many possible cross-sectional relationships across countries that may have very important implications regarding general equilibrium effects that standard trade flows and PPP studies ignore. My focus lies in the industry level studies and data, but I shall only briefly describe how these cross-sectional differences with macroeconomic data can help in explaining deviations from an assumed long run equilibrium, since this idea has also important implications in industry level studies. Hakkio (1984) compares two different estimates of the PPP relationship: one estimation done for each single country relating the exchange rate with an intercept, the ratio of national to foreign price levels and an error term that is modeled as an AR(1) process. His single equation estimates yield support for the PPP theory in only two out of four cases. The autocorrelation coefficient for the error term is smaller than one but significatively greater than zero, evidence for the existence of a pattern in the deviations. His second estimates are obtained as a simultaneous estimation of the four (for the four countries included in the sample) exchange rates and allowing for correlation in the error terms across countries, in a system as

$$\ln e_{it} = \alpha_i + \beta_i \ln (P_t/P^*_t) + u_{it}$$

where $\quad u_{it} = \rho \, u_{i, t-1} + \varepsilon_{it}$, $\quad E(\varepsilon_{it}) = 0 \quad$ and $\quad E(\varepsilon^2_{it}) = \sigma^2_\varepsilon,$

The results are similar to those otained for the single equation estimates: the PPP cannot be rejected for two cases out of four but the estimates now are better. The correlation in the disturbance terms among the countries for which PPP is rejected is higher than the correlation encountered among the countries for which PPP is accepted. Even though the estimate for β is significatively not different from 1, evidence for the PPP theory to hold in the long run, the estimated serial correlation coefficient is less than one (ρ = 0.85) which implies also that deviations are persistent. Hence, by introducing cross sectional variability Hakkio obtains better estimates for the long run equation and some evidence that correlation in the deviations among countries could be the factor that explains the failure of PPP for those countries. Since the estimated equation is derived from an macroeconomic equilibrium relationship, the correlation structure of the deviations could be due to (domestic) sticky prices and imperfect substitutes.

In industry level studies, as we study in a later chapter, individual characteristics shared across markets are an important element to introduce when explaining the behavior of prices in individual markets. Recent research is also carried on the dynamic misspecification of the pass-through equations at industry level studies as well as on the macroeconomic level with dynamic models of price adjustment that estimate an error-correction term to capture the dynamics of the adjustment process.

The results by Hakkio sugest also another implication of empirical studies on the exchange rate done at the aggregate level: the (bilateral) exchange rate should enter as an endogeneous variable. Few studies analyze empirically the endogeneity of exchange rate changes, but many authors point it out. The channels through which the exchange rate is determined by the (assumed) endogeneous variables are several: unresponsive trade prices can lead to more volatility of the exchange rates (Baldwin and Lyon, 1988), the reallocation of resources implied by an exchange rate change is costly and can alter its long run equilibrium value (Krugman, 1988), price stickyness can explain the pattern of covariances of exchange rate changes and the price level (Giovannini, 1988 and Dornbusch, 1987), and market structure changes induced by large exchange rate fluctuations can alter the responsiveness of trade prices to exchange rate shocks, and in turn change the (assumed) stable long run relationship between prices and exchange rates (Mann, 1986, Giovannetti, 1990, Baldwin, 1988 and Baldwin and Krugman, 1987).

Once the endogeneity of the exchange rate, and of the price level, is taken into account empirical results tend to give more support to the PPP theory. Looking at macroeconomic data for the 1920's and the 1970's, *Krugman* (1978) estimates an equation derived from a monetarist model where he specifies a price level equation, an exchange rate or PPP equation and a money supply equation. Once the autocorelation structure in the residuals of the exchange rate equation is taken into account, estimates for the exchange rate coefficients show a smaller standard error and the point estimates for the Pound- the French Franc- and the Swiss Franc /US$ are statistically not different from one. The PPP hypotheses is rejected for the DM/US$ exchange rate for any period considered. Krugman gives also a serial correlation estimation of the deviations of the real exchange rate from its mean in each period considered. These estimates are significant different from zero which gives evidence for persistent deviations from PPP[5].

In the rest of this section I shall describe the different empirical regularities and methods encountered in the study of the relationship between exchange rates and (import) prices at the industry level. Once the empircal results have been presented, I shall review the theoretical models aimed at explaining the different puzzles.

In a seminal paper *Dornbusch* (1987) found that the imperfect competition variables, such as degree of substitutability among the varieties in trade, the relative number of foreign producers and market structure, could explain the puzzling behavior of US domestic prices to the large US dollar appreciation during the first half of the 1980's. During that period of US dollar appreciation he found that the price of exports had increased relative to the price of imports in the US. This phenomena later called "pricing to the market" by *Krugman* (1987) implies a positive correlation between the exchange rate and the relative price of the imports and it was at odds with what the Law of One Price (or the strict version of the PPP theory) predicted.

Empirical studies done with industry level data, *Mann* (1987, 1989) and *Knetter* (1989), among others, found also that deviations from the Law of One Price seemed to be correlated and this correlation could be partially explained if the destination country of the good was introduced in the estimated equation. Hence, there was evidence that deviations

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[5]Krugman (1978) :"... *apparent failures of PPP in the short run actually represent the interaction of real shocks and endogeneous monetary policy. .....There is some evidence, then, that there is more to exchange rates than PPP. This evidence is that the deviations of exchange rates from PPP are large, fairly persistent and seem to be larger in countries with unisbale monetary policies*" p. 405-407.

did not follow a random walk. There was scope for an underlying pattern of behavior of relative prices[6].

In empirical studies done at different levels of aggregation the variables reflecting *market structure* were introduced and found, in very widely terms, to explain only partially the pattern of deviations from PPP for industry level studies. *Melvin and Bernstein* (1984) develop a cross-section study to explain the country-specific deviations by introducing two variables at high levels of aggregation to explain the deviations from PPP for 95 countries (developed and less developed) for 1975: (1) commodity *concentration of trade*: the more diversified the trade, the less sensitive the country to a random shock affecting one individual good, and the lower the expected shifts in the PPP relation will be, and (2) *openness of the economy*: the more important imports to total trade in a particular industry, the greater the effects of exchange rate changes on the industry price. Their empirical results support the hypothesis that the more concentrated the exports, the greater the deviations from PPP and the more open the country to international trade, the smaller the deviations will be[7]. Melvin and Bernstein do not question the arbitrage hypothesis. They just point out the fact that structural factors may shift the PPP relation, so that their hypothesis deals with the relative version of the PPP. *Feinberg* (1986) and *Utton* (1989) find that market structure variables could explain partially the response of import prices to exogenous exchange rate changes in two different studies developed for US and UK imports. *Utton and Morgan* (1989) in a lengthy UK- rest of the world trade study find also support for market concentration as a factor explaining the long-term UK price adjustment to exchange rate fluctuations.

But concentration measures have, in general, not had a very significant success in explaining the different pass-through elasticities across countries or over time. *Kreinin, Martin and Sheehy* (1987) study periods of monotonic change in the US exchange rate vis-a-vis the main trading partners at disaggregate level and introduce the *differential response hypothesis*: depending on industry structure variables the price adjustment in some industries can differ from other industries. They introduce the following five industry characteristics: (1) *market structure variables*: concentration, advertising and "buy American", (2) industry *margins*, (3) *factor-intensity* variables, (4) *human capital* variables

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[6] see Isard (1977, p. 942-948),:" Evidence that disparities between the common currency prices of different countries are systematically correlated with exchange rates rather than randomly fluctuating over time is a strong denial of the Law of One Price for the products being compared".
[7] deviations from PPP are measured as the standard deviation from the assumed equilibrium PPP.

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and (5) capacity utilization, productivity and wage rates. The results did not show much support for market structure variables but variables related to advertising intensity do have a significant and positive effect on the pass-through estimated equations. Factor intensity variables are the most important determinants of the differential pass-through in prices as well as in quantities in the different industries. Industries with a relatively high capital intensity do have a higher pass-through estimated coefficient than industries with a lower capital intensity, all else equal. Labour intensity and wage changes have a small significance in the estimations. This study points out some evidence in favour of the market share hypotheses and that the expectations of the exporter regarding the exchange rate fluctuation matters. Little significance, though, seems to have the effects that changes in the exchange rate might have in the relative variable costs. *Feinberg* (1986) introduces *import penetration* and *market concentration* to explain the different degrees of pass-through observed in German import domestic prices. He finds that market concentration has a restraining influence on the pass-through elasticity and that about 3/4 of the changes in nominal exchange rates are reflected (on average) in changes in sector-specific real exchange rates. Import penetration, for the German sample 1977-1983, does not have a significant effect on the pass-through relationship, however. *Feinberg* (1991) for a US sample finds that the higher the *share of imported inputs* in the production of the exported good, the higher the observed industry level pass-through elasticity. More capital-intensive industries tend to be more isolated from exchange rate surprises. Product differentiation, or the degree of substitutability between domestic and imported varieties of the same good, appear also as having a negative and significant effect on the pass-through. All of these studies face the simultaneity problem: they introduce in a single equation a structural variable (concentration measure) and aim at explaining the equilibrium price (or quantity) assuming the exogeneity of the structural variable[8]. *Feinberg* (1993) estimates a simultaneous equation model for a pricing equation and finds slight support for the concentration index for a sample of US industries. He finds that a higher concentration in any industry tends to reduce the pass-through elasticity in to import (or domestic) prices. He acknowledges, though, more significance to other variables.

Another important line of criticism of the Law of One Price is that arbitrage does not rule, or it is impeded by the existing barriers to trade and market structure. In this line of criticism *Richardson* (1978) has tested the arbitrage hypothesis for US-Canada trade and rejected the Law of One Price in all cases studied. *Webster* (1986) develops a cross-

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[8]on the importance of the simultaneity problem for industry level studies, see Martin (1979) and (1984).

section study for manufactured goods trade in the UK and the US for the 70's to test the arbitrage hypothesis. For very disaggregate data he doesn't find support for arbitrage in his sample. To explain the *differential response* hypothesis across industries to exchange rate changes, he introduces some market structure variables: import penetration, degree of product differentiation and concentration measures. He does not find support for the arbitrage hypothesis, but says that the adjustment process takes different forms in the various industries which is only partially explained by market structure variables.

Since arbitrage can be ruled out in many industries, we can conclude that many markets in international trade are segmented and hence different equilibrium prices will obtain. This differences in the equilibrium prices, once they are converted in a common currency unit, can be the result of price discrimination, or due only to the segmentation hypotheses in which case no market power needs to be present. One way to test the existence of market power is comparing empirically two pricing rules and their implications: (1) pricing to the market rule, and (2) perfect competition with segmented markets. Rather than acting as price takers, exporters might exploit some market power in the destination market. If there is scope for market power, one possible strategy for the exporter is the pricing-to-the-market, by which market share matters and any pricing decision is taken to keep or increase the market share in the destination market. One testable implication of this pricing rule is that prices of the good in the destination market currency are much more stable than they would be if the Law of One Price had been applied. This implication has been tested and found, in general, widely support for it. *Woo* (1984) criticizes the use of reduced form equations by showing that there is no unambiguous relationship between exchange rates and the price level, since both are endogenous variables. He models the price and quantity adjustment to exchange rate changes in a simultaneous equation system and finds support for the hypothesis that the pass-through in the US markets is incomplete, and that foreign exporters to the US prefer to stabilize prices in the US market. *Mertens* (1990) in an empirical study for the automobile industry in the European Union finds that French and Italian car producers when exporting to Germany tend to follow German production costs rather than their own domestic country costs shifts, and that the exchange rate changes have not a very significant effect in the pricing of the exports. He found the same for Japanese and British exports to Germany. This did not happen, though, in the Belgian or the UK markets, where exchange rates and own (exporters) costs, were found to be important determinants of the price differentials of two similar cars. The stabilizing pricing policy seem to take place in big destination markets where home or national producers have a significant share of the market. *Knetter* (1989,

1991 and 1990) found that German, British and Japanese exporters tend to stabilize prices (expressed in US$) in the US market during the 1980's. The "local currency price stabilization" (LCPS) rules for exports to the US, but not for US exports to Germany, UK, France and Japan. His tests reject the constant demand elasticity hypotheses, which would imply no relationship bvetween export prices and the exchange rates. He found also, as *Mann* (1986 and 1989) and *Ohno* (1989), that the *destination* market (or country specific) effect included in the regressions was almost always significant in the pass-through equations, which, if products are assumed to be homogeneous, rules out the competitive model. Two arguments are proposed to explain the asymmetric pricing behavior of exporters depending on the destination country: (1) market share matters, which implies a more stable pricing policy, and (2) the fact that in the US market, the German exporters faces a higher number of rivals and hence, as any Cournot model would predict, as the number of foreign importers relative to domestic producers gets smaller, the pass-through is negligible. This empirical finding, though, is not robust to the specification or the time period used. The *destination* market, on the other hand, seems to be more relevant in explaining the differential response of exporters to exchange rate changes. The LCPS policy has been tested in different pricing specifications. Three dimensions seem to bear the highest explanatory power: (1) the industry in which the policy is tested, (2) the differentiation of the good in trade with respect other substitutes, and (3) country (of origin /destination) specific effects. The homogeneity hypotheses of equal pricing behaviors across *source* countries (or exporting countries) within each industry could not be rejected for the vast majority of (US, UK, German and Japanese) industries considered. The country of origin, when modeled as a specific effect, collects the different market structures and degrees of competition encountered by each producer in its own domestic market. The relevance of this factor depends heavily on the empirical specification and the context used: while for total merchandise, it is not clear if the source country matters (Knetter, 1989, 1991, and Mann, 1986, 1989), for specific industries, like automobile, it is more evident that the country of origin explains partially the different pass-through elasticities (Knetter, 1991). Price stickyness is observed for many industry level studies (for Japan, Germany, France and the US), especially with respect the exporter's currency, evidence in favor of the invoicing of the contracts in the exporter's currency, rather than in the buyer's currency. Asymmetric invoicing policies by the exporters alone cannot explain, though, the persistent and significative price differentials observed in the automobile (Knetter, 1990 and 1991, Verhoben, 1993, Kirman and Schueller, 1990 and Mertens and Ginsburgh, 1985 and Mertens 1990) and other industries (Knetter, 1989, Feinberg, 1986 and 1989).

Mann (1989) differentiates between the trend and the volatile (or noise) part of the exchange rate movements and does not find strong evidence for the effects of volatility on export prices. But she explains that data on exchange rate volatility has two draw-backs: aggregate exchange rate data do not exhibit the big increases in exchange rate risk faced by the exporter at industry level (we shall come back to this point in next chapter), and aggregate data on export price behavior is often in contradiction with the price data at industry level. She defends the need for more industry level empirical studies in order to clarify who bears the risk of exchange rate changes (exporters or consumers) and if volatility affects prices or quantities. This last distinction is important for two reasons: the fact that volatility affects prices is enough support for assuming that there is imperfect competition in the industry under study, and, furthermore, it helps in clarifying the role of strategic behavior and of cost schedules in international trade. She does not find robust evidence for any effect of volatility on export prices, especially for the case of German and Japanese exporters. Furthermore, Mann finds evidence in favour of a perverse relationship between export prices and exchange rate trends for German and Japanese exports to the US. This empirical finding gives additional support to the idea of local price stabilization policy by exporters. *Woo* (1984) further criticizes the use of reduced form equations by showing that there is no unambiguous relationship between exchange rates and the price level, since both are endogenous variables. He models the price and quantity adjustment to exchange rate changes in a simultaneous equation system and finds support for the hypothesis that the pass-through in the US markets is incomplete, and that foreign exporters to the US prefer to stabilize prices in the US.

Apart from market structure and expectation variables, barriers to trade have been reported to have also an effect on the pass-through elasticity. *Feenstra* (1986) found that Voluntary Export Restraints (VER) applied to Japanese automobile imports into the US did significantly reduce the elasticity. *Feinberg* (1991 and 1992), also with a US sample, finds that barriers to trade (as measured by the ratio selling costs/ total sales) entered his reduced form pass-through equations significantly and with a negative sign reducing, therefore, the pass-through effect.

Lastly, I want to mention another crucial aspect of international trade that has a direct influence on the pass-through elasticity: the *degree of substitutability* among the domestic and the imported goods[9]. In international trade, product differentiation seems to

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[9]In Chapter 3 I propose a theoretical model in which differentiation among the different varieties in trade is allowed. Here I review briefly some empirical results.

be one of the most important aspects to take account of. During the last three decades the highest growing type of trade in the world has been the so called intra-industry trade, that is, trade among goods that are close, but imperfect, substitutes and which are produced by similarly endowed countries[10]. In industry level studies several major problems arise when introducing the differentiation dimension: lack of reliable studies for certain industries on the degree of substitution among the goods in trade, empirically non-robust estimates of product differentiation and non-comparability of estimates obtained for the US and for other countries. I just want to mention here the importance of this dimension in any disaggregate study. In fact *Feinberg and Kaplan* (1992) introduce a measure of substitution between domestic and imported goods in the US calculated by *Shiells, Stern and Deardoff* (1986) for 122 -3 digit industries for the period 1962-78 and use it as a measure of substitutability in the producer price equation. Once the degree of substitutability has been introduced they find that the pass-through elasticity is positively and significatively related to the degree of substitution among the goods in trade, that is, the closer the goods in trade as perceived by the foreign consumers, the higher, ceteris paribus, the translation of an exchange rate change into an import price change. Furthermore, *Feinberg* (1993) finds that there is an indirect effect of any exchange rate change into the domestic, as opposed to import, price level in an industry that works via the degree of substitution of the domestic and the imported varieties. He estimates that while the (percentage) change in the import price to an exchange rate change was -0.36 (when this elasticity was assumed to be the same across industries in the US), the percentage change in the *domestic* price when an exchange rate change was of -0.17. In a simultaneous equation system he finds that the major determinants of the domestic price level for the US sample were the wage rates and the import prices and found no significant effect for the exchange rates. Hence, Feinberg, finds that the main channel through which exchange rates have an impact on the domestic price level is via the effect that the change in the exchange rate has on the import price level and in turn, the correlation between the import and the domestic price level (which he finds very significant, 0.88). This correlation between both price indices is determined, in his empirical study, by market structure (with a restraining influence) and by the degree of substitution among the domestic and the foreign goods, which enhances a higher pass-through elasticity. *Brown* (1989) in a calibrated oligopoly model also concludes with the importance of the degree of substitution for the pass-through adjustment and for the welfare effects.

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[10]as reported in Grimwade, N. (1989).

Hence, there is ample empirical evidence that international trade takes place in imperfectly competitive markets and that this affects pricing decisions when there is exchange rate uncertainty.

4. Models of Imperfect Competition Explaining the Pass-through Relationship

I will group these models and review them with the help of a general oligopoly model and extend it in different directions. This provides a partial unifying framework in which to study the response of export prices to changes in the exchange rate and so put forward the main explanations and pricing policies possible in international trade. The main elements I will introduce are: uncertainty, economies of scale, dynamics, hysteresis, and the entry/exit decision.

In another chapter I develop an oligopoly model where I deal with three other important factors in determining the pass-through elasticity: heterogeneity on the firm side, aggressiveness in the strategic choices of each oligopolist, imperfect substitutability among products (product differentiation), and a certain kind of uncertainty that permits the modelling of the random shock by focusing on the trend and the volatility.

Now I depart from the assumption of perfect competition, where the Law of One Price, in logs, is

$$p_i = p_i^* + e \qquad (4)$$

When dealing with imperfect competition I now allow for a mark-up of price (p) over marginal cost (c) that I call, m. In the following argument, to introduce the pass-through relationship I follow *Mann* (1987) and *Ohno* (1990). I can now express the equilibrium price for industry i as

$$p_i^* = c^* + m^*$$

and using (4) we can express in terms of increments:

$$\Delta p_i = \Delta c^* + \Delta m^* + \Delta e \qquad (6)$$

where c^* is the cost in foreign currency terms of producing the good in the foreign country, e is the exchange rate and m^* is the margin over marginal cost in foreign currency terms. In equation (6) we have that a proportional change in the price (in home currency) equals the proportional change in in cost plus the proportional change in the margin plus the proportional change in the exchange rate. It is very possible from (4) that if c^* is constant, the domestic currency import price changes less than the exchange rate does when the foreign margin, m^*, adjusts; that is, the pass-through is incomplete.

The reason given by *Mann* (1987) for an incomplete pass-through is that this is due to profit margin fluctuations but as *Baldwin* (1987) and *Ohno* (1989) point out this is an effect rather than a cause of exchange rate fluctuations. Empirically it has been found that profit margins do change proportionally to exchange rate changes, whereas import prices may have different patterns of behavior (Mann, 1989). In one seminal paper, *Dunn* (1970) found evidence in six Canadian industries for mark-up adjustment, rather than price adjustments, to exchange rate changes. If the objective of the firm is to maintain stable prices in the destination market *"to the extent that exporters in a world of flexible exchange rates stabilize prices in foreign markets through variable price discrimination, the volume of trade tends to be unaffected by the exchange rate"* (Dunn, 1970, p.141).

4.1. The General Framework: an Oligopoly Model of International Trade

I start with two markets, indexed by $k = 1, 2$ (second subscript), and two producers, indexed by $i = 1, 2$ (first subscript). Each producer is initially a monopolist in its own market (country) and for comparison purposes the initial situation is that of autarky. The cost function for now shows constant returns to scale (constant marginal costs): $C(x_i) = c_i x_i$, where $c_i > 0$ is continuous for all x_i, positive for all $x_i > 0$, and continuously differentiable in x_i. C'_i exists and is constant: $C''_i = 0$. Goods are assumed to be homogeneous (perfect substitutes), although this hypothesis does not matter for the autarkic case. The (inverse) linear demand facing each monopolist in each country is:

$$p_i(x) = \alpha - \beta x_i \qquad (8)$$

The monopoly equilibrium (x^m, p^m) in each market k assuming the monopolist is risk neutral is given by:

$$x_k^m = (1/2\beta)(\alpha - c_i)$$
$$p_k^m = c_i + (1/2)(\alpha - c_i) \tag{9}$$

Now let trade open up between the two countries. I assume there are no barriers to trade and that a flexible exchange rate e measures the number of units of country 1's currency per unit of country 2's currency. Each firm can sell in the other country if it finds it profitable to do so. For firm 1 in market 2 profit is[11]:

$$\Pi_{12} = e_t\, P(x_{12} + x_{22})\, x_{12} - c_1\, x_{12}$$

Knowing that total profits for firm 1 are the sum of the profits obtained in each market and assuming constant returns to scale, which enables the use of the separation property, I can obtain the pair of reaction functions $x_{12}(x_{22})$ and $x_{22}(x_{12})$ for market 2 (and symmetrically for market 1). Taking expectations through the objective function and calling the expected value of the exchange (assumed to be known by the firms), $E(e_t) = \mu$. In the duopoly case with linear inverse demands I obtain a pair of reaction functions, two for each market, two for each firm (one as exporter for the foreign market, and one as domestic supplier in duopoly),

$$x_{22}(x_{12}) = \frac{\alpha - c}{2\beta} - \frac{1}{2}x_{12}$$

$$x_{12}(x_{22}) = \frac{\alpha - \left(\dfrac{c}{\mu}\right)}{2\beta} - \frac{1}{2}x_{22} \tag{10}$$

and symmetrically for the other market. Both reaction functions together define the Nash-Cournot equilibrium, as the pair of production levels (x^*_{i2}, x^*_{i2}) that maximize the payoff of each firm given the choice of the rival.

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[11]The existence of reaction functions is assumed since the assumptions of the model imply: (1) that the profit function is convex in the level of quantity, and (2) that profit function is twice continually differentiable in x_{ik} and x_{ij}.

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From equations (10), changes in the mean exchange rate will shift the reaction function of the exporter as shown in Figure I.

Figure I: changes in the exchange rate and the Nash- Cournot equilibrium
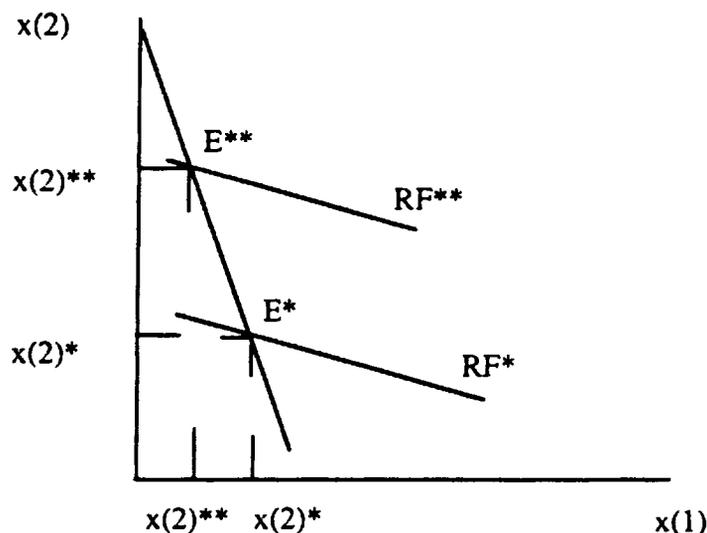
$E^* = (x_1^*, x_2^*)$ is the original equilibrium. When the destination market currency appreciates, the new Nash equilibrium is E^{**}, (x_1^{**}, x_2^{**}), where the exporter (firm 2) sells more and the domestic firm sells less. The shift is induced by lower marginal costs for the exporter and higher (relative) variable and marginal costs for the domestic firm, as in equations (10). The changes in the exchange rate shift the intercept of the reaction function but leave the slope unchanged. The gain for the exporter has two elements: the direct and the indirect effects. The *direct effect* is the gain in revenues due to the higher value of the foreign currency. The *indirect effect* comes via the strategic interaction among the duopolists: an increase in the strategic variable of the exporter (quantities) implies a decrease in the strategic variable by the rival and a decrease in the rival's profits, and an additional increase in the foreign firms' profits[12].

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[12]This distinction is based on the fact that in this model goods are strategic substitutes. This determines the type of strategic interaction that rivals will have and implies, $(\partial\Pi_j/\partial x_i x_j)>0$. On this distinction see Bulow, Klemperer and Geanakoplos(1985).

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The Nash-Cournot equilibrium (x^*_{12}, x^*_{22}) is obtained by solving the pair of reaction functions (10) for each market simultaneously. Equilibrium outputs in market 2 is

$$x^*_{12} = \frac{\alpha - c\left(\frac{2}{\mu} - 1\right)}{3\beta} \qquad x^*_{22} = \frac{\alpha - c\left(2 + \frac{1}{\mu}\right)}{3\beta} \qquad (11)$$

and the corresponding price is

$$p = \frac{\alpha + c\left(1 + \frac{1}{\mu}\right)}{3} \qquad (12)$$

By taking the derivative of the Nash-Cournot equilibrium with respect the expected exchange rate change, $E(e)=\mu$, I can show that after a positive shock firm i will increase its exports to the foreign market, the domestic firm will reduce its home production. The pass-through relationship, the way the price in country 2 changes is of order (c/3). A negative shock will have opposite effects and of the same magnitude. This result is due to *Bertola* (1987) and *Hooper and Kohlhagen* (1978) where the latter use another specification of demand and cost schedules letting the firms be risk averse. More volatility, they concluded, reduced the amount exported for a given price[9]. Volatility in this framework amounts to increasing the variance of the distribution of the exchange rate changes.

From the Nash-Cournot equilibrium in (11) and (12) I can derive an expression for the pass-through relationship in market k

$$\frac{\partial P_k}{\partial \mu} = -\left(\frac{c}{3}\right)\left(\frac{1}{\mu^2}\right) \qquad (13)$$

or in elasticity terms:

$$\varepsilon_p = \left(\frac{\partial P_k}{\partial \mu}\right)\left(\frac{\mu}{P_k}\right) = -\left(\frac{c}{3}\right)\left(\frac{1}{\mu}\right) \qquad (14)$$

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[9] empirically, the question whether more volatility affects prices or quantities in international trade has received a lot of interest, as in Mann(1989), Caballero and Corvo (1990), Feinberg(1987), Kreinin, Martin and Sheehy(1987).

where c is the marginal cost for the exporter (assumed to be identical for all exporters) and the price elasticity, ϵ_p , is evaluated at the expected value of the exchange rate change, $E(e_t)= \mu$. From the expression of the pass-through (elasticity), a percentage increase in the mean of the exchange rate is not fully passed under duopoly to the final equilibrium industry price. The change in the exchange rate is passed in proportion (1/3) of its effect on the marginal cost schedule of the exporter: *the pass- through is incomplete.*

The results mentioned have been obtained under very strict demand and cost assumptions, as in Bertola (1987) and Knetter (1991). More general formulations were proposed by Hooper and Kohlhagen (1978), Mann (1989), Giovannini (1988), Baron (1976) and Dornbusch (1987), and results do not differ fundamentally. The more general model dealing with oligopolistic interaction and market structure is the one proposed by Fisher (1989). As with more restricted demand and costs conditions, he finds that the effects of exchange rate changes will be more complete the more competitive the industry configuration and that only with concentrated market structures it is possible to obtain perverse pass-through elasticities. Incomplete pass-through elasticity is a general characteristic of any Cournot oligopoly international trade model and is the first argument to put forward for explaining the aggregate incomplete response of industry prices to exogenous exchange rate fluctuations.

The derivation of the pass-through expressions has been obtained under the assumption that the exporters are risk neutral. In a later chapter I introduce a different objective function for each firm facing exchange rate risk that allows the exporters to have (some) aversion or attraction towards risk. *Mann* (1989) models risk averse exporters and using the first two moments of the distribution of exchange rate changes she obtains expressions for the pass-through relationships very similar in nature to those obtained in equations (13) and (14), plus a term with the risk aversion coefficient and the variance of the exchange rate changes. This specification of the pass-through elasticity is later tested empirically to study if exchange rate trends are passed into import prices differenty than the exchange rate variance, or volatility. The results do not show any significant relationship between volatility of the exchange rate changes (as measured by the standard deviation) and export prices. Exporters, overall, do not seem to be risk averse regarding exchange rate changes. *Hooper and Kohlhagen* (1978) and *Gotur* (1985) could not find either any real linkage between exchange rate volatility and export prices. *Akhtar and Hilton* (1984) and *Cushman* (1983 and 1986) did find a positive and significant relationship for aggregate data

between volatility and *import* prices, and this relationship might be due to risk aversion on the part of foreign consumers rather than on the part of the exporters. These studies focus on the pricing decisions of the exporters when exchange rate volatility. Other studies have dealt with an export volume equation, that is, the relationship between volatility and the level of exports. *Caballero and Corbo* (1989) tested the hypotheses that more volatility depresses the volume of trade and found widely support for it for a big sample of developed and less developed countries. They found that in the short- as well as in the long run, more volatility reduced the level of texports significantly, even more so in the long run.

4.2. The Separation Property

When a firm is deciding how much to produce and faces two (or more) destination markets, the optimal choice can be split in each separate market only if demands or costs functions in each market are not related with one another. I assume for the moment that there are no demand links, and that the only inter-relations among markets might arise from economies of scale.

A clear case to consider is when constant returns to scale, in which case the firm can separate its profit in each market and treat each independently since there are no economies of scale (or scope) to exploit. If we assume that the cost function exhibits constant marginal and average costs[13], $C'(.) = k$, then we can express the cost function as: $C(x_{11}+x_{12}) = kx_{11} + kx_{12}$. Now we can make use of the separation property: the firm will obtain the same optimal production plan if it jointly maximizes profits in both markets, or if it considers each market separately. If firms are symmetric and the products are homogeneous, the assumption of constant marginal costs leads to the following result: an appreciation of the exporter's currency (a devaluation of the destination market currency) leads to an increase in the equilibrium price of the destination market and to an increase in the quantity sold by the exporter in the destination market. The effect of the exchange rate change on the quantity sold by the domestic firm in its own (destination) market depends on whether the goods are strategic substitutes, in which case the domestic firm will reduce

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[13]with this assumption we are in fact also ruling out economies of scope.

its sales, or strategic complements, in which case the domestic firm will change sales in the same direction as the exporter does[14].

The separation property has one important implication: it rules out any arbitrage. Clearly, if arbitrage were allowed, no price differentials would be possible (complete integration of the markets). The *segmented markets hypothesis* can be made only in those industries where there are reasons to assume that arbitrage would take a long time or is very costly. It was first used by Krugman (1987), and then by Bertola (1987), Baldwin (1988), and Mann (1989) among others. It has not been directly tested in the context of the pass-through at disaggregate level,[15] but independent studies, as Kirman and Schueller (1991), Gual (1989) and Knetter (1991), have concluded that in some durable goods industries (e.g. automobiles) there are big and lasting enough price differentials among the EEC countries so that we can accept the segmented markets hypothesis as a relevant characteristic of the industries under study.

4.3. Price Sluggishness: Incomplete and Slow Pass-through

One empirical observation regarding the pass-through has been its lag-structure. The majority of empirical studies use a general regression of the type:

$$\ln p_{it} = \alpha + \sum \beta_i \ln e_t + \gamma_i \ln x_{it} + u_t \qquad (15)$$

where p_{it} is the price of the product of industry i at time t in the destination market currency, e_t is the exchange rate and x_{it} is a vector of other factors (barriers to trade, market structure variables, barriers to entry...) affecting the pass-through relationship. Usually the β_i coefficient has a lag structure over T periods, with respect to which several hypothesis can be tested. *Mann* (1987) found that foreign exporters to the US would pass the exchange rate change almost fully during a period of two-to four years. *Feenstra* (1987) found the import tariffs and exchange rate changes were passed into import US

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[14]with slight modifications their result was obtained by Hooper and Kohlhagen(1976), Dornbusch(1987), Bertola (1987), Hens, Kirman and Phlips (1992), Fisher (1989) and Mann(1989).
[15]even though it seems very much possible to do it with structural specifications of the industry equilibrium.

domestic prices with the similar lag-structure and concluded that both variables were treated by exporters in the same way.

Two lines of arguments are put forward to explain the price-sluggishness: (1) the kinked demand model of Sweezy (1939), and (2) expectations and the planning horizon of the firm[16]. The kinked demand model was first applied to the question of exchange rate flexibility by *Dunn* (1975) who put forward the idea that in imperfectly competitive markets firms will prefer price stability to the "skimming" strategy of taking all the possible profit from any exchange rate change in the short run, since *"realities of imperfect markets make stable prices likely over a range of exchange rates"* . He tested this hypothesis in six Canadian industries and found support for it.

4.4. Price Discrimination and Pricing to the Market

In this section I review the main pricing policies in international oligopolistic markets. I start with a simple case of one supplier based in each market. Assume the i-th exporter has n different destination markets in which to sell its homogeneous product. Since I deal with imperfect competitive markets, he faces a downward sloping demand curve (in foreign currency units) in each market: $P_k^* = P_k^*(x_{ik}, x_{jk})$ where $P^{*'}(x) < 0$, and $P^{*''}(x) > 0$, for all $x_{i,j}$. Assume that the exporter quotes its prices in each destination market's currency, so that knowing that the exchange rate is $e_t = (P_m^*/P_k)$. I model e_t, the exchange rate, as a random multiplicative disturbance to the demand schedule. The firm maximizes over all destination markets (n)

$$\text{max. } \Pi_i = \sum_{k=1}^{N} P_k^*(x_{ik}, x_{jk})\, e_i\, x_{ii} - C\left(\sum_{k=1}^{N} x_{ik}\right) \tag{16}$$

where $i = 1.....N$. Assume further that the cost function shows constant returns to scale so that the exporter can split the optimization problem in each different market. The first order conditions give a basic common result of price discrimination (assuming risk neutral firms):

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[16] I deal with this line in a later Section.

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$$P^*_k = (c_i / e_t)(\varepsilon_{ik})/[(\varepsilon_{ik}-1)] \qquad (17)$$

where c_i is the constant marginal costs, which if we assume that firms are symmetric will be common to each firm (expressed in each firms country's currency), ε_{ik} is the perceived elasticity of demand by firm i in market k, itself a function of the number of firms in the industry, and e_t is the exchange rate. Equation (17) tells us that each firm will charge a price above marginal cost in each market depending on the perceived elasticity of demand, the level of home country marginal cost and the exchange rate. *Price in one market need not be equal to the price in any other market if demand elasticities differ.* If there is a positive random demand shock in market k (an increase in e_t, an appreciation of the foreign currency), then, ceteris paribus, the price reduction will be

$$(\partial P_k/\partial e_t) = -[(\varepsilon_{ik}/(\varepsilon_{ik}+1))(c_i/e_t^2)] \qquad (18)$$

The difference in the pass-through elasticity in two different locations may come from the different concentration ratios in each market: if in market k firms have a small market share each but in market m there are a smaller number of firms of larger relative magnitude each, the perceived elasticity will be higher in the k market and so the pass-through after an exchange rate shock will be smaller. The firm in market 1 that sells to two markets, its home one, indexed by 1, and the foreign one, market 2, can have different perceived elasticities of demand in each market, and hence will face different equilibrium prices and will pass the change in the exchange rate into the domestic import price in a different manner, depending on ε_k. This price discrimination result in international markets in Cournot type of models has been first called *pricing to the market* by Krugman (1987), and then studied by Bertola (1987), Baldwin (1987), Mann (1989), Cowan (1989), Knetter (1989) and others, and it is one main argument to defend the empirical observation that import prices need not behave similarly in different countries even though the exchange rate is moving in the same direction, as long as market structure variables differ. This pricing policy has led in the empirical literature when testing the effects of exchange rate changes in the prices of different industries at disaggregate level to the *differential response* hypothesis: as Webster(1986), Kreinin, Martin and Sheehy (1987), Knetter (1989), Knetter and Gagnon (1989) and Feenstra (1989) have shown, different industry prices respond with various patterns to exogenous exchange rate shocks.

An important case that we have not dealt with so far has to do with dynamics of the exchange rate fluctuations and market structure. An important devaluation of the home

country currency can cause the exit of some exporters of the industry. The change in the number of firms can, in turn, change the perceived elasticity of demand facing each incumbent and this will change the pass-through elasticity[17]. Since the exit or entry decisions of the firms can be viewed as long-term decisions this shift in the pass-through elasticity can be estimated empirically as a structural break in the pricing equation. In fact, several empirical studies for the US have shown some evidence for structural changes in the pass-through elasticity of foreign firms in the US markets during the 1980's[18].

Brown (1989) also comes to the conclusion of incomplete pass-through by introducing *free entry/exit* in the industry in a static framework. She studies one-period price-setting behavior with differentiated commodities when exchange rate uncertainty. In the empirical part she finds support for the hypothesis that the higher the elasticity of cross-substitution between different varieties, the lower the pass-through will be since consumers will be very sensitive to any price change and be able to switch to another brand. She also studies the empirical observation of why the US import prices increased so little during 1985-88 when the dollar was declining and gives an alternative explanation to why foreign producers squeeze on profit margins rather than increasing prices. Contrary to *Krugman* (1987) and *Giovannini* (1988) who explained this observation in terms of the firms' maximizing multi-period profits and avoiding in this manner short run fluctuations in market share, Brown offers the explanation that this behavior is also consistent with one-period-profit maximization if we allow for free entry/exit in the market: the depreciation reduces profit opportunities available to firms exporting to the US, profits become negative and firms exit the market until the zero profit condition is restored. She finds that barriers to trade introduce a lag in the exchange rate pass-through but do not reverse it.

With expression (18) we can also see the two extreme cases of pass-through: monopoly and perfect competition. Assuming that the price elasticity of demand is constant, full pass-through occurs when $(\partial P_k/\partial e_t) = - [(\varepsilon_{ik})/ (\varepsilon_{ik} -1)](c/e_t^2) = - (P^*_k/e_t)$, where e_t is the (bilateral) exchnage rate and ε_{ik} is the price elasticity of demand in market k as perceived by firm i taken in absolute value and a greater elasticity implies a higher ε_{ik} in absolute value. When monopoly, on the other hand, after a unit percentage devaluation of the destination market currency, the price changes in the proportion, $(\partial P_k/\partial e_t) = - (1/2)$ (c/e^2), which is the lower bound value for the pass-through relationship. The higher the

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[17]the perceived elasticity of demand in Cournot models can be expressed as a direct function of the number of (symmetric) firms in the industry, as in Neumann, Boebel and Haid (1985).
[18]see Baldwin (1988) and Mann(1989).

perceived elasticity of demand, the higher the pass-through will be. This relationship can be evaluated at the expected value of the exchange rate that we can normalize to one, $E(e_t)=1$, and we obtain $[\partial P^m/\partial E(e_t)]/c_i = -(c/2)$, for the monopoly case. When dealing with oligopoly we move between these two extreme cases.

If an indefinite number of firms is introduced in the industry I can show, as in *Cowan* (1989), *Krugman* (1989), *Dornbusch* (1987) and *Herguera* (1993), that the higher the number of firms, the smaller the mark-up obtained by each firm and the greater the pass-through of exchange rates into import prices will be. In fact, as in *Neumann et. al.* (1985), that the perceived elasticity will depend on the number of firms in the industry and on the relative market shares of each firm. This conclusion is obtained only in Cournot type of competition and when collusive market structures, but not when Bertrand competition with homogeneous goods is assumed[19], in which case the market structure (i.e. number of firms) does not influence the pass-through relationship.

$$P_k = (c_i \, \varepsilon_k)[1/\, e_t \, (\varepsilon_{ik}+1)] \qquad (19)$$

In equation (19) I can also state the two main sources of changes in the behavior of the pass-through relationship in the absence of any strategic interaction: (1) the *cost mark-up*. This margin of price over marginal costs depends on the perceived elasticity of demand of the individual firm which can shift after an appreciation of the currency; (2) the relationship between the *cost and the exchange rate*. The higher the correlation among the two, the higher the pass-through relationship[20].

This explanation takes account so far of a certain sluggishness in the price response. In order to explain the "perverse" pass-through I need to introduce another hypothesis regarding the behavior of the firm: that market share matters.

An exporting firm can have a different planning horizon than a domestic producer. In the initial phases of the export activity, the foreign firm might have the objective of maximizing sales rather than profits in the short run. The difference in the objectives of the firm can lead to perverse pricing policies in the foreign market. Assume a German firm

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[19]it is not realistic to model international trade with homogeneous goods in trade, though.
[20]this correlation between exchange rates and cost schedules is not modelled here, but can have importance in the pricing decisions.

exporting to the US market. If the dollar devalues, the German firm can face two different equilibrium price behaviors:

(1) the DM -denominated price can increase, so as to keep the DM price (in foreign currency units) close to the pre-devaluation level. The firm loses some market share in the US market, but will maintain the same mark-up in the destination market as it had before. This pricing policy is called *"skimming"* policy[21] and implies a full pass-through,

or alternatively, (2) $-denominated price (in home currency units) is kept close to the pre-devaluation level, in which case the firm loses some revenues per unit of product sold, but keeps the market share intact. In this case the pricing policy is called the *"penetration"* or market -share matters policy.

When the dollar appreciates, the opposite holds. An appreciation of the destination market currency (i.e.the home currency) makes the market more attractive for the exporting firm. After an appreciation of the US dollar the German firm can face either: (1) a reduction of its dollar-denominated price, so as to keep the foreign (DM) currency price close to the pre-appreciation level. The firm will thus increase its market share in the US market and this pricing policy, *"penetration"* strategy implies a pass-through elasticity of 1 (full pass-through), or else (2) the US dollar-denominated price is kept close to the pre-appreciation level, in which case the firm gains higher marginal revenues for the units sold in the US market. It gains no additional market share but its profits from exporting are higher. This *"skimming"* strategy implies no pass-through. In the next table[22] we synthesize this classification, taking into account that the currency that fluctuates is the home (or US dollar) one.

Currency Movement	Pass-through	Pricing Policy
Depreciation	$p_t = 1$	skimming
	$p_t = 0$	market share
Apreciation	$p_t = 1$	market share
	$p_t = 0$	skimming

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[21] as Sundaram, A. and Mishra, V. called it.
[22] the taxonomy of the table is taken from Sundaram and Mishra (1989).

4.5. Economies of Scale and the "Perverse" Pass-through

When the exporting firm produces the good with a different technology, we have to consider a second effect in order to predict the sign and degree the pass-through relationship. Economies of scale (or of scope) link the different destination markets where the exporter might ship its good. Markets become inter-related and the equilibrium price (or quantity) in location i depends also on location i+1 [23]. As soon as we introduce inter-markets links via the cost function, the separation property holds no longer and this has important implications for the way the firm will respond to exchange rate changes.

In *Hens, Kirman and Phlips* (1991) a comparative static analysis is developed introducing two relaxations of two hypothesis used before: economies of scale and of scope, and the strategic substitutes/complements hypothesis. In a symmetric firm duopoly, two-country setting with a homogeneous commodity, they study the pass-through elasticity. Calling x_{ik} the quantity that firm i sells in country k, and x_{kk} quantity that firm of country k sells in its own domestic market (market k) and dealing only with two markets, $k = i = 1,2$, if both firms engage in reciprocal trade, an exchange rate appreciation (of country 1 currency) implies that market 1 is more attractive for firm 1 and for firm 2 (belonging to country 2). Hence x_{21} increases and x_{22} decreases. These two changes induce two different effects:

1. *cost effects*: depending on whether country 2 firm has increasing- or decreasing marginal production costs, the increase in its exports (i.e. in x_{21}) will induce a decrease or increase in its domestic sales (i.e.in x_{22})

2. *strategic nature of the goods*: when the goods are strategic substitutes, the increase in the exporting sales (in x_{21}) will cause the sales of country 1 domestic firm to decrease (reduce x_{11}), but not so if goods are strategic complements. In turn, these effects induced on the rival have also further effects on the rival's production (or sale) decision, since it will move the firm along its average (and marginal) production costs.

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[23]Economies of scale have also implications for the stability conditions in oligopoly. On this point see Dixit (1986) and Hens, Kirman and Phlips (1991)

When no strategic interactions among the (symmetric) firms are allowed and with diseconomies of scope the pass-through cannot be "perverse", that is, it cannot happen that the level of price of the country whose currency appreciates (country 1) increases together with a reduction in the price of the country where devaluation of its currency takes place (no matter that goods are strategic substitutes or complements). But in the case of diseconomies of scope and goods being strategic substitutes both prices can move in the same direction (or the "surprise" pass-through), i.e. both prices, of country 1 and of country 2, increase (decrease) when country's 1 currency appreciates (devalues), as long as the direct effect for country 1 firm is small and whenever its indirect cost effect is negligible. When firms have different cost schedules, it is possible that they move along different intervals of the average costs curves and react differently, in sign and degree, to the cost and strategic effects mentioned earlier. In fact Hens, Kirman and Phlips (1992) show that for general cost and demand functions and with asymmetric firms, it is possible to obtain the "perverse" pass-through in a static framework.

Few empirical studies deal with the question of the cost structure of exporters. *Hooper and Kohlhagen* (1978) tested in a reduced form export volume equation how volatility affects quantities or prices of traded goods when marginal costs have different shapes. They find evidence for the hypothesis that US import prices rather than quantities were affected by exchange rate changes, which leads them to conclude that based in their sample, exporters face increasing marginal costs of exporting.

5. Dynamics

5.1. Expectations, Planning Horizon and Market Share Matters

The idea that market share matters has a long history and especially in the study of the pass-through relationship some authors suggested it could have special relevance [*Dornbusch* (1987); *Krugman* (1987); *Dixit* (1989); *Baldwin* (1987); *Klemperer and Froot* (1988)]. In the case of the so called intra-industry trade, i.e. trade in commodities that belong to the same industry category, where product differentiation is a key element and

where demand elasticity perceived by each producer is less elastic market share can show inertia over time. The firm might incur additional (adjustment) costs if it wants to increase its market share from one period to the next. The exporter, even if risk neutral, might then not be willing to see its market share fluctuate as much as the exchange rate does. In order to avoid such fluctuations the exporter will smooth out the exchange rate changes according to a different (longer) planning horizon (*Ohno,* 1990). The fact that firms maximize multiperiod-profits, instead of period-by-period makes them pass the exchange rate changes incompletely depending on the discount rate applied (reflecting the risk aversion on the part of the exporters). *Ohno* uses the standard Cournot quantity setting model with one exporter and one domestic firm, where the former maximized profits in the whole game, composed of t periods) and compares this strategy with maximizing profits period-by-period. In his model inertia is driven by the existence of marginal cost for the firm of increasing its market share from one period to another, of say, s units of product. When an appreciation occurs and the exporter wants to increase its market share, it will incur in the additional cost, s (that we can think of as menu costs). Hence, if we assume linear demands and constant marginal costs, for periods of appreciation of the US dollar (indexed by odd subscripts), the exporter (1) in the foreign market (2) has the problem:

$$\text{max. } \Pi_t = [\alpha - \beta (x_{12}+x_{22})] x_{12} e_t - (\alpha x_{12} + s x_{12}) \tag{23}$$

for $t = 1, 3, 5.....$ T,. For periods of depreciation of the currency ($t = 0,2,4...$), he faces the same objective function without the term in s. These two types of objective functions give two different reaction functions. The exporter will increase its market share from period, say, $t = 3$ to $t = 5$, if the expected appreciation is higher than the marginal cost it has to incur in order to increase its market share. If the appreciation is low enough, the exporter will keep its prior Cournot-Nash equilibrium quantity in the market, and the equilibrium price does not change. Pass-through will be incomplete, or even equal to zero. The effect of introducing this additional cost in the exporter's side is to shift its reaction function inwards. The hysteresis obtained here applies only to small exchange rate changes and the main idea of the article is to put forward the idea that additional costs can delay, or even impede, the price (or quantity) adjustment that the exchange rate change can bring about initially if the firms maximize profits over a long planning horizon. If the firm maximizes short-run profits, period-after-period, it will pass (1/3) of the exchange rate change into the exporting market for any period of appreciation of the foreign currency, and will reverse the pass-through for periods of depreciations, as in any Cournot standard

model. Long-term profit maximizing firms will pass only part of the exchange rate fluctuation.

But the argument in favor of market share has strong implications and leads not only to smoothing the exchange rate impacts on import prices, but can also lead to "perverse" pass-through.

This is the main argument put forward by *Froot and Klemperer* (1989) in studying the behavior of import prices in the US during the 1980-87 period. They study the pass-through when future demands depend on current market shares and test empirically if the expected future exchange rate provided a clue on the puzzling behavior of US import prices. They start by observing that the price differentials of similar commodities in the US and other importers was sensitive to the level of the exchange rate. In a two period Bertrand competition model with product differentiation, they represent the domestic firm by the superscript d and the foreign firm by f. The foreign firm will maximize the discounted value of the two period horizon:

$$\text{max. } \Pi^f = e_1 \ P^f_1(p^d, p^f, e_1) + \lambda^f e_2 \ P_2^f(\sigma^f(p^d, p^f), e_2) \tag{20}$$

where the subscript refers to the period $t = 1, 2$, σ^i denotes market share, λ is the discount factor and p^f and p^d are the prices charged by the foreign and home firm (in the common domestic currency) respectively. Constant marginal costs are assumed for both types of firms and the exchange rate is assumed to be exogenous. After obtaining the first order conditions for each firm and for each period, they derive the pass-through expression and obtain two equations that reflect the pass-through in terms of the expected duration of the exchange rate change $t = 1, 2$, as:

$$dp^i/de_1 = - c_1^f \ (\partial p^i/\partial c_1^f) - \lambda \ (\partial p^i/\partial \lambda) \tag{21}$$

and

$$\partial p^i/de_2 = -c_2^f(\partial p^i/\partial c_2^f) + \lambda \ (\partial p^i/\partial \lambda) \tag{22}$$

These two expressions reflect the effects of a temporary increase in the exchange rate in period 1 and 2 respectively, and they separate the total influence into two effects: (1) *the cost effect*: the first, say, period cost effect is, $-c_1^f \ (\partial p^i/\partial c_1^f) < 0$ and implies that a

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dollar appreciation will decrease the foreign firms' marginal costs and so it will reduce its price. This effect in this two stage game can also have a feed-back from the second to the first period as long as prices in period t =1 are affected by future costs or discount factors (the terms $\partial p^i/\partial c_2^f$ and $\partial p^i/\partial \lambda$). This feed-back happens if market share matters, since lower second period costs imply an increase in the marginal value of market share, and the exporter will increase its market share in period t =1 by lowering its price. We obtain from the cost effect that not only the first period dollar appreciation will reduce the equilibrium price, but also the expectation of an appreciation in the second period will drive today's prices down; and (2) *the interest rate effect*, which are the second terms in expressions (21) and (22) and will be positive also only when market share matters: temporary appreciation makes the profits in the US market in the second period less valuable than current profits. The rate of return on market share falls and the firm will follow a short-term profit maximization strategy: maximizing profits in this period, by raising its prices; $-\lambda(\partial p^i/\partial \lambda)$ > 0, so that when dollar appreciates, the interest rate effect tends to increase import prices $(\partial p^i/\partial e_t) > 0$. In the short-run, if the interest rate effect dominates the cost effect, the final pass-through will be perverse.

To study the effects of a permanent exchange rate change, they study together expressions (21) and (22) and obtain that under a permanent exchange rate appreciation the dollar prices will diminish more than under a temporary appreciation, since the cost effect will always be greater in magnitude than the interest rate effect. When a permanent exchange rate change the interest rate effect will dominate the cost effect only for very risk averse firms.

The market share hypothesis, hence, can explain the "perverse" pass-through of exchange rates into import prices when each firm places a high value to its past market share or when firms have a high degree of risk aversion.

Few empirical studies have studied expectations of the firms regarding exchange rate changes. *Froot and Klemperer* (1989) provide also an empirical study where they give evidence for the fact that firms pricing decisions are in fact more sensitive to expected exchange rate changes than to current exchange rate movements. They explain this based on the slow adjustment of consumers to changes in the relative price of the imported varieties. *Dohner* (1984) finds support for this hypotheses, too. *Feinberg and Kaplan* (1992) estimate an producer (relative) price equation for the USA for the period 1974- 87 using the anticipated exchange rate value as the expectation variable for the firm. They

found that when the actual and the anticipated exchange rates are introduced together in the estimated equation, the anticipated exchange rate seems to explains better the (relative) producer price for each industry in the sample. Noting that the expected signs of the actual exchange rate in the equation is negative (an appreciation of the destination market currency, the US$, implies a reeduction in the $ denominated import to the US) and that the sign for the anticipated exchange rate is negative (i.e., an expected appreciation of the US$ makes the market share for the German exporter in the future less valuable and hence will tend to raise the US$ denominated price of the good that imports into the US) they obtain the following elasticity point estimates: for the actual exchange rate, -0.2, and for the expectations, + 0.5, that is, a higher pass-through elasticity of the producer price with respect the exchange rate when expectations are taken into account. The hypotheses of equal pass-through elasticities (for the actual and the anticipated exchange rates) across industries is rejected. These elasticities are reduced when barriers to trade are present and when barriers to entry are significant across industries.

From the supply side some authors have explained different possible patterns of behavior of the pass-through relationship by incorporating sunk costs in the planning horizon of the firm. In static models it is possible to obtain inertia in the market share and the corresponding incomplete and even perverse pass-through elasticities, based on the following hypotheses: (1) market share matters and hence firms will try to smooth out the impact of exchange rate changes on prices so as not to have a volatile market share and total revenues, (2) stabilizing destination market prices when the exporter quotes its prices in the destination market currency, (3) price discrimination across destinations, or (4) economies of scale (or scope) in the production process. The (dynamic) models that deal with hysteresis, uncertainty together with sunk costs in the entry/exit decision of the firm, make the firm reluctant to pass all of the exchange rate change on to prices, once it has entered the foreign market. The firm is willing to pass on to the domestic price the exchange rate change only when this change is perceived to last for a prolonged period of time, since an instantaneous and full pass-through can imply a reduction in the market share of the exporting firm and in the initial periods the firm might prefer to recoup all the sunk costs it incurred to enter the market. But as *Krugman* (1987) and *Dixit* (1989) have shown, the mere introduction of uncertainty can lead to the firms to adopt a "wait-and-see" attitude that will reduce the pass-through elasticity. The hysteresis result obtained in stochastic models extends the basic conclusion reached before with more simple forms of uncertainty that more uncertainty makes agents more conservative and reluctant to change strategic variables.

5.2. Hysteresis in Trade and the Unresponsiveness of Import Prices to Exchange Rates

We have seen how different expectations and planning horizons by the exporters may give rise to strange, or even perverse, price responses to exchange rate surprises. Next we can put forward the hysteresis and bottlenecks stories that also explain the "perverse" pass-through in a dynamic framework. *Baldwin* (1986) and *Krugman and Baldwin* (1989) argued that a firm that wishes to enter a foreign market may wait until the exchange rate is favorable to do so. To enter the market it has to incur in sunk costs that it cannot recoup if the firm exits the market once the exchange rate turns unfavorable. This irreversibility may lead to the firm not to react to exogenous variable changes in the short run.

Dixit (1989) models the real exchange rate as a random walk in continuous time and thinks of the entry/exit decision of the firm in a foreign market as an option that can be exercised by the firm according to exchange rate movements. He introduces sunk costs in exiting (λ), and in entering the foreign market (k) that must be incurred by a firm which has a technology with constant returns to scale. There are an indefinite number n of possible exporters into the US market. Firms are assumed to be price-takers, to have rational expectations regarding exchange rate fluctuations, and to be symmetric in their variable costs schedules. w_n is the average variable costs of production (expressed in the exporter's currency) which is constant for all firms. With free entry/exit in a competitive industry, once the US dollar appreciates, new (say, Japanese) firms would enter the US (or destination) market. The introduction of sunk costs of entry/exit changes the responsiveness of the firms to the random fluctuations of the exchange rate. Each exporter faces a Yen-market price of ($p\,e_t$), where e_t is the bilateral (Yen/dollar) exchange rate. The profit function for a representative Japanese exporter is given by $\Pi(p\,e_t, w_n)$, from which we can derive the supply function as, $\Pi_1(p\,e_t, w_n)$. Let $x(p)$ be US import demand. The equilibrium condition in the industry when the number of Japanese exporters is fixed (at n) is

$$x(p) = \sum_{j=1}^{N} \Pi_1(p\,e_t, w_j)$$

We can differentiate the equilibrium condition (that gives the resulting equilibrium industry price) to see the effects of a change in the exchange rate and obtain

$$x'(p) \, dp = \sum_j \Pi_{11} \, (p \, e, \, w_j) \, (\, p \, de + e \, dp) \qquad (24)$$

Let us call $\varepsilon = [\, -p \, x'(p)/ \, x(p)]$ the US import demand elasticity, and $\eta_j = [p \, e \, \Pi_{11}(p \, e, w_j)/ \, \Pi_1(p \, e, \, w_j)]$ the foreign firm supply elasticity, $j = 1,.....,N$, where w_j is the variable costs. Rearranging terms in the first order condistions we obtain the pass-through (in elasticity terms) as

$$- (dp_t/p_t) \, (e_t/de_t) = [\, \eta \, / \, (\eta + \varepsilon)] \qquad (25)$$

In Dixit's model the demand elasticity is assumed to be constant, so as to avoid demand side effects of currency appreciations. Given that average production costs are constant, the (individual) supply elasticity is the driving force of the pass-through elasticity. In the general formulation of the problem, after finding an approximate solution for the first order condition of the exporter, Dixit finds an exchange rate band in which exchange rate movements will not cause any response from incumbent or potential firms. These "trigger" exchange rates, for which hysteresis occurs, is valid only for constant average costs. Inside this interval any exchange rate movement will have a zero effect in the import domestic price (as no entry or exit occurs). Changes in the exchange rate that happen outside the band will cause an immediate exit (or entry) of firms and hence a higher pass-through elasticity.

Dixit (1989) interprets this result as a structural break in the pass-through relationship. In the initial phase the change in the exchange rate occurs inside the critical interval where no response happens. After a period of successive devaluations (or appreciations) of the currency, the exchange rate jumps outside the no-action zone, and pass-through becomes complete as the industry adapts to its new equilibrium.

Baldwin (1988) tests two different hysteresis models: the beachhead and the bottleneck model. In the *beachhead model,* the firm must incur sunk costs (as market entry costs) that may be recouped only partially if the firm exists the market. Once the firm entered the US market the irreversibility of part of the entry investment implies that when the dollar devalues not all firms that entered in the first place will exit the market. The type of expectations of the firm regarding the exchange rate changes are crucial in these models.

Baldwin considered perfect foresight with respect overvaluations of the US $. *Baldwin and Krugman* (1986) relaxed this assumption by making the exchange rate distribution independent and identically distributed over the time period considered.

Bottleneck hysteresis comes about because the firm faces a distribution capacity constraint (or marketing bottleneck) in the short run. After a period of successive appreciations of the destination market currency, the firm will be willing to invest in new capacity as the shadow costs of being capacity constrained is high in periods of high US $. But with devaluations of the currency, the capacity constraint is not binding and the firm may not need to pass on to higher prices the fall in the exchange rate since its marketing (short run) costs fall simultaneously.

Graph 6: the bottleneck model and hysteresis
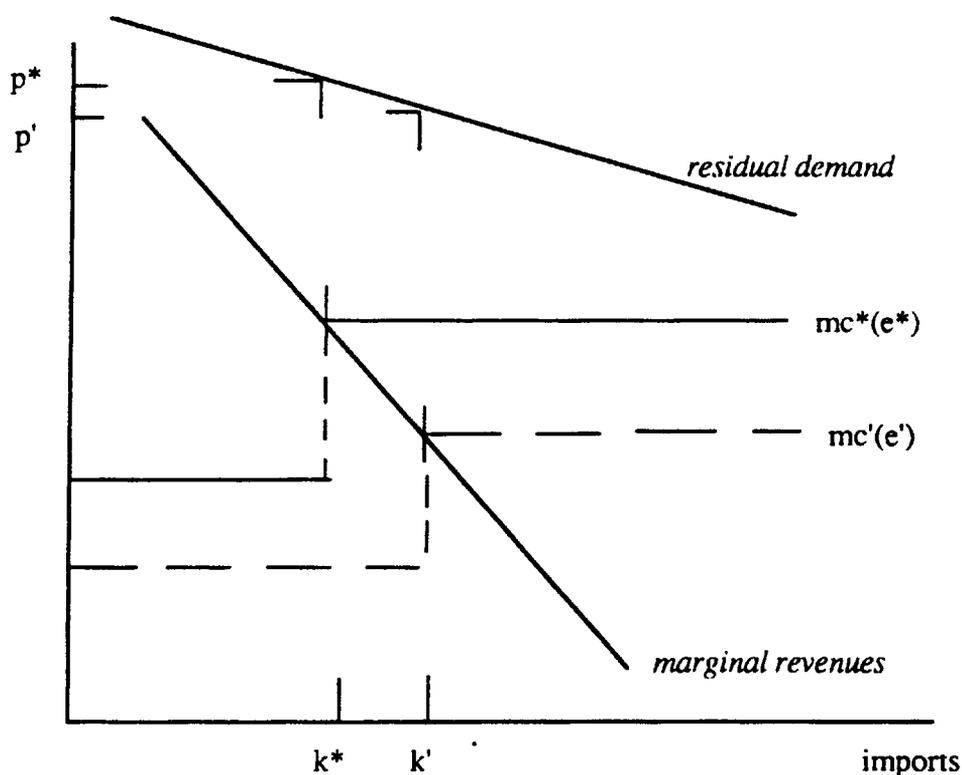
Graph 6 depicts the bottleneck model. The discontinuity in the marginal cost schedule comes about because of the critical capacity utilization, k*, after which the firm can only produce additional units of the good at higher marginal (and average) costs.

Initially the equilibrium price is p* with capacity k*. After a period of appreciation the firm adopts new capacity, k', and its the marginal costs schedule shifts downwards The new equilibrium is price p' and capacity (and production level) k'. The pass-through occurs as industry capacity and sales expand. The marketing bottleneck results in discontinuous pass-through, since the dollar denominated marginal costs of supplying the US market are a discontinuous function of the exchange rate.

Demand side factors may also lead to hysteresis. If consumers in the destination country are imperfectly informed about the new goods, new entrants will initially face periods of low demand. After the consumers have learned the qualities of their goods, their demands will increase. If a devaluation of the destination market's currency occurs, not all foreign firms will be willing to exit the market and incomplete (or null) pass-through can be obtained.

The empirical studies done on the hysteresis hypothesis give support to the idea of the structural break in the US pass-through relationship for the 1980- 1988 period, but are not very conclusive on the causes and permanent effects of this break. *Baldwin* (1988) found that during the period 1985- 87 where the real value of the dollar decreased vis-a-vis the main trading partner currencies, the real import US dollar price index did not increase significantly. Mostly the exchange rate change was absorbed by reduced mark-ups by foreign firms. He argues that reduced mark-ups are an implication, not a cause, of the slow pass-through observed during that period. The bottleneck model predicts that the import demand (volume) equation should shift simultaneously with the pass-through relationship. *Baldwin* (1988) and *Baldwin and Krugman* (1989) find that the US import volume equation did have a structural break in the first half of the period 1980-1988, an observation that gives more support for the beachhead than for the bottleneck model. One problem encountered in the empirical tests is the lack of certain data at the very disaggregate level: in order to test the beachhead model thoroughly, data on varieties of commodities in trade is needed and to test the bottleneck model, data on capacity measures and utilization is needed. Without these data, results are only tentative. The assumption of constant elasticty of demand, as in Dixit (1989), does not find much empirical support. Any major exchange rate change that induced foreign firms to enter a new market might shift the elasticity of demand as well. *Knetter* (1989) imposes this condition in his empirical work but suggests that demand should be allowed to have different degrees of convexity when exogeneous exchange rate changes were of significant magnitude.

6. The Error-correction Representation: Deviations from the Law of One Price and Short-run Dynamics

During the last decade there has been a development in the econometric literature that is having important repercussions in the empirical studies of the pass-through relationship: the issue of co-integration. We focus here on some developments in the co-integration literature that concern the pass-through relationship. For aggregated as well as industry level studies, it has been found that the variables that usually enter the regression (i.e. exchange rates, prices, wholesale price indices, and indices for cost schedules) are non-stationary, that is, they have (at least) one unit root. When the variables in a time series regression are non-stationary (or integrated of any order) the estimation of an OLS model might lead to a spurious relationship, that is, even though the R^2 of the regression might be very high, the explanatory power of the (assumed) exogenous variables in explaining the changes in the dependent variable (usually, a price index) is very low or non-existent. The problem is that the variables when non-stationary show a common trend that should be taken into account in order to investigate the real explanatory power of the model. A first hand diagnosis for co-integration is given by the Durbin-Watson statistic that measures auto-correlation in the residual term. After testing the unit root hypothesis in each variable, if the R^2 of the regression of all the relevant variables is higher that the DW statistic, variables could well be co-integrated. A natural way to proceed with co-integrated variables is to estimate the same model with differenced variables and get rid of the common trend. The problem that this procedure implies is that by taking first differences a lot of information is lost. *Granger* (1981), *Granger and Engle* (1987), *Hendry* (1986) and others have proposed to re-parametrize the original (static) model so as to incorporate in the regression only stationary variables (or variables integrated of order zero) and an additional term, the error-correction- mechanism, that would capture the adjustment in the short run to the long run equilibrium relationship.

To obtain the error-correction mechanism, or dynamic adjustment to the long-run equilibrium, *Kasa* (1992) studies the case of an exporting firm that faces quadratic adjustment costs in output when it deviates from the long-run output level. These adjustment costs lead to differences in the marginal costs of supplying the foreign markets.

From a quadratic costs specification it is possible to derive, as in *Knetter* (1991) and *Gagnon* (1989), an error-correction term, i.e. a term in the steady-state solution of the problem that reflects the deviations in the pricing policy with respect the assumed long run true equilibrium relationship. Kasa investigates the hypothesis that short term fluctuations will be absorbed by the mark-ups of individual producers, while long term changes in the value of the currency wil be passed into the domestic import price of the destination market currency. He finds support for this hypothesis in his US sample. The advantage of the error-correction models is that they separate the long-run equilibrium (i.e. the Law of One Price) from the short term deviations that occur from them.

At disaggregate level, several studies [*Kasa*, (1992), *Knetter*, (1991), *Gagnon* (1989), *Juselius* (1992) and *Bardalas* (1993)] have found that exchange rates and import prices do have a common trend in the long run[24].

Following *Knetter* (1991) and *Gagnon* (1989) the intertemporal problem of the exporter (assumed to be a monopolist in his country of origin) that ships its (homogeneous) good to different destinations can be stated for each location as

$$\max. E_{t-1} \quad \sum_{i=0}^{\infty} \theta^i \left\{ p_{t+i} x_{t+i} - c_{t+i} x_{t+i} - \lambda \, \pi_{t+i} \left(\frac{(x_{t+i} - x_{t+i-1})^2}{e_t} \right) \right\} \left(\frac{1}{\pi_{t+i}} \right)$$

subject   to

(1) $p^*_t = (a - b x_t) \pi^*_t$

(2) $c_t = \pi_t$

where θ is the discount rate for the firm, p_{t+i} is the nominal price of the good exported i-periods ahead, $\dot{\pi}_{t+i}$ is the inflation rate of the exporter's country i-periods ahead and c_t is the marginal cost of production. The first restriction is just the inverse linear demand expressed in the destination market currency and the second restriction is a simplifying

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[24]the estimation procedure with co-integrated variables is explained in the next chapter.

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assumption that equates marginal costs to the inflation rate for the exporter. This last hypothesis should be understood as an instrument in the estimation procedure: the inflation rate differential between two locations is used as a proxy of marginal costs shifts. In the objective function, the adjustment costs for the exporter enter in a quadratic form in the term in parenthesis, multiplied by the λ coefficient which determines the size of such costs. No strategic interactions are introduced; the exporter is assumed to be the only exporting firm in the destination market.

After taking the first order conditions, assuming an AR(1) process for the exchange rate variable and rearranging terms, *Knetter* (1991) and *Gagnon* (1989) end up with a reduced form export price equation (expressed in the exporter's currency) of the form

$$\frac{\partial p_t}{p_t} = \frac{\partial \pi^*_t}{\pi^*_t} - \frac{\partial e_t}{e_t} - (1-\alpha)\left\{ \frac{e_{t-1}p_{t-1}}{\pi^*_{t-1}} - \Gamma - \frac{\Phi e_{t-1}p_{t-1}}{\pi^*_{t-1}} \right\} \qquad (26)$$

where α, Γ and Φ are functions of the underlying demand and cost parameters and π^* is the destination market inflation rate (equal in this model to the marginal costs of the domestic firms). An increase in e_t implies an appreciation of the exporter's currency, and hence a devaluation of the destination market currency. The first two terms in the right hand side of equation (26) give the long-run equilibrium relationship between the exchange rate and the (real) import price changes. In equation (26) we see that the short run effect of a change in the exchange rate, the terms in brackets, is to lower the export price proportionately, and that the short run effect is greater than the long run effect. *Knetter* (1991) and *Gagnon* (1989) report differences in the pattern of pricing to the market attributable to destination country characteristics. *Knetter* (1991) analyzes total automobile trade of the US, Japan and Germany, and found that even the same models of cars sold in the same destination country but imported from different source countries show significant and persistent price differentials in the sample. None of these studies introduce strategic interaction or the degree of product differentiation. They advanced several hypothesis that could explain price differentials and the evidence of pricing to the market. Input level adjustment might be more costly to adjust in German and Japanese manufacturers than for US counterparts, which could explain the stabilizing policy followed by these two exporters. *Kasa* (1992) reports that adjustment costs for US, German and Japanese exporters appear always significant, more so in durable goods industries like automobile production.

This line of research has important implications for the study of price responses to exogenous shocks. First it takes care of the co-integration property among the variables in the regression and while maintaining the long-run information on the stable relationship among the variables, it can focus on the short term response of endogenous variables to exogenous shocks. Second, it allows the study of the short run deviation from the assumed long-run equilibrium relationship. Finally, it seem appropriate to introduce adjustment costs in industries where production decisions take time before they are realized.

Chapter 3

Exchange Rate Fluctuations, Market Structure and the Pass-through Relationship

1. Introduction

The Law of One Price states that there is perfect arbitrage in commodity trade and that price differentials between homogeneous products in different countries reflect only the existing barriers to trade and the exchange rate. Empirical studies in international trade flows do not, in the short and medium term, support this theory of price behavior (*Kravis* and *Lipsey*, 1977; *Krugman*, 1988)[1]. The main line of criticism regards the perfect competition assumption of the theory. If the Law of One Price were to hold, the pass-through relationship, that is, the way import domestic prices change with exchange rate movements, would be one. This implies that an exchange rate devaluation of the importing country is passed into a fall of the imported quantity that in turn will drive the imported equilibrium price down in exact proportion to the fall in the exchange rate. The direct implication for the exchange rate pass-through is that we should observe a one-to-one relationship between any change in the exchange rate and the import domestic price.

It has been empirically found, though, that the pass-through relationship, tested for different levels of aggregation, is not equal to one (the absolute version of the Law of One Price) and not even constant along time (the relative version of the Law). Not only are exchange rate changes not reflected one-to-one in import domestic prices, but also evidence has been found that changes in certain variables (like tariffs) are passed on incompletely into domestic prices. *Feenstra* (1988) has studied the pass-through of exchange rates on

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[1] In both articles the main objective was to test the relative version of the Purchasing Power Parity doctrine.

the one side, and of import tariffs on the other, and found that the way that tariffs and exchange rates were passed into the domestic import price had similar lag structures.

The empirical observation that import prices adjust incompletely to exchange rate changes gives support to the hypothesis of imperfect competition in international trade. In fact in the last three decades the greatest growth in international trade has taken place in intra-industry trade, i.e. international trade in imperfectly competitive markets where the interactions among firms influence the behavior of prices and quantities traded. In a seminal article *Dornbusch* (1987) proposed the introduction of imperfect competition models, coming from the IO literature, to explain pricing behavior in international markets. In the rest of the paper I follow the basic model of Dornbusch (1987) and Mann (1989).

2. An Oligopoly Model of Trade with Uncertainty and Risk Averse Firms

2.1. Context and Scope

The literature on the pass-through relationship has a short but intense life. *Dornbusch* (1987) introduced the idea of analyzing the behavior of prices at a disaggregate level when the exchange rate fluctuates by introducing various forms of imperfect competition in the markets, linking in this way two literatures: that of Industrial Organization(IO) and of international trade. Afterwards, *Bertola* (1987), *Mann* (1989), and *Knetter* (1990) used the IO framework to study the behavior of prices in international markets. *Krugman* (1987) applied a general Cournot oligopolistic model to explain the "pricing to the market" policy and the price differentials between different countries of the same good. *Giovannini* (1987) explained deviations from Purchasing Power Parity with the introduction of three elements: (1) exchange rate surprises, (2) price-staggering and (3) ex-ante price discrimination. In order to study the price discrimination element we need to use models of imperfect competition. *Mann* (1989), using a general specification of demand functions and modeling exchange rate uncertainty with the first two moments of the distribution of exchange rate changes, introduced the idea that risk aversion on the part of the firms as well as of consumers matters. In this section I start from the general specification used by *Mann* (1989) and extend it in two ways. First in Sections 1 and 2,

specific linear demands for the case of quantity setting firms are introduced. An indeterminate number of firms is modeled allowing two different types of rivals that might have different strategic behaviors: exporters and domestic producers. A special form of product differentiation is introduced: goods produced in different locations (i.e. countries) are regarded as different varieties of the same good by the consumers. It is shown that the relative number of each type of rival in the industry (whether exporter or national producer) is crucial in determining the optimal pass-through elasticity. Secondly, the conjectural variations approach is used in Section 3 to study different types of competition assumed by each rival and their implications for the pass-through relationship: the adjustment in prices and quantities traded after exchange rate uncertainty is introduced. It is found that a whole range of pass-through elasticities is possible.

2.2. The Invoicing Currency, the Source of Risk and the Pass-through

Before setting out the model, we need to specify the source of risk. Each firm has the choice of invoicing its contracts on its own currency or in the destination market's currency. If the (say, German) exporter quotes the price of the goods in the foreign (destination, i.e. the US) country's currency then it will be facing a "price risk", since the final price, or unit revenues, will depend on the realization of the exchange rate[2]. In this case the equilibrium price will be affected by the relative risk aversion of the exporter, since it is the exporter who is facing an uncertain home currency price (in DM). On the other hand, if the exporter invoices the contracts in its home country's currency then he will face a "quantity risk" because the final demand will depend on the realization of the exchange rate. In this case the final destination market price (in US$) is uncertain and the consumer's risk aversion matters as well.

When uncertainty is introduced in an oligopoly model the choice of the strategic variable has two main implications: (a) it affects expected profits, and (b) the choice of the strategic variable together with the invoicing currency of the contract determine the source of risk of the firm. *Klemperer and Mayer* (1986) have shown that if an additive demand shock is introduced in an oligopoly model, the firm will be better off if it chooses quantities rather than prices as the strategic variable when there are decreasing marginal costs and

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[2] The distinction in the invoicing currency is based on Mann (1989).

should choose prices when there are increasing returns to scale. If there are constant marginal costs, both strategic variables yield the same expected profits. Furthermore, the choice of the strategic variable affects the source of risk for the firm. If competition is of the Cournot type, the firm faces random unit revenues, as will happen if Bertrand competition is assumed and the firm quotes its prices in the destination market's currency. Table I gives a summary of the interactions between these three elements.

Table I: the choice of the strategic variable,

the invoicing currency and the source of risk

(P and P* are the domestic and the foreign currency prices, respectively)

Strategic Variable	Invoicing Currency	Uncertainty
	Foreign	Price (unit revenues)
Prices		
	Domestic	Quantity (P*)
Quantities		Price (unit revenues)

To model exchange rate uncertainty I introduce a stochastic multiplicative shock into the export (foreign) demand for the oligopolist in the lognormal form:

$$E = \mu e^{\sigma \varepsilon} \qquad (1)$$

$$\text{with} \qquad \varepsilon - (0,1)$$

The stochastic shock in (1) models the exchange rate fluctuations (E) where μ is the mean of the shock, σ^2 is the (constant) variance and ε is a white noise. The random shock has two different components: a mean (μ) that we can interpret as the expected value of the (equilibrium) exchange rate, and (σ^2) reflecting the volatility. By using a Taylor series expansion[3] it is possible to obtain the approximation

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[3] Expanding the random distribution around the mean value $\mu=0$, applying the substitution theorem and checking that the series converges to zero after the third term in the expansion, we obtain the approximation.

$$E = \mu\, e^{\sigma\varepsilon} \approx \mu\,(1 + \sigma\varepsilon)$$

that can be used directly in the demand function[4].

There are two types of firms: (1) n_1 exporters, that is, firms belonging to country h that export to market f (denoted by the subscript i), and (2) n_2 domestic producers (denoted by j), that is, firms that belong to country f and produce only for home consumption. In the case of price or unit revenues risk faced by the exporter and when the perceived (inverse) demand curve in the destination market is assumed to be linear, we have

$$P_{hf}^i = \alpha - \beta\left(\sum_{i=1}^{n_1} x_{hf}^i + \omega \sum_{j=1}^{n_2} x_{ff}^j \right) \qquad i = 1,\dots n_1 \qquad (3.a)$$

$$P_{ff}^j = \alpha - \beta\left(\sum_{j=1}^{n_2} x_{ff}^j + \omega \sum_{i=1}^{n_1} x_{hf}^i \right) \qquad j = 1,\dots n_2 \qquad (3.b)$$

where α is the demand intercept, β is the slope of the (inverse) demand curve and ω is the degree of product differentiation among the goods between the h-country and the f-country varieties ($0 < \omega < 1$). If $\omega = 0$, h-country and f-country varieties are independent in demand. When $\omega = 1$, they are perfect substitutes. An implication of the demand system (3.a) and (3.b) is that h-country varieties are perfect substitutes one for another and the same happens with f-country varieties.

2.3. An international oligopoly model with risk averse firms

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[4] The approximation is valid only for a certain range of the parameters of the distribution, i.e. $(1-\delta\sigma) > 0$, for any σ which is equivalent to be working with small values of the variance of the random distribution. This approximation helps us in linearizing the multiplicative random demand shock and simplifies greatly the algebra afterwards.

We assume that each firm is risk averse, which we model with the use of an objective function that has two parts: the expectation of profits minus a loss function times the degree of risk aversion of the exporter[5],

$$\max_{x_{hh}, x_{hf}} \quad \Gamma = E(\Pi^i) - \delta\sqrt{Var(\Pi^i)} \tag{4}$$

where x_{hh} and x_{hf} is production for the home and the export (foreign) market respectively, and δ is the Arrow-Pratt measure of (absolute) risk aversion, $\delta = u(\Pi)''/u'(\Pi)$. $E(.)$ and $Var(.)$ are the expectations and the variance operators. Our cost function is of the form: $C_i(x_{hf}+x_{ff}) = c\, x_{hf}+ c\, x_{ff}$. By assuming constant returns to scale and Cournot competition we are in fact segmenting the home and the export markets: each firm takes two decisions regarding each market; that is, the firm sees each country as a different market and there is no arbitrage among markets. This *separation property* has important implications[6]. The firm also is able to choose the strategic variable it wants to set in each market[7].

We do not allow the firm to hedge for the exchange rate changes in a forward market. The risk, in terms of profit variability, that faces an oligopolist due to exchange rate variations is higher than when perfect competition. More so if we assume that the exporter is somehow risk averse. For the sake of simplicity, we rule out the possibility of futures hedging[8].

Profits are measured in units of the h-country currency since we are modeling the case when the exporter has uncertain domestic price[9]. Substituting these expressions into the objective function (4), and maximizing we obtain the first order conditions for each firm and from here their reaction functions, one for each market. We can solve the system of reaction functions and finally obtain the Nash-Cournot equilibrium.

[5]this objective function with risk aversion is also used in Mann (1989)

[6] This property depends on the particular form of the pay-off function, even though in our context this is implied by the constant marginal costs together with the Cournot behavioral assumptions.

[7] The first subscript (i = f,h) denoting the country of origin (and production) and second subscript (j = h,f) indexes the destination country.

[8]on this possibility and the important implications that it has in oligopoly, see Von Weiszacker and Von Ungern (1991) and Donnenfeld and Zilcha (1991).

[9]we are modeling Cournot competition when quoting contracts in the home currency and the firm perceives the price as uncertain.

From the first order conditions we obtain two types of reaction functions, one for each representative exporter (i = 1,2.....n_1) and one for each domestic producers (j = 1,2.....n_2) all competing in market f:

$$\begin{pmatrix} n_1 + 1 & \omega\, n_2 \\ \\ \omega\, n_1 & n_2 + 1 \end{pmatrix} \begin{pmatrix} x^i_{hf} \\ \\ x^j_{ff} \end{pmatrix} = \begin{pmatrix} \alpha - z \\ \\ \alpha - c* \end{pmatrix} \qquad (6)$$

where $\qquad z(c,\mu,\sigma) = \dfrac{c}{\mu(1 - \delta\sigma)}$

When $n_1 = 1$ and $n_2 = 1$, we have the special case of duopoly, one exporter and one domestic producer. We draw this case when products are perfect substitutes ($\omega=1$) in Figure 1.

Initially the Nash-Cournot equilibrium is depicted in Figure 1 in N where the reaction functions R(h) and R(f) cross. After an appreciation of the destination market's currency, the reaction function of the exporter, R(h), shifts north-east in proportion to [(c/(2β)], to R*(h) and the reaction function of the domestic producers stays where it was, at R(f). The new Nash-Cournot equilibrium lies at N(μ), where the exporter produces a higher output, (x**(h) > x*(h)) and the domestic producer reduces the optimal production plan (x**(f) < x*(f)). Even though the domestic firm does not directly face exchange rate uncertainty, its equilibrium quantity traded does change after an appreciation of its currency.

Figure 1: An Appreciation of the Foreign Market Currency
and the Nash-Cournot Equilibrium
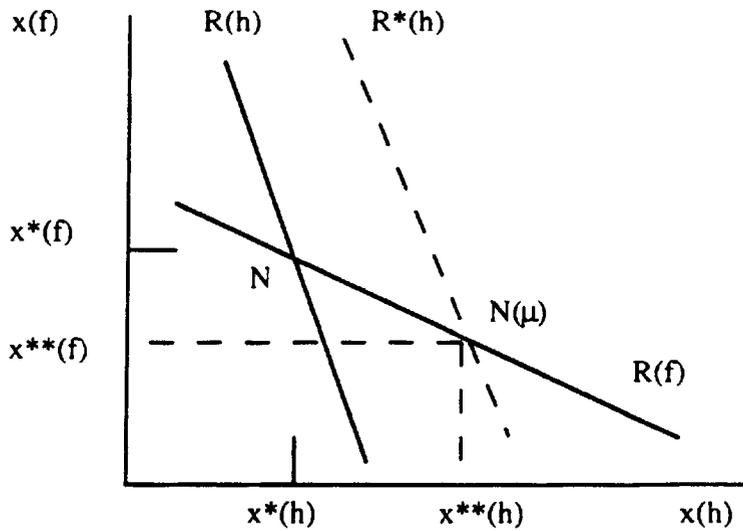
Solving simultaneously the $n_1 + n_2$ reaction functions given by (6) for two representative agents, i an j, we obtain the Nash equilibrium, which is defined as the combination of home production and export quantity for the h-firms, and domestic production for the f-firms, $x^*_{hh}{}^i$ and $x^*_{hf}{}^i$ and $x^*_{ff}{}^j$, such that they are the best response given the optimal choice of the rivals. For the representative exporter, $x_{hf}{}^i$, we obtain the Nash-Cournot equilibrium quantity

$$x_{hf}^i = \frac{\alpha\left[1 + n_2(1-\omega)\right] + c^* \omega\, n_2 - (n_2 + 1)\, z}{\beta\left[N + 1 + n_1 n_2 (1 - \omega^2)\right]} \qquad (7)$$

where $N = n_1 + n_2$ and c^* and $z = (c/\mu(1-\delta\sigma))$ are the marginal costs schedules for the two types of firms: constant schedule for the home producer and a function of the first two moments of the random distribution for the exporter.

If we allow for different values of the risk aversion coefficient of each firm, or for the value of the first two moments of the distribution of exchange rate changes to differ among countries, equilibrium prices will differ among the two markets. This is not price discrimination policy by the firm, but the result of ruling out arbitrage among the different markets where the firm operates and the fact that each firm is facing different elasticities of demand in each market. This result, called *pricing to the market* by *Krugman* (1987), *Knetter* (1989, 1991) and *Mann* (1989) is a direct implication of the segmented markets hypothesis in an oligopolistic model. We can see this result already in the first order

condition of the representative exporter when it faces the shipping decision: how much quantity to send to each market (its home one, h, or the destination market, f). The equilibrium prices, in terms of deviations from marginal costs, for both firms are:

$$P_{hf}^i - z = \frac{(1+n_2)(\alpha - z) - \omega\, n_2(\alpha - c^*)}{A} \qquad (8.a)$$

$$\text{and} \qquad P_{ff}^j - c^* = \frac{(1+n_1)(\alpha - c^*) - \omega\, n_1(\alpha - z)}{A} \qquad (8.b)$$

where $A = N + 1 + n_1 n_2(1 - \omega^2)$.

From equations (7) and (8.a) and (8.b) we can see that the first two moments of the exchange rate distribution (μ,σ) affect the equilibrium as expected: the variance (σ^2) and the absolute risk aversion coefficient (δ) negatively affect the quantity sold by each firm facing the shock. The uncertainty as represented by the first two moments, *has an asymmetric effect in the optimal strategy of each type of firm*, affecting in opposite directions the equilibrium quantities traded: the exporter increases the quantity traded after a unit increase in μ, and the domestic producer reduces the quantity of equilibrium but in smaller amount than the initial increase in the exporter's quantity.

To reach an expression for the pass-through relationship (in prices) we notice that the moments of the random distribution affect the equilibrium quantity and price via the random marginal costs schedule of the exporter, $z(c,\mu,\sigma)$. First we obtain the Nash equilibrium price of the industry and compute

$$\left(\frac{\partial P_{hf}}{\partial \mu}\right) = \left(\frac{\partial P_{hf}}{\partial z}\right)\left(\frac{\partial z}{\partial \mu}\right) \qquad (9)$$

In our case we have linear demands and cost schedules, and we find that $(\partial P_{hf}/\partial z) > 0$ and $(\partial z/\partial \mu) < 0$, so that the pass-through relationship is negative. In terms of the parameters of the model, we evaluate expression (9)

$$\frac{\partial P_{hf}}{\partial \mu} = \frac{-z}{\mu}\left(\frac{B}{n_2 + 1 + B}\right) < 0$$

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where $B = n_1 + n_1 n_2 (1 - \omega^2)$. The pass-through has a negative sign because it reflects the effect on the domestic price of a unit increase in the mean of the exchange rate (i.e. an appreciation of the destination market's currency), and hence it models a positive shock for the exporter. Note that if goods are perfect substitutes, the denominator is just the total number of firms in the market (exporters and domestic producers) plus 1, and the higher the number of firms in the market, the lower the pass-through relationship for each individual exporter.

There are two different effects when an appreciation (or devaluation) occurs: (1) a *substitution effect*: the market becomes more (less) attractive due to the reduction in the marginal costs schedule. The exchange rate change (i.e., in μ), shifts the marginal cost schedule of the exporter, $z = z(\mu, c, \sigma)$ and defines a new equilibrium quantity to export. We can directly see this effect in the Nash-Cournot equilibrium, by differentiating the equilibrium quantity for the firm with respect to μ and checking the resulting expressions are positive; and the (2) "income effect"[10] or rather *a decreasing risk aversion effect*: the increment(decline) in demand in home currency units makes the firm increase (decrease) its quantity sold to the foreign market and it will be willing to take up more risk. This amounts to a movement north-east along the concave utility function of the firm. The further from the origin, along the utility function, the smaller the relative risk aversion coefficient for the firm.

3. The Pass-through Relationship and Market Structure

The pass-through relationship in prices, i.e. the way the import domestic price changes with changes in the exchange rate, can be derived from the Nash equilibrium. We can decompose the pass-through in two parts: the *pass-through for the expected value of the exchange rate* (μ):

$$\cdot \frac{\partial P_{hf}}{\partial \mu} = \frac{-z}{\mu} r_1 \qquad (10)$$

and the *pass-through for the volatility* part of the exchange rate (σ)

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[10] As Katz, Paroush and Kahana called it.

$$\frac{\partial P_{hf}}{\partial \sigma} = \frac{z\,\delta}{(1-\delta\sigma)^2}\,r_1 \qquad\qquad (11)$$

where $r_i = (n_i/(n_1 + n_2 + 1))$ is the relative number of firms of type i in the industry. Both expressions are obtained for the case of perfect substitutability among the varieties in trade ($\omega = 1$). The pass-through of the volatility has the opposite sign as the one for the trend of the exchange rate because exporters we assumed are risk averse. The pass-through for the volatility depends on the degree of risk aversion of the firms (δ): this expression reflects the way that an oligopolies will pass into the final equilibrium price the increased volatility in exchange rates.

Proposition 1: *an increase in the expected value of the exchange rate (i.e. in μ) causes a decrease in the (Nash-Cournot) equilibrium price of the industry. The reduction in the equilibrium price (i.e. the pass-through relationship) is an increasing function of the level of marginal costs and a decreasing function of the total number of firms in the industry (N). Since we distinguish between exporters (n_1) and domestic producers(n_2), we can conclude also that the higher the number of exporters, the higher the pass-through will be[11].*

To show the first part of this proposition, we just check the two effects working in the determination of the pass-through relationship: (1) the effect of a higher expected exchange rate in the marginal cost schedule, $(\partial z/\partial \mu)$, and (2) the effect of a change in the marginal cost schedule on the equilibrium price, $(\partial P_{hf}/\partial z)$. The total effect is $(\partial P/\partial \mu) = (\partial P/\partial z)(\partial z/\partial \mu)$. We have that, in our case with linear schedules, $(\partial P/\partial z) > 0$, which together with $(\partial z/\partial \mu) < 0$ implies that $(\partial P/\partial \mu) < 0$.

The reduction in the equilibrium price will be bigger the higher the number of exporters in the industry relative to home producers. We want to compute,$(\partial/\partial n_1)*(\partial P/\partial \mu)$,which we decompose into, $(\partial/\partial n_1)*(\partial P/\partial z)*(\partial z/\partial \mu)$. We obtain that, $(\partial/\partial n_1)*(\partial P/\partial z)<0$, and $(\partial z/\partial \mu)<0$, so that the total second derivative is defined only for positive values (> 0).

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[11]this proposition is just the linear case extension of Dornbusch (1987), Fisher (1989) and Mann (1989).

The relative number of each type of firm (whether exporters or home producers) determines the degree of the pass-through relationship[12]. We have two different effects working in the opposite direction depending on whether we increase the number of exporters (n_1) or the number of domestic producers (n_2) in the destination market.

If we include only one exporter ($n_1 = 1$, $n_2 = 0$, and $r_1 = 1/2$), we obtain the monopoly pass-through, which takes the value ($c/2$). As we increase the number of exporters (n_1) (keeping constant the number of home producers), the pass-through increases with n_1 and the upper limit of the pass-through is the level of marginal costs (c). Whereas increasing the number of home producers (n_2) drives the pass-through to zero. Clearly then, as we increase the number of rivals that don't face directly the exchange rate uncertainty relative to the number of exporters, the impact of exchange rate changes will be smaller in the industry equilibrium.

In Figures 2 and 3, the pass-through relationship ($\partial P/\partial \mu$) is shown when both the number of exporters and the number of domestic producers increases. In the vertical axis we draw the pass-through values, and these two figures are drawn for the following parameter values: $c = 4$, $\beta = 0.5$. Two different schedules are obtained: the first one, AE, is the adjustment of the industry price when the number of exporters is let to increase (from 1 to 30), keeping the number of domestic rivals fixed(at 1). In Figure 3 the schedule AD describes the pass-through relationship when the number of domestic producers is allowed to vary. We can imagine the two polar cases easily: if only exporters are selling a product in a destination market, exchange rate pass-through in perfect compeition will be complete. If only domestic producers exist, no pass-through is obtained. When the number of domestic producers is higher than the number of exporters, pass-through will be incomplete. Hence, the size of the pass-through elasticity does not tell us the degree of competition of an industry by itself, we need to know also the market structure of that industry to asses how competitive the estimated pass-through is.

Figure 2: The Pass-through when the Number of Exporters Increases, when $c = 4$, $\mu = 1$, $\sigma = 0$ and $n_2 = 0$, where $N = n_1 + n_2$.

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[12]the incomplete pass-through that we obtain here, is also explained in Bertola (1987) and Dornbusch (1987).

12
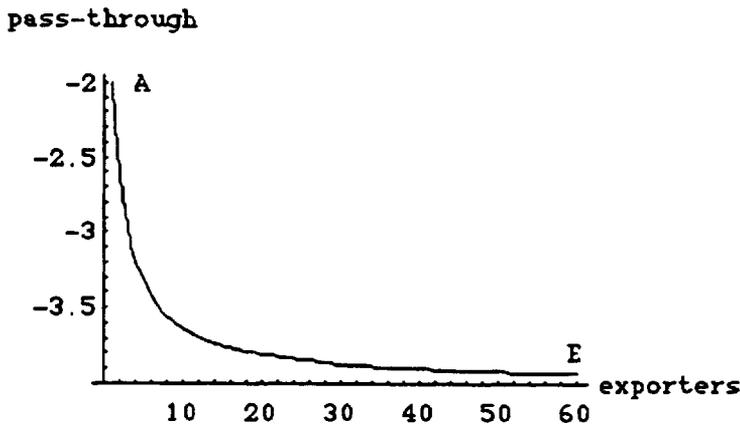
pass-through

In the schedule AE, *as the number of exporters (n₁) increases, the reduction in the industry price* due to the positive shock of the exchange rate *increases as well*, until it reaches the level of marginal costs (set at 4). The pass-through is shown to be negative in this case, because a unit increase in μ is a positive shock (i.e. an appreciation of the foreign market's currency) for the exporter and this drives the price closer to marginal cost level.

The schedule AD, in Figure 3, shows how the pass-through decreases with increasing number of domestic producers (n2), until it approaches zero(keeping n₁ = 1).

Figure 3: The Pass-through when the Number of Domestic Producers Increases (n2), when n₁ = 1, c = 4, μ = 1, σ = 0.

pass-through

13
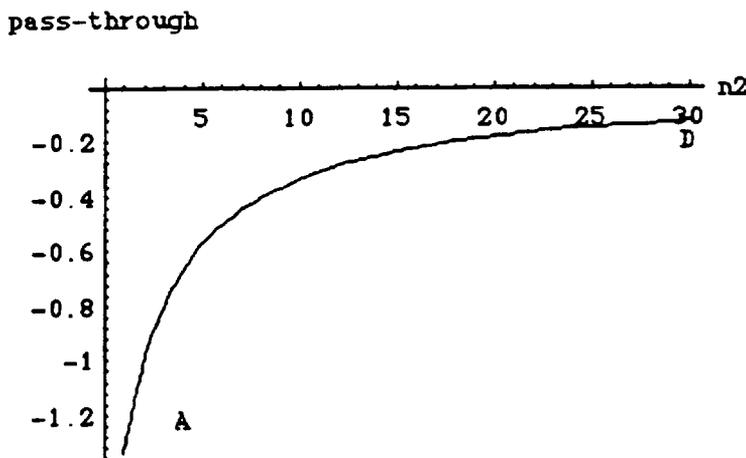
Hence with Cournot competition the pass-through relationship will be determined by the absolute number of each type of firms in the industry as well as by the relation exporters/home producers in the industry: home producers tend to reduce the influence of exogenous exchange rate changes into the domestic price level, and foreign producers tend to increase the pass-through in the equilibrium price.

From the equilibrium quantity traded for each firm, by taking the partial derivative with respect the expected value of the exchange rate(μ), we obtain the pass-through in quantities, at the Nash-Cournot equilibrium, of a unit change in the equilibrium exchange rate. Calling $r_2=(n_2)/(N+1)$, i.e. the relative number of home producers, and assuming for now that $\omega=1$, we have

$$\frac{\partial x^i_{hf}}{\partial \mu} = \left(\frac{\partial x^i_{hf}}{\partial z}\right)\left(\frac{\partial z}{\partial \mu}\right) = \frac{z}{\beta \mu}\left(r_2 + \frac{1}{N+1}\right) \qquad (12)$$

which is the optimal pass-through in quantities for the exporting firm after a unit change in the expected exchange rate value, evaluated at the Nash equilibrium. Three variables are relevant in explaining the pass-through in quantities: (1) *market structure*: (the second term in (12)), i.e. the relative number of domestic firms in the industry and the inverse of the total size of the market; the higher the number of domestic rivals, the smaller the perceived elasticity of demand for each firm in the industry: the pass-through, then, will be smaller; (2) *the level of marginal costs* (c), which determines the upper limit of the pass-through when the number of exporters goes to infinity, and (3) the *elasticity of demand and the degree of substitutability of the varieties* in trade (ω)[13].

Proposition 2: *an increase in the expected (equilibrium) exchange rate (in , μ), will cause the exporter to increase the optimal quantity sold in the destination market in proportion to the ratio (c/β). The optimal adjustment depends directly on the relative number of domestic rivals (r_2) in the industry.*

We have that at the Nash equilibrium, $x_{hf}(n_1,n_2,z(.))$, so that a change in the expected exchange rate affects the optimal quantity traded via the marginal costs term $z(.)$.

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[13]Market structure and level of marginal costs, and the way they are influenced by exchange rate changes, had been stressed as determinants of the pass-through relationship by Mann (1986), Fisher (1989), Hooper and Kohlhaagen (1984) and Hens, Kirman and Phlips (1991).

We need to find the sign of $(\partial x_{hf}/\partial\mu)$, and we can divide this expression into two terms, $(\partial x_{hf}/\partial z)$ and $(\partial z/\partial\mu)$. It is easy to find that, $(\partial z/\partial\mu)<0$, and that $(\partial x_{hf}/\partial z)<0$, so that $(\partial x_{hf}/\partial\mu)>0$. Applying the chain rule we can compute the sign of, $(\partial/\partial n_2)*(\partial x_{hf}/\partial\mu)$, and obtain that the second derivative is positive which tells us that the higher the relative number of domestic rivals in the industry (r_2), the higher also the individual pass-through in quantities for each exporter will be.

Developing the analysis in the opposite market (the home one), it is easy to see that the prices (expressed in a common currency) of the same variety in both markets will differ[14].

Proposition 3: *a unit increase in the volatility of the exchange rate (in, σ), leads to an increase in the equilibrium price and a decrease in total quantity traded in the industry (see Appendix for the proof).*

In Table III, expressions for the two measures of the pass-through relationship are given in terms of the first two moments of the distribution of the exchange rate changes and of the market structure variables.

Table III: The Pass-through (Pt) for (μ,σ^2) in the Nash Equilibrium of the Industry with Different Market Structures, when $\omega=1$ and $i=h,f$.

Pt for the expected value	for the volatility

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[14] Different optimal quantities sold in each market can lead also to different equilibrium prices, even though other market structure variables might be identical in both locations. This would be understood as "pricing to the market" and not as price discrimination. For empirical tests on this, see Knetter (1991).

$$\left.\frac{\partial P}{\partial \mu}\right|_{\substack{\mu=1 \\ \sigma^2=0}} = -c \, r_1 \qquad\qquad \left.\frac{\partial P}{\partial \sigma^2}\right|_{\substack{\sigma^2=1 \\ \mu=1}} = \frac{c \, \delta}{(\delta-1)^2} r_1$$

$$\left.\frac{\partial x_{hf}}{\partial \mu}\right|_{\substack{\mu=1 \\ \sigma^2=0}} = \frac{c}{\beta}\left(r_2 + \frac{1}{N+1}\right) \qquad\qquad \left.\frac{\partial x_{hf}}{\partial \sigma^2}\right|_{\substack{\sigma^2=1 \\ \mu=1}} = \frac{-c \, \delta}{\beta \, (\delta-1)^2}\left(r_2 + \frac{1}{N+1}\right)$$

$$\left.\frac{\partial x_{ff}}{\partial \mu}\right|_{\substack{\mu=1 \\ \sigma^2=0}} = \frac{-c}{\beta} r_1 \qquad\qquad \left.\frac{\partial x_{ff}}{\partial \sigma^2}\right|_{\substack{\sigma^2=1 \\ \mu=1}} = \frac{c \, \delta}{\beta \, (\delta-1)^2} r_1$$

As can be seen for any of the expressions in Table III the higher the slope of the (perceived) demand function, β, the higher the market power for the individual exporter and the higher the individual pass-through will be. The same argument applies for the relative number of exporters, r_1, in the industry. The degree of risk aversion, has no clearcut effects on the pass-through relationship[15].

Since we are in a quantity setting model, the individual adjustment takes place via quantities. From expression (12) we saw that the adjustment in quantities for each firm is a decreasing function of the number of exporters and an inverse function of the number of domestic rivals. The picture we obtain, Figure 4, graphs the opposite adjustment to that obtained when studying the pass-through in prices (Figures 3 and 4). Graphing on the horizontal axis the number of exporters and of home producers (n_1, n_2), the schedule BE describes the pass-through in quantities when the number of domestic rivals is fixed at 1, and the number of exporters is let to increase, that is, it is the limit as

$$\lim_{n_1 \to \infty}\left(\frac{\partial x_{hf}}{\partial \mu}\right) = 0$$

The individual pass-through is a decreasing function on the number of exporters. The schedule BD, on the other hand, describes the individual adjustment in quantities by

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[15]though it can be shown that for a relatively wide range of parameter values, the risk aversion coefficient has a negative impact in the quantity traded and a positive impact on the equilibrium price.

the representative exporter when the number of domestic rivals increases (and the number of exporters is fixed, $n_1 = 1$):

$$\lim_{n_2 \to \infty} \left(\frac{\partial x_{hf}}{\partial \mu} \right) = \frac{c}{\beta}$$

The pass-through is an increasing function of the number of domestic producers due to the no entry/exit in the industry hypothesis.

Figure 4: The Pass-through in Quantities when the Number of Exporters and the Number of Domestic Rivals Increase (for $c = 4$, $\omega = 1$ and $\beta = 0.5$)
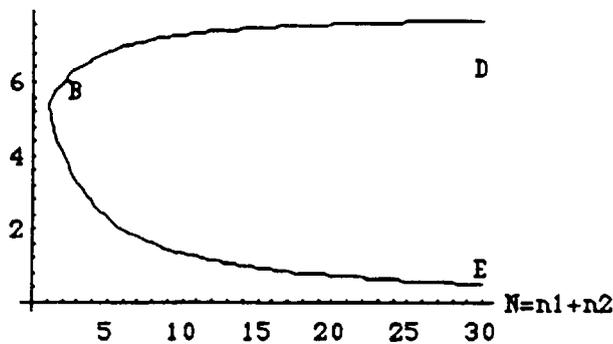
So far we have seen how market structure variables and the risk aversion on the part of the exporters influence the adjustment of prices an quantities to exogenous shocks. The other determinant of this adjustment comes next: it is the expected type of competition to be played by the rivals.

4. The Pass-through Relationship Under Different Types of Competition

In order to study the sensitivity of the pass-through relationship with respect to different types of competition played by the firms we introduce next conjectural variations parameters. We develop in the section the approach for the case of homogeneous goods with an indeterminate number of two different types of competitors in the industry: the home producers and the exporters. We find that under Cournot competition, the higher the number of firms in the industry, the closer the pass-through will tend to the competitive outcome, i.e. the Law of One Price. Bertrand conjectures imply a constant and more competitive price adjustment than Cournot conjectures for any market structure and the collusive case shows important implications for price adjustment when exchange rate uncertainty.

The idea with the conjectural variations approach is to capture the indirect effect of a change in one firm's strategic variable on the rival's strategic variable level with a parameter that enters the first order condition of the representative exporter. Call the conjectural parameter $\lambda_i = (\partial x_{ff}^j/\partial x_{hf}^i)$.; it reflects the way the rival (firm j in market f) reacts to a change of the firm's (firm i in market f) strategic variable, x_{hf}^i. With the conjectural variations approach we can model different aggressiveness in the expected response of the other firms in the industry (i.e. collusion among one type of firm) not easily modeled otherwise. The representative exporter faces a foreign inverse demand curve: $P_{hf}(x_{hf}, x_{ff})$ $= P^*_{hf}(x_{hf}, x_{ff})E$, where E is the bilateral exchange rate. The firm maximizes profits in each market, the home and the foreign one, and because of constant returns to scale technology, it can separate the optimization problem in each market. In the foreign market (subscript f) its profit function can be expressed as: $\Pi_{hf}^i(x_{hf}, x_{ff}) = P_{hf}(x_{hf}, x_{ff}) x_{hf}^i E - C_i(x_{hf})$. If we introduce, as before, the possibility of risk averse firms, we can use the objective function in (4). Substituting the profit expression into (4) we arrive at the first order conditions for the exporter as

$$\left[n_1 + 1 + (n_1 - 1)\lambda + \omega\, n_2\, k\right] x_{hf} + \omega\, n_2\, x_{ff} = \frac{\alpha - z(\mu, \sigma)}{\beta} \qquad (13.a)$$

$$\omega\, n_1\, x_{hf} + \left[n_2 + 1 + (n_2 - 1)\lambda + \omega\, n_2\, k\right] x_{ff} = \frac{\alpha - c^*}{\beta} \qquad (13.b)$$

where $\lambda = (\partial x_{hf}^k/\partial x_{hf}^i)$ and $k = (\partial x_{ff}^j/\partial x_{hf}^i)$ are the conjectural variation parameters that reflect the belief of firm i of country h with respect the expected response of its rivals (those

of the exporters and the domestic firms, respectively) in the foreign market (indexed by f). We let this parameter to vary across firms.

From the first order conditions we obtain the reaction curves for each firm in each market. Solving them yields the Nash equilibrium from which we can derive expressions for the pass-through relationship under different conjectures. We consider the following type of beliefs on the part of the firms:

a. when $\lambda=0$ that reflects the *Cournot conjecture*: each firm assumes that its rivals will not react to any change in its own strategic variable so that the indirect effect term is equal to zero. We can see in expression (15) that the Cournot behavioral assumption implies that the additional term in λ is equal to zero, and the first order conditions now become the same as in the case we studied before in Section 2.

b. when $\lambda=1$, the *collusive conjecture*: which reflects the belief of the part of the firm that market share matters, since each change in its own strategic variable is believed to be matched by the rivals. The indirect (or strategic) effect here is at its maximum. With this conjecture the firm believes that it can affect total industry output but not its on market share.

and c. when $\lambda=-1$, that represents *Bertrand conjectures*, in that it resembles the price competition case. Each change in the strategic variable will be matched by the rival. This conjecture makes sense if we think of the firms as competing in prices. When linear demands and constant marginal costs, Bertrand conjectures are also consistent conjectures, in that this conjecture is equivalent to the optimal response of the rivals at the equilibrium defined by the conjecture itself[16].

Table IV: The Pass-through in Prices and Quantities with Different Conjectures
($\omega = 1$)

Pass-through:	Cournot	Bertrand	Collusion

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[16] Whereas Cournot and the collusive conjectures are not consistent conjectural equilibria, but we study them in order to gain insight into the different aggressiveness in the behavior that they imply.

$$\left.\frac{\partial P}{\partial \mu}\right|_{\substack{\mu=1 \\ \sigma^2=0}} = -c\, r_1 \qquad\qquad \frac{-c}{2}\, n_1 \qquad\qquad \frac{-c}{2}\left(\frac{n_1}{N}\right)$$

$$\left.\frac{\partial x_{hf}}{\partial \mu}\right|_{\substack{\mu=1 \\ \sigma^2=0}} = \frac{c}{\beta}\left(r_2 + \frac{1}{N+1}\right) \qquad \frac{c}{2\,\beta}\left(\frac{n_1-2}{N-2}\right) \qquad \frac{c}{2\,\beta\,N}\left(1+\frac{n_2}{N}\right)$$

From table IV we see that when Cournot competition the responsiveness of the import price to an exchange rate change is inversely proportional to the number of firms in the industry (evaluated at the expected value of the exchange rate), wherelse it is directly proportional to the number of exporters in the industry when Betrand conjectures are introduced. When firms concern for keeping their market share in the destination market, the pass-through (in prices) is incomplete and the proportion of exporters to total number of rivals becomes a crucial determinant for the pass-through elasticity.

So far we have introduced an indeterminate (but fixed) number of rivals in both markets (the domestic and the foreign one). When free entry is allowed only the competitive behavior (i.e. conjecture) will be a consistent conjectural equilibrium[17]. We focus here only on the three conjectures mentioned above when the number of exporters and of domestic rivals is fixed (but can be very large).

4.1 The Pass-through Relationship

In Figure 5 the different pass-through elasticities are graphed. The picture is drawn for the special case when goods are perfect substitutes, no domestic producers ($n_2 = 0$) and constant marginal costs schedules (for the graph fixed at the level c = 4). As the number of exporters increases, all three different adjustments in the equilibrium price tend towards the full pass-through, i.e. the equilibrium price in the industry will reflect the whole change in marginal costs due to the exchange rate movement, as under perfect competition.

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[17]on consistent conjectures, see Bresnahan (1981)

Figure 5: the pass-through after a unit increase in the equilibrium exchange rate
$(c = 4, n_2 = 0 \text{ and } \omega = 1)$

pass-through
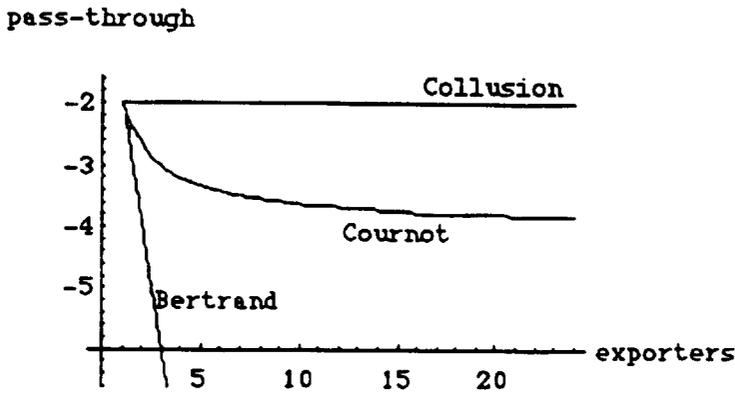
The picture changes as soon as we introduce a variable number of domestic rivals. Since domestic forms do not face directly the exchange rate changes, an increase in the number of domestic producers implies that in the limit the price adjustment to an exchange rate shock will be negligible, which is what happens with all of the different types of behavior modeled as the number of domestic firms increases. From both Figures (5 and 6) we can see that the exchange rate adjustment depends on the relative number of the different types of firms in the industry. For all of the three conjectures introduced, exporters, on the one hand, tend to make the adjustment in prices closer to what the Law of One Price predicts (full pass-through), and domestic producers, on the other hand, tend to reduce the impact of exchange rate changes in the industry price.

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Figure 6: The Pass-through when the Number of Domestic Rivals Increases
$(n_1=1)$
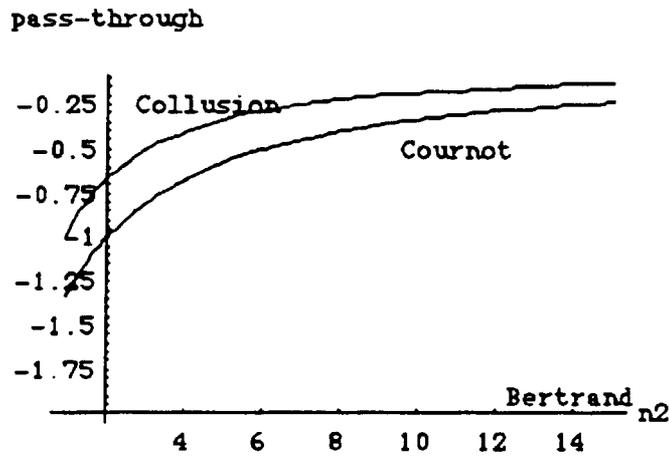
pass-through

4.2. The Adjustment in Quantities

The other side of the adjustment process is the quantity pass-through. In Figure 7 is depicted the quantity adjustment with different aggressiveness in the expected response of the rivals. The constant pass-through corresponds to the Bertrand case, in which case it does not matter the number of exporters in the industry: the adjustment in quantities is constant and equal to the level of marginal costs $(c = 4)$. This is the reflection of the more competitive behavior modeled with Bertrand beliefs: there is no strategic effect and each exporter behaves as under perfect competition. This can be interpreted as the Bertrand paradox in our context.

When no domestic rivals are incorporated we find that the collusive pass-through *declines faster* that the Cournot equilibrium price adjustment when the number of exporters increase. The reason for this is clear if we take into account the specific linear demands that we use: under collusion, and in order to keep the change in the equilibrium price constant (at $-c/2$), i.e. the same pass-through as under monopoly, the market share of each individual exporter must decline at a faster rate than under Cournot, and the individual mark-up (our measure of pass-through in quantities) decreases with an increasing number of exporters due to the fact that the demand elasticity increases with the export volume.

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Figure 7: The Adjustment in Quantities when Bertrand, Cournot and Collusive
Conjectures are held among the Exporters
(for the case when c = 4, ω = 1, β = 0.5 and n_2 = 0)
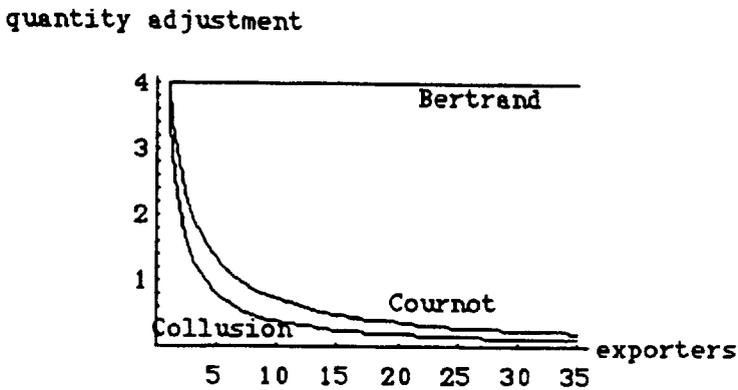
If we increase the number of domestic rivals (n_2 > 0) we find that now the relative number of each type of firm in the industry becomes the crucial determinant of the sign and degree of the pass-through elasticity when Bertrand and collusive beliefs are introduced, as shown in Figure 8.

Under Cournot conjectures as the number of domestic producers (n_2) increases, the pass-through in quantities converges to zero, as happened also for the case when only exporters served the whole destination market. The interesting case is when Bertrand conjectures are introduced, since then the adjustment takes place in the negative quadrant (in Figure 8). If a unit increase in μ comes as a positive shock to the exporter, this can only be explained by the fact that under Bertrand conjectures the relative number of domestic producers determines the sign of the adjustment in quantities.

In terms of expected competitive responses, Bertrand supposes a more aggressive behavior than Cournot and in turn this models a still more aggressive behavior than under the collusive conjecture[18].

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[18]as in any standard oligopoly model would obtain.

Figure 8: quantity pass-through for different conjectures
($\omega = 1$, $\beta = 0.5$, $c = 4$ and $n_1 = 1$)
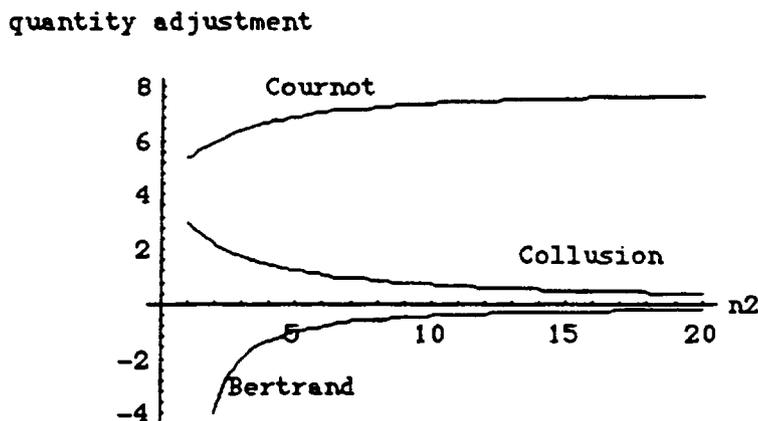
5. Exchange Rate Risk and Economic Exposure: the Role of Strategic Behavior

When the exchange rate appreciates (increase in μ), there are two effects influencing the behavior of the foreign firm: (1) as the per unit price in foreign currency increases, the revenues increase as well for the exporter: the *direct effect*, and (2) after an appreciation, the exporter will change the quantity supplied to the destination market, and given that the goods are strategic substitutes, the home producer will reduce its market share. This *indirect effect* is the channel through which the home producer(s), even though it is not facing the exchange rate fluctuations directly, is affected also by them. To account for the two effects is crucial the assumption of strategic substitutes in determining the final equilibrium outcome of the industry. It is also easy to see that the higher the number of firms in the industry, the smaller this indirect effect will be. We can see these two effects in the following way: lets express the profit function of the exporter as, $\Pi_{hf}(x_{hf}) = \Pi(x_{hf}(e), x_{ff}(x_{hf}))$, that is, the optimal quantity shipped to the export market depends on the exchange rate (e). We can now express the first order condition as

$$\left(\frac{\partial \Pi_{hf}^{i}}{\partial e}\right) = \left(\frac{\partial \Pi_{hf}^{i}}{\partial e}\right) + \left(\sum_{j=1}^{n_2} \frac{\partial \Pi_{hf}^{i}}{\partial x_{ff}^{j}}\right)(k)\left(\frac{\partial x_{hf}^{i}}{\partial e}\right)$$

$$\qquad\quad A \qquad\qquad\quad B \qquad C \qquad D$$

where A > 0 is the direct effect, and BCD the indirect effect. Since the goods are strategic substitutes, we have that B < 0, since ex-post, C (k = $(\partial x_{ff}/\partial x_{hf})$) < 0, and we know that D > 0 (an increase in e means an appreciation of the home currency), then we have that the indirect effect will be overall positive, which strengthens the direct positive effect in A.

In would be different if the goods were strategic complements: in which case the term in B will be bigger than zero, also C > 0, but $(\partial x_{hf}/\partial e)$ < 0 and the overall effect will be negative. In fact, as *Mishra and Sundaram* (1989)[19] point out, for conjectures other than Cournot, the first order condition will be based on the total derivative of profits with respect to the quantity, rather than the partial derivative, which is enough in the Cournot case if we consider that the Cournot behavioral assumption implies that $[\partial x_{ff}/\partial x_{hf}]$ = C = 0 and hence the perceived marginal profit for firm i from reacting to the exchange rate change will consist of the direct effect alone, leaving BCD = 0.

The distinction between exchange rate risk and economic exposure now becomes clear: exchange rate risk implies a random unit revenue, due to the volatility in the export foreign price, and economic exposure is the effect that the variations in the unit price have on the equilibrium profits of the firm. In oligopoly, and because of the strategic interdependence among the firms, the exposure is higher than under perfect competition. The direct effect accounts for the exchange rate risk, in the profits level, that has a direct relationship with the price fluctuation. As long as the indirect effect, BCD >0, the economic exposure will be higher than the direct effect alone.

In oligopoly the uncertainty affects the level of profits more than under perfect competition, and as the number of competitors tends to infinity, the indirect effect tends to zero, and the only remaining influence of the exchange rate change will be the direct one, $\partial \Pi/\partial e$. *Von Weiszaecker and Von Ungern* (1989)[20] have studied the optimal hedging policies for an oligopolist when facing exchange rate uncertainty. In a similar model they concluded that the hedging policy, defined only at the Nash-Cournot equilibrium and for

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[19] For this point also Bulow, Geanakoplos and Klemperer (1985).
[20] Von Weiszaecker and Von Ungern (1989).

the expected value of the exchange rate, will be of magnitude bigger than twice the Nash-Cournot quantity. The hedging in this model that each firm performs, is by selling(buying) foreign currency in the futures (perfect) market at an expected price.

6. Conclusions

In an international oligopolistic model with exchange rate uncertainty, we have seen how volatility can affect total amount of goods traded depending on the risk aversion attitude of the firms, the market structure and the degree of product differentiation of the varieties in trade.

In a simple extension of an oligopoly model with uncertainty we ahve found that in determining the sign and the degree of the pass-through relationship it is important to take account not only of market structure elements but also the more or less aggressive response expected from the rivals. We have shown how by increasing the number of participants in the industry or by assuming a more aggressive response among the firms competing in an international market with uncertainty, results get closer to the Law of One Price.

More empirical evidence at a desegregated level is necessary in order to gain insight into other elements that might be influencing the behavior of international prices, and more specifically, the sluggishness in the response of prices to exchange rate movements in the short and medium term. Market structure variables, and types of competition can explain only part of this price inertia.

Appendix

A.I. Derivation of the pass-through expressions

In our oligopoly model with the multiplicative shock in the demand functions, we defined the objective function of the risk averse exporter as

$$\text{max.} \quad \Gamma = E(\Pi^i) - \delta\sqrt{Var(\Pi^i)}$$

$$x_{hh}, x_{hf}$$

where we introduced in the quantity setting case a multiplicative random shock into the inverse linear demand functions facing each firm of the form

$$E = \mu e^{\sigma\varepsilon} \quad \text{where} \quad \varepsilon - (0,1)$$

This can be approximated by Taylor expansion by

$$E = \mu e^{\sigma\varepsilon} \approx \mu(1 + \sigma\varepsilon)$$

Our profit expression is,

$$\Pi_{hf}^i = \left[\alpha - \beta\left(\sum_{i=1}^{n_1} x_{hf}^i + \omega\sum_{j=1}^{n_2} x_{ff}^j\right)\right]\mu(1+\sigma\varepsilon)\, x_{hf}^1 - c\, x_{hf}^1$$

Maximizing the objective function for each exporter and each domestic producer, we obtain a system of $n_1 + n_2$ first order conditions, as

$$x_{hf}\left[2 + \left(\frac{\partial\sum_{i=1}^{n_1-1} x_{hf}}{\partial x_{hf}}\right) + \omega\left(\frac{\partial\sum_{j=1}^{n_2} x_{ff}}{\partial x_{hf}}\right)\right]\beta = \alpha - \frac{c}{\mu(1-\delta\sigma)} - \beta\sum_{i=1}^{n_1-1} x_{hf} - \beta\omega\sum_{j=1}^{n_2} x_{ff}$$

From this system of first order conditions we obtain the reaction functions for each rival in terms of the domestic rivals and of the exporters.

We can now apply the symmetric firms hypothesis and get the condensed reaction functions, that is, a reaction function for the i-th exporter in terms only of the domestic rivals as

$$
\begin{pmatrix} n_1 +1+(n_1 -1)\lambda + \omega\, n_2\, k & \omega\, n_2 \\ \\ \omega\, n_1 & n_2 +1+(n_2 -1)\lambda + \omega\, n_1 k \end{pmatrix} \begin{pmatrix} x_{hf}^i \\ \\ x_{ff}^j \end{pmatrix} = \begin{pmatrix} S_{hf} \\ \\ S_{ff} \end{pmatrix}
$$

where $\lambda = (\partial x_{hf}^k / \partial x_{hf}^i)$ and $k = (\partial x_{ff}^j / \partial x_{hf}^i)$, $S_{hf} = (\alpha - z)/\beta$, $S_{ff} = (\alpha - c^*)/\beta$, and $z = (c/(\mu\,(1 - \delta\sigma))$. Let *Det* be the determinant of the matrix on the left hand side. Note that for $\lambda = k = 0$, and $\omega = 1$, *Det* = N + 1. From here by inverting the matrix on the left hand side and after some manipulation we find the Nash-Cournot equilibrium, x^*_{hf} and x^*_{ff} :

$$
\begin{pmatrix} x_{hf}^{i*} \\ \\ x_{ff}^{j*} \end{pmatrix} = \frac{1}{\beta\,\mathrm{Det}} \begin{pmatrix} [n_2 +1+(n_2 -1)\,\lambda + \omega\, n_1\, k][\alpha - z] & \omega\, n_2\,(\alpha - c^*) \\ \\ [n_1 +1+(n_1 -1)\,\lambda + \omega\, n_2\, k][\alpha - c^*] & \omega\, n_1\,(\alpha - z) \end{pmatrix}
$$

$$(A.3)$$

Writing the condensed reaction functions in terms of deviations from marginal costs,

$$
\begin{pmatrix} P_{hf} - z \\ \\ P_{ff} - c^* \end{pmatrix} = \beta \begin{pmatrix} S_{hf} \\ \\ S_{ff} \end{pmatrix} - \beta \begin{pmatrix} n_1 & \omega\, n_2 \\ \\ \omega\, n_1 & n_2 \end{pmatrix} \begin{pmatrix} x_{hf}^* \\ \\ x_{ff}^* \end{pmatrix} \qquad (A.4)
$$

and substituting into the system (A.4) the Nash-Cournot equilibrium quantities, x^*_{hf} and x^*_{ff} obtained in (A.3), we finally get the market clearing prices, P^*_{hf} and P^*_{ff}. The expressions for equilibrium price are complex; they have been obtained with the help of the software Mathematica. As a special case, when $k = \lambda = 0$ (i.e. Cournot conjectures), we obtain

$$
P_{hf}^i = \frac{\alpha\big[n_2(1-\omega)+1+\omega\, n_2\, c^* + z\, n_2\,(1+A)\big]}{N+1+n_1\, A}
$$

and $\quad P_{ff}^j = \dfrac{\alpha\big[n_1(1-\omega)+1+c^*\, n_2(1+A)+z\,\omega\, n_1\big]}{N+1+n_2\, B}$

where $A = n_2(1 - \omega^2)$ and $B = n_1(1 - \omega^2)$.

From the Nash equilibrium we can check that, $z = z(c,\mu,\sigma,\delta)$, $x_{i2} = x(c^*, z(.),n_1,n_2)$, and $P = P(n_1, n_2, z(.))$. Any change in any of the two moments of the random distribution affects the Nash equilibrium via $z(.)$.

From the Nash equilibrium we can derive different expressions for the pass-through relationship, in prices or in quantities, by taking the appropriate derivative. After some manipulation we obtain expressions in Table IV. Second derivatives re used to get the speed of adjustment of the equilibrium price to exchange rate changes with respect to the market structure and the degree of product differentiation in the industry.

A.II. Proof of Proposition 3

As before, we just need to check that $(\partial P_{hf}/\partial z) > 0$, and that $(\partial z/\partial \sigma) > 0$, so that the total effect is positive, $(\partial P_{hf}/\partial \sigma) > 0$, for the first part. To prove that total quantity traded declines with more volatility, we have that $(\partial x_{hf}/\partial \sigma) < 0$ and that $(\partial x_{ff}/\partial \sigma) > 0$, and we only need to check that

$$\left|\frac{\partial x_{hf}}{\partial z}\right| > \left|\frac{\partial x_{ff}}{\partial z}\right|$$

which is true always since in our case this condition reduces to $[(n_2 + 1)/n_2] > 1$.

A.III. The Invoicing Currency of the Contract and the Choice of the Strategic Variable

The type of exchange rate risk I deal with is based on the distinction between a mean-preserving increase and a spread-preserving increase in the assumed probability distribution of the random shock, in our case the distribution of the exchange rate changes[21].

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[21] this approach is used by Rotschild,Arrow (64),Laffont (90) and Stiglitz ( ).

I introduce a stochastic shock in one of the equations of the model. This shock can be modeled as composed of different parts; in my case a permanent and a noise part. By taking the first two moments of the shock in the objective function, or in the first order conditions for the firm, I obtain an equilibrium expressions in terms of the first two moments of the distribution. We can distinguish between

1, A spread-preserving increase: that is a shift in the location of the probability distribution of the shock to the right or left of the original location without changing the shape of the distribution, and

2, A mean-preserving increase, we can think of this as an expansion of the bell of the distribution above its initial level. This reflects the introduction of more noise in the distribution. We can think of this as an increase in the exchange rate volatility.

Based on this distinction we can model the exchange rate changes as composed of two elements:

1. a trend, μ,   with $\mu \sim (\mu, 0)$

2. a volatile part or noise ε,   where $\varepsilon \sim (0, \sigma^2)$.

When a random shock is introduced, the equilibrium conditions can be derived based on the expectation of the shock, ex-ante, or in terms of the values of the different moments of the distribution, ex-post.

A.III.1. The Choice of the Strategic Variable and the Source of Risk

Usually we can reach different conclusions in oligopoly depending on the type of competition we assume the firms are playing, if Bertrand (in prices) or Cournot (in quantities) competition. When a random disturbance is introduced, the choice of strategic variable can be of importance because it might yield different expected profits. In fact, *Klemperer and Mayer* (1986)[22], have shown that if an additive demand shock is introduced, the firm will be better off if it chooses quantities rather than prices as the strategic

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[22] Klemperer,P and Mayer,M.:"Quantity vs. Price Competition: the role of Uncertainty", Bell Journal of Economics.

variable if marginal costs are decreasing and will be indifferent if marginal costs are constant. When increasing returns to scale it will better off by competing in prices.

If the firm competes in prices it can choose the currency of denomination of the contract: if it chooses to denominate its foreign contracts in foreign currency units, then the risk will be absorbed by the firm and it will face a home currency price risk, because the price in the foreign market say in US units, is the control variable and will change only in function of the foreign demand fluctuations but not in function of the exchange rate. If the firm quotes its prices in home currency units, the final destination market price in dollars will fluctuate according to the exchange rate and hence the final quantity demanded by US customers will fluctuate, so the firm is facing a quantity risk (*Mann,*1989). If the firm competes in prices it can choose between facing a "quantity risk", and at the same time the foreign consumers would face a price fluctuation, or facing a "price risk", where foreign consumers face a quantity disturbance. In both cases the risk attitude of the foreign consumers would matter.

If competition is of Cournot type the (equilibrium) price will be such as to clear the market where the good is sold. The exchange rates introduce only an additional random disturbance in the price movements, but only in the exporting firm's national currency price, that is, in its unit revenues. By competing in quantities the firm cannot avoid the price risk (in his own home currency), but avoids the quantity risk, since it will let the P^* be the one that clears the market and final foreign demand will not fluctuate with the exchange rate. The price in his own home currency units is the price that will be random, hence we can express the inverse linear demand facing the firm (a) in the exporting market (b) as

$$P^* = P^*(x_{ab}^*, x_{bb}^*) = a^* - b^*(x_{ab}+x_{bb})$$

or in terms of his home currency

$$P = P(x_{ab}(e), x_{bb}^*) = [a^* - b^*(x_{ab}+x_{bb})] \, e$$

where e is the foreign currency price of one unit of home currency- an increment in e means an appreciation of the home firm's currency-. In this way, the firm will absorb the exchange rate risk because the firm competes in quantities and gets the exchange rate fluctuations in its home unit price (and revenues) directly, and the foreign price does not fluctuate with the exchange rate.

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To see how the exchange rate uncertainty can affect in different degrees the export price, we can see the following case (based on *Giovannini*, 1987). Let p and p* be the home and the foreign currency denominated prices. There are two different markets with two demands: D(p) and D*(p^f,p*), where our firm produces for both markets x_1 and x_1^* and has the choice of setting the price in either currency. Since the exchange rate is unknown it wants to maximize the expected value of profits. The costs function is assumed to have constant returns to scale, so that we can use the separation property. If the firm quotes the foreign price in home currency(p^f), then its problem is

$$\max_{p,p^f} E(\Pi) = E\{p\ D(p) + p^f\ D^*(p^f(1/e),(1/e)p^d) - C(D^*(...))\}$$

After differentiating the objective function with respect each price (p,and p^f,where p^d is the domestic firm's price in the exporting market), become

$$D(p) + p\ D'(p) - c' = 0 \tag{1}$$

$$E\{D^*(p^f(1/e),\ p^d(1/e)) + p^f(1/e)\ D_1^{*\prime}(p^f(1/e),\ p^d(1/e)) + p^f\ (1/e)\ \lambda_1 - c'\} = 0 \tag{2}$$

where $\lambda_1 = (dp^d/dp^f)$ is the conjectural variation of firm 1 with respect the expected response of the rival (2). If, on the other side, the foreign firm quotes its export price in the foreign currency (p_1^*), then its problem becomes:

$$\max_{p_1,p_1^*} E(\Pi) = E\{\ p_1\ D(p_1) + e\ p_1^*\ D^*(p_1^*,\ p_2^*) - c\ (D^*(p_1^*,p_2^*))\}$$

and the FOC's are

$$D(p) + p_1\ D'(p) - c' = 0 \tag{3}$$

$$E\{e\ D^*(..) + ep_1^*\ D_1^{*\prime}(..) + ep_1^*\ D_2^*(..)\lambda_1\} - c' = 0\} \tag{4}$$

In this case the stability conditions are not influenced by the exchange rate as long as the constant returns to scale assumption is maintained. It is direct to see that if the marginal costs are constant and normalized to zero, c'= 0, for any type of conjectures the firm might

have regarding the expected response of the rivals, a mean preserving increase in the distribution of the exchange rate does not change (3) or (4), and hence we can conclude (as in *Giovannini*, 1987) that increasing risk leaves the home and the export (in foreign currency) prices unchanged. The firm, by quoting prices in the foreign currency can isolate itself from export quantity fluctuations and face only the home denominated price (or revenues) risk.

If the firm competes in quantities and sells x at home and x^f abroad and letting P(x) and P*(x^f, x*(x^f)) represent the home and foreign demand for the goods respectively, we have

$$\max_{x,\, x^f} E(\Pi) = x\ P(x) + x^f\ P*(x^f, x*(x^f))\ e - c(x + x^f)$$

where $P*(x^f, x*)\ e = P(x^f, x*)$. Then, we obtain

$$E\{P(x) + x\ P'(x) - c'(x) = 0\} \tag{5}$$

$$E\{e\ P*(..) + x^f\ P_1*'(..)\ e + x^f\ P_2*(.)\ e\ \lambda_1 - c'(x^f) = 0\} \tag{6}$$

where can also directly see from the first order conditions, (5) and (6), that if c'(x+x^f)=0, a mean preserving increase, an increase in the volatility, will leave the home, P(x), and the export prices (P*(x^f, x*)) unchanged for any conjectures that we consider. The conjectural variations enter the FOC, in the cross derivative of demand with respect the rivals strategic variable - $\partial x_2*/\partial x^f = \lambda_1$ -. By setting the quantity, the firm has isolated again itself from the export quantity fluctuations due to exchange rate changes. This is no surprise, since with Cournot competition and constant returns to scale, we can separate the problem of the firm in each market, and the firm by setting the optimal quantity will not be driven by the exchange rate. The firm faces still uncertain unit revenues, whether competing in prices or in quantities.

The choice of strategic variable and the source of risk: *if the firm competes (a) in prices and sets the export prices in the destination market currency, or if it competes in (b) quantities, in both cases it will face only random unit revenues. If it competes in (c) prices and denominates the export prices in its home currency it faces "quantity uncertainty": the quantity demanded fluctuates randomly because the foreign*

consumers are facing an uncertain final price. The choice of strategic variable hinges upon the risk attitude of the firm.i.e. on the shape of the profit function[23].

A.III.2. Stability Conditions when Cournot or Bertrand Competition

A. *When Price Setting Firms*

If the firm quotes the export price in its home currency (p^f) the foreign demand will be a function of (p^f/e) and (p^d/e), both in the exporter's home currency:

$$\Pi_1(p^f, p_2{}^*, e) = D^*(p^f/e, p^d/e)\, p^f - C(D^*(p^f/e, p^*))$$

$$\partial\Pi_1(p_1{}^f, p_2{}^*)/\partial p^f = D^*(..) + p^f\,(1/e)D_1{}^*(..) + p^f(1/e)\,\lambda_1 - C'(..)$$

from the first order condition we can see that a spread-preserving increase will affect the equilibrium price(p^f),since it affects the perceived marginal profits for the exporter. The second order condition (SOC) assuming the firms have Bertrand conjectures $\lambda_1 = 1$ and $\lambda_{12} = 0$, and omitting the terms in parenthesis, becomes:

$$\partial^2\Pi_1(p^f, p_2{}^*)/(\partial p^f)^2 =$$

$$2(1/e)D_1{}^* + 2(1/e)D_2{}^* + p^f(1/e)^2(D_{12}{}^* + D_{21}{}^*) + p^f(1/e)^2[D_{11}{}^* + D_{22}{}^*] < 0$$

and for stability we need that $D_{ii}{}^*(..) > D_{ik}{}^*(..)$ in absolute value.

In the case of price setting and home currency denomination we can also study the curvature of the profit function with respect the exchange rate. We can do so by differentiating twice the first order condition with respect the exchange rate, and we obtain:

$$[\partial^2\Pi'/\partial e^2] = (2p^f/e^3)\,[D_1{}^*(..) + D_2{}^*(..)] < 0$$

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[23]this as basically an extension of Giovannini (1988)

If the firm quotes the export price in the foreign currency (p_1^*),

$$\max.\Pi_1(p_1^*,p_2^*(p_1^*)) = D^*(p_1^*,p_2^*)\,ep_1^* - C(D^*(..))$$

from where

$$\partial\Pi_1(p_1^*,p_2^*)/\partial p_1^* = e\,D^*(p_1^*,p_2^*) + e\,p_1^*\,D_1^*(..) + e\,p^*D_2^*(..)\,\lambda_1 - C'(D^*(..))$$

where if we set marginal costs equal to zero $C'(..)= 0$, we can directly conclude that a spread-preserving increase in the distribution of the shock will not affect the export price (p_1^*). If the marginal costs are constant, but positive, the spread-preserving increase will affect the first order condition in proportion to the level of marginal costs, but does not affect the stability conditions. The SOC is:

$$\partial^2\Pi_1(..)/\partial p_1^* =$$

$$2e\,D_1^* + eD_2^*\,[2\lambda_1 + p^*\,\lambda_1 + p^*\,\lambda_{11}] + e\,p^*D_{11}^* + e\,p^*\,\lambda_1\,D_{21}^* + ep^*(\lambda_1)^2D_{22}^* < 0$$

Let $\lambda_1 = 1$, and the stability condition becomes:

$$2eD_1^* + eD_2^*(2+p^*) + ep^*(D_{11}^* + D_{22}^*) + ep^*D_{21}^* < 0$$

We can see that the exchange rate does not affect the stability condition in the SOC. The stability condition in this case reduces to goods being strategic complements. With constant returns to scale and Bertrand competition the conditions for stability of the Nash-Bertrand equilibrium and the effects of a spread-preserving increase in the distribution of the exchange rate depend on the currency of denomination of the contract and on the curvature of the demand function:

a) If the exporter quotes its prices in its *home currency*, given the goods are strategic complements, the stability will hinge on the curvature of the demand function: it is to be concave.

The sign of the effect of more uncertainty in the equilibrium export price will depend on the sign and the degree of concavity(convexity) of the demand,i.e. on the degree of risk aversion of the consumers,since in this case the firm faces an uncertain final

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demand and on the risk attitude of the exporter (curvature of the profits function with respect the exchange rate).

b) If the firm quotes its prices in the *foreign currency:* the stability condition for the Nash-Bertrand equilibrium implies that goods be strategic complements together with the condition $D_{11}*(..) \geq D_{12}*(..)$, in absolute value.

The increased volatility will not affect the export prices(as in the FOC),and hence the firm faces only uncertain unit revenues (in home currency units).

B. Whith Quantity Setting Firms

Let the quantity that firm 1 sends to the export market depend on the exchange rate value, $x_1*(e)$, then

$$\max. \Pi_1(x_1*(e),x_2*) = P*(x_1*(e),x_2*) \, x_1*(e) - C(x_1*)$$

Calculating the first order condition (FOC):

$$\partial \Pi_1(x_1*(e),x_2*)/\partial x_1* = (\partial x_1*/\partial e P*(..) + x_1*(e) P_1*(..)(\partial x_1*/\partial e) + x_1*(e) \lambda_1 - C'(..)$$

Let $\lambda_1 = 0$ and assume $C'(..) = 0$, then we see that a spread-preserving increase will not affect the perceived marginal profits of the exporter and hence it does not affect either the Nash-Cournot quantity nor the equilibrium price[24]. If marginal costs are increasing or decreasing at a constant rate, the stability condition is not affected, but the sign of the effect of more uncertainty in the equilibrium prices becomes ambiguous.

SOC:

$$[\partial^2 x_1*/\partial e^2][P*(..) + x_1*(e) P_1*(..)] + \qquad\qquad I$$

$$+ [\partial x_1*/\partial e]^2[2 P_1*(..) + x_1*(e) P_{11}*(..)] + \qquad\qquad II$$

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[24] with returns to scale different than constant, the spread-preserving increase affects the Nash equilibrium via the cost function.

$$+ [\partial x_1 */\partial e][\lambda_1 + x_1*(e)P_{12}*(..)] + \lambda_1 < 0 \qquad \qquad III$$

For stability, lets divide the three terms in the SOC and take account that $\partial e > 0$, i.e. an appreciation of the foreign currency and it implies, $(\partial x_1 */\partial e) > 0$:

I: if the exchange rate affects the quantity traded in a constant fashion, or at least in a non-increasing way, i.e. $[\partial^2 x_1 */\partial e^2] \leq 0$, then we can guarantee that $I \leq 0$.

II: since $P_1*(..) < 0$ and $(\partial x_1 */\partial e) > 0$, the condition rests now on the curvature of the inverse demand function; if concave, $P_{11}*(..) < 0$, the condition for stability is guaranteed, $II < 0$,

III: letting $\lambda_1 = P_2*(..) = 0$, and knowing that the goods are strategic substitutes, $P_{12}*(..) < 0$, we have $III < 0$.

If increasing returns to scale are introduced, the existence and stability conditions for the Nash-Cournot equilibrium change. I relate the conditions on the cost and on the profit function for a simple case[25]. The firm maximizes the objective

$$max.\Pi(x_1, x_2, e) = x_1 P*(x_1, x_2(x_1)) e - C(x)$$

I assume now that the firm has increasing returns to scale, $C(x_1) = a + x - (d/2)x$. It is easy to derive now the FOC

$$eP*(..) + e x_1 P_1*(..) + e x_1 P_2*(..)\lambda_1 - 1 + dx_1 = 0$$

and the SOC:

$$2e P_1*+ 2e \lambda_1 P_2*+ ex_1 [P_{11}*+P_{22}* \lambda_1^2]+ e x_1 \lambda_1 [P_{12}*+P_{21}*]+ d < 0$$

which if Cournot conjectures, i.e. $\lambda = 0$, it becomes:

$$2 e P_1*+ e x_1 P_{11}* + d < 0$$

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[25]for a more thoroughly treatment of the stability conditions when increasing returns, see Hens, Phlips and Kirman, 1992.

where we see that a spread-preserving increase does not affect the stability condition as long as d=0, in which case the stability depends on the curvature of demand $P_{11}*$. If d>0, the firm has increasing returns to scale, then the stability of the Nash-Cournot equilibrium depends on two elements: the curvature of demand and the extent of the economies of scale:

a. if demand is *concave*, $P_{11}*(.) < 0$, the system is stable as long as $(2P*+xP*) > (d/e)$, in absolute values,

b. if demand is *convex*, $P_{ii}*(.) > 0$, if $|2P_1*| \geq [x_1 P_{11}*(..)+(d/e)]$, in absolute value, the equilibrium is stable.

With constant returns to scale (and no economies of scope),and Cournot competition our conditions for the curvature of the profit function reduce to conditions on the curvature of the demand function $P*(x_1*(e),x_2*)$, and the rate of change of the quantity traded when the exchange rate changes $(\partial^2 x_1*/\partial e^2)$ which has to be non-increasing.

If linear inverse demand functions and constant, but positive, marginal costs, for the case of a duopoly in fact we obtain this condition, since $(\partial^2 x_1*/\partial e^2)=-(4c/3b)$, evaluated at the expected value of the exchange rate $E(e) = \mu= 1$, and at the Nash-Cournot equilibrium (x_1*, x_2*).

Chapter 4

Mark-up Adjustment and Exchange Rate Pass- through in Oligopoly: a Panel Study at the Product and the Firm Level in the Spanish Automobile Market, 1981:1- 1991:4

1. Introduction

The objective is to estimate a reduced form pricing equation for the automobile industry in Spain to test the different hypotheses about pricing behaviour of importers when exogenous exchange rate changes. I have constructed a data base for the Spanish automobile market with monthly data for the period 1981:1- 1991:4. In studying the pricing policy of any of the exporting firms I consider each model produced and exported by each producer as a different product, produced with an independent technology.

The first step is to provide a long run relationship between prices and exchange rates as expressed by the relative version of the Law of One Price, which, after taking logs can be expressed as

$$p_{it} = a_{it} + e_t + p_{it}^* \qquad (1)$$

where p_{it} is the price of good i at time t in domestic currency, e_t is the nominal exchange rate (number of domestic currency units divided by one foreign currency unit), p_{it}^* is the price of the same good (model of car) expressed in foreign currency units, and a_{it} is the "shift" parameter that reflects barriers to trade and any other imperfection that impedes the rapid adjustment of the domestic price to nominal exchange rate changes. Empirical tests run on the Law usually estimate a relationship of the form:

$$p_{it} = a + b \, e_t + \varepsilon_t \qquad (2)$$

If the strict version of the Purchasing Power Parity holds, then we should accept the joint hypothesis H_0: $a = 0$, $b = 1$ and ε_t being white noise. For the relative version of the PPP, we would have, H_1 : $a \neq 0$, and $b = 1$.

When imperfect competition is introduced there is evidence that the Law of One Price does not hold in the short and medium term, as reflected by the fact that the estimated parameter b takes values less than 1[1]. Our interest lies in this parameter. I shall introduce a lag structure on the exchange rate variable. When comparing different pricing policies by each automobile producer, I shall also make inference on the intercept parameter and give some interpretation of the results. Moreover, in imperfectly competitive markets and in a study at the product level disaggregation we cannot assume the Law of One Price to hold. I assume that there is a long run industry equilibrium in an oligopolistic industry with product differentiation, interaction among the producers and a demand schedule affected by exogenous demand side random shocks.

In order to justify the variables chosen in the estimation procedure I now derive a best response function for an exporter facing uncertain exchange rate changes assuming that the strategic variable is prices and that goods are strategic complements. There is only one exporter (firm 1) and one domestic producer (firm 2)[2]. The exporter sets the price of the differentiated good in its own currency units (the country of origin), p_1^*, which can be translated in destination (or foreign) markets currency units with the identity $p_1^* = e_t \, p_1$. The exporting firm faces a linear demand of the form

$$x_1 = \alpha - \beta \, p_1 \, E_t + \gamma \, p_2$$

where $E_t = f(e_t)$ is the distribution of exchange rate changes, that we assume has the first two moments independent of time. β is the parameter that shows the own price effect and γ collects that cross-price effects among the different varieties in trade. The exporting firm faces an additional cost when exporting since the good has to pay an import tariff, t, for each unit of car shipped to the destination market. Hence total costs of production for the foreign firm are $C_1 = c_1(x_1) + t \, (x_1)$, where c is the constant marginal costs of production and t is the constant tariff rate applied to all imports. The exporter faces the problem

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[1] as in Webster (1986), Mann (1989), Knetter (1989, 1991) and Krugman (1988).

[2] it is easy to generalize the model for an indefinite number of exporters and domestic producers. See Chapter 3.

$$\text{max. } \Pi_1 = (x_1) \, p_1 \, E_t - C_1 = [\, p_1 \, E_t - c_1 - t] \, [\, \alpha - \beta \, p_1 \, E_t + \gamma \, p_2]$$

expanding this expression and after taking the first order conditions and the expectations through the objective function we obtain,

$$p_1 = (1/ \, 2e_t)(\, (\alpha/\beta) + c + t + (\gamma/\beta) \, p_2) \qquad (3)$$

which is the best response function of firm i to any price strategy set by the rival (firm 2), and where e_t is the first moment of the exchange rate distribution $E \, (E_t) = e_t$. This reaction function, for the duopoly case, depends on the (mean of the) exchange rate, e_t, the size of the market the slope of the market demand, (α/β), the import tariff rate, t, and the rivals price, weighted for the degree of substitutability of the products (γ/β). For the domestic firm the best response function can be derived similarly and we can solve for the Nash-Bertrand equilibrium. The equilibrium price[3] for the exporting firm (firm 1) is

$$p_1 = (1/A) \, (1/e_t) \, \{ \, \alpha \, (2\beta + \gamma) + c \, \beta \, (\gamma + 2\beta) + \text{tariff} \, (2\beta^2) \} \qquad (4)$$

where $A = 4\beta^2 - \gamma^2$. This equilibrium price can also be expressed in terms of the mark-up for firm 1 as

$$m_1 = \{ \, p_1 - (c_1 \, /e_t) \, (B/A) \} = \{ (C/A) \, (1/e_t) + (\, 2\beta/A) \, (1/e_t) \, (\text{tariff}_t) \} \qquad (5)$$

where $B = \beta \, (\gamma + 2\beta)$ and $C = \alpha \, (2\beta + \gamma)$. The mark-up depends on the value of the exchange rate, the size of the import tariff and demand parameters. This basic expression is the one that will justify the panel estimations develop in the following sections.

2. Previous theoretical and empirical work

Previous studies in the automobile industry and the issue of the exchange rate pass-through focused on the estimation of the pass-through in the short and in the long run (Knetter 1990), on country-specific effects (Gual, 1989), on the strategic nature of the competition among the producers in selected countries of the EU (Kirman and Schueller, 1990 and Verboven, 1993), and on the type of product discrimination

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[3]derivation of the Nash-Cournot equilibrium is shown in the Appendix.

developed by big producers in different destination markets (Mertens, 1990 and Mertens and Ginsburgh, 1985). In this Chapter I estimate first pass-through elasticities by companies and by types of models imported in Spain and find that the pass-through varies significantly among models of the sample. Secondly, I study the possibility of different pricing policies and explain it based on different invoicing policies of the contracts. Third, I study the pricing to the market hypotheses for the company and the individual product level and estimate the extent to which exporters absorb partially the exchange rate change in their markups.

First I review the main characteristics of previous studies in the automobile industry in the European Union (EU). *Mertens* (1985) aims at explaining the significant price differentials observed among the same models of cars across countries in the EU for the period 1970-85 for Belgium, France, Germany and the UK. He estimates a price equation allowing for a sluggish price adjustment to exchange rate changes[4]. Assuming no arbitrage among the four countries considered he estimates a reduced form price equation derived from an heteregoneous goods static oligopoly model. The exchange rate can influence the pricing behavior of any exporter via the direct influence any change in the real exchange might have on the (relative) cost schedule of the exporter vis a vis the rest of the rivals. Hence the most important elasticity to be estimated is the price elasticity with respect the cost schedule of the firm and he tests whether this elasticity is different across source countries. The possibility of a price differential here is due solely to a less than unity cost elasticity for the firm. He constructs new price series for each cars once the changes in qualities made in each model had been taken into account (hedonic regressions). Two specifications were compared: the one with the dynamic adjustment term and the one with complete and instantanous adjustment. The one with dynamic adjustment showed a better statistical fit. It was found that while Belgian and German car prices adjust almost instantaneoulsy , the mean lag for french cars was up to a year and a half and that French and German cars seem to adjust faster in their export markets than in their home markets. For the French and the German markets, domestic production costs seem to explain better the pricing behavior of all producers, whereas for the Belgian and the UK market, foreign production costs seem to be relevant. This empirical finding found a theoretical justification in Kirman and Shcueller, where they propose the Stackelberg leader-follower model to explain this evidence. Barriers to trade, as the VER's on Japanese autos in all four European markets under study was found to have a positive impact in the price equation. Exchante rates play only a partial role in explaining the observed differentials.

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[4]slow price adjustment arises in this context aa a consequence of quadratic adjustment costs for the firm, as in Knetter (1991) or Kasa (1992)

Mertend and Ginsburgh (1985) test the determinants of car prices in five EU countries. They explain the differences in the price differentials over time based on two factors: product differentiation and price discrimination. Based in a Cournot oligopoly model with individual effects, they estimate first an hedonic regresion to see what part of each price is explained by a common set of technical characteristics. They find that these technical characteristics explain, on avergae, the majority of price movements, 78% in all markets considered. All countries have similar hedonic prices slopes but different intercepts, hence evidence for different price levels in each country. They estimate a price discrimination (as a country of origin effect) and a product differentiation effects (as brand loyalty or goodwill) once the technical characteristics had been taken account for, and obtained estimates of similar magnitudes for both effects.

Kirman and Schueller (1990), study a Cournot oligopoly model where each firm plays Stackelberg leader in its domestic market and follower in the exporting markets. Even when demands are identical[5] in all markets price differentials are obtained due to differences in the (marginal) cost schedules of each domestic producer (the leader), which in turn affects the equilibrium price in each market. The model explains some observed facts presented in Kirman and Schueller (1990) and elsewhere (Mertens 1985 and Verhoben 1993 and Gual, 1989): domestic costs are important in explaining the pricing behavior in those countries where there are national producers and these have a significant market share in its own home market (Italy, France and Germany). They test, then, price differentials because of different strategic behavior by the firms in different markets: leader and follower roles in the domestic and the export markets, respectively. They do not report econometric evidence, but data analysis of 17 models sold across 5 European countries during 1982- 87. They also argue that exchange rate variablity has been much higher than price variability and a very small, if significant, pass-through should be expected. The main conclusion of their study is that prices are fixed in home currency units and when exporting, each firm follows closely the pricing of the leading (domestic) model sold in the destination market. The problem with their study is twofold: the leader-follower roles are assumed in an ad-hoc manner, which, even though explains an important set of observed facts in the car industry, the distribution of strategic roles in the market and the sequential equilibrium assumed from the outset should be endogeneous to the model. On the empirical side, they do not report any econometric evidence, which especially for the issue of the exchange rate pass-through is needed in order to confirm clearly any hypotheses.

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[5]though not related (market segmentation is assumed).

Gual (1989), using the same sample as Mertens and Ginsburgh (1985), studies in a fixed effects pooled cross-section and time series model the pricing behavior of a sample of car prices in the European Union (EU). He explains the pricing of any car in terms of its technical characteristics (the hedonic part of the estimated equation) plus a country of destination and the brand (fixed) individual specific effects. He finds that the country of destination effect is significant and also the effect of the brand is important in explaining the pricing behavior and both effects explain the variance of the price in a similar way. The fact that the country effects is heterogeneous among destinations also suggests, as Gual points out, that the segmented markets hypotheses is confirmed.

Verboven (1993) simultaneously estimates a pricing- together with a demand equation and studies the degree of collusive behavor as determinant of the price differentials in the European car market. He finds also that the country of origin is an important differentiating characteristic and that the markups of the producers in their own markets is higher than their markups in the destination markets, evidence that is in accordance with the explanation gievn in Kirman and Schueller (1990). Markups for Japanese cars when VER's were applied are higher than the markups of other rivals. He finds clear evidence for international price discrimination in the EU with a fixed effects model. The problem with his estimations is that the individual fixed effects collects too many factors: systematic differences in the marginal costs across countries, differences in average dealer mark ups and errors in measurements of tax rates, among others. He estimates also a set of conjectural variations coefficients that should give light to the degree of collusive behavior in each market. All conjectural variations estimates (except for France) are between zero and one: in Germany and the UK the conjectutal variation was close to one and markups were higher also for all car types. Price discrimination may be a result of cross -country differences in collusive behavior in addition to differences in trade regimes and different demand elasticities. Kirman and Schueller (1990) and Mertens and Ginsburgh (1985) explained the price discrimination based on the different degrees of market power of each domestic producer in its own market. Verboven (1993) explains this observed fact based on the degree of collusion that is heterogeneous in each market. So far, it is not possible to identify the cause of price discrimination.

In this section I test for the source of the price discrimination, whether it is due to different pricing policies by each firm, to differences in the pricing of each type of model, or due to other more general factors. I extend slightly the results obtained in this literature in two small but significant ways: (1) price discrimination, and the unresponsiveness of import prices to exchange rates, is due to a country of origin effect: that is, companies belonging to one country tend to have the same pricing strategies and objectives even though they conflict with other importers in the destination market. I find clear evidence

of pricing to the market, and where German firms tend to price with the objective of increasing their market shares, Italian and Japanese firms behave more as a competitive fringe, and (2) tariffs and exchange rates are not passed into import prices in the same way (contrary to Feenstra, 1989), and depending on the market power for each firm, markup absorption is more relevant for some companies than for others. I find also that, no matter the market share, companies of the *same* source country, price similarly their products. This is strickingly so for the German autos and also for the Japanese and Italian cars imported in Spain. Market share of the company, though, plays an important role in the pass-through relationship when different companies from different countries are compared: I find econometric evidence for a much higher pass-through elasticity for the German than for the Italian or Japanese cars imported in Spain. This can be evidence for a greater market power for the German exporters. Another source of different pricing behavior arises due to individual differences in the cars imported. Import tariff changes are passed more fully into import prices, and it is found that a significant part of the exchange rate changes are absorbed in the mark up of the different firms, which gives more evidence for the local price stabilization policy (pricing to the market).

3. Data analysis and the price differentials

The data set describes 20 price series for *models of cars* for the Spanish market. The period covered is 1981-1991, with quarterly data. There are 17 imported models (9 from Germany, 6 from Italy and 2 from Japan) and two reference nationally produced models from Spain (Ford Fiesta XR2 and Renault 5,GTL) which correspond to5 German based companies, 2 Italian, 1 Japanese and 2 Spanish- producing companies. The criterium to denote the nationality of a company is where the specific model has been produced. My aim is to test if there are different pricing policies for different companies with respect exogenous cost, exchange rates and import tariff changes. Earlier results *(Feinberg*, 1990, 1993, and *Knetter* 1993) indicate that the effect of exchange rate changes takes place in import prices with a significant lag of 2 to 8 months, depending on the exporter's pricing policy and on the extent of the exchange rate devaluation.

Several problems with the data have been dealt with prior to proposing any estimation method. There is the problem of disappearing models, i.e. models that last only for a subsample of the period length. When any model disappeared in the sample for longer than six observations (quarters), the model has been taken out of the sample. Some models changed their characteristics during the sample period. Two approaches

have been used: (1) introduction of dummy variables, and (2) in some cases since the characteristic changed only slightly (i.e. motor 1.2 to 1.3 cubic centimetres of capacity) and the observed price change is small, or non-existent, I have omitted the dummy variable.

The *prices* for the different models have been collected in nominal terms[6]. Data on *costs* has been collected from the *OCDE Monthly Report*. For all the countries listed the data contains an index constructed on labour unit cost (monthly data that has been averaged for quarters). In thre estimations, hence, I ignore capital costs and productivity trends along the ten years considered. Even though this may be a cause for misspecification in the estimations, capital costs in the EU countries as proxied by the interest rate published by any Central Bank have shown a similar behaviour along the period considered due to the existence of the monetary union. Interest rate parity guarantees that there are no significant and persistent deviations from perfect arbitrage in the integrated capital markets. The cost of ignoring capital costs is expected to be small in this study.

In the following graph, the evolution of the real exchange rate of the peseta vis-a -vis the DM and the yen is shown. The period can be considered to have two different trends: during the years, 1981:1- 1987:2, the peseta devalued vis-a-vis the DM and the yen. After 1987:2 the peseta revalued continuously against these two currencies.

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[6]a more detailed description of the data is presented in Appendix, A.1.

Evolution of the real (DM/peseta) and the (Yen/Peseta) exchange rates
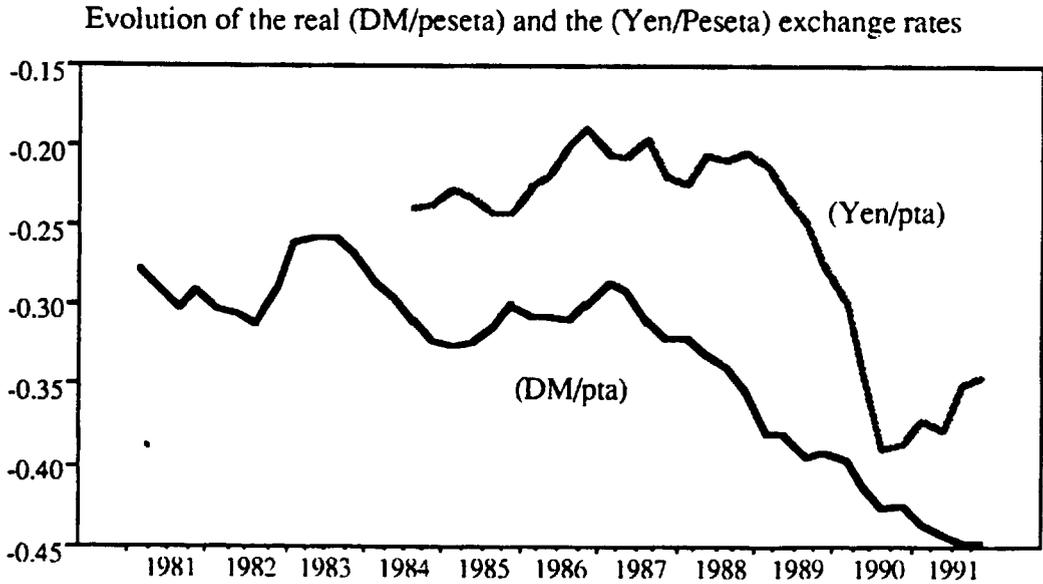
In contrast, the lira showed a more constant pattern of continuous devaluation against the peseta. A slight devaluation during the period 1986:2- 1987:3 and a lasting appreciation thereafter.

For *nominal prices* of each model of car considered data has been collected from different sources depending on the country. The nominal price of each car is the *Precio de Venta al Publico* or listed price as announced by the official publication of the Asociacion Nacional de Fabricantes de Automobiles. They recommend that distributors maintain those listed prices but some discounts in the retail markets are possible. We did not take them into account, even though these retailers might absorb part of exchange rate movements in their mark-ups. In the EC, though, discounts on official prices are not as significant as in other big markets (i.e. the US market).

Import tariffs show a regime shift in 1988:1. Due to the entrance of Spain into the European Union (EU) on January 1986, import tariffs were reduced gradually from then onwards. The main reduction took place in January 1988, as can be seen in the real tariffs applied to German and Italian cars.

Real import tariffs (t) for Mercedes 200 and Golf GTI, 1981:1-1991:4
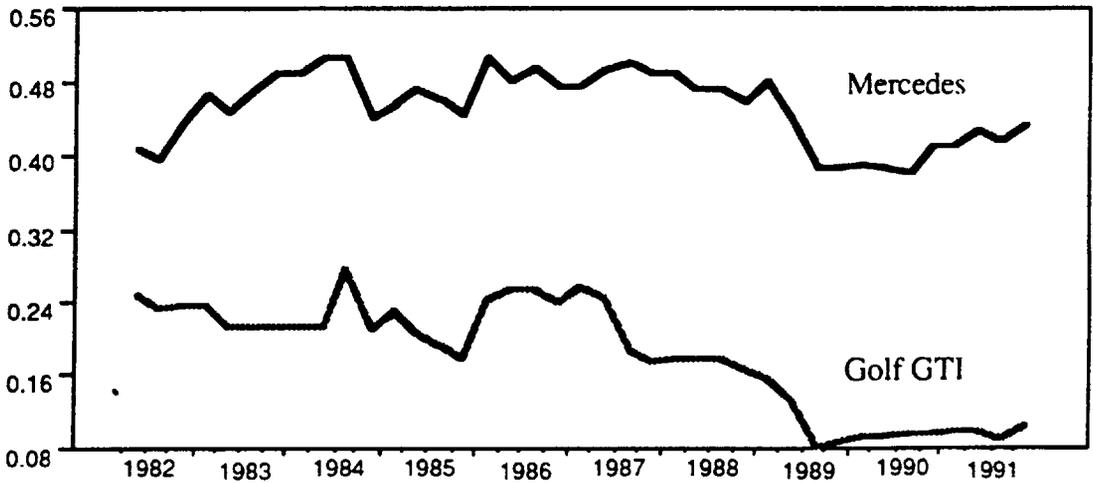
Real import tariffs for the Fiat Uno 60S and the Lancia Y10 Fire, 1981-91
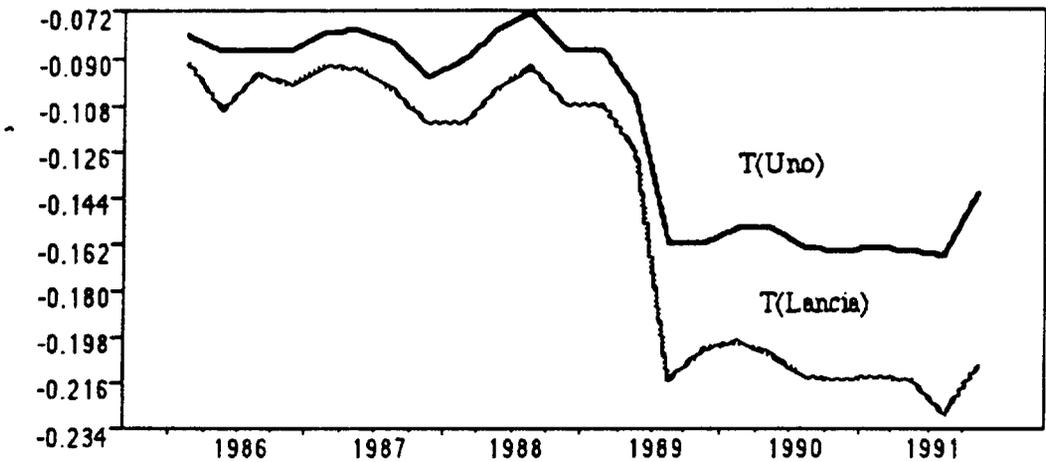
As stated earlier, the price differential between an imported and a nationally produced model should reflect changes in the import barriers, differences in the technical characteristics of each model, costs changes and exchange rate fluctuations. Import barriers are of two kinds: tariffs and quantitative constraints. The latter can be of two types: quotas and Voluntary Export Restraints (VER). The Spanish automobile market has had quotas only for the Japanese models for the whole period considered, 1981-91,

as well as different import tariff rates for all models in the sample. For quotas, reliable data has not been possible to obtain. Import tariffs are available from the official list prices of the ANFAC Association and are specified for each model considered. As it turns out, tariff changes are very important in explaining the behaviour of automobile prices.

Once I remove the import barriers from the regression I focus on the way exchange rate changes are passed into the domestic price. I expect that some misspecification will occur since the quantitative import restraints are not incorporated in the model and they have been relevant for Japanese imports in the period considered. The expected effect of a VER on the pass-through elasticity is to reduce the translation of exchange rate changes into prices[7]. Hence by not introducing this variable into the estimations I might face an upward bias in the estimated pass-through relationship for the Japanese models.

First I present a graph with the evolution of the price differential[8] in real terms (using the consumer price index, CPI) for three models of cars (Golf CL, GTI and Opel Kadett) that can be taken as typical in our sample with respect the reference nationally produced model, the Fiesta XR2.

Evolution of the real price differential between the Opel Kadett, VW Golf CL and GTI with the reference (national) model Ford Fiesta XR2

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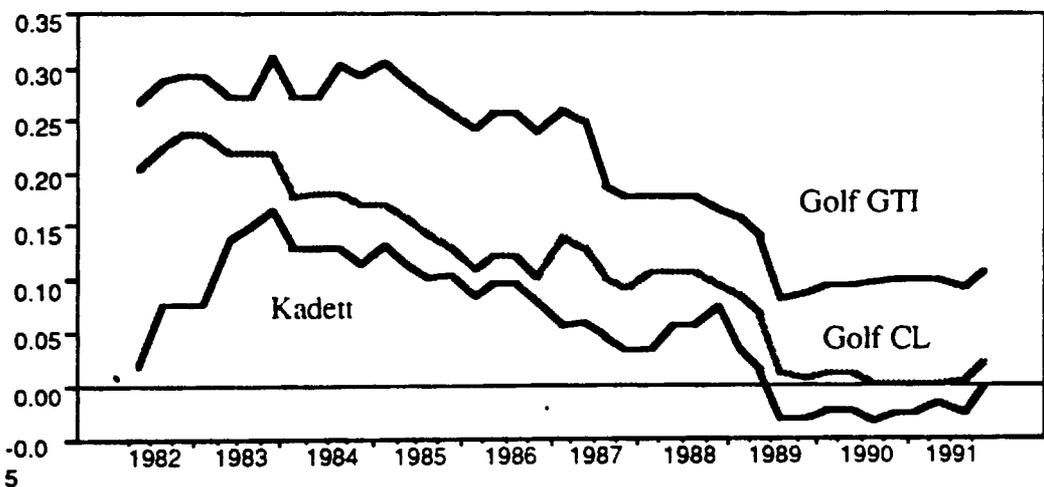
[7]for an empirical study on the effects of VER on the pass-through elasticity, see Feenstra (1985)

[8]price differentials, in levels and in first differences, for more models can be found in the Appendix, A.5.

From these price differentials it is clear that right after the entrance of Spain into the EU and the corresponding reduction of import tariffs, the price differential diminishes considerably untill it stabilizes in the second quarter in 1989. The price differential between the Italian cars and the reference national model follows a similar pattern.

Real price differential between the Fiat Uno 60S, Lancia Y10 Fire and the nationally produced Fiesta XR2, Spain, 1981:1-1991:4
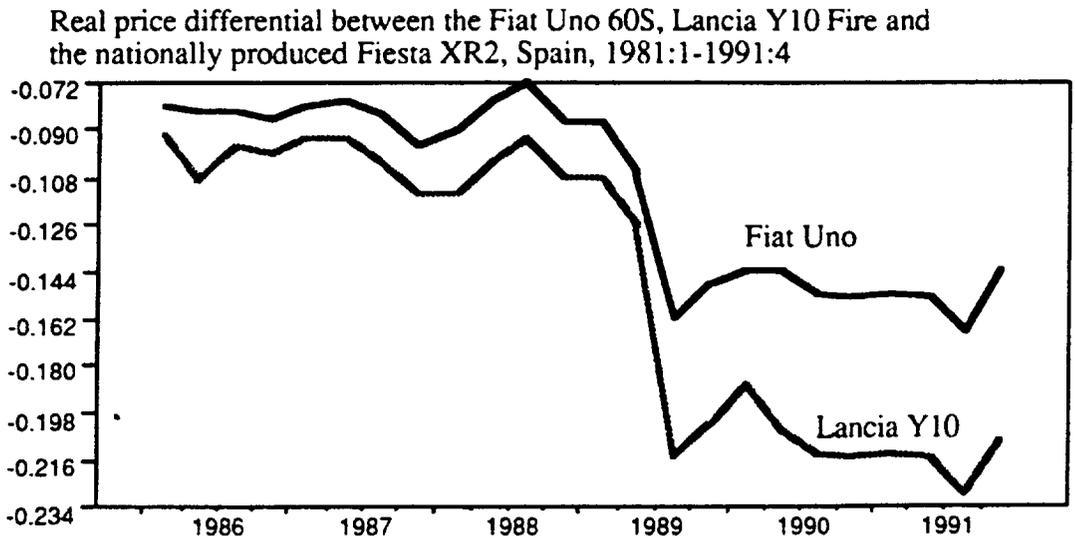
The variable cost differences, w, reflects the evolution of unit real labour costs between the exporting and the importing country, i.e. for German imports in Spain, w = (gw - sw), i.e., the index shows relative unit labour costs disadvantages of the German exporters vis-a-vis Spanish producers. As we can see in the following graph, the relative costs of producing in each country does not explain much of the price differential evolution. The German cost differential declines slightly throughout the decade, whereas the Japanese index declines even faster and the Italian (not shown here) keeps a constant track.

Evolution of unit real labour cost differential for Japan and Germany
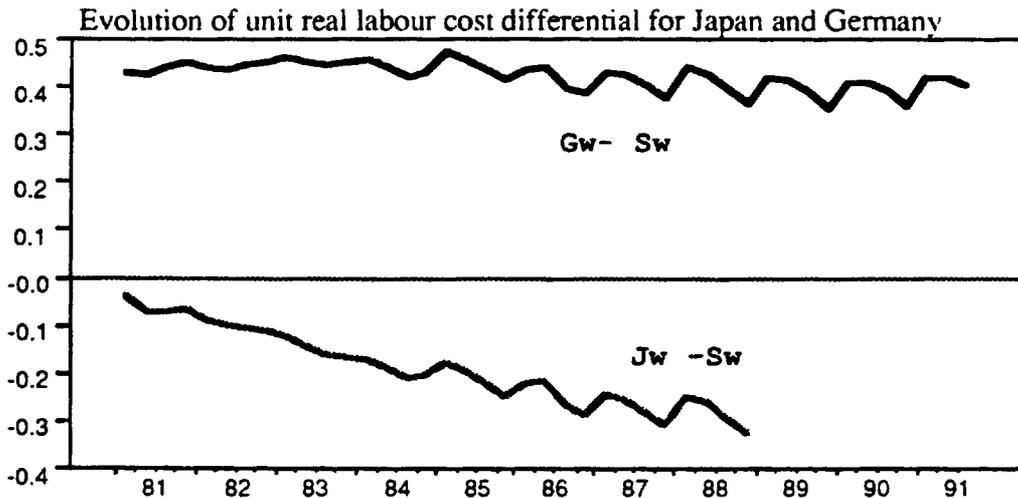
By looking at the graphs, it is apparent that the tariff reduction during the period, together with part of the exchange rate changes are good candidates to explain, even if only partially, the evolution of the real price differentials. What I shall develop in the next section is an estimation that tries to exploit other individual specific characteristics that, even if not well identified in the estimation procedure, can give some light on the behavior of the exporter's pricing decisions.

In table 1 the different market shares (as % of total sales or as % of total imports) for selected companies is presented. Throughout the period, the market share for the national producers (Seat and Renault) has dimished continuously from almost 30% for Renault in 1985 to 22% in 1991. Total imports from the EU increased and the share of imported cars coming from Volkswagen and Audi also increased. Ford (a German company in our sample) decreased total imports in Spain and Mercedes and Suzuki maintained their import shares. When studying the pricing policies, one important factor to take account of is whether the objective of the company was to keep market share. From table 1 we can see how at least Audi, Volkswagen, Mercedes, Nissan Suzuki and Peugeot had a concern for market share.

Table 1: imports by each company (as % of total imports)

	Oct. 1985	Sept. 1986	Oct. 1988	Dec. 1989	Oct. 1991
Domestic Producers (% of sales)					
Renault	29.7	23.7	23	21	22.3
Seat	24.8	16.1	9.8	11.9	10.7

Importers
(% imports)

Ford	18	9.3	14.7	8.6	10.4
Volkswagen	4.5	4.1	23.1	27	18.3
Mercedes	5.4	7.2	1.8	3.2	4
Audi	2.2	1.6	3.1	8.8	6.1
Peugeot	1.3	0.6	25.3	13.6	18.5
Nissan	0.5	0.5	0.1	2	7.1
Suzuki	0.05	0.09	0.02	0.7	0.7

The pass-through elasticity can take different values depending on the market structure, the number of foreign firms relative to domestic producers, the degree of product differentiation and the type of competition and expectations held by the firms operating in the industry[9]. If the industry can be approximated by perfect competition the pass through elasticity will be one (complete pass-through) which implies the Law of One Price, i.e. any change in the exchange rate is passed one to one into the domestic price. The price differential over time should follow a random walk, as the exchange rate does. In this section I estimate a price differential among two imperfectly but close substitutes in the car industry and study its behaviour over time. I find that the price differential can be partially explained by the exchange rate and cost changes. It does not follow a random walk in our sample, evidence for the existence of a pass-through relationship different than unity.

4. The model to estimate. Scope and limitations

Based on equation (4) the reduced form pricing equation that I test in this section can be expressed as

$$p^*_{it} = a + b_0\, e_t + b_1\, tar_{it} + b_2\, w_{it} + b_3\, D_{it} + u_{it} \qquad (6)$$

where all non-dummy variables are taken in logs and measured in real terms. The left hand side, p^*_{it}, is the (real) price differential between two closely related cars ($p_{it} - p_{jt}$), one foreign and one domestic. The domestically produced reference model is the Fiesta XR2. Both prices are expressed in the same destination market currency (pesetas in this sample). The term $w = (w_{it} - w_{jt})$ measures the real unit labour costs differential between location (or country) i and country j at time t, D_i is a set of dummy variables that reflect changes in the characteristics of the model being sold and main changes in the import

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[9]we dealt with these variables and their implications for the pass-through elasticity in a previous chapter.

barriers in the reference country, i.e. the entrance of Spain on January 1986 into the EU. The variable $(t_{it} - t_{jt}) = tar_{it}$ is a proxy for import tariffs: it measures in real terms the difference of taxes paid when purchasing the imported i-model less the real taxes paid when buying the nationally produced reference j- model (Fiesta XR2), and u_{it} is the error term. All variables are deflated by the Spanish Consumer Price Index (CPI).

I estimate a pooled cross- section and time series model in order to exploit the individual differences in the estimated pricing equations. Based on equation (6), we can expect a negative and significant sign for the exchange rate variable if pricing to the market is present. A positive sign if the perverse pass-through is the case anda zero coefficient if perfect competition (and the Law) is to hold. A positive coefficient for the import tariff variable is expected, since we expect the import tariffs reduction to be passed directly into lower import prices expressed in the destination market currency (i.e., Pesetas), even if incompletely (an estimated coefficient less than 1 in absolute value). The relative unit (real) variable costs, can have a positive or a negative sign, depending on the strategic interaction among the producers. It measures, i.e. for the German imports, Gw-Sw, the relative cost disadvantage of the German exporters vis a vis the Spanish producers, and an increment in the real labour costs should be reflected in higher prices if the German producers have any market power in the destination market. If German producers follow the pricing decisions of another (national) rival in the industry, the expected sign should be negative. The individual specific variables are explained below.

When estimating the pricing equation (6), several problems are present. The results should be taken with a certain distance. The endogeneity problem of exchange rates, price levels and mark-up determination is not taken care of in this study and this can be a cause of bias in the estimates. Due to lack of data, measures for non-tariffs trade barriers have not been possible to collect, and this poses the question of misspecification for the Japanese cars imported in Spain. I shall relate all the results with other (when appropiate) related results of the empirical literature on the pass-through relationship in the automobile and other industries, in order to highlite the similarities and contrasts and to give a context in which to judge the empirical results. I use the pooled cross-section and time series estimation method because it allows to exploit individual differences that , as it turns out, are crucial in the analysis. All in all, my results should be taken as another, if small, extension to this interesting problem.

5. Source of individual heterogeneity:

In order to see if the different companies follow different pricing policies we need to test the hypothesis that all parameters do not vary across individuals. There are three levels of analysis: *firms*, denoted by k= 1.....10, *models of cars*, denoted by subscript i=1....17 and *countries*, j = 1, 2,3. I test for heterogeneity across then different individuals in the sample. This individual specific effects (if assumed fixed or random) do give us important information on the different hypotheses addressed below. To test the significance of the different individual effects, I need to estimate three separate regressions:

$$p_{it} = a_i + b'_i \, x_{it} + u_{it} \qquad (7)$$

where x_{it} is an M*T vector of M exogenous variables as specified in equation (7) above, b'_i is the vector of the estimated coefficients, p_{it} is a column of i price differential variables (one for each model of car), u_{it} is the individual error component vector and a_i is the estimated intercept, which is allowed to be homogeneous or heterogeneous across individuals. Equation (7) with different estimated coefficients for each individual (H_1: $a_1 \neq a_2 \neq ... \neq a_N$, and $b_1 \neq b_2 \neq .... \neq b_N$)   is usually called the individual-mean corrected regression, or the unrestricted model, and equation (7) with the restriction of homogeneous coefficients is called the pooled regression, or restricted model. I proceed by testing two different hypotheses:

1.a. common intercept of the reduced form pricing equation

$$H_N: \quad a_1 = a_2 = a_3 = ... = a_N$$

with the F-test defined as,

$$F^* = [((SSR_r - SSR_u)/((N-1)(M+1))] / [SSR_u/(N*T - N(M+1)]$$

where SSR_u is the residual sum of squares of the unrestricted model, and SSR_r is the sum of residuals for the restricted model that is to be tested, and M is the number of exogenous variables, N stands for the number of individuals and T the number of time periods included in the sample. To find the critical values for the F-statistic we look for the F distribution with (N-1)(M+1), N(T-M-1) degrees of freedom.

The interpretation of this coefficient is not clearcut. The (fixed) effect for each individual reflects the individual price level of an imported car. This coefficient is found to be heterogeneous for all models or companies included and the reason for this is the

different technical characteristics of each car that are included in its own price via this individual term.

1.b. common pass-through coefficients: the vector of exogeneous variables, x_{it}, is composed of four different time-varying variables different for the individuals: exchange rate changes (e_t), differential cost changes (w_{it}), import tariff changes (tar_{it}) and trade regime changes (ce_t). I concentrate on the pass-through coefficients, b_{it} and g_{it}, for the exchange rate and for the import tariff changes respectively and test the hypotheses of common slopes for each variable separately. The model to be tested can be expressed as,

$$p_{it} = a + b_i (e_t) + g_i (tar_{it}) + d (x'_{it}) + u_{it} \qquad (8)$$

where x'_{it} is now the set of all independent variables except for the exchange rate and the import tariff. With the unrestricted model (H_1: $b_1 \neq b_2 \neq ... \neq b_N$) and the pooled model ($H_2$: $b_1 = b_2 = ... = b_N$) I test the following hypotheses:

$$H_N: \quad b_1 = b_2 = ... = b_N$$

$$H'_N: \quad g_1 = g_2 = ... = g_N$$

against the alternative of heterogeneous slope coefficients.

The interpretation of these two coefficients is the focus of this Section. Recall equation (6) derived from a Betrand oligopoly model with product differentiation. All variables in the panels are taken in logs and both coefficients represent the pass-through elasticity with respect the exchange rate changes (b_i) and the import tariff changes (g_i). Both coefficients can be assumed to be homogeneous across units (when company analysis) and are heterogeneous across countries and models. Heterogeneity in these slope coefficients imply different pricing policies of each firm with respect the exchange rates and import tariffs. I propose several factors to explain the possible heterogeneity in the pricing policies: market structure, invoicing currency of the contracts, degree of product differentiation, objectives and planning horizon of the firm.

To find out whether we can pool all the models belonging to the different companies in one pooled time-series and cross-section model, we need first to test if all models have the same estimated parameters (a and b).

I test three different sources of heterogeneity in the pricing equations for each model:

1. *country -specific effect:* to test hypotheses that the country of origin of the imported good matters for the pass-through elasticity. *Mann* (1989) and *Feinberg* (1989, 1991) found that the country of origin of the good traded was important in explaning the pass-through elasticity. This country of origin specific effect implies basically two things in my specification:

(a) that *market structure* in the country of origin determines the type of (more or less) aggressive pricing policy of the firm in the export markets. I find that German producers, who face a very competitve environment in their own domestic market, tend to pass more of the exchange rate change than any other exporter. This coincides with other regularities found for German exporters in other more aggregate studies (Mann, 1989, Knetter, 1989 and 1991). This market structure effect is collected with a (fixed) effect and should be equal across destinations.

and, (b) the *invoicing currency of the contract*. Several empirical findings (Mann, 1989, Knetter, 1989, Feinberg, 1991) tend to affirm that US exporters tend to quote their contracts in their own currency (US$), whereas European producers quote their contracts more often in the destination market currency. This policy has strong implications for the pass-through elasticity. The currency of invoicing of the contract can be understood as a country-of-origin specific effect, i.e., one striking regularity found in the sample is that companies from the same country, do price in the same way.

2. *company -specific effect:* to account for the possibility that each company has a different pricing policy in the exporting markets. I allow for an unobserved individual effect for each company that accounts for different pricing rules depending on the company specific characteristics. If different companies, from the same country of origin, price in different ways the (almost) same good, and this pricing rule depends on the market share of the firm, then the pricing-to-the-market hypotheses would be totally confirmed. If, on the other hand, the company level analysis does not explain differences in the observed heterogeneous pricing policies, the pricing to the market hypotheses might be only of partial importance.

3. *model -specific effect:* to account for the fact that different models might receive a different marketing and pricing strategy depending on their age and other characteristics specific only to each particular model. This hypotheses has important limitations in my study since I am not introducing the (hedonic) technical characteristics of each type of car explicitly into the analysis. I collect the differentiation dimension in a (random or fixed) specific effect for each model, but the degree of differentiation is not well identified. Once, I collect the degree of substitution in a fixed effect I expect the slope coefficients (for the pass-through elasticities) to be the same across models if all models have the pricing policy. Be these slope coefficients different across units, this would give ground for a more detailed analysis based on the different segments of the market in each location.

Table 2: Homogeneity Hypothesis of the Pricing Equations' *Intercept* of each Model Imported, where the Critical Value for the F-statistic is $F_c=1.53$, with 120 Degrees of Freedom in the Denominator and œ in the Numerator, and the Null Hypothesis to Test is that of Equal Parameters.

indiv. eff.	country	RSS_u	RSS_r	F*	$H_N: a_1=...a_N$
country		32.114	32.127	0.0039	cannot reject
company	Germany	0.2323	0.2339	0.052	cannot reject
	Italy-Japan	24.7	29.38	1.60	reject
model	Germany	0.1936	0.2339	1.45	reject
	Italy-Japan	0.055	29.38	3951	reject

The first source of heterogeneity in the pricing policies for each model of car that I test is the country of origin of the imported model. In Table 2 the F value that I obtain is 0.0039, and we cannot reject the hypotheses that the estimated intercepts are the same across models when country of origin of the imported good is taken into account[10]. Based on Table 2, and on results obtained below, except for the German subsample when organised by companies, I conclude that the homogeneity of the common intercepts in the pricing equations of the individuals included in the panel is rejected in the majority of cases.

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[10]the panel estimation is shown in the Appendix.

5.1. Country specific effects

To test the hypotheses that country of origin of the imported good is important in explaining a possible difference in the pricing of the good, I estimate the model,

$$p_{it} = a_i + b(x'_{it}) + u_{it} \qquad (9)$$

where $i = 1,2,3$ and denotes the country of origin of the good. Equation (9) is the individual-mean model, where individual country-specific, a_i's, effects are allowed and model (9) with the restriction $a_1 = a_2 = a_3$, is the pooled regression. The vector x'_{it} collects all independent variables.

To test the hypotheses that companies belonging to different countries price equally each exported model I group all companies (i.e. models) by countries and introduce a specific fixed effect. Now the hypotheses concerns the slope coefficients of two variables: exchange rates and import tariffs. Hence, I am testing now if there is any country of origin effects concerning the different pass-through elasticities.

I estimate an unrestricted model where the individual slope coefficients are allowed to vary and a restricted (or pooled) model where all individual slopes are assumed to be the same across countries as

$$p_{it} = b_i(e_t) + g(x'_{it}) + u_{it} \qquad (10)$$

$$p_{it} = d_i(tar_{it}) + g(x'_{it}) + u_{it} \qquad (11)$$

In the next table I summarise the results for the hypotheses that all pass-through coefficients for the exchange rate (b_i) and for the import tariff changes (d_i) are equal across countries, $H_N: b_1 = b_2 = b_3$ and $H'_N: d_1 = d_2 = d_3$ in models (10) and (11), respectively.

If the Law of One Price were to hold, we expect the b_i coefficients to be close to zero and the import tariff coefficients, d_i, to be not significatively different than one. Furthermore, in perfect competition the individual (if by country or by company) effect should not be of any significance, that is, any exogeneous shock that might affect one producer, will affect *all* producers in the same way. The slope estimates, then, should be the same across individuals.

Table 3: Homogeneity Hypotheses for Country-of-origin Specific Effects (i=1,2,3 for Germany, Italy and Japan respectively) in the *Slope Coefficients* where SSR_u and SSR_r are the Residual Sum of Squared of the Unrestricted and the Restricted (Pooled) Models Respectively, and F* are the resulting F-values.

	SSR_u	SSR_r	N	T	F*	H_N
b_i	0.3472	0.3541	17	44	1.33	cannot rej.
d_i	0.3472	0.6611	17	44	9.04	reject

The critical values for the F-test can be found by approximation. I have an F distribution with (N-1)(K+1) in the numerator and (NT- N(K+1)) in the denominator, where N is the number of individuals (3), K is the number of regressors (5) and T the number of time periods (44), and the critical value for the $F_{12,\ 114}$ is 1.83. From this table we can conclude that there is no country-specific significant effect for the exchange rate pass-through (b_i) but there is a country of origin effect for the import tariff pass-through (d_i). By pooling the data we explain the same or a higher proportion of the exchange rate pass-through elasticities than by estimating the heterogeneous slopes model (both adjusted R^2 take the values $R^2_r = 0.81$ and $R^2_u = 0.65$). Based on the F-test, we reject the hypotheses of heterogeneous slopes for the pass-through relationship based on country specific effects, although for the import tariff pass-through some heterogeneity is present. In the next table I show the restricted and the unrestricted models for the case of exchange rate pass-through when heterogeneity is allowed and it is based on country effects

Table 4: Country Effects and the Exchange Rate Pass-through Elasticity. t-statistics in parenthesis .

	Individual effects	Pooled model
exchange rate	--	0.12 (3.5)
import tariff	0.78 (29.8)	0.78 (26.3)
cost differential	0.13 (6.2)	0.18 (9.1)
trade regime	-0.01 (-5.6)	-0.008 (-4.9)
b_1 *(Germany)*	0.27 (6.5)	--
b_2 *(Italy)*	-0.01 (-1.8)	--
R^2	0.82	0.81
SSR	0.34726	0.35410

The regressions explain the evolution of price differentials of imported models similarly. In the pooled regression, exchange rate changes are passed incompletely, only 12%, to the import domestic price differential, import tariffs are passed more completely (78%) and unit costs differential changes are passed partially also to the imported price (13% and 18% respectively). In the individual effects specification, German companies pass 27% of the change in the exchange rate and the Italian and Japanese firms pass a much smaller amount to the import price. Import tariff pass-through, 78%, is the same in both specifications. This result obtained in table 4 contradicts the homogeneity assumption accepted in table 3. I shall study these elasticities in more detail in next sections and we shall see the constancy of the pass-through elasticities throughout the different specifications proposed.

From tables 3 and 4, we can conclude that the way exchange rates and import tariffs are passed into import prices is different between the German goods and Italian and Japanese imports. Especially so for the import tariffs elasticity.

5.2. Company Specific Effects

In this section I test for heterogeneity in the pricing equations when the source of heterogeneity is the company, i.e. if different companies have different pricing policies in the destination market regarding exchange rates, variable costs and import tariffs.

I group all the individuals by companies, 6 for the German case, 3 Italian companies and one Japanese firm. In order to test for homogeneity hypotheses I test three different homogeneities: in the intercept of the pricing equation,

$$H^1_N: \quad a_1 = a_2 = \dots = a_K ,$$

in the exchange rate pass-through coefficients (slopes),

$$H^2_N: \quad b_1 = b_2 = \dots = b_K ,$$

and in the import tariff estimated coefficients,

$$H^3_N: \quad d_1 = d_2 = \dots = d_K$$

The two models to test, the unrestricted and the pooled models, can be expressed as

$$p_{it} = a_i + b_i (e_t) + d_i (tar_{it}) + g (x'_{it}) + u_{it} \qquad (12)$$

I estimate first model (12) including all car models in the sample and defining the units of observation as firms, $k=1...10$. Then I estimate the pooled regression model where no individual specific effects are included, i.e. with the restyriction that coefficients are the same across units. With the F-statistics I test the different hypotheses specified in H^1_N, H^2_N and H^3_N . In the next table I show the results obtained with the covariance estimator.

As we saw in equations (1) and (2) of Section 1 when we expressed the Law of One Price, the (constant) intercept term , a, reflects the barriers to trade that impede an instantaneous and complete price adjustment. This barriers to trade can be of different nature in each country and even for each company. If in the estimated equation (12), we find a significant intercept coefficient, a, this should not be evidence that the Law of One does not hold. If this coefficient is individual (i.e., company) specific, it is so probably because of the imperfect substitutability of the cars offered by one company and the reference (domestic) model. The focus of the analysis are the slope coefficients (b and d), which under perfect competition should be identical across companies.

Table 5: testing for homogeneity in the slope coefficients for the pass-through elasticity of exchange rates with respect to import prices in German imported cars when company effects are allowed in the estimation. t -statistics in parentheses

	Unrestricted	Pooled model
exchange rate	--	0.32 (7.2)
import tariff	0.71 (21.99)	0.71 (23.07)
cost differential	0.13 (6.22)	0.11 (5.44)
trade regime	-0.01 (-8.29)	-0.018 (-8.5)
b_1 *(BMW)*	0.30 (4.97)	
b_2 *(Mercedes)*	0.22 (2.35)	
b_3 *(Golf)*	0.37 (4.9)	
b_4 *(Audi)*	0.39 (5.18)	
b_5 *(Porsche)*	0.14 (1.54)	
R^2	0.85	0.85
$N*T$	390	390
SSR	0.2376	0.2364

For the German sample, in both specifications the same import tariff and similar costs differential elasticities are obtained, 71% and 11% and 13% respectively. A clear estimated parameter constancy is obtained also for the exchange rate pass-through when individual effects are included, except possibly for the case of Porsche. All German companies pass exchange rate changes incompletely into import prices, 30% for BMW, 22% for Mercedes, 37% for VW, 39% for Audi models and 14% for Porsche. The average pass-through elasticity is 29%, not significantly different from the pooled elasticity estimate, 32%, obtained for the combined German firms. From the R^2 and the sum of squared residuals it is apparent that no relevant information is lost when pooling all the German models in one sample.

Table 6: company effects in the pass-through (*slope*) elasticity (b_i) for the Italian and Japanese models when estimated with the covariance (individual-mean) and with the GLS (pooled model) estimators. t- statistics in parentheses

	Individual-mean model	**Pooled model**
exchange rate	--	0.18 (2.18)
import tariff	0.59 (7.2)	0.49 (5.2)
cost differential	-0.003 (-0.04)	-0.03 (-0.41)
trade regime	0.007 (1.11)	-0.001 (-0.20)
b_7 *(Fiat)*	-0.006 (-0.97)	
b_8 *(Lancia)*	0.028 (3.2)	
b_9 *(Alfa)*	0.03 (2.5)	
R^2	0.47	0.43
*N*T*	149	145
SSR	0.1515	0.15804

For the Italian and Japanese models more heterogeneity is present in the estimated pricing equation. The import tariff and the exchange rate pass-through elasticities change significantly if the estimation is done with individual effects. 59% of the import tariff changes are passed into import prices and an average of 3% of the exchange rate changes is passed into the price when individual effects are allowed. But when pooling the individuals, the exchange rate pass-through changes significantly, to 18%. The lower size of the Italian and the Japanese sample and the existence of quotas for Japanese cars can make difficult to make inferences in this sample. Import tariff pass-through is not significantly different in both specifications, but exchange rate pass-through is. I test in the next section for the causes of this parameter variation. The first conclusion to draw is

that pricing policies are more heterogeneous within the Italian and the Japanese models than within the German models imported in Spain.

Table 7: F-test for homogeneity of estimated *slope* coefficients for the pass-through elasticities of exchange rates, b_i and import tariff changes, d_i, respectively when company-specific effects are included.

	H_N: $b_1 = b_2 =... = b_k$	H_N: $d_1 = d_2 =...= d_k$
German models	$F^*= 0.019$ (cannot reject)	$F^*= 2.8$ (reject)
Italian-Japan. models	$F^*= 0.32$ (cannot reject)	$F^*= 1.22$ (reject)

With the F- test we are comparing the sum of squared residuals in the restricted and the unrestricted models and this gives us the within-group heterogeneity in the pricing equations' slopes, i.e. the heterogeneity within each group. In Table 7, after taking care of the company effects on the slope coefficients of the pass-through relationship we can accept (i.e. not reject) the hypotheses of common exchange rate pass-through slopes for the German, Italian and Japanese models, but we reject that hypotheses for the import tariff price- elasticities for all the models and companies of the sample. For the Italian and Japanese case the F value is on the borderline of acceptance/rejection of the null hypotheses (critical value for the F (49, 222), by approximation, is 1.30 and our F value is 1.22).

From tables 6, 7 and 8 another important finding comes clear: the way the unit (real) unit costs differential affects the import price is different among countries. All German models have a positive price elasticity with respect the (unit) costs, i.e., an increase in the German costs relative to the Spanish production costs, w= Gw- Sw, is translated into a higher destination currency price for the German product sold in Spain. This finding holds also when model effects are introduced. But for Italian and Japanese cars the coefficient for the relative costs is negative: they seem to follow more closely Spanish unit costs than their own costs schedules. This evidence for pricing to the market by Italian and Japanese companies will be reinforced when mark-up absorption is studied. German products show a high pass-through elasticity, reatively high market share in total imports and to follow more closely their own production costs.

5.3. Model Specific Effects

In next table I show the results for the covariance estimator of the individual and pooled model to test hypotheses if different pricing policies exist and if they are due to differences in the characteristics of the models imported or to the models belonging to different companies and each having a different market power.

Table 8: test for homogeneity of the pass-through (slope) elasticity coefficients when model specific effects are introduced for the case of the German models imported. t-statistic in parentheses.

	Individual-mean model	Pooled model
exchange rate		0.32 (7.2)
import tariff	0.70 (21.2)	0.71 (23.07)
cost differential	0.13 (6.1)	0.11 (5.14)
trade regime	-0.01 (-8.2)	-0.018 (-8.5)
b_1 *(BMW318)*	0.37 (3.7)	
b_2 *(BMW520)*	0.19 (2.01)	
b_3 *(BMW730)*	0.35 (3.7)	
b_4 *(M200)*	0.22 (2.3)	
b_5 *(Golf)*	0.34 (3.4)	
b_6 *(GTI)*	0.41 (4.2)	
b_7 *(Audi 8)*	0.35 (3.6)	
b_8 *(Audi 1)*	0.45 (4.4)	
b_9 *(Porsche)*	0.14 (1.5)	
R^2	0.85	0.85
$N*T$	390	390
SSR	0.23546	0.23641

For the German cars, the exchange rate pass-through is very similar for all products once the individual model characteristics have been taken into the fixed effects term. From table 8 and 10, we cannot reject the hypotheses of homogeneous pass-through for German models imported in Spain. One model, Porsche 911 cc, has a lower pass-through (14%) than the others.

Table 9: individual effects in the Italian and Japanese sample when model-specific time-invariant effects are allowed; t -statistics in parentheses.

	Individual-mean model	Pooled model
exchange rate	--	0.18 (2.1)
import tariff	0.70 (7.3)	0.49 (5.2)

unit cost	0.05 (0.63)	-0.03 (-0.41)
trade regime	0.008 (1.25)	-0.001 (-0.20)
b_{11} *(Fiat Estate)*	-0.03 (-3.3)	
b_{12} *(Fiat Uno60)*	-0.004 (-0.39)	
b_{13} *(Fiat Regata)*	-0.0003 (-0.03)	
b_{14} *(Y10)*	0.016 (1.2)	
b_{15} *(Thema2)*	0.012 (0.99)	
b_{16} *(Alfa33)*	0.018 (1.5)	
R^2	0.46	0.43
$N*T$	149	145
SSR	0.149645	0.14804

The Italian sample has an interesting feature: the pass-through is low and with the expected sign (a negative pass-through for the Italian case because the exchange rate was defined inversely: number of Italian Lire/ one unit of Peseta), but for three models, Lancia Y10, Lancia Thema 2.0 and Alfa 33, 1.3, the pass-through has the wrong sign. First, based on the magnitude of the estimated coefficients, *the pass-through is very low, if significative, for all Italian models.* Second, some models exhibit the perverse pass-through. Italian market shares in the Spanish market are lower in all cases than for German companies and have not increased over time significantly. And third, Italian pricing rules follow more closely Spanish production costs that Italian costs. The Italian companies are pricing to the market. One rationale for the behavior of Italian and Japanese firms might be the one offered by Kirman and Schueller (1990): due to the different strategic roles assumed by a company in its own market (the leading role) and in the destination market (a follower role), the pricing decisions are different. This argument, though, does not seem to apply to the case of German imports.

Table 10: F- tests for the homogeneity hypotheses of equal pass-through elasticities of exchange rate changes, b_i, and import tariff changes, d_i, among the different imported models when individual *slope* heterogeneity is allowed

	H_N: $b_1 = b_2 =...$ b_N	H_N: $d_1 = d_2... = d_N$
German models	F*= 0.01 (cannot reject)	F*= 1.17 (cannot reject)
Italian-Japanese models	F*= 0.042 (cannot reject)	F*= 0.086 (cannot reject)

From the results in Table 11 we see how the elasticities do not differ when company or model specific effects are included. Only when a pooled model is estimated and the individuals are grouped by countries, the elasticities for the Italian and the Japanese imports differ significantly from those obtained when company effects were

estimated. This might be due to the fact that by pooling all the models in the country-estimation (the first row in Table 11), the high import tariff elasticitiy of the German models affect also in upgrading the elasticities for the Italian and the Japanese models, which in all other estimations done are always lower in magnitude and in significance than the German tariff pass-through elasticity.

Table 11: exchange rate (e_e) and import tariff (e_{tar}) estimated intra-groups pass-through elasticities (in %) when *slope heterogeneity* and different individual effects are allowed: (1) country effect, (2) company effect and (3) model effect (source: Tables 3, 4, 5, 7, 8).

	German sample		Italian and Japanese sample	
	e_e	e_{tar}	e_e	e_{tar}
by countries	27	78	1	78
by companies	32	71	18	49
by models	32	71	18	49

In table 11 several results of this Section are gathered. The import tariff- and the exchange rate- pass-through is similar for the German imports, no matter if we group them by country, by company or we compare these with the individual mean estimates. Much higher import tariff (78% for the German and 49% for the Italian and Japanese) than exchange rate pass-through (32% and 18%, respectively), although more variability in the pass-through estimates is obtained in the Italian and Japanese sample depending on the method of estimation and on the relevant individual effect estimated.

5.4. Within-groups Pass-through Elasticities: Company Level Panel Analysis

The entire sample of imported cars has been divided in one sample for each company, except for those cases where one company has exported only one model of car. I compare the two estimators: the covariance and the GLS estimators. With the F-statistic the hypotheses of homogeneity is tested and the results are summarised in Table 17. From these results it is apparent that two companies, Volkswagen and Fiat, price each exported model differently.

Table 17: homogeneity hypotheses of equation *intercepts* tested within groups (companies) with respect the different characteristics of each model, where the F-critical value is $F(15, 60) = 1.75$. RSS_u and RSS_r are the residual sum of squares of the unrestricted and the restricted models, respectively.

indiv. firm	RSS$_u$	RSS$_r$	F*	H$_N$: g$_1$ =... = g$_N$
BMW	0.0922	0.1408	0.35	cannot reject
VW	0.0204	0.0304	5.25	reject
Audi	0.0220	0.0231	0.56	cannot reject
Fiat	0.0467	20.33	2916	reject
Lancia	0.00016	0.00017	0.65	cannot reject

In next Table I present the intra-group elasticities, i.e.coefficients estimated individually and separately for each exporting company. The exchange rate pass-through coefficients should be negative for the Italian firms since the exchange rate for these imports has been defined as (Lira/Pesetas).

Table 18: intra-groups (firms) estimated pass-through elasticities (in %) of exchange rate changes, b$_i$, on the import price charged by each company, where N is the number of different models exported by the firm included in the sample.

	b$_i$ (CV)	b$_i$ (GLS)	N
Volkswagen	29	28	2
BMW	58	53	3
Opel	24		1
Audi	32	28	2
Porsche	12		1
Mercedes	23		1
Fiat	3	-18	3
Lancia	0.8	0.2	2

From Table 18, when comparing both estimators for the German models, we obtain similar pass-through elasticities in magnitudes. An estimated exchange rate pass-through elasticity of 12% for the Porsche company, the lowest, to an estimated elasticity of 58% for BMW when these coefficients are estimated independently for each company. The import tariff pass-through elasticities, in Table 19 are significantly higher, 45% for the BMW and 95% for the Porsche company and show constancy when any of the two estimation methods is used.

Table 19: intra-groups estimated pass-through elasticity of the import price with respect the import tariff changes, d$_i$.

	d$_i$ (CV)	d$_i$ (GLS)	N
Volkswagen	60	60	2
BMW	45	45	3
Opel	75		1
Audi	78	78	2
Porsche	95		1
Mercedes	78		1
Fiat	45	65	3
Lancia	98	97	2

Table 20: individual OLS estimations for the exchange rate, import tariff and cost pass-through elasticities for three German companies: Mercedes, Opel and Porsche.

	Mercedes	Opel	Porsche
exchange rate	0.23	0.24	0.12
	(1.87)	(2.01)	(0.94)
import tariff	0.78	0.75	0.95
	(7.5)	(7.3)	(9.32)
unit cost diff	-0.10	-0.12	-0.13
	(-1.74)	(-2.07)	(-1.71)
ce	-0.014	-0.016	-0.012
	(-2.6)	(-2.84)	(-2.05)
R^2	0.83	0.87	0.80
SSR	0.0149	0.0155	0.0162
DW	0.65	0.73	0.69
N	39	34	39

The fact that exchange rate elasticities are less than 1 in all cases considered together with the fact that unit costs pass-through is very small in magnitude, and even negative in some cases, lead me to think that there is evidence of *pricing to the market* in the automobile imports. Perfect pricing to the market would imply an estimated coefficient for the exchange rate pass-through, and for variable costs, not significantly different than zero. And, the other extreme case, perfect pass-through, would imply an estimated coefficient for the exchange rate changes equal to one. Throughout all the cases considered the estimated elasticities are always of intermediate magnitudes, except for the unit costs pass-through that is not significantly different from zero in several cases, i.e. in Tables 12 and 14 for the Italian and Japanese sample. Import tariff changes, on the other

hand, have been passed almost completely to the final import price. The fact that exchange rate pass-through is present but incomplete and that differences in the pricing equations are better explained by the country of origin of the good for the German cars and mostly by model specific effects leads me to conclude that the heterogeneity in the pricing equations is better explained by the degree of product differentiation of the models imported (as collected by the intercept terms) and by the invoicing currency of the contracts. In Graph 2.b I have drawn the heterogeneity obtained in the estimation procedure. In the vertical axis I have drawn the final destination (import) price in the destination market currency (Pesetas) and in the horizontal axis is the real exchange rate. The 45 degrees line shows the case of perfect pass-through, i.e. any change in the exchange rate (e_t) will be passed on completely to the final (import) price (p_{it}); this would be the estimated price equation if perfect competition was the case. My estimations on the slope coefficients for the pricing equation show a pass-through elasticity of exchange rates bigger then zero but smaller then one in magnitude and equal among models and companies but different among countries. This incomplete pass-through is drawn in the (estimated) lines p and p*. The invoicing currency of the contract can rotate the pricing equation clockwise: if the German exporter quotes its contracts in the destination market currency (Pesetas), when the exchange rate changes final demand (in real pesetas) does not change and hence the equilibrium price in the destination market should not vary. The fact that the firm is invoicing the contracts in the destination market currency implies, ceteris paribus, a rotation of the 45 degrees line (or full pass-through schedule) to the right, as we can see in Graph 2.b when we move from the 45 line to the p-schedule. The firm will find optimal to reduce the quantity shipped to the destination market and this could lower the industry price, but this is a possible second order effect. Whereas if the German exporter quotes its prices in DM, any change in the bilateral (peseta/DM) exchange rate will be directly translated into the final imported price, and the estimated price equation should look more like the Full pass-through schedule.

Graph 2.b: heterogeneous pricing intercepts
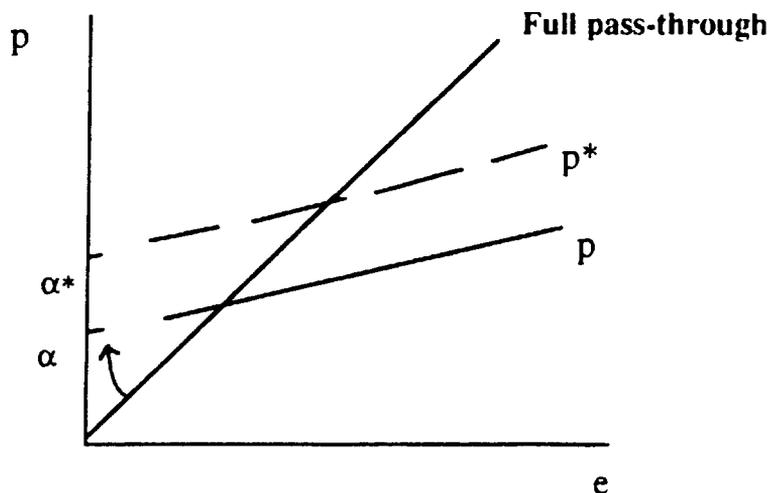
The heterogeneity in the pricing equations intercepts, a_i , and homogeneity in the slope coefficients (b_i) imply the same response of that particular model of car to any exogenous exchange rate change but a different price level. This is due partially to factors not included in my study, as the importance of foreign inputs in the production process of each model, to the distribution network and mark-ups associated with it in the final price or to technical characteristics of the cars.

Table 21: individual model effects in the BMW sample

variable	b_i (CV)	b_i (GLS)
constant	- -	0.59
		(9.10)
exchange rate	0.58	0.53
	(5.76)	(5.5)
import tariff	0.45	0.45
	(6.5)	(7.07)
unit cost diff	0.03	0.15
	(0.66)	(2.54)
ce	-0.03	-0.06
	(-5.3)	(-6.54)
BMW 318i	0.01	-0.27
	. (1.72)	(-8.6)
BMW 520	0.01	-0.18
	(1.72)	(-8.6)
R²	**0.74**	**0.98**
SSR	**0.0976**	**0.0869**
DW	**0.71**	**0.82**
N*T (df)	**117 (108)**	**117 (110)**
F - test		**1124.1**

For the BMW, Audi and Volkswagen companies, the pass-through elasticities show constancy across the two methods of estimation applied. Audi and VW show very similar pass-through elasticities with respect exchange rate, import tariff and unit cost changes. Some estimated coefficients change signs when the GLS method is applied. BMW seems to pass more the exchange rate changes than VW or Audi do and BMW follows German labour costs while the others follow the destination market costs, evidence that is in accordance with the invoicing currency of BMW being the destination market currency and having no concern for market share. The lack of close substitutes for the BMW models in the destination market might also have a direct influence in the size of the pass-through elasticity.

Table 22: fixed effects for VW sample

variable	b_i (CV)	b_i (GLS)
constant	--	0.24
		(6.7)
exchange rate	0.29	0.28
	(3.5)	(3.4)
import tariff	0.60	0.60
	(8.4)	(8.5)
unit cost diff	-0.27	-0.24
	(-6.02)	(-4.5)
ce	-0.018	-0.02
	(-3.6)	(-3.03)
Golf GTI	0.001	-0.04
	(0.42)	(-5.9)
R^2	0.93	0.95
SSR	0.0283	0.0279
DW	1.09	1.10
N*T (df)	78 (71)	78 (72)
F- test		322.1

Table 23: fixed effects for Audi subsample (2 models), group estimator

variable	b_i(CV)	b_i(GLS)
constant	--	0.22
		(4.7)
exchange rate	0.32	0.28
	(3.34)	(3.14)
import tariff	0.78	0.78
	(12.8)	(13.5)
unit cost diff	-0.11	-0.03
	(-2.6)	(-0.79)
ce	-0.02	-0.03
	(-4.14)	(-4.7)
Audi 100	0.004	-0.02
	(1.08)	(-3.15)
R^2	0.93	0.96
SSR	0.0286	0.026

DW	0.84	0.93
N*T (df)	78 (71)	78 (72)
F -test		412.5

Table 24: effects for Fiat subsample (3 models)

variable	b_i (CV)	b_i (GLS)
constant	--	0.07
		(0.22)
exchange rate	0.036	-0.18
	(0.23)	(-0.62)
import tariff	0.45	0.65
	(2.4)	(2.22)
unit cost diff	-0.47	-0.60
	(-1.66)	(-1.9)
ce	-0.006	-0.02
	(-0.32)	(-0.83)
Fiat Uno	0.004	-1.53
	(0.42)	(-40.7)
Regata	0.014	-0.06
	(1.28)	(-1.65)
R^2	0.16	0.99
SSR	0.0818	0.0807
DW	0.48	0.52
N*T (df)	64 (55)	64 (57)
F -test		4216.7

For the Fiat subsample, as I concluded from Tables 8 and 12, the individual specific effects are significantly different for each model.

Table 25: fixed effects for subsample Lancia (2 models)

variable	b_i (CV)	b_i (GLS)
constant	--	-0.009
		(-0.46)
exchange rate	-0.008	0.002
	(-0.9)	(0.18)
import tariff	0.98	0.97
	(91.4)	(68.9)
unit cost diff	0.03	0.04
	(2.8)	(2.69)
ce	-0.001	-0.002
	(-1.6)	(-0.19)
Thema 2.0	-0.0	-0.011
	(-0.26)	(-1.46)
R^2	0.99	0.99
SSR	0.00013	0.0001
DW	2.38	2.39
N*T (df)	68 (41)	48 (40)
F-test		229436

This company level analysis allows for a distinction that could not be stated before: all German companies, as well as the Italian and Japanese ones, except for BMW, follow Spanish labour costs rather than German costs in their pricing decisions. Even though our measure of real labour costs is a gross proxy for the automobile industry real variable costs, the results obtained when individual model effects were included lead to one conclusion: there is *pricing to the market* in the automobile industry. The fact that exchange rate pass-through is high for all German models and that they seem to follow closely Spanish costs, suggests that German exporters quote their contracts in DM (domestic market currency), so that in the short run, exchange rate pass-through is very significative. But the fact that German unit costs are not a clear determinant of the price differential and the evolution of German market share in the Spanish market indicate that their objective is market share, rather than period by period profit maximization. That German exporters in Spain do enjoy some market power is clear when looking at the estimated pass-through elasticities. If they were competing in perfect competition, pass-through of any individual model would be close to zero, as is the case for the Italian and Japanese imports[11].

The case of Italian and Japanese exporters is different: the pass-through elasticities are relatively small in magnitude and in significance, in some cases close to zero. They follow also Spanish costs rather than domestic costs, which indicates that they do not enjoy market power. In fact, the Italian cars imported in Spain pertain to the small cars segment, where competition is fierce and product differentiation is not so crucial. Hence, pricing to the market also for Italian and Japanese cars, due, this time, to a low market power.

From the results presented so far we can also conclude that exchange rate changes have not been passed on completely in to domestic prices, as any model of imperfect competition a la Cournot would predict. One reason why exchange rate pass-through is incomplete could be the expectations horizon of the firms. In order to allow for the lag-effects of exchange rate fluctuations, I have estimated the same relationship as in (7) allowing for lagged exchange rate values. But the results, reported in the Appendix[12], show no special significance of the lag structure (up to eight quarters).

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[11]in the Appendix (A.2) two methods estimators are compared, the covariance and the Generalized Least Square (GLS) pooled estimators. Results are very similar to those reported in this Section.

[12]Appendix, Section A.3.

6. Mark-up Adjustment by Individual Exporters when Exchange Rate Changes

When exchange rate fluctuations are perceived by the exporter as being only temporary, its size not being very important or the market structure is competitive, several authors (Mann, 1986, Dornbusch, 1987, Giovannini, 1987, Baldwin, 1987, Kollintzas, 1990, Knetter, 1989, 1992, Fischer, 1991) have proposed different explanations of why the pass-through elasticity should be incomplete based on the idea that the exporter will absorb changes in the exchange rate in its mark-up in the destination market. *Knetter* (19991,1993) finds some evidence for this in a study with industry-aggregated data for German and Japanese exports to the US. *Mann* (1989), at even more aggregated trade data explains the pass-through behaviour in the US during the 1980' s, and a structural break in the sample, based on the hypotheses of mark-up absorption. Similar conclusions were reached by *Baldwin* (1988) and *Baldwin and Krugman* (1988) for a US sample for the hysteresis hypothesis. They suggest that the hysteresis effect implies a structural break in the pass-through equation. *Klemperer and Froot* (1989) propose a model of low pass-through based on the idea that past market share matters, even when the empirical part of the paper does not give strong support for the hypothesis. In the following we examine the hypothesis of mark-up absorption at the individual product-level in the automobile trade sample constructed for Spain.

6. 1. The model to estimate

When exchange rate changes, an exporter faces two different effects: (a) the cost effect, and (b) the marginal revenue shift effect. They are depicted in Graph 6 and 7 respectively.

In the *cost effect*, the (German) exporter to the US produces the good in Germany with DM denominated costs. If we graph these costs in German currency units and assume that initially all firms in the industry, the US and the German firms respectively, have the same marginal costs of production, at the level depicted as mc, the industry equilibrium is given by equating marginal costs to marginal revenues. Since the exporters are facing the residual demand, A-S, they will produce x at price p in equilibrium. Once the (DM/$) exchange rate decreases, i.e. the dollar devalues vis a vis the DM, the costs in DM of the German producers increase with respect the costs of the US rivals (expressed in a common currency). Hence a shift in the cost schedule of the

foreign producers, from mc to mc*. With higher costs, and facing a more elastic (residual) demand schedule, the exporters will be able to pass only partially the increment in costs due to the exchange rate appreciation. They will absorb most of the change in the costs in reduced mark-ups. When the change in the import price (in foreign currency units) is equal to the change in the cost level (induced by the change in the exchange rate), there is *full pass-through* and the mark-up remains constant. Whenever this change in the import price is lower than the change in the costs, we say there is *incomplete pass-through*, in which case part of the change in the exchange rate (and in the costs structure) is absorbed by the mark-up of the individual exporter. The shape of the residual demand, and hence the explanation of the size of the pass-through relationship, is given by factors such as market structure, degree of substitutability among the varieties in trade, and barriers to trade.

Graph 6: price adjustment to an exchange rate induced cost shift
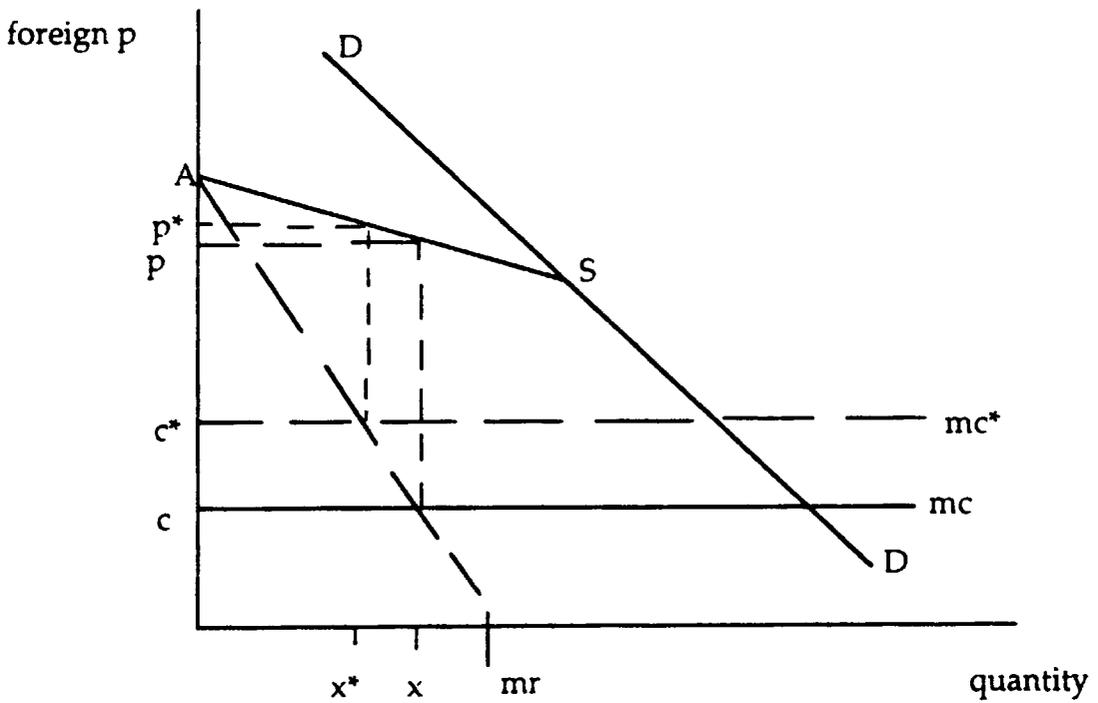
The *marginal revenue effect* works in a similar way. Total US demand expressed in US$ is p(x), and the demand expressed in DM is given by (p*(x) e). Once the exchange rate devalues (decreases), total demand, and so residual demand, decreases. Hence the shift in the residual demand schedule from A-S to B -S*. After the devaluation each exporter will equate marginal revenue to marginal costs in the destination market.

Each German firm will export x* at the price p* to the US. The individual mark-up decreases, as seen by the difference, (p-c) < (p*-c).

Graph 7: the pass-through relationship and mark-up adjustment when residual demand shifts
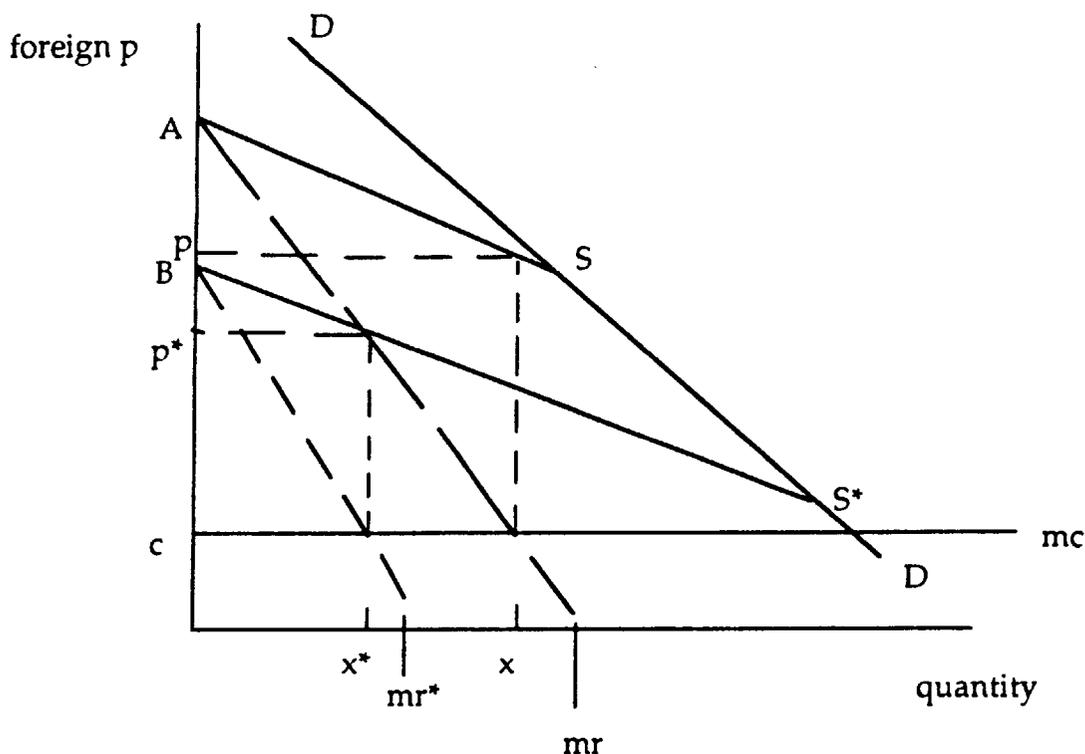
I propose to estimate a simple oligopoly long-run equilibrium relationship in which the steady state solution for the representative exporter depends on the following variables:

$$p_{i,t} = p (w^*_{i,t}, \text{tariff}_{ti}, e_t, p_{i,t-i}, D_{it}) \qquad (20)$$

that is, the Nash-Bertrand equilibrium in any given period t depends on the average price charged by the rivals, $p_{j,t}$, on the average costs of the producer (i.e. the exporter) in its own domestic currency, $w^*_{i,t}$, on the tariff rate tariff_{ti} of the particular model, the exchange rate e_t and on the history of past prices by the producer, $p_{i,t-i}$. I include also a set of dummy variables D_{it} that will collect changes in the trade regime occurred in the destination market. As *Knetter* (1989) pointed out, exchange rate changes can affect an individual exporter in two ways: (1) via the cost schedule: a devaluation of the exporters domestic currency implies a lowering of its production average costs and hence an increase in its mark up, and via (2) marginal revenues, since the exporter receives the

income in foreign currency, an appreciation of the destination market currency implies an increase in the marginal revenues from selling the product. We are taking care of the first effect, i.e. the effect that exchange rate changes have on the *relative* average production costs of the exporter vis a vis the domestic competitors.

We define the mark-up for the exporter i as

$$(p_{i,t} - tar_{i,t} - w^*_{i,t}) = \text{mark- up},$$

where $p_{i,t}$ is expressed in nominal terms and $w^*_{i,t}$ is an index of hourly monthly earnings in the manufacturing sector (quarterly data as provided by the OCDE Monthly Report). Since we want to focus on the relative costs of the producer in its domestic market, we can express the average costs in terms of its domestic currency as,

$$[(P_{i,t} - tar_{it})/wpi) - w^* e_t (1/wpi^*)] = \text{real mark-up}$$

where now the costs are expressed in the producers (i.e. German) purchasing power units (in real terms, since we divided the cost index by the wholesale price index (wpi*) of the exporters country). Since the price of the i-th model of car is also expressed in real terms (in terms of the destination market purchasing power units), we are measuring the real mark-up of the exporter. The next graph shows the evolution of this measure of mark-up for selected models of cars[13]

Evolution of the real mark-up of the models BMW 520, VW Golf GTI and Opel Kadett, 1981:1-1991:4

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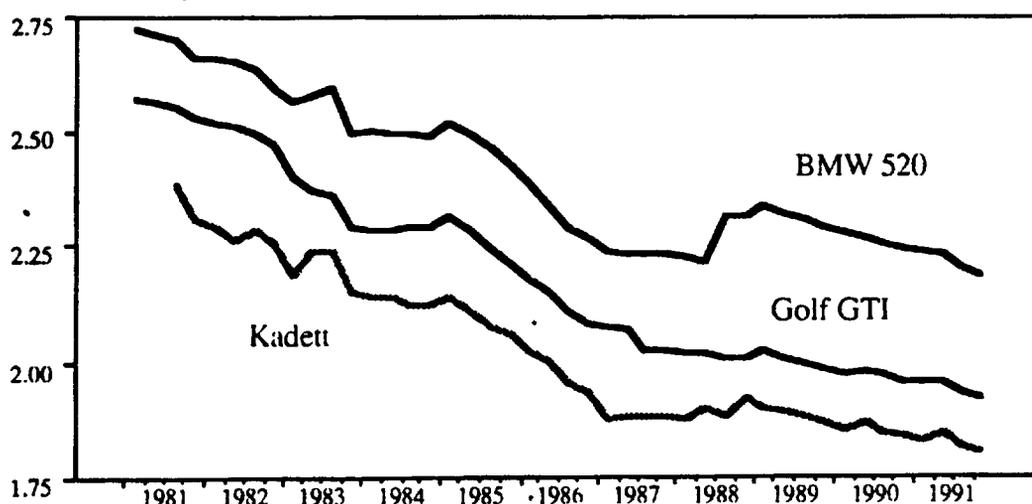
[13]in the Appendix the mark-up for additional models is showed. All mark-ups present a a very similar downwards pattern.

The second term in the left hand side of the mark-up equation reflects the labour costs of producer i in its own country's currency, w*, that reflects better the volatility of German unit costs due to exchange rate and price level changes. In the next graph I plot the German unit labour costs index as given by the OCDE Monthly Statistics (Gw) and the real unit costs expressed in the producer's currency (w*).

Evolution of the real labour unit costs (Gw) and the costs expressed
in real DM (w*), Source OCDE Monthly and Banco de Espana
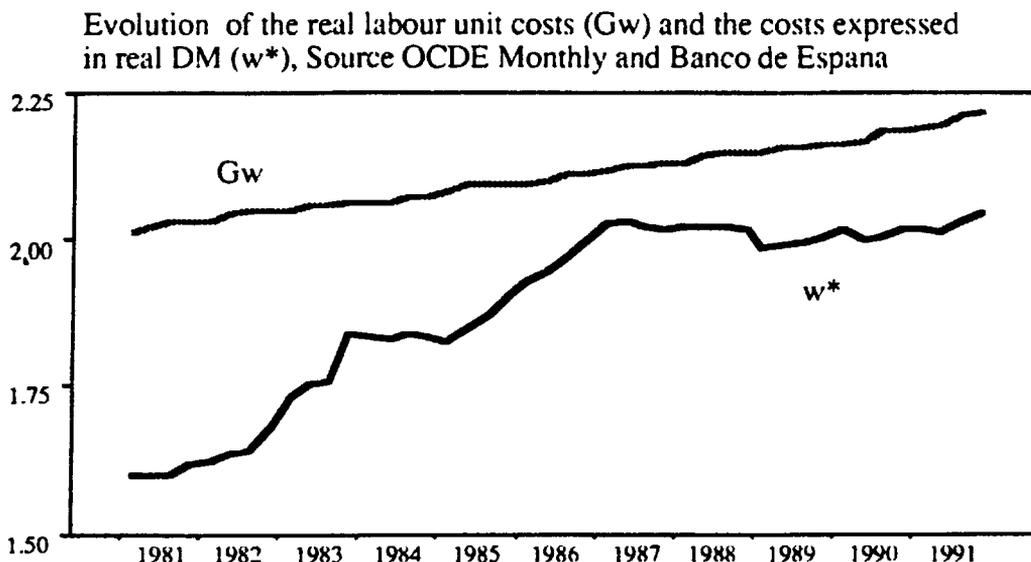
6.2. Intra-groups Estimated Adjustment

Individual mark-ups have a continuous downward trend along the ten years studied. In the next graph it is depicted the first difference of the mark-up for one German model, Golf GTI, and the evolution of the rates of change of the real (ptas/DM) exchange rate. From this graph we can see how the mark-up and the exchange rate changes move in opposite and symmetric directions for the two major exchange rate fluctuations of the exchange rate occurred during the period 1981-1991. First, during 1982:1 - 1984:1 the peseta devalued vis-a-vis the DM, the Lira and the Yen. This devaluation should have a depressing effect on the individual mark-ups. In the next graph we can see how during this period the mark-up for the Golf GTI (as well as for the rest of the models) declines sharply during 1982:2- 1984:1. Another (real) devaluation of the destination market currency (i.e.the peseta) happened during 1985:1- 1987:2, and again we can see in the graph how the mark-up show a clear decline in that same period 1985:1- 1987:3. A strong appreciation of the peseta took place right afterwards, during the period 1987:3- 1991:4 which, for constant destination market prices in the short run, should imply an increase in the individual mark-ups. As can be seen this clearly happens for the short period 1987:3-1989:2.

Evolution of the change in the real (ptas/DM) exchange rate and the
rate of change of the mark-up for the VW Golf GTI, 1981:1-1991:4
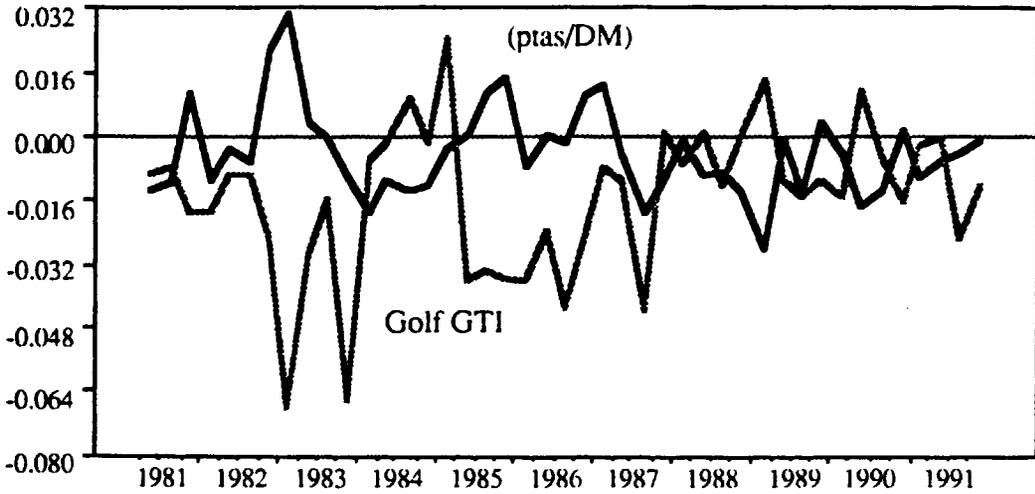
The symmetric and opposite movement in exchange rate changes and mark-up changes happens for all German and Italian models considered[14]. As examples I next plot the evolution of both variables in first differences for one additional German (BMW 520) and one Italian model (Lancia Y10 Fire).

Evolution of the changes in the real exchange rate and changes in the
real mark-up for the model BMW 520, 1981:1-1991:4

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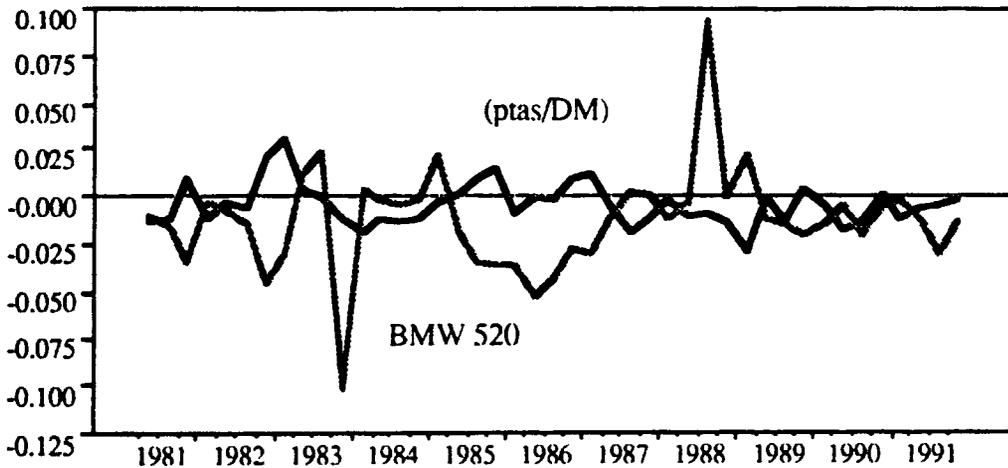
[14] in the Appendix I show the graphs for the models Mercedes 200, BMW 318i, BMW 730, Opel Kadett and Fiat Uno 60S.

Evolution of changes in real exchange rate and the real mark-up for
the model Lancia Y10, 1981:1-1991:4
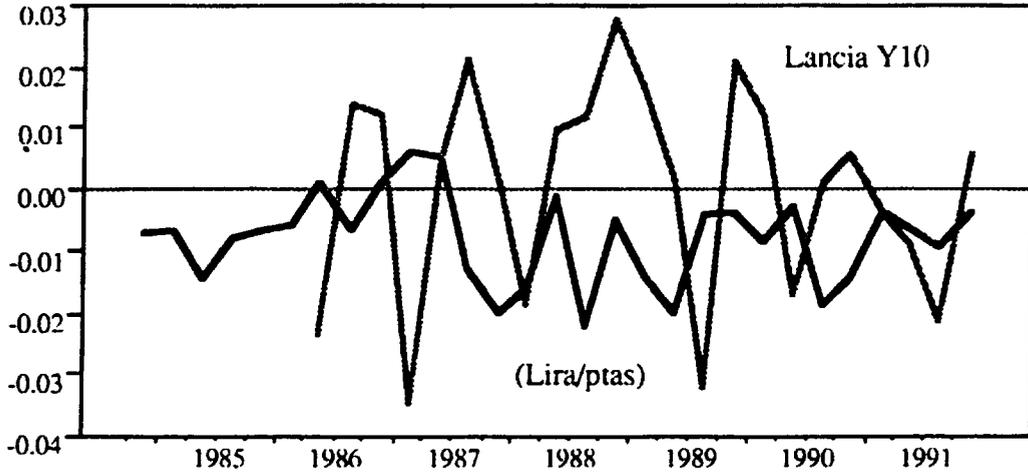
The graph of the mark-up for any of the cars imported shows a clear downward
trend along the sample period. Since the mark-up responds in each model (i.e or firm) to
changes in the environment, I propose to introduce a term, $m_{i,t-1}$, which tries to capture
the dynamic response of the individual mark-up to changes in the exogenous variables.

I estimate a model of mark-up adjustment where it is assumed that exchange rate
and import tariff changes are exogenous to the firm, as

$$m_{it} = a_i + b_{it} (e_t) + g_1 (ce_{t-1}) + g_2 (swpi_t) + g_3 (m_{i,t-1}) + u_{it} \qquad (21)$$

where m_{it} is the real mark-up for product i at time t

e_t is the bilateral exchange rate in time t

$swpi_t$ is the Spanish wholesale price index

ce_{t-1} is the change in the trade regime (entrance of Spain in the EU)

$m_{i,t-1}$ is the individual mark-up in the previous period, t-1

u_{it} is the error term

Equation (21) is an expression for the system of N-equations to be estimated as a
combined cross-section and time series panel analysis. I shall allow and test parameter
homogeneity in the intercept, a_i, and in the exchange rate coefficients, b_i, across units,
and impose time constancy of the estimated parameters.

Table 2.1: the random effects estimator (GLS) and the pooled model estimation of mark
up adjustment in all the models of the sample when country specific effects are taken into
account.

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	b$_i$ (GLS)	**b (Pooled model)**
constant	0.67 (16.8)	--
exchange rate	--	-0.28 (-6.4)
trade regime	-0.02 (-9.3)	-0.002 (-0.78)
Swpi	-0.73 (-21.8)	-0.28 (-6.3)
mark-up (t-1)	0.53 (26.5)	-0.79 (41.3)
country 1 (Germany)	-0.54 (-22.8)	
country 2 (Italy)	0.0	
R^2	0.99	0.92
DW	2.2	1.96
NT (deg. freedom)	427 (422)	583 (562)
SSR	0.05826	0.72835

Table 2.2: Fixed vs. Random effects when (5) company-specific effects are included in the German sample and slope heterogeneity is allowed

	b$_i$ (CV)	**b$_i$ (GLS)**
constant	--	-0.014 (-0.38)
exchange rate (common)	--	--
trade regime	-0.012 (-10.2)	-0.015 (-4.5)
Swpi	-0.48 (-13.6)	-0.11 (-4.12)
Mark-up (t-1)	0.69 (36.3)	0.84 (38.1)
BMW	-0.36 (-11.5)	-0.02 (-2.6)
Mercedes	-0.36 (-8.0)	-0.02 (-2.12)
Volkswagen	-0.36 (-10.2)	-0.02 (-2.8)
Audi	-0.36 (-10.3)	-0.02 (-2.5)
Porsche	-0.36 (-8.0)	-0.019 (-1.77)
R^2	0.99	0.98
DW	1.78	1.61
NT (deg. freedom)	427 (409)	427 (418)
SSR	0.086776	0.12746

For the estimated slope coefficients of the adjustment equation for each German company (BMW, Mercedes, VW, Audi and Porsche), i.e. a coefficient of -0.36 implies a reduction of 36% in the mark-up of the exporter in its own currency due to a one percent devaluation in the bilateral exchange rate. The equality of the slope coefficients in the German case when company specific effects are allowed is evident and it supports the hypotheses, tested earlier, that the pricing policies among German firms are very similar,

and in turn, the effects of exogenous exchange rate changes on the mark-up is very homogeneous.

The same homogeneity of slope coefficients with respect the exchange rate changes occurs in German sample when model-specific individual time-invariant effects are allowed in the estimation[15]. Hence, we can conclude that exogenous exchange rate changes have very similar effects, in sign and in magnitude, across all companies and models of cars imported from Germany.

For the Italian and the Japanese case, higher variability in the estimated coefficients is obtained, but the main conclusion still holds: the estimated coefficient of exchange rate and its effects on the mark-up adjustment is not significatively different for any company or model considered in the sample, if we divide the units by countries.

Table 2.3: the covariance and the GLS estimators for individual specific firm effects.

	b_i (CV)	b_i (GLS)
constant	--	-0.63 (-2.3)
exchange rate (common)	--	--
trade regime	0.015 (1.81)	-0.01 (-0.82)
SWPI	0.016 (0.19)	0.09 (0.69)
Mark-up (t-1)	0.50 (10.4)	0.89 (40.2)
Fiat	-0.032 (-2.03)	-0.02 (-1.5)
Lancia	-0.029 (-1.67)	-0.01 (-0.68)
Alfa	-0.028 (-1.32)	-0.01 (-0.58)
R^2	0.57	0.93
DW	2.2	2.2
N*T (deg. freedom)	155 (142)	155 (148)
SSR	0.404188	0.58333

From Table 2.3. we can see the equality of the estimated coefficients for the individual effects with both estimation methods. The same homogeneity is obtained when model specific effects are estimated.

Table 2.4: Model specific individual effects in the Italian and Japanese models imported

	b_i (CV)	b_i (GLS)

---

[15]results are presented in Table A.2.3 in the Appendix.

constant (common)	--	-0.60 (-2.2)
exchange rate (common)	--	--
trade regime	0.015 (1.7)	-0.015 (-0.93)
SWPI	0.018 (0.21)	0.054 (0.41)
Mark-up (t-1)	0.51 (10.2)	0.87 (38.2)
Fiat Estate	-0.04 (-2.03)	-0.07 (-3.12)
Fiat Uno	-0.03 (-1.39)	-0.01 (-0.98)
Fiat Regata	-0.02 (-1.0)	-0.01 (-0.72)
Lancia Y10	-0.02 (-1.31)	-0.02 (-1.04)
Lancia Thema	-0.02 (-1.3)	-0.01 (-0.91)
Alfa 33, 1.3	-0.02 (-1.2)	-0.01 (-0.99)
R^2	0.56	0.95
DW	2.2	2.2
N*T	155 (139)	155 (145)
SSR	0.402163	0.5668515

From Tables 2.1-2.4 we can conclude that exchange rate changes always have a negative impact on the individual mark-ups: if all the models are included in the pooled estimation, 28% of the exchange rate changes is absorbed by the mark up, and 36% is absorbed by the mark up of each company when only German imports are included. In Table 2.2 the absorption by the different German firms is the same in magnitude (36%) and always significative and in Table 2.3 the homogeneity in the estimated magnitudes of absorption happens also for the Italian and Japanese firms, although the absorption is much lower in this case (around 3% for all companies). For the Italian and Japanese models between 2%-4% of absorption has been found if we focus on individual models. There are important dynamics in the absorption hypotheses that I have not taken account of, but the coefficients of lagged mark-ups is always significative for all cases considered.

The main factor in explaining the different absorption's by the firms of exchange rate changes seems to be collected in Table 2.1, where country effects were present. The individual effect for the German cars is significant and important in magnitude whereas the Italian coefficient is zero.

Two elements are implied by the country of origin: (1) the *market structure*, and (2) the *invoicing currency* of the contract. Market structure in the country of origin could have an influence in the pricing of exports if it affected all German companies in the same manner. But this is not so in the German market. The source of homogeneity for the German pricing is the *currency of invoicing*: it is hard to give a satisfactory explanation of

why all exporters quote their price in their home currency (DM). When exporting to other EU countries, German companies may be aware of the relative stability of the DM exchange rate vis a vis any other major currency in the past 20 years. *Knetter* (1989) points out that German exporters tend to invoice their contracts in DM when exporting, except when to the US, and suggests that asymmetric invoicing policies among exporters might reflect differences in the fundamentals that any study done at the industry level may be ignoring.

The size of the estimated coefficients is high: in all the specifications the absorption is higher for the German models (average of 36%) than for any other (average 3% absorption for Italian companies). The findings in this Section support what was concluded before: German companies quote their contracts in their own domestic currency, their pricing policy can be described as pricing to the market when market share matters, i.e., they maximize profits in the long run rather than period by period as can be seen by the short run absorption of exchange rate changes in the mark-up. They also enjoy some market power, as reflected by high and significant pass-through elasticities. The Italian and Japanese cases are somewhat different and can be described as the competitive fringe in the industry: small pass-through elasticities and market shares, lower degree of differentiation vis a vis their rival products and (only) some mark up absorption.

7. Conclusions

I have studied the response of product domestic prices to exogenous exchange rate and import tariff changes in an oligopolistic industry: the automobile industry in Spain during the period 1981:1-1991:4 with the aim to exploit the individual differences in the pricing behavior of the different exporters in a combined cross-section and time series estimation procedure. Different hypotheses have been tested regarding the way exchange rates and tariff rates are passed on to import domestic prices. Two main estimations have been carried out: (1) a price differential estimation and, (2) the mark-up adjustment by individual products and by companies.

The overall pass-through effects (the way exchange rate changes are passed into domestic import prices) seem to be consistent with what a Cournot oligopoly model would predict: the pass-through is incomplete. In our sample, 27%, on average, of the change in the exchange rate is passed by the German (30%), Italian (24%) and Japanese

(16%) exporters into the domestic price in the long run; while in the short-term the pass-through varies widely from company to company (and among models of the same exporter), averaging 30% across all German models. The way import tariff changes have been translated on to domestic prices is even more significant in the short- as well as in the long-run. Import tariff changes are passed more intensely than exchange rate changes are. On average Italian firms translated 60% and German firms 60% of the change in the real import tariff. Different pricing policies are followed depending on the country of origin of the firm: whereas German firms tend to pass more of the exogenous fluctuation to the domestic price, Italian firms seem to enjoy less market power in the export market. No significant differences have been found among the German (i.e. Italian) firms in their pricing behaviour, i.e. the within estimators for each company (or model) are not significantly different from other companies estimated pass-through. Mark-up seems to absorb a very important part of the exchange rate fluctuations: each exporting company absorbs on average 28% of the unit change in the exchange rate by German, Italian and Japanese exporters, although individual heterogeneity in mark-up adjustment is present: German firms seem to absorb a higher proportion of the exchange rate fluctuations (36%) than other exporters do (3% and 4% for the Italian and the Japanese exporters respectively).

An important factor in explaining the adjustment of prices in the period considered is the entry of Spain in the European Union in January 1986. The reduction of tariff rates took place slowly, but the reduction in the individual prices of the models due to the elimination of trade barriers and import tariffs is undoubtful.

There is a different pass-through for the exchange rates depending on the country of origin of the product: German exporters tend to pass more the currency fluctuations than Italian exporters do, a finding in correspondence with that of Mann (1989), Knetter (1989) and Feinberg (1989) for more aggregated studies of trade flows. This has been found in this study to be due to the invoicing currency policy of German exporters: it has been found that they price in the domestic market currency (i.e., in DM) which implies that exchange rate changes affect directly the (import) price in the short run. Pricing to the market across all the imported models considered has also been found present: the fact that the pass-through elasticities are less than 0.5 for almost all models considered and that , except for BMW, all other companies followed more closely Spanish production costs than their own costs leads to conclude that the importers are pricing to the market. These last two facts imply that the estimated pricing equation is steeper than the 45 degree lines that would imply the Law of One Price for this level of disaggregation. The pass-through is higher always for the German than for the Italian or Japanese producers, as it is the mark-up absorption, evidence for some market power or German importers which

together with the fact that follow Spanish production costs in their pricing decisions, shows that market share matters for these exporters. Italian and Japanese imports do not seem to enjoy any market power, they act as the competitive fringe.

Mark-up absorption is significative for all models considered. German models seem to absorb a higher proportion of exchange rate changes (36%) and they do so regardless of the company the good is being produced by. The evidence for absorption for the Italian and Japanese cases is less clear.

The degree of product differentiation has been found to be relevant in explaining the price differential level between two closely related automobiles over time and some evidence is drawn to the fact that competition in the automobile industry might be better captured if segmented in different markets (i.e., small , large and luxury cars).

The very low pass-through estimated coefficient for the Japanese model that we included in the sample can be due to the existence of Voluntary Export Restraints (VER) in the European Union(EU)-Japan trade, that, as in Feenstra (1986), tends to reduce the responsiveness of import prices to exogenous exchange rate changes. To draw strong conclusions, though, based on the inclusion of just one Japanese model in the sample is impossible.

I have found different pricing policies by different exporters in a market where product differentiation, strategic interaction and market segmentation are crucial determinants of the industry equilibrium. I have based part of the empirical analysis in the clear heterogeneity due to a "country effect" in my sample. This evidence is in accordance with other empirical studies done for the automobile industry in other countries (Knetter , 1989 and 1991, Gual, 1989, Kirman and Shcueller, 1990, Mertens 1990 and Mertens and Gisnburgh 1985, and Verboven, 1993) and with other industry level studies (Knetter, 1991, Mann, 1989, Kreinin, Martin and Sheehy, 1986 and others). The country effect collects, in this study, mainly the invoicing currency of the contract which, as found here, is different depending on the country to which the exporting firm belongs to. Still, no real rationale for this asymmetry has been given, nor here, nor anywhere else. An important limitation of this study lies in this question. Risk aversion on the part of exporters, the interaction between the foreign exchange (and the capital) market and the contracting in the goods in the spot market in oligopoly and (labour market and international trade) institutions might play a crucial role in explaining the asymmetric contracting of the goods in international trade by different agents. This must be left for future research.

The limitations of the study are several. From a theoretical point of view, justification could be developed for the estimation of a long-run reduced form pricing schedule for the oligopolistic exporter from a dynamic model that incorporates uncertainty in demand shifts. Market structure variables have not been incorporated in the model explicitly and behavioural hypothesis should also be incorporated and tested. The possible endogeneity of exchange rates fluctuations has been ignored in the estimation procedure. These extensios must wait for future research.

Appendix

A.1. Data description

Exchange rates have been collected also in nominal terms with monthly data.
Since for the Spanish sample, quarterly data has been used, I have constructed a quarterly average exchange rate index out of the monthly data. Real variables have been constructed using the Indice de Precios al Consumo (WPI) as reported by the monthly Boletin Estadistico del Banco España.

For the *exchange rate* data nominal monthly exchange rates vis-a-vis each exporting country have been collected from the Boletin Estadistico Mensual del Banco de Espana. From the original monthly nominal data, an index has been constructed for real exchange rates, and then quarter averages have been calculated by averaging the first and the third month of each quarter. The IPC (*Indice de Precios al Consumo* or Wholesale

Price Index) published monthly by the Banco de España has been used to construct the real terms series. Also, for comparison, the WPI constructed by the OCDE Monthly Report has been used for the estimations. The WPI for Italy, Japan, Germany, Belgium, Sweden, France and the USA has been also collected from the OCDE Monthly Statistical Report.

For *nominal prices* of each model of car considered data has been collected from different sources depending on the country. The nominal price of each car is the Precio de Venta al Publico or listed price as announced by the official publication of the Asociacion Nacional de Fabricantes de Automobiles. They recommend the distributors to maintain those listed prices, but some discounts in the retail markets are possible. We did not take them into account, even though these retailers might absorb part of exchange rate movements in their mark-ups. In the EC, though, discounts on official prices are not as significant as in other big markets (i.e. the US market).

Taxes and *import tariffs* have been collected for each model of car considered in the sample. The official statistics on listed prices published by the ANFAC, lists also the nominal amount of total tax receipt to be paid by each car. The tariff rate in our estimations has been proxied by the instrument constructed as the difference between the total tax receipt to be paid after the purchase of a nationally produced car (for the Spanish sample the reference model is the Fiesta XR2) and the amount in taxes to be paid when purchasing an imported car. This difference, even if it might reflect also a difference in the tax rate applied to different sizes of cars, is our proxy for import tariffs. The evolution of this difference does not change if we selected another nationally produced car as the reference model for the import tariff instrument (i.e. the Renault 5 or Renault 19). An important fact to be considered when analysing the evolution of tax rates on imported cars is the entrance of Spain into the European Union (EU) on January, 1986.

Other indices that are available have been collected from various sources. The Indice de Produccion Industrial, the general for the whole manufacturing sector, as well as the more disaggregate for the automobile sector, have been obtained from the Monthly Report of the Banco de España. GDP and unemployment rates for the countries considered have been obtained from the OCDE Monthly Report and from Eurostat, and the IMF Financial Statistics.

A.2. Estimates of Intra-groups Pass-through Elasticities

From Table 2,6 9 and 9.b we saw that the *slope* coefficients for the pass-through elasticities, b_i's, did not significantly change when individual effects were excluded in the pooled model except possibly for the Italian and Japanese models when model or company specific effects were introduced. The same constancy occurred with slope coefficients for the import tariff and cost differential estimated elasticities. But in Table 1 the estimated *intercepts* of the pricing equations, the a_i's, did differ among the different models, grouped by countries or by companies. In this section I allow for the intercept of each pricing equation to vary and in order to interpret this parameter variation I introduce a random individual time-invariant specific effect with the GLS estimation procedure. I compare, then, the GLS estimator for the pass-through elasticities with the covariance estimator and compare both results. As we shall see in this section the estimators do not yield significantly different results for the vast majority of cases considered.

I estimate in this section a panel with all models grouped by companies with two different methodologies: the fixed and the random coefficients models. In the fixed coefficients model, the individual (firm, model or country) specific effects are assumed to be constant, whereas in the random coefficients model the individual effects are assumed to be drawn from a random sample and all the unobserved (or omitted) variables are assumed to behave as a random variable. The methods should not yield very different estimates in my sample. The covariance estimator of the fixed effects model is unbiased and efficient when N is large, whereas when the individual effects are assumed to be random, the covariance estimator is no longer efficient but the generalised least squares estimator, the one used in my random coefficients estimations, is unbiased and efficient when N, or T, go to infinity. In the fixed effects model all variables are subtracted from their individual means and hence the constant term vanishes. For the random effects estimation, the model to be considered is

$$p_{1t} = \mu + \alpha_1 + b\, x_{it} + u_{it}$$
$$p_{2t} = \mu + \alpha_2 + b\, x_{it} + u_{it}$$
$$\cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots$$
$$\cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots \cdots$$
$$p_{nt} = \mu + b\, x_{it} + u_{it} \tag{18}$$

where μ is the (common) mean intercept, b is the elasticity parameter with respect each of the explanatory variables (i.e. exchange rates, import tariffs, trade regime and unit cost

differential) that is assumed to be constant across units[16] (i.e. companies, countries or models) and time invariant in this section and u_{it}, the disturbance term, is assumed to be a random variable and be composed of three terms

$$u_{it} = \alpha_i + \lambda_t + v_{it} \tag{19}$$

where α_i is the individual specific effect, λ_t is the time effect and v_{it} is a random term. Since all the time varying variables used in the estimations are the same for all imported prices I assume that there are no time-specific effects in my sample. Time specific effects have been used in similar contexts in order to estimate shifts in the marginal costs schedules of the different firms in the industry when marginal costs were unobservable, as in Knetter (1990). The unobservable component in my sample, α_i, is the pricing policy of the individual firm, that is, the aggressiveness in the pricing of its exports and this factor is time invariant and specific to each individual firm. Hence, the random coefficients model that I estimate has only two variance components: the individual specific and the random term,

$$u_{it} = \alpha_i + v_{it} \,, \qquad \text{where} \qquad E(\alpha_i) = E(v_{it}) = 0$$

$$E(\alpha_i \, v_{it}) = 0 \,, \quad E(\alpha_i \, \alpha_j) = \sigma^2_a \,, \quad E(\, v_{it} \, v_{jt'}) = \sigma^2_v \,,$$

$$E(\alpha_i \, x_{it}) = E(v_{it} \, x_{it}) = 0.$$

The introduction of the individual specific effects α_i, introduces correlation in the residuals of each firm in the sample of cross-sections. Since the random component u_{it} contains the individual specific effects α_i, the covariance estimator will be biased and to get efficient and unbiased estimates we need to apply the generalised least squares estimator method (GLS). In the next tables I use whenever possible the covariance (CV), or fixed effects, and the generalised least squares (GLS), or the random effects, estimators knowing that the GLS estimator is more efficient in my sample where T is relatively large. In the system of equations (18) I omit one individual specific effect, for the last individual, in order to avoid perfect collinearity among the individual time invariant variables.

In order to discriminate among the three sources of heterogeneous pricing equations, I estimate in this section a set of pooled regressions introducing the different individual specific effects that I propose as relevant. First I test whether the country of

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[16]as was tested in Tables 1, 2, 3 and in estimations done in Section 3.

origin of the imported model is relevant in explaining the different pricing equations. For this I introduce two country-specific variables, d_1 and d_2, for Germany and Italy respectively. I left out the third country-specific variable (Japan) to avoid perfect collinearity among the explanatory variables. In Table 10 I show the results obtained in the pooled time series and cross section model when the covariance (CV) and the generalised least squares (GLS) methods are used.

Table 12: country specific effects in a fixed and in a random coefficients model, where d_i is the individual time-invariant estimated effect grouped by country of origin.

variable	b_i (CV)	b_i (GLS)
constant	--	0.68
		(4.5)
exchange rate	0.09	0.06
	(2.5)	(1.53)
import tariff	0.79	0.80
	(26.2)	(26.6)
unit cost diff	0.14	0.12
	(5.9)	(4.8)
ce	-0.018	-0.02
	(-5.2)	(-6.04)
d_1*(Germany)*	0.006	-0.01
	(2.5)	(-2.43)
d_2 *(Italy)*	0.013	-0.02
	(3.7)	(-3.43)
R^2	0.82	0.81
SSR	0.3449	0.39194
DW	0.71	0.65
N*T (df)	546 (523)	546 (539)

Even though both country-specific effects are significant, an F- test applied to this regression, i.e. the unrestricted model, and to the restricted model, i.e. the pooled model with no country specific effects, to check the hypotheses of homogeneity in pricing equations, yields an F value of 0.0039, lower than the critical value and we cannot reject the hypotheses of homogeneous pricing equations based on this individual effect. In Table 10 the estimated overall pass-through elasticities, for the exchange rate and for the import tariff changes respectively, are 9% and and 80% respectively, with a small divergence in the exchange rate pass-through if we estimate it with the CV or with the

GLS methods. Similar results are obtained when these elasticities are estimated with company-specific and with model-specific effects. If we compare the elasticities reported in Tables 3 and 10 we realize that they are slightly different in magnitude, i.e.when comparing both (pooled) GLS estimators I obtained a 12% exchange rate pass-through for Table 3 and 6% in Table 10; for the import tariff pass-through estimates results are very similar: 80% and 78% respectively. In order to compare both types of elasticities we have to have in mind that in Table 10 I have introduced *intercept* individual effects (by country of origin of the good) and in Table 3 I estimated the coefficients with *slope heterogeneity*. It is probably due to some misspecification of the reduced form pricing equation that the individual (random) effect collects the influence of other omitted variables when the equation intercepts are allowed to vary.

The second source of variation focuses on the company-effect. The hypotheses to test is that each company might have a different pricing policy for its models of cars to export. The pricing policy, based on the pricing equation to be estimated, consists of two elements:

a.- *the invoicing currency of the contract*, whether the home or the destination market currency is used in the contract

b.- *the aggressiveness in the pricing* of the models, i.e. a very aggressive pricing equation would imply high pass-through elasticity estimated coefficient for all the models belonging to the same company. This conduct variable is the unobserved individual component, a_i, in the panel estimation and is assumed to be time invariant and specific, in this section, to each company.

In order to test the importance of belonging to a certain company and its effects on the heterogeneity of the pricing equations, I introduce K-1 individual specific variables, where K is the number of exporting firms in the market, and estimate the random (GLS) and the fixed coefficients (CV) models for the whole sample.

Table 13: fixed and random effects estimations for all imported cars with individual firm-specific effects (a_i) and equation intercepts are allowed to vary across units. t -statistics are given in parentheses.

variable	b_i (CV)	b_i (GLS)
constant	--	0.59
		(5.0)

exchange rate (e_t)	0.10	0.09
	(2.55)	(2.38)
import tariff (tar_{it})	0.78	0.77
	(26.02)	(24.08)
cost diff.(w_{it})	0.14	0.12
	(5.8)	(4.4)
ce_t	-0.018	-0.025
	(-5.2)	(-5.99)
a_1 (BMW)	0.006	-0.016
	(1.98)	(-2.21)
a_2 (Mercedes)	0.006	-0.016
	(1.35)	(-2.04)
a_3 (VW)	0.006	-0.021
	(1.75)	(-2.7)
a_4 (Audi)	0.006	-0.018
	(1.75)	(-2.39)
a_5 (Porsche)	0.006	-0.011
	(1.35)	(-1.42)
a_6 (Opel)	0.006	-0.022
	(1.35)	(-2.73)
a_7 (Fiat)	0.011	-0.048
	(2.72)	(-6.15)
a_8 (Lancia)	0.014	-0.012
	(3.15)	(-1.57)
a_9 (Alfa)	0.014	-0.014
	(2.46)	(-1.55)
a_{10} (Nissan)	--	--
R²	**0.83**	**0.82**
SSR	**0.319**	**0.403**
DW	**0.78**	**0.63**
N*T (df)	**739 (516)**	**546 (515)**
F -test		**191.8**

If we include all the firms (10) and models (17) in the pooled estimation, we obtain a pass-through elasticity of 10% and of 78% with respect the exchange rate and the import tariff changes respectively, which is very similar to the estimated elasticities of Table 10. Cost differential changes are also passed significantly into the import price,

14% and 12% intra-group elasticity depending on the estimator chosen. In all cases considered the sum of the exchange rate, tariff change and unit cost differential changes pass-through elasticity amounts to one. A general result obtained with the different estimations, although exceptions must be made for specific companies, is that import tariff changes are passed on more completely than exchange rate changes are, and these, in turn, are translated more completely than unit cost changes to the import price. From Table 11 we can conclude also that the individual random effect specific to each company in the sample is equal for all German firms and in turn significantly similar for all the Italian firms. The source of heterogeneity in the intercept of the pricing equations comes from the country or the model specific effects rather than the company that exports the good, especially for the German case. Comparing Table 11 with Table 10, where country specific effects were included, and with Table 13, where model specific effects are included, we see that the source of the heterogeneity in the pricing equation comes from the country of origin of the good. In Table 13 for example, all German models have the same estimated individual effect coefficient, 0.012, which, together with the accepted hypotheses of equal pass-through (or slopes) estimated coefficients, implies the same pricing equation for each model and, based on Table 11, also for each company of the German sample. Greater heterogeneity has been found for the Italian and the Japanese companies and models.

To see the different pricing policies of different firms, we need to estimate the pooled time series- cross section sample organised by companies (5 German, 4 Italian and 1 Japanese) and estimate the different elasticities in each pooled regression. In the next Table I show the results obtained by pooling the Italian and the Japanese companies.

Table 14: Italian and Japanese CV and GLS pass-through estimates when company individual effects are present, t -statistic in parentheses and where N is the number of units (companies), T the total number of periods observed and df is the degrees of freedom of the panel estimation.

variable	b_i (CV)	b_i (GLS)
constant	--	0.66
		(2.3)
exchange rate	0.29	0.24
	(2.1)	(1.11)
import tariff	0.41	0.44
	(3.5)	(2.44)
unit cost diff	-0.05	-0.20
	(-0.53)	(-0.97)

ce	0.004	-0.011
	(0.36)	(-0.59)
a_1 *(Fiat)*	-0.01	-0.06
	(-1.48)	(-4.5)
a_2 *(Lancia)*	0.001	-0.009
	(0.20)	(-0.63)
a_3 *(Alfa)*	0.001	-0.014
	(0.01)	(-0.87)
R²	**0.43**	**0.44**
SSR	**0.1435**	**0.26**
DW	**0.62**	**0.315**
N*T (df)	**145 (131)**	**145 (137)**
F -test		**17.3**

The a_i's are the individual firm specific effects (fixed and random, respectively) estimated, i.e. different pricing equations intercepts. Except for the individual coefficient for the Fiat company, the individual effects are not significant for the Italian and the Japanese sample. The estimated R^2 are lower than for the German subsample, as are the total number of observations available (145) and the degrees of freedom (131 and 137). The pass-through of all Italian and Japanese models amounts to 29% and 41% for the exchange rate and the import tariff changes respectively. The estimated coefficient on the unit labour cost differential and the variable that collects trade regime changes, ce_t, are not significant at the 5% level. These estimates are slightly lower than the ones obtained in the German case.

In order to introduce the degree of product differentiation we estimate the pooled model for the German sample allowing for model-specific effects, g_i, where i =1.....N (N=10). This specific effect collects not only the different pricing policy adopted by each firm with respect the particular car considered, but also the degree of product differentiation among the ten models included. Both effects can be considered individual specific time invariant and I cannot separate them in the estimation procedure. Once this individual effect is taken into account, in Table 13, results suggest that the pass-through of exchange rate changes to prices is 30% for the German cars and 70% pass-through for import tariff changes, irrespective of the method of estimation. Results in next table are in accordance with the F-test carried on in Tables 1 and 2, where we rejected the hypothesis of homogeneity in the German sample when model individual effects were included. In Table 13, all individual effects are positive and significant. Also results in Table 13 are

consistent with the other pass-through estimates obtained in Tables 3, 4, 5 and 6: the exchange rate pass-through is of magnitude 30% and the import tariff elasticity is larger, 70%, when individual effects are included. These magnitudes are obtained, with no significant difference, in all specifications studied.

Table 15: fixed and random effects with model specific individual effects for the German cars (N=10)

variable	b_i (CV)	b_i (GLS)
constant	--	0.14
		(10.8)
exchange rate	0.30	0.29
	(6.75)	(6.66)
import tariff	0.70	0.70
	(22.9)	(23.5)
unit cost diff	0.04	0.002
	(1.7)	(0.09)
ce	-0.03	-0.04
	(-8.8)	(-9.8)
g_1 *(BMW318i)*	0.012	0.072
	(2.79)	(7.9)
g_2 *(BMW520)*	0.012	0.11
	(2.79)	(9.03)
g_3 *(BMW730)*	0.012	0.22
	(2.79)	(10.1)
g_4 *(Mercedes2)*	0.012	0.13
	(2.79)	(9.1)
g_5 *(VW Golf C)*	0.012	0.01
	(2.79)	(2.2)
g_6 *(Golf GTI)*	0.012	0.04
	(2.79)	(6.8)
g_7 *(Audi80)*	0.012	0.08
	(2.79)	(8.2)
g_8 *(Audi100)*	0.012	0.11
	(2.79)	(9.02)
g_9 *(Pors 911)*	0.012	0.24
	(2.79)	(9.6)
R^2	**0.86**	**0.99**
SSR	**0.2217**	**0.2127**

DW	0.82	0.87
N*T (df)	390 (367)	390 (376)
F- test		3659.4

In Table 14, for the Italian and the Japanese models, the pass-through varies greatly between the CV estimator (40%) and the GLS estimator (27%). When model individual effects are included in the pooled regression, Italian and Japanese models show no significative individual effects except for the Fiat Uno 60S, Lancia Y10 and the Alfa 33, 1.3 (models 12, 14 and 16 respectively). The Japanese model considered, the Nissan Bluebird 1.8, does not have either an individual specific effect in my sample. In Table 1, we rejected the hypothesis of homogeneity of pricing equations for the Italian and Japanese models once individual model specific effects had been included. Comparing Tables 5 (company effects) and Table 14 (model specific effects) there seems to be an individual effect coming from the company level rather than the individual products considered, especially for the Fiat company.

Table 16: effects for Italian and Japanese subsample, model specific effects

variable	b_i (CV)	b_i (GLS)
constant	--	0.48
		(1.75)
exchange rate	0.40	0.27
	(2.69)	(1.56)
import tariffs	0.31	0.44
	(2.47)	(2.93)
unit cost diff	-0.07	-0.24
	(-0.80)	(-1.65)
ce	0.006	-0.006
	(0.52)	(-0.43)
g_{11} *(Fiat Estate)*	-0.014	-1.53
	(-1.65)	(-11.2)
g_{12} *(Fiat Uno)*	-0.003	-0.06
	(-0.36)	(-0.45)
g_{13} *(Fiat Regata)*	0.02	0.016
	(-2.38)	(0.13)

g_{14} *(lancia Y10)*	-0.0001	-0.08
	(-0.014)	(-0.58)
g_{15} *(lancia Thema)*	-0.001	0.22
	(-0.21)	(2.28)
g_{16} *(Alfa 33)*	-0.002	0.016
	(-0.28)	(0.13)
R^2	**0.44**	**0.99**
SSR	**0.1385**	**0.1363**
DW	**0.60**	**0.62**
N*T (df)	**145 (128)**	**145 (134)**
F- test		**5991.1**

For the Italian and the Japanese models considered, the source of heterogeneity in the pricing equation intercept is more complex. From Tables 11 and 12, where company specific effects were included, there is heterogeneity in the estimated company specific effects, as well as different pricing intercept can be found in Table 14 where model specific effects were included. Hence, for the Italian and Japanese cars the source of the differences in the pricing of the models comes, in our sample, from two facts: (1) different pricing policies by each company, and (2) differences in the pricing of each model by each company.

A.3. Exchange Rate Pass-through and the Lag-structure

Table AI: single equation estimation of price differential by models of car imported in Spain, 1981:1- 1991:3, of equation (1) with OLS.

$$(p_{it} - p_{jt}) = a + \sum b_0 e_t + b_1 (t_{it} - t_{jt}) + b_2 (w_{it} - w_{jt}) + b_3 D_i + u_{it} \qquad (A1)$$

	Mercedes	BMW	BMW5	BMW7	Audi1	Audi8	Senator	GolfCL
constant	0.04	0.09	0.16	1.2	-0.01	0.21	0.14	0.33
	(.44)	(1.01)	(3.13)	(6.2)	(-0.13)	(2.6)	(2.4)	(6.4)
e$_t$	0.55	0.58	0.49	0.06	0.64	0.57	0.46	0.71
	(2.25)	(2.3)	(1.97)	(0.09)	(2.8)	(2.6)	(1.41)	(3.1)

e_{t-1}	-0.35 (-.84)	-0.42 (-0.99)	-0.41 (-0.99)	0.94 (0.91)	-0.58 (-1.55)	-0.54 (-1.47)	-0.35 (-0.73)	-0.98 (-2.4)
e_{t-2}	-0.27 (-.65)	-0.09 (-.23)	.007 (.01)	-.53 (-.54)	-0.13 (-.33)	0.15 (0.39)	-0.05 (-0.11)	0.43 (1.3)
e_{t-3}	0.10 (0.24)	0.07 (0.18)	.07 (.18)	.37 (.41)	0.09 (0.27)	0.13 (0.37)	0.06 (0.14)	0.42 (1.36)
e_{t-4}	-0.30 (-.78)	-0.38 (-0.99)	-.41 (-1.08)	.48 (.83)	-0.44 (-1.25)	-0.46 (-1.3)	-0.34 (-0.80)	-0.22 (-.69)
e_{t-5}	-0.22 (-.57)	-0.23 (-0.6)	-.21 (-.56)	-.54 (-2.7)	-.23 (-0.6)	-0.19 (-0.56)	-0.20 (-0.46)	-.43 (-1.2)
e_{t-6}	0.13 (0.32)	0.62 (2.4)	0.70 (2.9)	--	0.61 (2.7)	0.68 (3.16)	0.63 (2.2)	0.74 (2.3)
e_{t-7}	0.50 (1.98)	--	--	--	--	--	--	0.18 (0.59)
e_{t-8}	--	--	--	--	--	--	--	-0.49 (-2.3)
w_t	-0.04 (-.36)	-0.01 (-0.12)	-.07 (-.80)	-.54 (-2.7)	-0.02 (-0.25)	0.03 (0.41)	-0.06 (-0.61)	0.50 (4.7)
tax_t	0.90 (6.9)	0.78 (5.4)	0.86 (9.8)	-.16 (-.88)	0.80 (7.3)	0.66 (5.9)	0.91 (8.5)	0.23 (2.7)
tax_{t-1}	0.18 (1.5)	0.20 (1.3)	--	--	0.31 (2.8)	0.16 (1.6)	--	0.12 (1.4)
ce	-0.05 (-4.5)	-0.04 (-4.4)	-.05 (-4.9)	-0.03 (-1.18)	-0.05 (-5.3)	-0.03 (-3.3)	-0.04 (-3.2)	-.015 (-1.6)
R^2	0.92	0.95	0.90	0.58	0.97	0.96	0.81	0.97
DW	1.94	1.49	1.69	0.86	1.55	1.18	1.68	1.35
$F(,)$	38	79	36	7.4	136	86	15.5	120
$DF(u_t)$	-5.6	-4.5	-5.06	-3.4	-4.6	-3.7	-4.6	-4.2

	GolfGTI	Kadett	KadII	Porsche	Uno	Regata	Thema	LanY10
const	0.13 (1.79)	0.12 (3.06)	0.12 (2.9)	-.004 (-.06)	0.01 (0.40)	-3.4 (-11.4)	0.01 (0.47)	.05 (1.35)
e_t	0.38 (1.02)	0.55 (2.2)	0.56 (2.2)	0.59 (2.07)	0.03 (0.33)	-.44 (-.81)	-.01 (-.26)	.014 (0.16)
e_{t-1}	-0.40	-.43	-.44	-.32	0.10	0.91	.038	.032

|	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(-0.64)	(-1.01)	(-1.04)	(-.67)	(0.6)	(1.1)	(.59)	(0.25)
e_{t-2}	-0.01	-.001	-.008	-0.30	-0.20	-.25	-.007	.016
	(-0.03)	(-.002)	(-.02)	(-.64)	(-1.19)	(-.29)	(-.10)	(0.11)
e_{t-3}	0.21	.07	.08	.004	0.03	-.25	-.06	-.16
	(0.44)	(.18)	(.20)	(.016)	(0.21)	(-.29)	(-.97)	(-1.21)
e_{t-4}	-0.14	-.33	-0.32	--	0.14	-.04	.03	0.12
	(-0.28)	(-.86)	(-.83)		(0.86)	(-.05)	(.62)	(0.93)
e_{t-5}	-0.32	-.28	-.29	--	-.09	-.19	.04	.06
	(-0.59)	(-.73)	(-.75)		(-.87)	(-.22)	(.68)	(.55)
e_{t-6}	0.22	.67	0.67	--	--	0.74	-.08	-.12
	(0.43)	(2.7)	(2.7)			(1.15)	(-1.15)	(-.82)
e_{t-7}	-0.03	--	--	--	--	--	.058	0.26
	(-.07)						(1.22)	(1.9)
e_{t-8}	0.29	---	--	--	--	--	--	-.15
	(0.84)							(-1.57)
w_t	0.03	-.05	-.05	-.05	-.012	0.21	.006	.03
	(0.2)	(-.58)	(-.54)	(-.46)	(-.31)	(0.95)	(0.34)	(.85)
t_t	0.77	.88	.88	1.05	.87	-.014	.98	0.92
	(5.8)	(7.4)	(7.3)	(12.4)	(14.03)	(-.04)	(35.3)	(19.7)
t_{t-1}	0.18	--	--	--	--	--	--	--
	(1.3)							
ce	-0.05	-.04	-.04	-.05	--	--	--	--
	(-3.6)	(-4.6)	(-4.6)	(-4.7)				
R^2	0.95	0.94	0.94	0.88	0.98	0.35	.99	.99
DW	1.58	1.69	1.69	1.47	1.14	0.92	1.69	1.76
F(,)	60.7	58.7	58.1	39.8	230	2.04	1646	745
DF(u_t)	-4.99	-5.02	-5.02	-4.56	-2.39	-3.4	-5.5	-3.7

where F(,) is the F-statistic with 30 degrees of freedom for the German cars and 25 degrees of freedom for the Italian and Japanese models, DF(u_t) is the Dickey-Fuller statistic applied to the residual of each regression to test for unit root and DW is the Durbin-Watson statistic for correlated residuals.

A.4. Evolution of the Real Mark-up in Levels and in First Differences for Selected Models

Evolution of the real mark-up for the German models Porsche 911 cc, Mercedes 200 and BMW 318i, 1981:1-1991:4
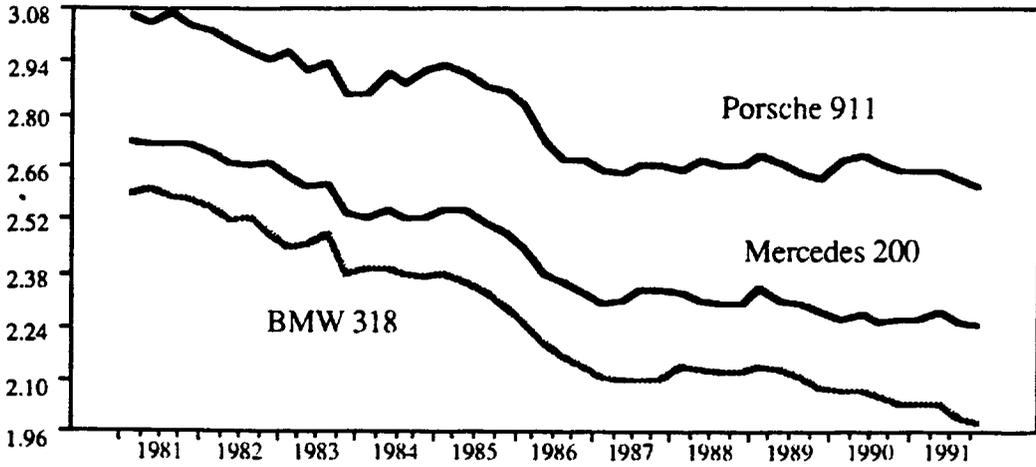

Evolution of the real mark-up for the Italian models Fiat Regata, Fiat Uno 60S and Lancia Y10 Fire, 1981:1-1991:4
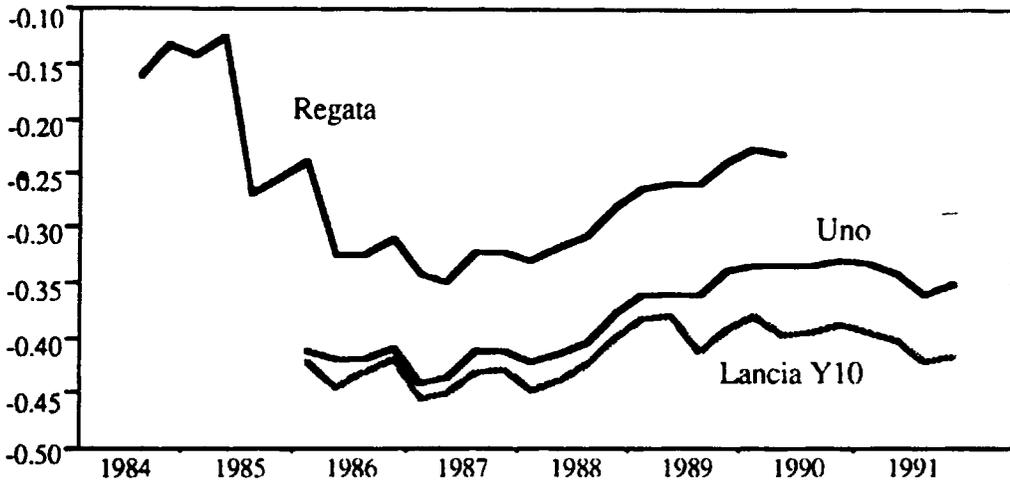

Evolution of changes in the real exchange rate and changes in the real mark-up for the model BMW 730, 1981:1-1991:4
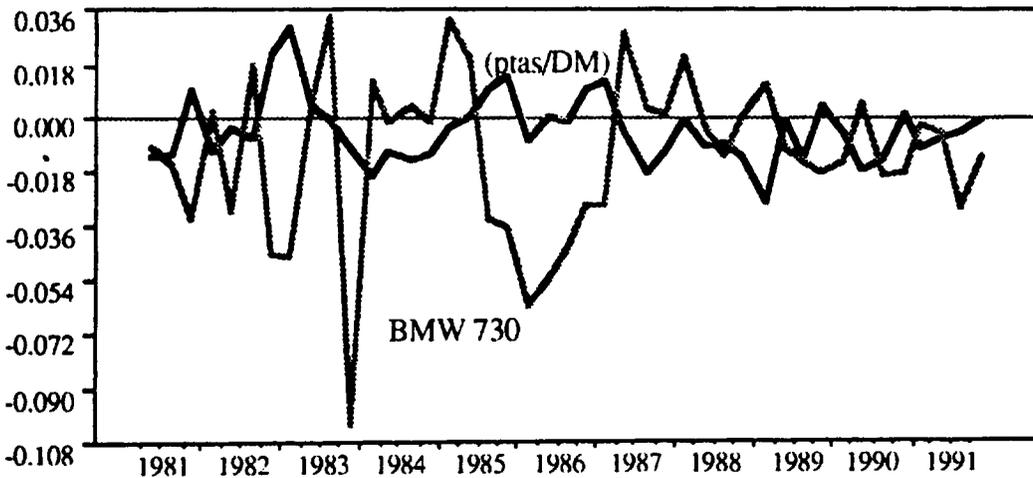
Evolution of changes in the real (Lira/ptas) exchange rate and the real mark-up for the imported model Fiat Uno60S, 1981:1-1991:4
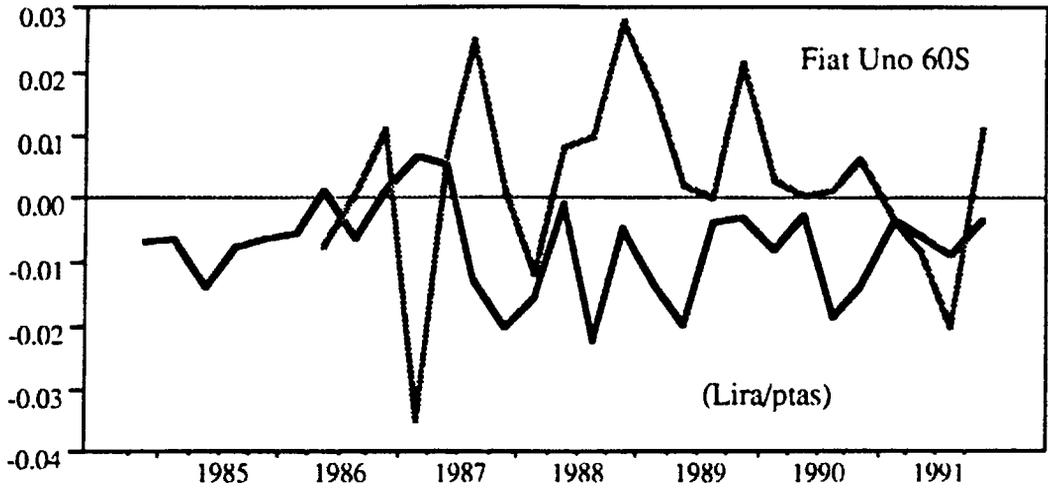
Evolution of the real (Ptas/DM) exchange rate and the real mark-up for the imported Opel Kadett, Spain, 1981:1- 1991:4
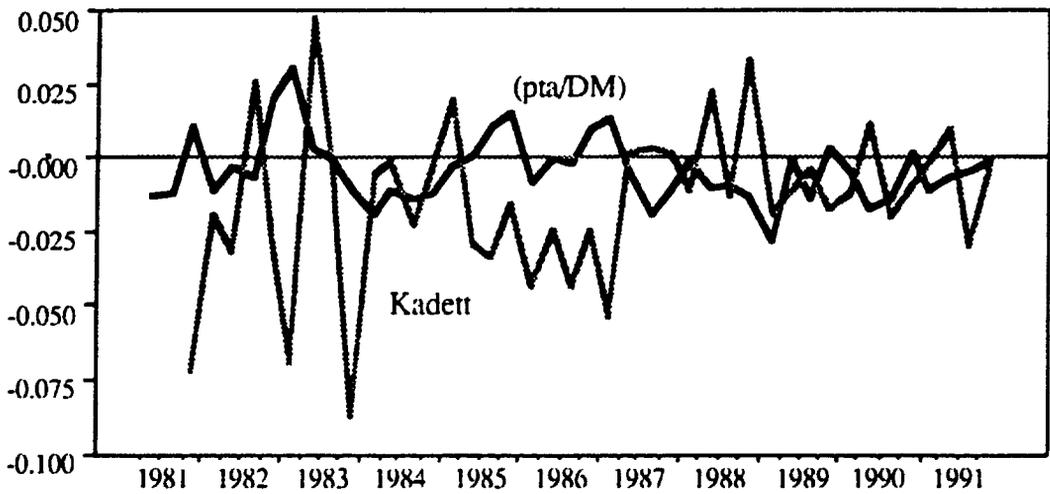
Evolution of the real (ptas/DM) exchange rate and the real mark- up for the Mercedes 200, 1981:1-1991:4
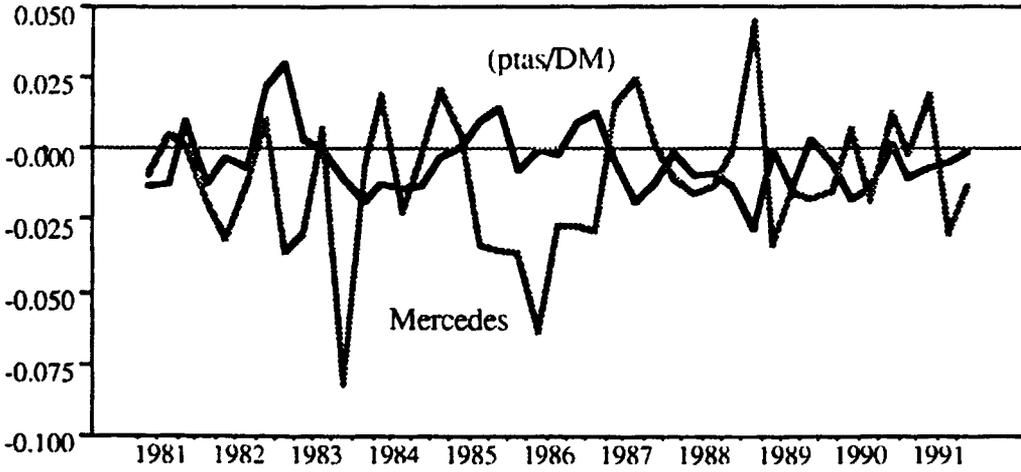
Evolution of changes of the real exchange rate and changes of the real mark-up for the model BMW 318i, 1981:1-1991:4
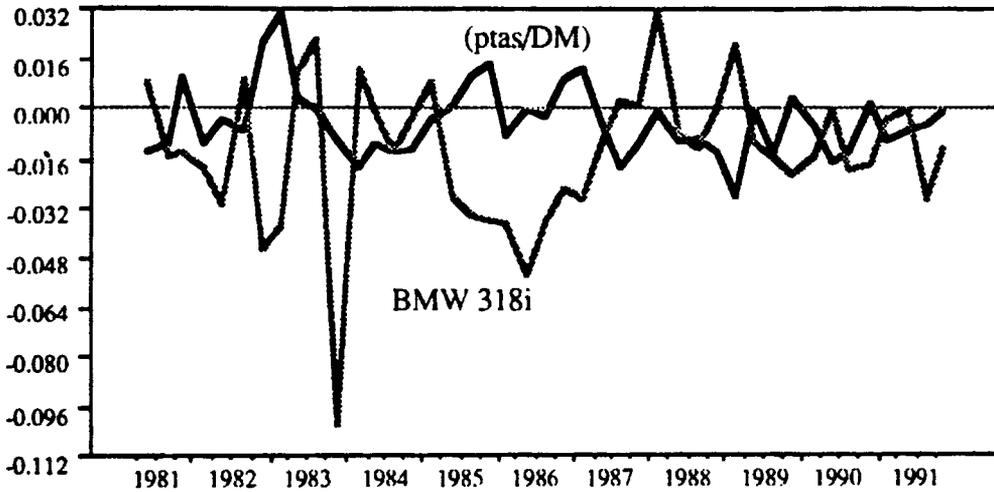
A.5. Real Prices and Price Differentials for Selected Models

Real prices of Mercedes 200 and Opel Senator, 1981:1-1991:4
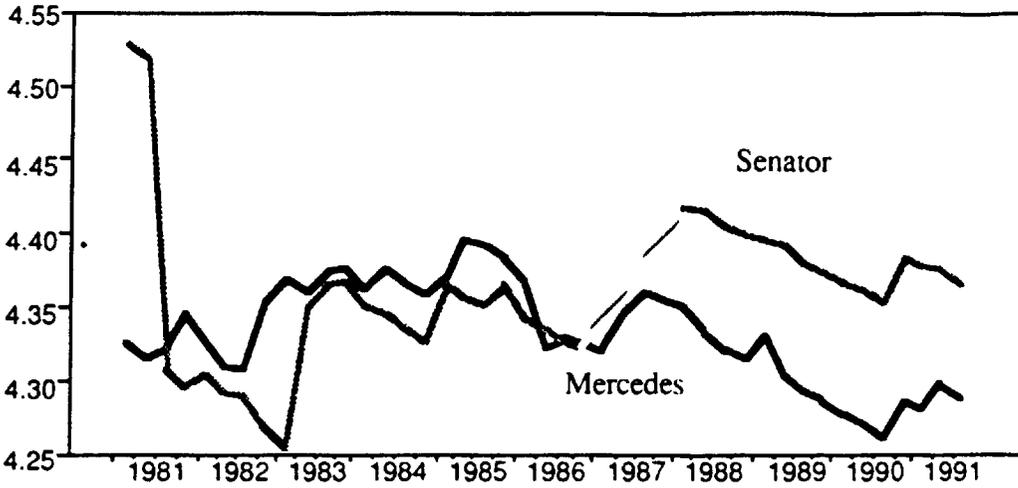
Evolution of the real price differential between the Mercedes 200, BMW 318i, and the nationally produced Fiesta XR2, Spain, 1981:1-1991:4
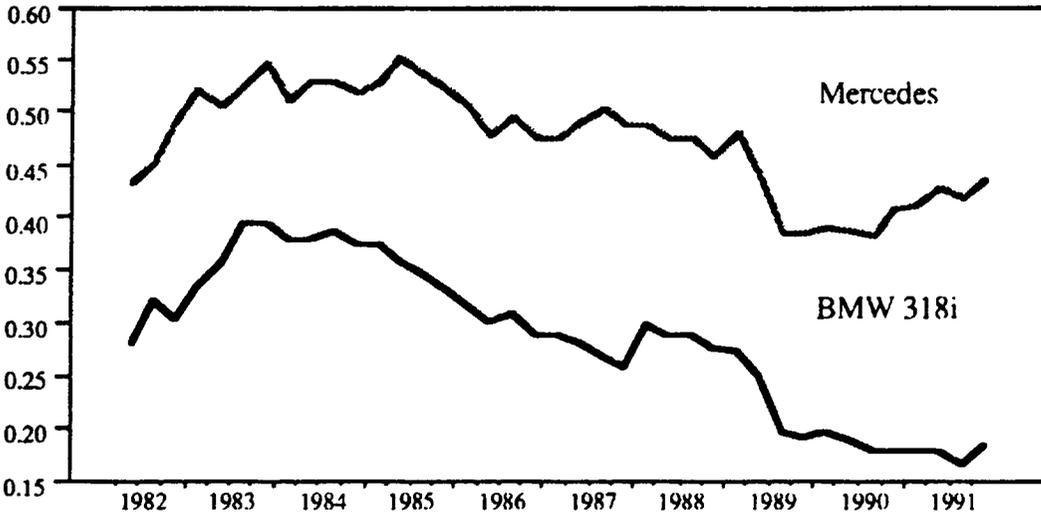
Real price differential between the Nissan Bluebird SGX and the national model Fiesta XR2, Spain, 1981:1- 1991:4
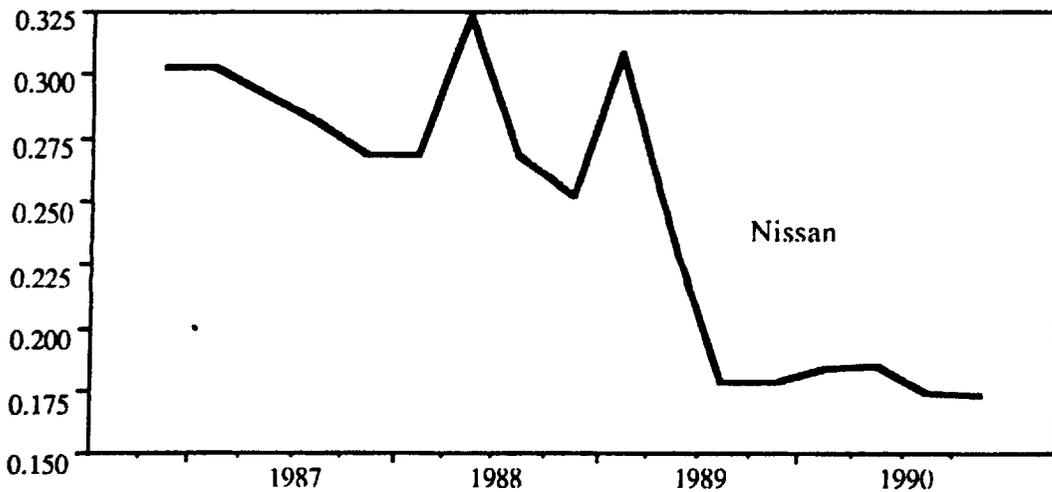
Table I : OLS estimations of the long-run price differential between an imported model and the national (reference) model (t-statistics in parenthesis)

|	constant	e_t	w_t	t_{it}	ce	R^2	DW	DF(u_t)
Mercedes	0.18 (2.7)	0.21 (1.91)	-0.12 (-1.2)	0.79 (7.4)	-0.05 (-4.7)	0.88	0.99	-3.7
BMW318i	0.20 (3.5)	0.32 (2.6)	-0.14 (-1.5)	0.73 (7.2)	-0.06 (-5.4)	0.94	1.12	-4.2
BMW520	0.15 (3.1)	0.15 (1.73)	-0.13 (-1.33)	0.81 (8.8)	-0.05 (-5.09)	0.85	1.07	-4.2
BMW730	0.90 (7.3)	0.94 (5.01)	-0.60 (-3.07)	0.07 (0.6)	-0.05 (-2.5)	0.58	0.70	-2.95
Opel Kadett	0.12 (3.8)	0.29 (2.4)	-0.16 (-1.6)	0.74 (6.9)	-0.05 (-5.1)	0.91	1.17	-4.6
Golf CL	0.32 (7.6)	0.44 (4.6)	0.27 (3.5)	0.31 (3.2)	-0.03 (-4.2)	0.96	1.1	-3.73
Golf GTI	0.17 (3.3)	0.27 (2.5)	-0.08 (-1.0)	0.80 (8.3)	-0.06 (-5.9)	0.95	1.43	-4.9
Senator	0.17 (4.2)	0.15 (1.8)	-0.17 (-1.7)	0.76 (9.4)	-0.04 (-3.5)	0.80	1.25	-3.76
Porsche	0.068 (0.91)	0.05 (0.59)	-0.03 (-0.3)	0.99 (11.8)	-0.05 (-4.3)	0.86	1.14	-3.91
Audi80	0.19 (3.5)	0.29 (2.55)	-0.08 (-.96)	0.77 (8.7)	-0.04 (-4.5)	0.93	1.14	-4.3
Audi100	0.10 (1.3)	0.13 (0.89)	-0.06 (-.63)	0.93 (9.0)	-0.05 (-4.5)	0.95	1.07	-3.84
Uno	0.02 (0.69)	0.03 (1.36)	0.015 (0.47)	0.86 (20.7)	--	0.98	1.5	-3.54
Lancia	0.002 (0.09)	0.008 (0.41)	0.012 (0.55)	0.98 (41.7)	--	0.99	2.18	-5.04
Thema	0.96 (9.16)	0.53 (9.57)	0.092 (0.64)	--	--	0.82	0.88	-2.6
Regata	0.17 (0.7)	0.26 (1.5)	0.38 (1.57)	0.89 (3.4)	--	0.79	0.81	-2.3

The estimated regressions show very high R^2 and low Durbin-Watson statistics. This can be evidence of serial correlation in the residuals. I test the hypothesis of

integrated residuals, with the Dickey-Fuller statistic, DF(u_t), and I reject the hypothesis of integration of first order, except for the BMW 730, Fiat Thema and Regata (critical value of D-F statistic for 40 observations is, $DF_c < -3.2$). Total number of observations are 45 for German cars and 30 for Italian models. The dummy variable that reflects main trade regime changes, ce, (the entry of Spain in the EU) is significant in all models.

Since the specification of the estimated equation is in logs, its partial derivatives can be directly interpreted as pass-through elasticities of the price differential with respect to exchange rates and import tariff changes respectively, i.e. $(\partial p_{it}/\partial e_t) = b_1$, $(\partial p_{it}/\partial tariff_t) = g_2$. In this section we interpret these elasticities as pass-through elasticities.

Exchange rate pass-through is significantly different from zero for all models except for Audi 100 and Porsche 911 and for the Lancia Y10. Average exchange rate pass-through is 30% for the German cars and 20% for the Italian cars, i.e. a 100% devaluation (or appreciation) of the (DM/peseta) exchange rate is expected to be translated with a 30% increase (reduction) in the peseta denominated final price and with a 20% increase for the (lira/peseta) devaluation case.

Import tariff pass-through is significant and different from zero in all cases except for the BMW 730. The average translation effect is 70% for the German cars and 91% for Italian models. The hypothesis that import tariffs pass-through is equal to one (i.e. full pass-through) is not rejected in any model and tariffs are passed in magnitude more always than exchange rate changes are (except for the VW Golf CL).

The way import tariff changes and exchange rate changes have been passed on to domestic prices have different patterns. I test the null hypothesis, $H_N : b_i = g_i$, i.e. same pass-through elasticity of exchange rates and of import tariff changes, in each regression with the F-test, $F = ((RSS(H_N) - RSS(H_A))/n)/((RSS(H_N))/(T-K)) \sim F(n,T-K)$, where n is the number of restrictions, T, total number of observations included in the sample, K is the number of parameters to be estimated under the alternative hypothesis (H_A) and RSS is the residual sum of squares under the null or under the alternative hypothesis. The null hypothesis is rejected in all cases except for the Fiat Regata and the BMW 318i, for which the pass-through of exchange rates into prices is lower in magnitude than the pass-through of tariff changes on to domestic prices. For the Golf CL, the pass-through of exchange rates is greater than that of tariff changes. For the majority of cases, though, the pass-through of tariff changes is always greater in magnitude than that of exchange rates.

The variable that collects trade regime changes, ce_t, is significant for all German models considered. The estimated coefficient of the dummy, entrance in the EC, has a negative and significant sign, implying that the reduction of entry barriers and the lowering of import tariffs between Spain and its EC partners due to the integration of the Spanish and the European Community markets led to a significant reduction in the price differential between the imported and the national models of cars.

Real prices of VW Golf CL and GTI and Ford Fiesta XR2, 1981:1-1991:4
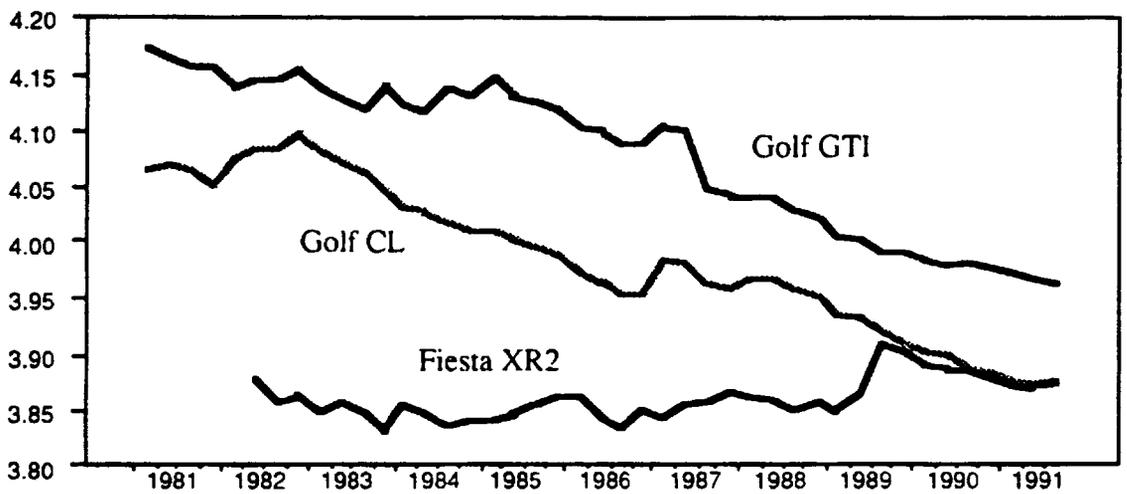
Real prices of Ford Fiesta XR2, Lancia Y10 Fire and Fiat Uno 60S,1981:1-91:4
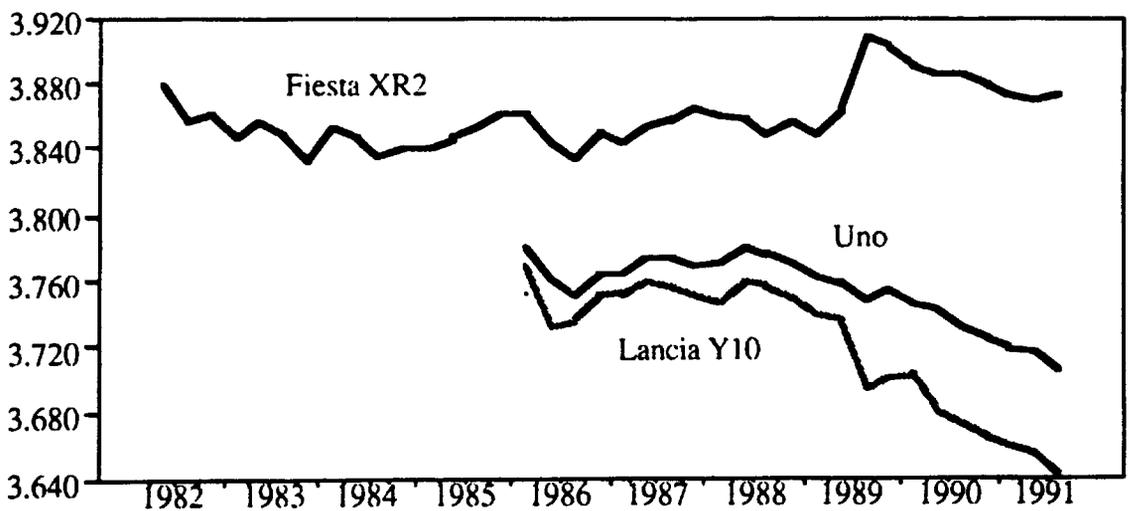
Real prices of Opel Kadett (I) and Ford Fiesta XR2, 1981:1-1991:4
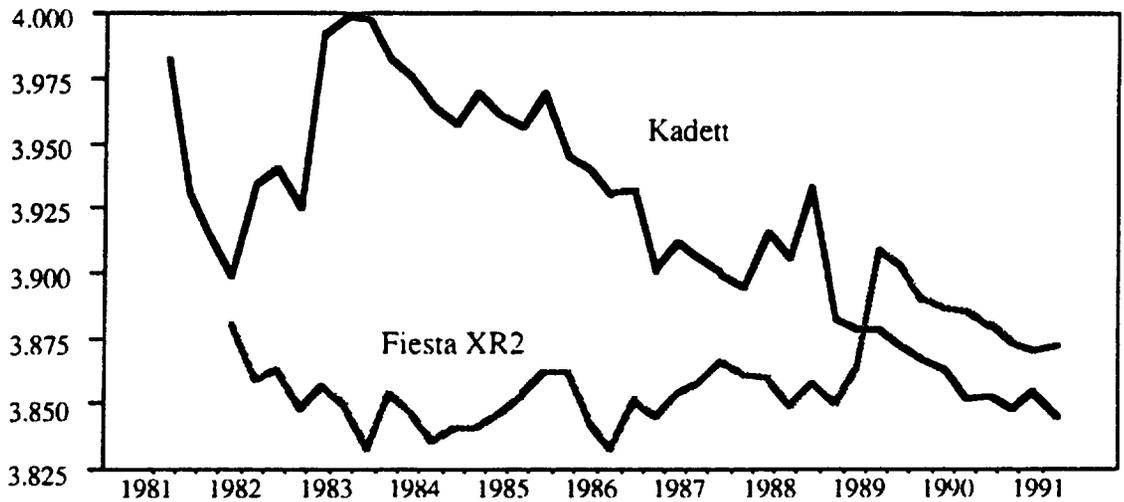
Table VII: estimated individual mark-ups for each model of car imported, 1981:1-1991:4

	const.	Δe_t	$\Delta tariff_{it}$	ce_{t-1}	$m_{i,t-1}$	ini_{t-1}	R^2	DW	F(4,33)
Mercedes	0.43	-0.42	0.30	-0.04	-0.17		0.28	1.97	4.7
	(2.7)	(-1.2)	(2.12)	(-2.6)	(-2.8)				
GolfGTI	0.18	-0.66	0.17	-0.02	-0.08		0.31	1.85	5.2
	(2.09)	(-2.5)	(1.5)	(-1.85)	(-2.3)				
Golf CL	0.11	-0.53	0.02	-0.008	-0.06		0.18	1.99	3.1
	(1.12)	(-1.6)	(0.2)	(-0.53)	(-1.38)				
BMW31	0.27	-0.78	0.28	-0.03	-0.12		0.19	1.86	3.2
	(1.93)	(-2.36)	(1.74)	(-1.94)	(-2.05)				
BMW52	0.45	-0.81	0.47	-0.04	-0.18		0.39	1.58	6.9
	(2.7)	(-2.4)	(3.6)	(-2.5)	(-2.8)				
BMW73	0.57	-0.68	0.02	-0.05	-0.20		0.21	1.85	3.5
	(2.5)	(-1.81)	(0.19)	(-2.7)	(-2.5)				
Audi8	0.16	-0.88	0.46	-0.019	-0.07		0.25	1.74	4.08
	(1.1)	(-2.3)	(2.9)	(-1.05)	(-1.2)				
Audi100	0.26	-0.52	0.24	-0.03	-0.10		0.17	1.81	2.99
	(2.2)	(-1.59)	(1.65)	(-2.25)	(-2.4)				
Senator	0.71	-0.83	0.43	-0.04	-0.28		0.36	1.7	5.5
	(2.8)	(-2.17)	(2.8)	(-2.6)	(-2.8)				
Kadett	0.35	-0.73	0.40	-0.04	-0.17		0.25	1.91	4.2
	(2.5)	(-2.11)	(2.3)	(-2.5)	(-2.6)				

Porsche	0.94	-0.53	0.51	-0.07	-0.32		0.58	1.75	13.7
	(4.6)	(-1.66)	(4.6)	(-4.3)	(-4.6)				
Lancia	-0.08	-0.67	0.29		-0.20		0.22	1.86	3.12
	(-1.37)	(-1.63)	(1.68)		(-1.33)				
Regata	-1.8	-0.28	0.19	-0.06	-0.37	0.84	0.19	1.92	2.07
	(-2.1)	(-0.27)	(0.68)	(-1.81)	(-2.06)	(2.11)			
Nissan		0.36	0.60		-0.28		0.66	1.67	10.9
		(1.33)	(3.6)		(-1.39)				

As can be seen from Table VII, with equation (8) only a small part of the mark-up variation could be explained: an overall average of 30% of individual mark-up changes in the sample. As I stated before, the first difference of the mark-up shows a very random behavior in my sample, and even though the model specification that I used might be improved, I doubt whether a much bigger part of this mark-up could be explained. As can be seen from the Durbin-Watson and the Dickey-Fuller statistics[17], residual terms are not correlated (also from DF statistic) and the rest unexplained part of the behavior seems to be white noise. There are some regularities in these estimation that I want to comment.

The short run absorption of the exchange rate change in any significative proportion by the German models takes place in 9 out of the 11 models considered, for which the effect of a unit increase in the exchange rate is passed significantly and with a negative sign to the mark-up of the product. This sign is negative in all cases as we could expect, since a devaluation of the destination market currency (an increase in e_t), if the destination market price is unchanged, implies a reduction in unit revenues for the exporter, and an appreciation of the foreign currency (a decrease in e_t) implies an increase in the individual mark-up.

Table A.2.3: Fixed vs. Random effects estimatiuon of individual model -specific effects are allowed. German cars imported in Spain, and heterogeneous slope coefficients, where e1 ...e9 stand for each of the exporting companies.

	b_i (CV)	b_i (GLS)
constant	--	0.0
exchange rate(common)	--	--
trade regime	-0.01 (-10.1)	-0.012 (-10.2)
Swpi	-0.48 (-13.5)	-0.48 (-13.7)
Mark-up (t-1)	0.69 (36.1)	0.69 (36.6)

[17] reported in the Appendix

e1	-0.37 (-8.06)	-0.37 (-8.16)
e2	-0.36 (-7.9)	-0.36 (-8.09)
e3	-0.36 (-8.01)	-0.36 (-8.11)
e4	-0.36 (-7.9)	-0.37 (-8.16)
e5	-0.37 (-8.06)	-0.36 (-8.03)
e6	-0.36 (-7.9)	-0.36 (-8.11)
e7	-0.36 (-8.01)	-0.37 (-8.2)
e8	-0.37 (-8.14)	-0.36 (-8.06)
e9	-0.36 (-7.9)	-0.36 (-8.3)
R	0.99	0.99
DW	1.78	1.78
N*T (degrees of freedom)	427 (405)	427 (415)
SSR	0.08676	0.086768

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