Stockholm School of Economics
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EXCHANGE RATE PASS-THROUGH & MARKET SHARE

- A Study on the European Car Market

ABSTRACT

This paper studies the relation between market share for domestic producers and how prices of imported cars respond to exchange rate changes. The exchange rate pass-through, ERPT is estimated using a panel data set of micro level pre-tax price data for 93 car models, from eight source countries to twelve European destination markets over the period 1993-98. The estimated pass-through is in the order of 11-24 percent for the estimates significant at a five percent level, and its relation to market share is found to be non-linear. As such, ERPT decreases with market share for small market shares and increases with market share when market share is large. The latter is sensitive to the inclusion of France. A strong home bias in demand in conjunction with a predilection for small cars leads to a low degree of substitutability between French and foreign brands, enabling foreign producers to pass-through a greater portion of an exchange rate change.

Authors:
Pia Bax
Bergslagsvägen 22, 2tr
168 75 Bromma
Tel: 0736 89 79 27
Mail: 19662@student.hhs.se

Eva Petersson
Armegatan 32, lgh 507
171 71 Solna
Tel: 0704 96 17 93
Mail: 18891@student.hhs.se

Supervisor:
Richard Friberg
Presentation:
27 May 2004, 15:15
Examiner:
Per-Olov Johansson

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ABBREVIATIONS AND ACRONYMS

CPI	Consumer Price Index
ECU	European Currency Unit
EMU	European Monetary Union
ERPT	Exchange Rate Pass-Through
EU	European Union
FEM	Fixed Effects Model
GDP	Gross Domestic Product
IFS	International Financial Statistics
IMF	International Monetary Fund
LSDV	Least Square Dummy Variable
OECD	Organization for Economic Corporation and Development
PPI	Producer Price Index
REM	Random Effects Model

TABLE OF CONTENTS

1 INTRODUCTION **1**

1.1 AIM 2
1.2 OUTLINE 2

2 THE STRUCTURE OF THE EUROPEAN CAR MARKET **2**

2.1 SOURCES OF PRICE DIFFERENTIALS & MARKET SEGMENTATION 3
2.1.1 National Regulations *3*
2.1.2 Selective Distribution and Exclusive Dealerships *4*
2.1.3 Non Regulatory Impediments to Cross-Border Trade *5*

3 THEORETICAL FRAMEWORK **6**

3.1 EXCHANGE RATE PASS-THROUGH (ERPT) MECHANISM 6
3.2 DETERMINANTS OF THE DEGREE OF PASS-THROUGH 6
3.2.1 Conditions for Complete Pass-Through *7*
3.2.2 Reasons for Incomplete Pass-Through *7*
3.3 ERPT AND MARKET SHARES FOR DOMESTIC PRODUCERS 8

4 TESTS OF ERPT AND ITS RELATION TO MARKET SHARE **8**

4.1 GOLDBERG & KNETTER (1997) 9
4.2 DORNBUSCH (1987) 9
4.3 GOLDBERG & VERBOVEN (1998) 10
4.4 FEENSTRA, GAGNON & KNETTER (1996) 10
4.5 OUR CONTRIBUTION TO THE FIELD 12

5 DATA OVERVIEW **12**

5.1 PROS AND CONS WITH THE USE OF PANEL DATA 12
5.2 PANEL DATA DIMENSIONS 13
5.2.1 Car Models and Source Countries *13*
5.2.2 Destination Markets *13*
5.2.3 Estimation Period *14*
5.3 VARIABLES 14
5.3.1 Pre-Tax Prices *14*
5.3.2 Exchange Rate *15*
5.3.3 Producer Price Index *15*
5.3.4 Gross Domestic Product *15*
5.4 DATA QUALITY 16
5.5 SELECTION CRITERION 16

6 METHOD **17**

6.1 PANEL DATA MODELS 17
6.1.1 Fixed Effects Model *18*
6.2 MODEL SPECIFICATION 18
6.3 CRITICAL ASSUMPTIONS 19

7 RESULTS OF THE EMPIRICAL ESTIMATION **19**

7.1 THE ESTIMATED DEGREE OF ERPT 19
7.2 THE RELATION BETWEEN THE ESTIMATED DEGREE OF ERPT AND MARKET SHARE 21

8 ANALYSIS **22**

8.1 ANALYSIS OF THE DEGREE OF ERPT 22
8.1.1 Why Pass-Through is Incomplete *22*
8.1.2 Logic behind Market Specific Pass-Through *23*
8.1.3 Why Pass-Through is lower Compared to Previous Studies *24*

8.2 ANALYSIS OF THE RELATION BETWEEN ERPT AND MARKET SHARE 24
8.2.1 Why ERPT is decreasing in Market Share *25*
8.2.2 Why ERPT increases in Market Share for Large Market Shares *25*
8.2.3 Robustness of the Relation between ERPT and Market Share *26*
8.3 SOME SUGGESTED FIELDS OF APPLICATION 26
9 CONCLUSIONS **27**
10 REFERENCES **28**
APPENDIX A DEPICTION OF CAR MODELS AND THEIR SOURCE COUNTRY **30**
APPENDIX B BASIS FOR SELECTION OF INCLUDED CAR MODELS **32**
APPENDIX C TESTING THE ASSUMPTIONS OF THE FIXED EFFECTS MODEL **34**

LIST OF FIGURES

FIGURE 1 *An Example of the ERPT Mechanism* p. 6
FIGURE 2 *Possible Relations between ERPT and Market Share for Foreign Producers* p. 11
FIGURE 3 *Relation between Estimated Degree of ERPT and Market Shares* p. 22

LIST OF TABLES

TABLE 1 *The Estimated Degree of ERPT per Destination Market* p. 20
TABLE 2 *Domestic Producer Market Share in 1994* p. 21

1 Introduction

The breakdown of the Bretton Woods regime and the subsequent oil shocks of the 1970's led to research on a phenomenon referred to by economists as *Exchange Rate Pass-Through,* henceforth ERPT. ERPT measures how prices of imported goods respond to exchange rate changes. The debate around ERPT culminated as researchers argued about the reasons behind the price differentials that were commonly observed across integrated markets. One hypothesis brought forward was the lack of a one to one relationship between the percentage change in exchange rate and price, i.e. incomplete ERPT. Since the early 70's a lot of research has been conducted on the ERPT mechanism, however research on how market structure affects ERPT is limited. A thorough understanding of ERPT and its relation to market shares is helpful for understanding how market structure may affect pricing decisions following changes in the exchange rate. This in turn is of strategic importance at not only the firm level, i.e. to a manufacturer who wants to analyse the likely reactions of foreign competitors to exchange rate fluctuations, but also at the macro level, i.e. where policy makers analyse competition in international trade and the effects of currency fluctuations on the trade balance. The relation between ERPT and market shares can hence increase policy makers understanding for how the ERPT mechanism works, which will be helpful in their attempts to stabilize the economy. To our knowledge, no previous studies have analysed the European car market during the 1990's regarding the relation between the degree of ERPT and market share. However, studies have been made covering the 70's and 80's. While these studies make use of less detailed data, comparisons can still be made and inferences regarding the dynamics can be drawn.

The main focus of ERPT research has shifted over the years. Throughout the 70's the spotlight was on macroeconomic implications of an exchange rate change with a main focus on trade balance and current accounts[1]. Theoretically, a depreciating currency should bring about an improvement in a country's trade balance as its exports become more competitive on the world market and vice versa. As it turned out a volatile exchange market had no significant implications on world trade. Relative prices were not adjusted; prices that consumers faced remained surprisingly stable. As such, the expected shift in demand towards goods originating from a country with a competitive exchange rate was much weaker than macroeconomists expected. To solve the mystery, the attention of economists was drawn towards the microeconomic repercussions of exchange rate changes, with special focus on geographical segmentation and price discrimination. Accordingly the firm now plays a central role in most ERPT research.

In this study we use micro level price data for the European car market during 1993-98 to estimate the relation between pass-through and market structure. The European market is of special interest considering the fact that the market is supposed to be integrated as from the Treaty of Rome in 1957. In spite of this, sizable price differentials have remained evident in many product markets, one of these being the European car market. One would think that the durable nature of cars in conjunction with the national price dispersions would induce consumers to "shop around" and buy the car where it is most favourable to do so, forcing prices to converge. The persistence of perceptible price differentials has been rendered possible by the producers' ability to segment markets geographically, which was further strengthened by the 1985 Block Exemption from EU competition law.

[1] See e.g. Friberg (1999).

1.1 Aim

The aim of this study is to use micro-level price data for the European car market to investigate the relation between market share for domestic producers and how prices of imported cars respond to exchange rate changes, ERPT.

1.2 Outline

The paper begins with section 2, "*The Structure of the European Car Market"*. It covers a description of the European car market including the competitive situation and sources of price differentials. The following section 3, *"Theoretical Framework",* provides a review of the ERPT mechanism and conditions for full and incomplete pass-through. The section is completed with a discussion of the relation between ERPT and market share. Section 4, *"Tests of ERPT and its Relation to Market Share"*, presents earlier papers on the topic. The section entails a description of the different methods used to measure ERPT as well as an overview of the estimated degree of ERPT and its relation to market structure. The section ends with a description of our contribution to the field. This is followed by section 5, *"Data Overview,"* which thoroughly goes through the dataset and the included variables. It includes a justification for the included variables, a presentation of their dynamic structure as well as the explanatory variables expected relation to the dependent variable. Finally, we present selection criterion used as a base for which car models and destination markets to include in the estimation. Section 6, *"Method",* addresses potential panel data models, specifically the Fixed Effects Model. Thereafter, the model specification is presented. The section ends with a summary of critical assumptions. Section 7, *"Results of the Empirical Estimation",* reports the results from the regression model accounting both for the estimated degree of ERPT and the relation between ERPT and market shares for domestic producers. This section is followed by section 8, *"Analysis",* which analyses the results found according to the theory presented. It also contains a discussion of some suggested fields of application. Finally, section 9, *"Conclusion"*, concludes our findings.

2 The Structure of the European Car Market

The Treaty of Rome in 1957 marks the beginning of a fully integrated European market. Under the treaty, the parties agreed to the removal of all tariffs within the Community. An integrated market can be defined as "one in which geography or nationality do not have systematic effects on transaction prices for otherwise identical products."[2] However, the car sector has to a great extent been exempt from this process, culminating with the 1985 ten-year Block Exemption.[3] The Block Exemption granted car manufacturers special privileges with respect to EU competition law. Member countries were allowed to keep or impose several non-tariff barriers to trade enabling car manufacturers to segment the European car market geographically. Traditionally the location of buyers and sellers has influenced the terms of transaction substantially[4] indicated by large and persistent price differentials across member states.

Lutz (1998a) examines the deviations from the law of one price, using biannual micro-level price data for the European car market during 1993-98, published by the European Commission. 88 car models across 12 national markets, specifically the member states of the European Union as of 1998 less Greece, Denmark and Finland for which data is missing, are investigated. The data published by the Commission is adjusted for differences in equipment, except for five items for which the author controls by using a hedonic price function. Lutz concludes that, even after controlling for the differing characteristics, there are large and persistent price differential across member states.

[2] Goldberg & Knetter (1997), p. 1245.
[3] Lutz (1998b), p. 3.
[4] Goldberg & Knetter (1997), p. 1245.

According to Lutz, the source of the price differences stems from two sets of variables, those related to price setting behaviour in segmented markets, such as home bias in demand and producer market share, and those related to the cost of arbitrage such as border and language effect.

2.1 Sources of Price Differentials & Market Segmentation

The size of the price differentials on the European car market cannot be fully assigned to cost differences, but is rather a signal of price discrimination, since the ratio of prices is most likely to differ from the ratio of marginal costs across member states.[5] After an illustration of the existing price differentials, we will address three major mechanisms that explain the source of price differentials and market segmentation.

The degree of price discrimination hinges on the firm's ability to segment the markets, which in turn requires costly arbitrage. Moreover, the firm must enjoy a certain degree of market power enabling the firm to set price above marginal cost. The underlying logic for why manufacturers wish to price discriminate geographically is their desire to utilize consumers' willingness to pay which may vary across nations.[6] The optimal pricing strategy for rational profit maximizing producers is to charge relatively high prices in markets characterized by a low price elasticity of demand, i.e. markets in which a price increase is followed by a relatively small decrease in demand for the car. This type of pricing strategy is referred to as pricing to market. For example, in May 1998 the pre-tax pound price of a Toyota Corolla was 30.7 percent higher in the United Kingdom compared to Belgium.[7]

The justification for the 1985 Block Exemption was based on the belief that the advantages would outweigh the competitive restrictions and that consumers would get a fair share of the resulting benefits.[8] Given the large and persistent price differentials the latter requirement apparently fails to hold. Consumers have traditionally been prevented from purchasing their car in the most competitive location. Consequently when the Commission renewed the Block Exemption for another seven years in 1995 they did so with minor restrictions. These were imposed to further increase competition between car manufacturers and to improve the situation faced by consumers, for example, making prevention of sales to non-residents illegal.[9] The remaining non-tariff barriers were in addition to transportation- and information costs, differences in national regulations and exclusive dealerships and selective distribution.[10]

2.1.1 National Regulations

The system of national type approval has long prevented consumers from exercising their Single Market right to purchase a car in the member state offering the lowest prices.[11] Country specific vehicle requirements were associated with costly modifications for imported cars. In addition, official importers were responsible for making sure that imported cars fulfilled national requirements putting them in a position were they had the power to delay certificates and charge excessive fees.[12] In connection to the Treaty of Amsterdam and the "1992 Program" for the completion of the common market, an agreement on common standards throughout the European Community was reached to harmonize the set of vehicle requirements across countries. The decision to allow national standards

[5] Cabral (2000), p. 168.
[6] ibid, p. 169.
[7] Authors' calculation from European Commission pre-tax price data.
[8] Commission press release, ip/02/1073.
[9] Lutz (1998b), p. 3.
[10] Goldberg & Verboven (1998), p. 6.
[11] Commission press release, ip/02/1073.
[12] Goldberg & Verboven (2004), pp. 9-10.

to coexist with the common ones delayed the desired harmonisation. To ease the harmonisation process, the common standards became mandatory in 1995.[13] Hence, since 1995 this can no longer be considered an obstacle to the integrated market, with the exemption for the right-hand drive regulation in the United Kingdom.[14]

A further obstacle to market integration stems from the system of national registration requirements. The system of national registration has effectively allowed governments to impose quantitative restrictions on imports from third party countries, limiting the extent of parallel imports especially from Asian countries. The government control of cross-border trade implied that only a limited number of Japanese cars could be registered in the relevant markets each year. Even though the members of the European Community agreed upon a common import quota in 1993 the national registration requirements remained as unofficial national quotas.[15]

2.1.2 Selective Distribution and Exclusive Dealerships

The Block Exemption enabled manufacturers to make use of both selective distribution and exclusive dealerships in order to strengthen their ability to price discriminate. Selective distribution refers to the manufacturer's power to choose and restrain its dealers from selling to other retailers or end-users not approved by the manufacturer. [16] During the time period of investigation, manufacturers have been in a position of power over dealers. Certain car manufacturers have used termination or threat of termination to prevent dealers from engaging in pro-competitive behaviour such as carrying more than one brand and selling to consumers from other member states.[17] Also, the quality and accessibility of service and repairs has been restricted for imported cars. Even though the 1985 Block Exemption specified that consumer rights should be protected this was not always upheld. Excessive delivery lags, lower discounts to foreigners, refusal to carry out after sale services are examples of the obstacles faced by consumers wishing to purchase their car abroad.[18] While manufacturers' powers were restricted through the 1995 revision of the Block Exemption, some manufacturers continued to exercise competition inhibiting behaviour. As an example of this type of firm behaviour, consider the case where Volkswagen was fined 102 Million ECU by the European Commission on 28 January 1998 for their refusal to sell Volkswagen and Audi cars to foreign buyers in Italy. Not only had the company been forcing their franchise dealers to sell only to Italians by threatening them to otherwise terminate their contract but they had also started to obtain vehicle registration information to find out which Italian dealers had sold cars to foreigners and other "unapproved" buyers.[19]

Exclusive dealerships concerns the manufacturer's right to assign territories to individual dealers, in effect restricting the dealers' ability to engage in active sales promotion outside the territory.[20] The justification for allowing the car sector to utilize exclusive dealerships is to avoid the problems of free riding stemming from investment externalities faced by both manufacturers and dealers. For example, from the point of view of the manufacturers, the incentives to invest in the training of sales people is lessened when a car dealer carries more than one brand, as some training investments, such as sales techniques are not brand specific but are also beneficial for rival manufacturers. For dealers

[13] Goldberg & Verboven (1998), p. 6.
[14] Verboven (2002), p. 13
[15] Goldberg & Verboven (1998), p. 9.
[16] Ibid, p. 7.
[17] Commission press release, ip/02/1073.
[18] Goldberg & Verboven (1998), pp. 7-8 & Goldberg & Verboven (2004), p. 11.
[19] Lutz (1998b), p.3.
[20] Goldberg & Verboven (1998), p. 7.

on the other hand, non-exclusivity may lessen the incentive to invest in service quality and advertising, since they may be unable to prevent rivals from enjoying parts of the resulting benefits. A dealer is naturally less willing to invest money in costly advertising if it implies that a part of the demand increase benefits another dealer.[21] Concluding, the combination of selectivity and exclusivity has made dealers remain dependent on car manufacturers, effectively easing the ability of the latter to limit price competition and thereby segmenting the market. The Block Exemption has been effective in preventing unauthorized dealers and independent resellers from exploiting arbitrage opportunities stemming from international price differentials.[22]

2.1.3 Non Regulatory Impediments to Cross-Border Trade

The cross-border trade restrictions described above are not the only potential causes of the observed price differentials and market segmentation. The presence of differing structural conditions, such as taxes, competitive conditions and exchange rate fluctuations can also serve as explanations for price differences.[23] Taxes have varied widely between countries[24], e.g. car taxes in Denmark have traditionally been approximately ten times higher than in Germany, giving manufacturers the incentive to compensate consumers in high-tax countries by charging lower pre-tax prices. When it comes to competitive conditions we can identify one major source of competitive constraint; demand substitutability, here defined as the elasticity of substitution between domestically produced cars and imported cars.[25] A low degree of substitutability implies that the producers have more power in pricing decisions.[26] Given that the elasticity of substitution can be nation specific, manufacturer market power, and hence optimal car prices, may vary across markets. Preferences vary across member states of the European Union, which is indicated by a home bias effect and producer market shares as discussed by Lutz (1998a).

Lastly, exchange rate volatility may also explain the observed price dispersions. If exchange rate changes are small and expected to be temporary the cost of adjusting prices may outweigh the benefits. Since "a floating exchange rate fluctuates literally by the minute it could be very costly to reoptimize offer prices every time the exchange rate changes."[27] These costs may, according to Keynesian theory, stem from (1) menu costs, i.e. the administrative cost associated with changing prices (2) distorted customer relationships and (3) price stickiness due to the company being tied down by contracts.[28]

[21] Cabral (2000), pp. 193-96.
[22] Goldberg & Verboven (2004), p. 11.
[23] Degryse & Verboven (2000), p. 7.
[24] Kirman & Schueller (1990), p. 71.
[25] Elasticity of substitution is defined as: $\xi_{i,j} = \frac{\partial\left[x_i(p,y)/x_j(p,y)\right]}{\partial\left[p_i/p_j\right]} \cdot \frac{p_i/p_j}{x_i(p,y)/x_j(p,y)}$
[26] Menon (1996), p. 436.
[27] Friberg (1998), p. 60.
[28] Burda & Wyplosz (2001), p. 238.

3 Theoretical Framework

This section gives an account of the general theory behind ERPT. Conditions for full and incomplete pass-through are offered followed by a discussion of what determines the degree of pass-through. Finally, the expected relation to market share is considered.

3.1 Exchange Rate Pass-Through (ERPT) Mechanism

Exchange rate pass-through can according to Menon (1996) be defined as "the degree to which exchange rate changes are reflected in the destination currency prices of traded goods"[29], i.e. the percentage change of nominal prices following a one percent change in the exchange rate between the exporting and importing country. After an exogenous exchange rate movement in combination with sticky labour costs the manufacturer will experience a cost shock. That is, an appreciation of the import country's currency in conjunction with sticky wages causes the labour costs in terms of that currency to decrease. This in turn distorts the market equilibrium and calls for an industry adjustment in price and/or quantity.[30] An illustration of the mechanism is given in *Figure 1* below. The example given is based on the Swedish producer Volvo and its pricing decisions on the British market following an appreciation of the Pound.

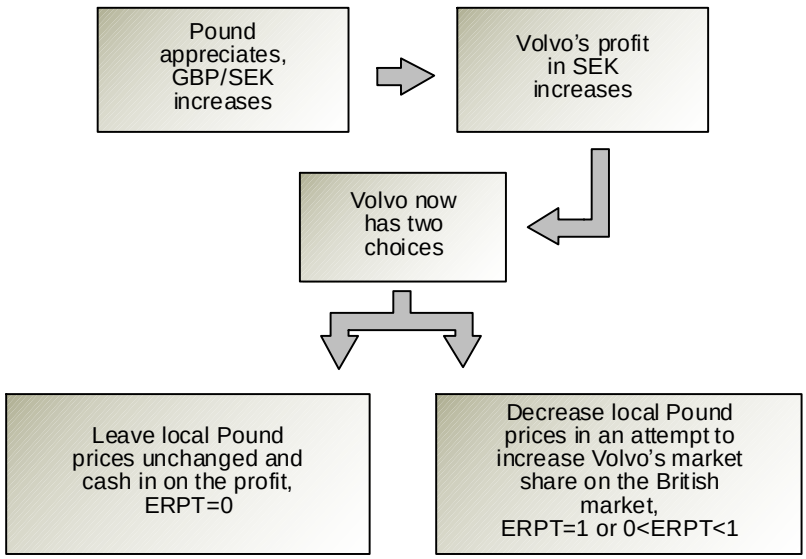


Figure 1. An Example of the ERPT Mechanism

3.2 Determinants of the Degree of Pass-Through

Previous studies have shown that the estimated degree of pass-though depends on the nature of the good[31] as well as export- and import country market characteristics. Furthermore Campa & Goldberg (2002) point out that the countries with relatively stable exchange rates experience a lower degree of ERPT. They also find that ERPT has decreased in the OECD countries, which may be explained by the lower exchange rate volatility.[32]

[29] Menon (1996), p. 434.
[30] Dornbusch (1987), p. 93 & p. 95.
[31] See e.g. Haskel & Wolf (2001), Goldberg & Knetter (1997).
[32] Campa & Goldberg (2002), p. 2.

3.2.1 Conditions for Complete Pass-Through

If there is a one to one relationship between the percentage changes in exchange rates and prices we are in a situation with complete pass-through. Two critical assumptions need to be fulfilled for complete pass-through to hold: (1) constant mark ups of price over cost expressed in the producer's currency, which is guaranteed in the case of perfect competition where mark ups are zero, and (2) constant marginal cost also expressed in the producer's home currency. Illustrating, suppose that we have two countries, Sweden and the United Kingdom. Following a ten percent depreciation of the Pound Volvo's exports to the UK will be subject to an exchange rate shock. Assuming that revenues are invoiced in Pounds and costs in Swedish Kronor the mark up in Kronor will decrease. If Volvo wants to keep mark up in Kronor constant, export prices in Kronor must be kept constant. Hence, the ten percent depreciation of the Pound must be followed by a 10 percent increase in the Pound price.[33]

3.2.2 Reasons for Incomplete Pass-Through

There are several reasons why pass-through may be incomplete. These include (1) shifts in or movements along the marginal cost curve following a change in the exchange rate[34], (2) part of the manufacturers costs may come in currencies other than the manufacturers home currency, (3) price-elasticity of demand for a given car may not be constant (linear demand) and the elasticity of substitution between cars is less than perfect, (4) dynamic supply side effects implying that it is difficult for foreign manufacturers to rapidly adjust quantity,[35] (5) markets are not fully integrated.

Firstly, even if the assumption of constant mark ups over costs is valid, ERPT will be less than unity if the assumption of constant marginal costs fails to hold. At current nominal prices, a change in the importer's currency may be followed by a change in demand. If the marginal cost differs with quantity, e.g. there is a drop in marginal cost, mark ups may in fact be constant even though prices are not fully adjusted to the change in exchange rates.

Secondly, outsourcing combined with international production facilities, implies that part of the manufacturers marginal cost may come in the import country's currency or in a third currency. The currency in which the marginal cost is invoiced is of importance in terms of how marginal costs are affected by exchange rate changes.[36] Consider the extreme case when revenues as well as costs are accounted for using the import country's currency. In this case the optimal pricing decision of the manufacturer is independent of changes in the exchange rate. Consequently the manufacturer has no incentives to adjust prices following a change in the import/export exchange rate and ERPT is expected to be zero.

Thirdly, if the price-elasticity of demand is not constant, the manufacturer's optimal pricing strategy changes with the exchange rate, i.e. the optimal degree of ERPT depends on the shape of the demand curve. If the price elasticity of demand is low, a price increase is followed by a relatively small decrease in demand for the car, which gives the manufacturer a greater power to pass-through an exchange rate change. Of utterly importance is how price-elasticity of demand changes with price. If the elasticity increases in price, profit maximizing car producers will be more reluctant to increase price following a depreciation of the importer's currency. Consequently, mark ups must be lowered and as such pass-through will be less than unity. Moreover, the size of the price adjustment at a

[33] Goldberg & Knetter (1997), p. 1248.
[34] Ibid, p. 1248 & p. 1251.
[35] (2)-(4) Froot & Klemperer (1989), p. 637.
[36] Friberg (1998), p. 68.

particular point in time also depends on substitution between domestic and foreign goods and on the market structure. A low degree of substitutability between domestic and foreign goods is associated with a larger degree of manufacturer market power because a drastic change in car prices will be required to induce a substitution effect in consumption.[37]

Fourthly, if production decisions cannot be easily changed in the short run a price change may not be an optimal response to a movement in the exchange rate. The incentive for a price adjustment is greater when exchange rate changes are large and expected to be permanent. Furthermore, the incentives are strongest when it is of strategic importance to increase market share at the expense of domestic producers.

Fifthly, costly arbitrage, home bias and regulation implies that car producers have the power to segment the national markets geographically as explained in the section 2.1. This in turn leaves the manufacturer more room to adjust mark ups rather than prices. In addition, the degree of ERPT will be determined by the relative dominance of domestic producers to which we turn next.

3.3 ERPT and Market Shares for Domestic Producers

The competitive structure of the market is one determinant of the degree to which exchange rate changes pass-through. For instance if the market is perfectly competitive, prices equal marginal cost and mark ups are zero. In the case of perfect competition, if all car producers are foreign, there will be a one to one relationship between exchange rate changes and price adjustments. The relation between ERPT and market shares for domestic producers is one way of analysing how market structure influences pricing decisions. Dornbusch (1987) uses theoretical models to show that one would expect pass-through to be decreasing in the ratio of domestic to foreign firms. The logic behind the relation is that when market share for domestic producers is low, foreign firms face little competition from domestic firms. They will therefore have a greater ability to pass-through a cost shock caused by a change in the exchange rate without the risk of loosing market share to domestic producers. Consider ten car producers among which some are foreign and some are domestic. Following a depreciation of the import currency, all foreign producers experience a similar cost shock. The greater the combined market share of foreign producers, the greater is their power to adjust prices according to their new cost structure. Intuitively, foreign producers will have more power in a situation where nine out of ten producers are foreign relative to the case when all but one is domestic.

4 Tests of ERPT and its Relation to Market Share

Since the early 70's, many researchers have become absorbed in studies of the ERPT mechanism. Still little research has been made on the relation between ERPT and market structure. In this section four seminal papers are presented. The first by Goldberg & Knetter is a well cited survey and is included due to its thorough discussion of the ERPT mechanism. The second paper by Dornbusch presents a general framework for the ERPT mechanism and its relation to the relative number of foreign firms. The third paper is a paper by Goldberg & Verboven adapting the ERPT framework to the European car market. Further, the paper slightly touches upon the relation of ERPT and market structure. The fourth and final paper presented is a technical paper by Feenstra, Gagnon & Knetter focusing on the relation between market share and pass-through on the world automobile market. The section ends with a description of our contribution to the field.

[37] Markusen et al (1995), p. 57.

4.1 Goldberg & Knetter (1997)

Goldberg & Knetter develop a framework appropriate for future micro economic studies regarding the importance of the competitive structure in international markets. Their framework is particularly well suited for explaining price adjustments to exchange rate movements and deviations from the law of one price. Of special interest to our thesis is the authors' presentation of the exchange rate pass-through phenomenon as well as their suggested generic regression model for measuring the price response to exchange rate changes. They adapt a textbook definition of ERPT focusing on price adjustments following an exchange rate change for transactions between exporting and importing countries. Their discussion is based upon the following generic regression model:

$$p_t = \alpha + \delta X_t + \gamma E_t + \psi Z_t + \varepsilon_t$$

where subscript t denotes time. All variables are in logs and are defined as follows; p is the local currency import price, X is a control variable measuring the exporter's cost, E is the import/export exchange rate and Z is variable controlling for shifts in import demand. The coefficient of main importance is γ which captures the degree of ERPT. Full pass-through is depicted by $\gamma = 1$ and incomplete ERPT occurs when $\gamma < 1$.

Surveying previous studies Goldberg & Knetter conclude that pass-through for the United States average around 60 percent during the period of floating exchange rates. Other countries are found to experience a higher degree of ERPT. Deviations from the law of one price and incomplete pass-through can according to the authors to a large extent be attributed to third degree price discrimination. The firm's nation specific market power combined with the ability to segment markets results in destination specific adjustments of mark ups rather than a complete price adjustment.

4.2 Dornbusch (1987)

Dornbusch examines ERPT in a number of theoretical models of imperfect competition. The author uses a partial equilibrium approach and assumes that the exchange rate is exogenous. He describes the ERPT mechanism as follows; an exchange rate change in combination with sticky wages will induce a cost shock which forces firms to alter prices and quantities. Hence, he depicts a model where price movements are due to changes in relative costs. The proposed explanations for the degree of price adjustments are market concentration, product homogeneity and substitutability and market shares for domestic and foreign firms respectively. Utilizing a Cournot oligopoly model the author derives a formula for the elasticity of equilibrium price with respect to exchange rate, also known as ERPT elasticity.

$$\varphi = \left(n^*/N\right)\left(ew^*/p\right)$$

where n^*/N is the relative number of foreign firms and ew^*/p is the ratio of marginal cost to price faced by foreign suppliers.

From this formula one can conclude that pass-through increases with the ratio of foreign firms to total number of firms as well as with the ratio of marginal cost to price.

4.3 Goldberg & Verboven (1998)

Goldberg & Verboven document and analyse price dispersion across the European car market. The motivation for their study is to isolate a theoretical and empirical base upon which conjectures of the European Monetary Union, EMU, can be based. The model is applied using list prices for 150 car models in five European markets, Belgium, France, Germany, Italy and the UK and covers the period 1980-1993. To control for differences in car characteristics the authors construct a hedonic price function. Their ERPT model specification is inspired by the hedonic price function and takes the following form:

$$\ln\left(p_{jmt}^{\exp}\right) = w_{jmt}\gamma + \delta tax_{mt} + \theta_c + \theta_f + \theta_{st} + \theta_{sm} + \beta_{sm}\ln\left(e_{smt}\right) + \varepsilon_{jmt}$$

where the subscripts *j, m* and *t* refer to product *j*, market *m* and year *t*. The variable *lnp* refers to the natural log of prices expressed in the exporter's currency, w_{jmt} refers to potential differences in physical car characteristics between markets, *tax* depicts any cross-country tax differences and lne_{smt} is the logged exchange rate expressed as source country currency units per destination market currency unit. The other variables included are dummy variables which control for the following: θ_c controls for destination specific effects, θ_f captures firm specific effects, θ_{st} is a source country time specific dummy included to control for common cost shocks faced by firms located in the same country of origin and finally θ_{sm} is included to capture source country destination market fixed effects.

The β coefficient measures the ERPT elasticity in such a way that a value of zero equals full pass-through and a value larger than zero equals incomplete pass-through. It measures the pass-through of the exchange rate change from a specific source country to a specific destination market. The paper concludes that large and significant price differences remain even after controlling for quality and tax differences. A large correlation between price differentials and exchange rates is found, indicating that local currency prices do not fully respond to exchange rate movements, i.e. there is incomplete pass-through. Of particular relevance to our analysis is the authors' estimation of the relation between the degree of pass-through and market share. According to their findings, pass-through increases with market share, but at a decreasing rate.

4.4 Feenstra, Gagnon & Knetter (1996)

Feenstra, Gagnon & Knetter focus on the pass-through from a specific source country to a specific destination market in relation to the combined market share of the source country's firms on this market. They expect pass-through to increase with market share of the source country firms. The reason is that all firms from the same source country experience the same change in cost following an exogenous change in the exchange rate. The greater their combined market share, the greater their market power to adjust prices according to their new cost structure. The authors set out from a profit maximizing condition and derive an expression where the ERPT elasticity dependents on the elasticity of demand and the shape of the demand curve. When the market share of foreign producers is small the authors find the degree of ERPT to be approximately 50 percent. As the market share of foreign producers increases, pass-through can be greater or less than 50 percent depending on the nature of demand.

A further conclusion of the paper is that pass-through would be complete when market share of foreign producers equals unity. The authors conclude from their mathematical derivations that the relation between ERPT and the combined market share for firms from the same source country would theoretically take one of the forms depicted in *Figure 2* below. The curve received depends, as

noted, on assumptions of demand and firm interaction. As shown in the figure, pass-through should increase with market share when market share is large. For small market shares pass-through could either increase or decrease with market share.

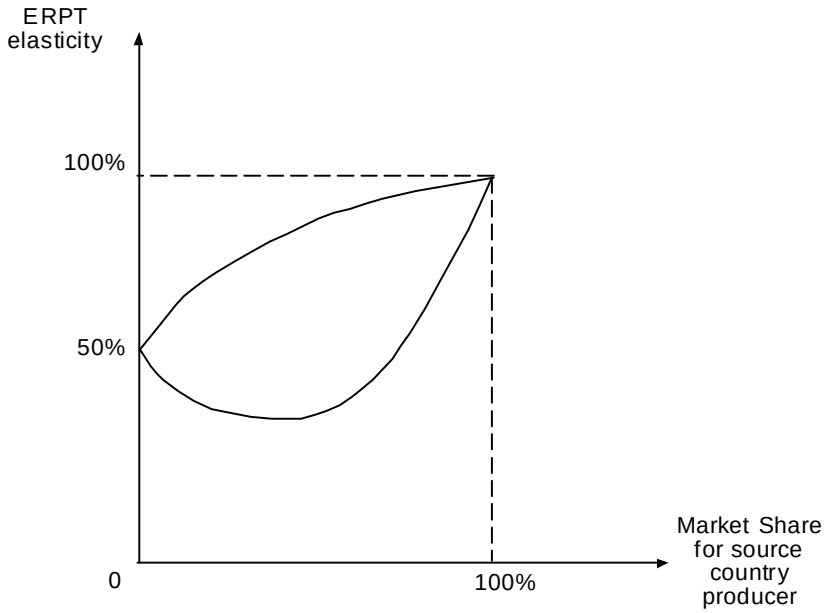


Figure 2. Possible Relations between ERPT and Market Share for Foreign Producers

The paper continues with an empirical implementation on the world automobile market. The authors use a balanced panel data set including price data for seven automobile producing countries and an additional five non-producing countries covering the period 1970-88.[38] The price data equals unit values of shipments aggregated on a country level. The unit value from each respective production country to each import market is found by aggregating the total export value of cars in the export country and dividing it by the number of cars exported. The unit price for domestic sales is found by subtracting the value of exports from the value of domestic production and dividing by the number of cars sold domestically. The data is hence not very detailed. The regression model takes the following form:

$$\ln p^{*}_{ijt} = \mu_{ij} + \beta_{ijt} \ln c^{*}_{it} + \left(1 + \beta_{ijt}\right)\ln\left(p^{-i}_{jt} / e_{ijt}\right) + \gamma_{ij} \ln\left(I_{jt} / e_{ijt}\right)$$

where subscriptions *i*, *j* and *t* denote source country, destination market and year respectively. *lnp* is the logged price in the exporters currency, *lnc* controls for costs measured in the exporters currency, p^{-i} is the aggregate price of all varieties on the destination market except those from source country *i*.

The estimated pass-through is then put in relation to market shares for foreign producers. The authors find evidence for the j-shaped curve depicted in *Figure 2* above. Hence, for small market shares pass-through is decreasing in market share while for larger market shares pass-through is increasing in market share.

[38] The producing countries are Canada, France, Germany, Japan, Sweden, the United Kingdom and the United States. The non-producing countries include Norway, Finland, Austria, Switzerland and Israel.

4.5 Our Contribution to the Field

To our knowledge no previous systematic study makes use of micro level data to estimate how the degree of ERPT depends on market structure. The issue has been addressed by Feenstra, Gagnon & Knetter (1996) but they have access to less detailed data. The more detailed data utilized in our study provides us with more precise measures of ERPT. While the level of detail of our data corresponds to that of Goldberg & Verboven (1998), the latter have no main focus on ERPT and market structure. In addition we develop a model that has not yet, to our knowledge, been adapted to the car market. The regression model we use is based on the general model suggested in Goldberg & Knetter (1997). The variables chosen to capture exporters' costs and shifts in import demand will be presented and justified in section 5.3. Our study will investigate an aggregate pass-through to a specific destination market from all source countries. This is equivalent to producing an average of all the pass-through coefficients to a specific destination market produced by Feenstra, Gagnon & Knetter as well as by Goldberg & Verboven. Contrary to Feenstra, Gagnon & Knetter we use consumer prices rather than prices at the border. The use of consumer prices accounts for price adjustments at the producer level as well as the additional retail level, allowing two parties to share the effect of a change in the exchange rate. The estimates of the degree of ERPT found in this study should thereby be of a smaller magnitude.

We will furthermore look at the relation between *domestic producers'* market share and the degree of ERPT. The reason is that a change in the exchange rate tends to affect all foreign producers similarly. Consequently their greatest obstacle to adjust prices is, except for a change in demand elasticity, competition from domestic producers who have not experienced the same exchange rate shock. Hence, in our opinion, the relation between domestic and foreign producers' market shares is more interesting than focusing on the combined market shares for all producers from the each respective source country. The 1990's has been a period of relatively stable exchange rates as compared to the two previous decades and combined with the trend of decreasing ERPT for the OECD countries found by Campa & Goldberg (2002), we expect to find a lower degree of pass-through than studies of the car industry covering these earlier time periods. Although we expect the size of ERPT to be lower we do not expect the relation between ERPT and market share to be significantly different. Given our specification, we hence expect the plot of the relation between ERPT and market share to be inverted as compared to *Figure 2* in section 4.4.

5 Data Overview

The data set upon which we base our estimation is an unbalanced panel data set with three dimensions. Below we first discuss some pros and cons with using panel data. We then present an overview of the panel data dimensions as well as the variables included in the regression model. Thereafter, we turn to a discussion of the data quality. The last section provides a description of the selection criterion determining which countries and car models to include in our estimation.

5.1 Pros and Cons with the Use of Panel Data

Our estimation utilizes a panel data set meaning that we need to use an econometric model able to handle the multidimensional nature of the data. According to Baltagi (2001) there are several pros and cons with using panel data. The ones most relevant to this study are the following:

- ✓ Panel data allows us to control for individual heterogeneity. This is of importance in this study since the data set contains several car models and we want to be able to control for model specific characteristics that may influence pre-tax prices.

- ✓ Panel data give "more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency."[39]
- ✓ The use of panel data allows for studies of the dynamics of change. Although it would be interesting to see how the relation between ERPT and market share evolves over time, we will not utilize this advantage. Instead of measuring the destination specific ERPT for each year we have decided to measure an average over our sample period. The reason is that we have not been able to find reliable estimates of market shares for each observation period. Moreover, a time period of six years might be too short to draw any reliable conclusions of the dynamics of the relationship.
- ✓ Panel data is often measured in micro units providing more accurately measured variables. Many previous studies have used aggregate level data rather than micro level data providing them with less precise measures.[40]
- ✓ A potential draw back of our data is that we may face problems with missing values. Certain car producers have failed to report accurate price information to the Commission and car models are being added to or subtracted from the producers' product lines during our estimation period.

5.2 Panel Data Dimensions

As described above the data set used in this study comprises panel data of three dimensions:

- ✓ 93 different car models originating from eight source countries
- ✓ 15 different destination markets
- ✓ 12 measurement periods, biannual from 1993-98

5.2.1 Car Models and Source Countries

This study utilizes pre-tax price data for 93 car models published by the European Commission. The data controls for differences in equipment except for five items; air conditioning, automatic gear box, power steering, Automatic Breaking System and airbag. Several earlier studies have chosen to also control for these by using a hedonic price function. However, according to Lutz (1998a) the remaining equipment differences not controlled for by the Commission do not have any significant impact on the results.[41] Hence, we have chosen not to account for any remaining equipment differences.

The results of the ERPT analysis are sensitive to the definition of "source country" for each car model. Several problems arise when trying to specify the "source country" since production often takes place across several different countries and some brands have merged over the years. We have addressed this issue by designating a car's "source country" as our perception of the brand's origin. An overview over the models and their respective source countries is depicted in Appendix A.

5.2.2 Destination Markets

As mentioned in the introduction we have chosen to focus on the European car market. The reason for focusing on the EU member countries is that the European Commission provides comparable price data for its member states. As of 1998, these member states were; Belgium (B), Germany (D), Spain (E), France (F), Finland (SF), Ireland (IRL), Italy (I), Luxembourg (L), The Netherlands (NL), Austria (A), Portugal (P), Denmark (DK), Greece (G), Sweden (S) and the United Kingdom (UK).

[39] Baltagi (2001), p. 6.
[40] Menon (1996), p. 435.
[41] Lutz (1998a), p. 4.

5.2.3 Estimation Period

The data set comprises biannual measurement periods for the years 1993-98, all in all twelve observations. The choice of start and end date is motivated by the availability of comparable data starting at 1993 as well as our wish to avoid the added complexity caused by the establishment of the EMU in 1999.

5.3 Variables

The general model presented in Goldberg & Knetter (1997) is, as mentioned, the point of departure for our research. A careful consideration of previous work motivates the choice of which explanatory variables to include in our regression estimating the degree of ERPT. The dependent variable, pre-tax prices, will be regressed on the exchange rate between the importer's currency and the exporter's currency, E, the producer price index of the source country, PPI, the gross domestic product of the importing country, GDP and a dummy variable for all but one car models.[42] Below we will present a more thorough description of each variable as well as the reason for including them in the regression.

5.3.1 Pre-Tax Prices

The dependent variable is the pre-tax price for each car model in each destination market. Prices are reported to the Commission on a biannual basis; the first observation per year is reported on May 1st and the second on November 1st. Since taxes are paid in the market where the car is registered and not where it is purchased, pre-tax price is the relevant price upon which rational consumers should base their purchasing decision. Moreover list prices, rather than the more accurate final prices, are used for the analysis because they are more readily and more widely available. Since consumer discounts and other financial benefits may be country as well as brand dependent, the cross country price differences may not be adequately captured. This in turn could have an impact on the estimated pass-through coefficient.[43] Contrary to Feenstra, Gagnon and Knetter we use, as already mentioned, consumer prices instead of prices at the border.

The pre-tax price data originates from the European Commission and has been compiled by Dr. Mathias Lutz, University of St. Gallen. According to the Block Exemption car manufacturers are obliged to provide the Commission with this data at a biannual basis.[44] After a thorough assessment of the data we have decided to exclude data that we found to be apparently wrong. For more details see section 5.5.

A fundamental assumption of regression analysis is that the dependent variable is stationary. If it contains a trend and this trend is shared by one or more of the explanatory variables we face a potential problem of spurious regression. In our model, inflation is an underlying trend in the dependent variable pre-tax prices and is likely to be shared by both PPI and GDP. To remove the trend and deal with the problem of spurious regression we have deflated these three variables with the rate of inflation. This was done by dividing the nominal value with the destination market specific inflation rate for the current quarter[45], using 1995 as base year.

[42] This is done to avoid the dummy variable trap. See e.g. Gujarati (2003), p. 642.
[43] Goldberg & Verboven (2004), p. 15.
[44] Lutz (1998a), p. 2.
[45] The inflation rate was derived from the country's consumer price index, collected from IMF's data base IFS.

5.3.2 Exchange Rate

The exchange rate variable is measured as importer currency per exporter currency and has been computed using the exchange rate generator at the website of the University of British Columbia. To match the exchange rate with the price observations we use the average exchange rate for the month prior to the price observation. We have further decided to lag the exchange rate variable six months, since the adjustment of import prices to exchange rate changes has been found to be completed in approximately two quarters.[46] Hence, the price observation in May 1993 is matched with the average exchange rate for October 1992, the price observation for November 1993 is matched with the average exchange rate for April 1993 etc. Note that the exchange rate for Luxembourg corresponds to the Belgian exchange rate. Our general conclusion from looking at the development of the exchange rates over time is that there has been some degree of exchange rate volatility but with a few exceptions no obvious trends or outliers can be detected.[47] We expect the relation between the exchange rate and pre-tax prices to be positive but of a smaller magnitude than found in research covering earlier time periods. A depreciation of the import country's currency implies that the foreign producer experience an increase in costs expressed in that currency. To offset the increase in costs, the foreign producer is likely to increase nominal prices.

5.3.3 Producer Price Index

The producer price index (PPI) measures the unit labour cost of production in the manufacturing industry in a local currency index. For each car model the relevant measure is the value of PPI in the particular model's source country. The data is in terms of aggregated manufacturing level, as separate cost indices for the car sector are not available. The variable is included in our regression to control for changes in production costs. The cost concept is important since a rational profit maximizing firm will base its pricing strategy on marginal cost. However, there are disadvantages associated with using cost indices as a proxy for marginal cost. By using cost indices the regression may be biased towards incomplete pass through, because the index may introduce measurement error into our regression which is correlated with the exchange rate.[48]

PPI has been transformed into half year averages by taking the average of quarterly data found in the OECD database. We have further lagged the variable six months. As such the last two quarters of the previous year are relevant for the price measurement in May and the first two quarters for the current year are matched with the price measurement in November. Production costs occur before the car reaches the market and pricing decisions are made, thus in this context a six month lag is appropriate. As mentioned in section 5.3.1 PPI has been deflated to remove the potential trend shared by pre-tax price. When looking at the development of PPI over time, we make the inference that a weak downward sloping trend is present in the deflated PPI.[49] Expressed in real terms the manufacturing costs used as a proxy for costs faced by car producers appear to have decreased during the time period covered in this study. We expect the relation between PPI and pre-tax prices to be positive since an increase in productions costs are likely to be offset by a price increase.

5.3.4 Gross Domestic Product

The gross domestic product (GDP) variable measures the national income at a quarterly basis and was collected from the OECD database. The variable is included in our regression to account for

[46] Menon (1996), p. 440.
[47] Graphs of the development of the exchange rates can be received on request.
[48] Goldberg & Knetter (1997), p. 1251.
[49] Graphs of the development of PPI can be received on request.

potential destination market specific shifts in import demand caused by changes in income level that may affect pricing decisions.

We have chosen to lag the GDP variable six months as it takes time for demand as well as prices to be adjusted according to a change in income. As such, the GDP value relevant for the price measurement in May is the value of the fourth quarter the previous year, whereas the price measurement in November is matched with the GDP of the second quarter the current year. GDP has been deflated to remove the potential inflationary trend shared with pre-tax price. When looking at the development over time, we can see that all countries with the exception of Spain, Austria and Sweden show no sign of seasonal dependence in the value of deflated GDP.[50] To make the results comparable, the same model specification must be used for all sample countries. Therefore we have decided not to correct for country specific seasonal variation. Furthermore, even after removing the trend caused by inflation, a weak upward sloping trend can be detected in all countries. Our time period of only six years, is too short to secure the presence of a trend, which is why we do not account for it. For more details, see section 6.2 below. We expect the relation between GDP and pre-tax prices to be positive since an increase in GDP will lead to an increase in the import country's purchasing power, which in turn may lower the price-elasticity of demand

5.4 Data Quality

The data sources utilized are all well-reputed and known for providing good quality data. However, the possibility of observational errors still remains. These may be the result of reporting and/or typing errors. We have checked the data thoroughly and have detected some errors in the price data. For two models, the first year observation has no logic value and hence is apparently wrong. Normally, in the case of missing or incorrect data observations one has the option of interpolating the values prior to and after the missing or wrong observation. In our case, this is not feasible since we do not have access to comparable information from observations prior to the incorrect value. Therefore we have chosen to exclude these observations. Another problem associated with the price data is the problem of nonresponses. Prices for Finland, Denmark and Greece have not been reported to the Commission during our time period. Consequently these countries have been removed from our study. A strength associated with the price data used in this thesis is that it controls for differences in characteristic which makes the results comparable between countries. A summary of the selection criterion used as a decision rule regarding which car models to include for each destination market is presented in the next section.

5.5 Selection Criterion

Every effort is made to avoid the problem of missing values and inadequate data. Some car models are covered for only a few observations within our estimation period and thus have been excluded. Furthermore, some car models do not exist in all destination markets and data is not always accessible. To deal with these problems we have chosen the following selection criterion:

- ✓ Models that do not exist for seven or more observation periods have been excluded from our research. The number of remaining car models is thereby limited to 81.
- ✓ For each particular country a car model is excluded if we lack data for more than three measurement periods. However, since Austria and Sweden did not become members of the EU until 1995 the data for the first four measurement periods are not reported to the Commission for these countries. Hence, for Austria and Sweden we have allowed for one

[50] Graphs of the development of GDP can be received on request.

additional missing value meaning that cars are excluded if we lack more than five measurement periods. Consequently, the number of car models included in the estimation differs between markets.

- ✓ Finland, Denmark and Greece have been excluded since pre-tax price data for the estimation period is not available for these countries through the Commission. This is unfortunate since all three countries have high car taxes and it would be interesting to see how high tax levels affect the degree of ERPT. After removing these countries twelve destination markets remain.
- ✓ We have omitted year 1 for car model 3 and car model 22 in all countries, due to faulty data.

An overview over the models included in each country is found in Appendix B. In the table we account for the number of missing observations for each car model in each destination market, which in turn determines which models we include in the country specific regression.

6 Method

To be able to investigate the relation between ERPT and market share for domestic producers we must first estimate the degree of pass-through. In this section we will describe and motivate the method used to perform the latter. The relation to market shares will be presented in section 7, *"Empirical Estimation"*. This section first accounts for the nature of panel data models and especially the Fixed Effects Model. Thereafter we present our model specification. Finally, we will summarize critical assumptions for the estimation.

6.1 Panel Data Models

With the type of data used in this study, one is faced with the choice between two different panel data models; Fixed Effects Model, FEM, and the Random Effects Model, REM.[51] The choice between FEM and REM can be tricky matter and has been widely debated. The distinction between the two is that the FEM model assumes individual heterogeneity to be a fixed constant that is time invariant while the REM assumes heterogeneity to be a random variable[52], i.e. that the intercept is randomly selected from a larger population. Considering that the 93 car model for which price data is made available by the Commission are not randomly selected, the assumption of randomly selected variables fails to hold. In this respect, the FEM model seems more appropriate.

Moreover, the 93 car models in our data set are not directly comparable. For instance a Nissan Micra is a very different car as compared to a car from the BMW 7 series, considering price levels as well as characteristics. We do not expect these differences to change significantly during our time period, i.e. they are time invariant. Again this calls for the use of a fixed effects regression model.

Another important aspect when choosing between the REM and the FEM model is, according to Gujarati (2003), the correlation between the error term and explanatory variables. The assumption of an uncorrelated error term will fail to hold in the case of omitted variables. Since there is always a risk that an omitted variable is correlated with one or more explanatory variables as well as the dependent variable this also speaks in favour of the FEM model since the REM model hinges upon the assumption of an uncorrelated error term.

[51] See e.g. Baltagi (2001), Gujarati (2003), Stock & Watson (2002) and Wooldridge (2002).
[52] Maddala, (2001), pp. 574-75.

Finally, if one aims at making inferences about the cross-section unit under study rather than about the population from which the cross-section data is assembled, the FEM seems to be the correct model of choice. The car market is very specific in nature, and we expect the external validity of the degree of ERPT found in our study to be limited. This also calls for the use of the FEM model. Based on the indications from the discussion above, the Fixed Effects Model will be adapted in this study.

6.1.1 Fixed Effects Model [53]

The fixed effects model relevant for this study needs to be able to account for car model fixed effects, which is done by including a set of dummy variables for all but one car model. This model specification is known as the least square dummy variable, LSDV, model and takes the following general form:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \gamma_2 D2_i + \gamma_3 D3_i + ... + \gamma_n Dn_i + u_{it}$$

where β_0 captures the intercept for the excluded entity (car model) used as reference model, and where γ_i is a differential intercept coefficient capturing how much the intercept for the specific entity (car model) differs from the intercept of the reference model β_0. X_{it} is an explanatory variable. Of course the model is flexible and one may include more than one explanatory variable. If the fixed effects model is the correct model specification the LSDV estimates will be BLUE, i.e. best linear unbiased estimates.[54] As the number of time periods approaches infinity the fixed effect estimator β_1 is consistent, i.e. it approaches its true value as the sample gets larger.[55]

6.2 Model Specification

The model specification used in this study builds, as mentioned, on the more general regression model presented by Goldberg & Knetter (1997) and follows the fixed effects framework presented in the section above. It includes the variables presented in section 5.3. All variables have been transformed into logs to be able to interpret the coefficients as percentage changes. In view of the fact that we have deflated pre-tax prices, PPI and GDP we have removed any common trend caused by the inflation rate which could lead to spurious regression. As noted in section 5.3, a weak upward trend is present in the GDP variable while PPI contains a weak negative trend, even after deflating the values. If one of the variables included in the regression is non-stationary, i.e. entails a unit root, it is custom to transform all variables into first differences in order to make the series stationary. The presence of a trend can normally be tested for by using a panel data unit root test. However, our time period of only six years is too short to be able to draw any significant conclusions about unit roots, since the strength of the panel data test is weak when the time series is short. To conclude that a trend is present one needs to observe the pattern over a longer time period. Hence, we have chosen not to account for potential trends and thus all variables are in levels. Considering that we are interested in the pass-through coefficient for each country we estimate twelve regressions, one for each destination market. Note that the pass-though coefficient that we will estimate is an average coefficient for all car models, all export countries and all time periods to each destination market. With car model 93 as reference group our basic regression model thus looks like:

$$\ln ptp_{it} = \alpha_i + \beta_{it} \ln E_{it} + \gamma_{it} \ln PPI_{it} + \delta_{it} \ln GDP_t + D_{\text{model1}} + ,.....,+ D_{\text{model 92}} + e_{it}$$

[53] This section builds on Stock & Watson (2002), pp. 278-79.
[54] Baltagi (2001), p. 14.
[55] Gujarati (2003), p. 903.

where the subscripts *i* and *t* denote car model and time period respectively. *lnptp* is the log of pre-tax prices, *lnE* is the log of the exchange rate, *lnPPI* is the log of the producer price index and *lnGDP* is the log of the GDP.

6.3 Critical Assumptions

To be able to test exchange rate pass-through empirically we have to make some critical assumptions. Firstly, although car models are often produced in several locations we have decided to simplify the analysis by basing the source country definitions on our perception of the brand's origin depicted in Appendix A. Secondly, we assume that all production takes place in the exporter's home country and home currency implying an approximately equal marginal cost for all destination markets.[56] As such, the cost structure is the same for all destination markets, which allows us to focus on destination specific demand differences. This is a simplifying assumption since in practice the importance of foreign inputs in costs, the ability to substitute between foreign and domestic inputs at each plant, and the firm's ability to substitute between products from plants in different locations will generally determine the effect on firm marginal cost of an exchange rate induced increase in the price of foreign inputs.[57] Lastly, list prices rather than the more accurate final prices are used implying that we do not consider the existence of country dependent consumer discounts. These assumptions are necessary to avoid the complexity associated with controlling for all factors mentioned. Like previous studies, we neither have access to all the relevant information needed regarding firm specific production and cost and revenues structures.

7 Results of the Empirical Estimation

The model specified in section 6 has been estimated with the SPSS statistical package. *Figure 3* below has been produced using SPSS while the tables have been constructed manually. Tests of the assumptions underlying the Fixed Effects Model are given in Appendix C.

7.1 The Estimated Degree of ERPT

The results from running the twelve regressions are presented in *Table 1* below. We do not report the estimates for the fixed effects dummy variables since these are only included for a controlling purpose and are of no practical interest. Estimates for the variables PPI and GDP are included in the table. However, since they are also controlling variables and only of secondary importance we will here only provide brief comments upon and explanations for their respective sign and significance level. The coefficient estimates for the exchange rate variable measuring the degree of pass-through are bold so that they easily can be identified. They will be analysed in section 8.

[56] Gron & Swenson (1996), p. 71.
[57] Ibid, p. 72.

TABLE 1. THE ESTIMATED DEGREE OF ERPT PER DESTINATION MARKET

	(B)	(D)	(E)	(F)	(IRL)	(I)	(L)	(NL)	(A)	(P)	(S)	(UK)
E												
Coefficient	**0.2184*****	**0.1149****	**0.1348****	**0.2098*****	**0.2151*****	**0.0747***	**0.2393*****	**-0.0113**	**0.0843**	**0.0201***	**0.1217****	**0.1807*****
s.e.	(0.0524)	(0.0479)	(0.0532)	(0.0614)	(0.0489)	(0.0420)	(0.0528)	(0.0087)	(0.0528)	(0.0108)	(0.0575)	(0.0382)
P-Value	0.000	0.017	0.012	0.001	0.000	0.076	0.000	0.196	0.111	0.065	0.036	0.000
PPI												
Coefficient	0.4564***	0.2564**	0.1348	0.2098	-0.1417	0.0650	0.3782***	0.3521***	0.2278**	0.4150***	0.2742	0.2421**
s.e.	(0.1180)	(0.1000)	(0.0761)	(0.1177)	(0.0959)	(0.0877)	(0.1068)	(0.1009)	(0.1076)	(0.1287)	(0.2047)	(0.1121)
P-Value	0.000	0.011	0.124	0.189	0.140	0.459	0.000	0.001	0.035	0.001	0.182	0.031
GDP												
Coefficient	0.1417	0.4950**	0.1664	-0.1206	-0.0045	0.4302***	0.0320	-0.2969**	-0.0554	0.3168**	0.8085***	0.2092
s.e.	(0.1568)	(0.2104)	(0.1066)	(0.1434)	(0.0296)	(0.1643)	(0.0510)	(0.1220)	(0.1427)	(0.1529)	(0.1339)	(0.1492)
P-Value	0.366	0.019	0.119	0.401	0.879	0.009	0.531	0.015	0.698	0.039	0.000	0.162
Adj R^2†	0.972	0.974	0.977	0.973	0.977	0.978	0.974	0.973	0.982	0.969	0.975	0.962
N, Models	70	69	61	65	59	60	70	69	65	50	35	64
N * Obs	746	736	634	685	611	636	736	738	507	523	273	675

*** *Significant at 1% level*
** *Significant at 5% level*
* *Significant at 10% level*
† The adjusted R^2 is calculated manually since the statistical package does not provide this statistic. The formula used is taken from Gujarati (2003), p. 218. We have adjusted for the degrees of freedom.
Notes: The constant is not reported. All explanatory variables are lagged six months. The fixed effects dummy variables are not reported.

As can be seen in *Table 1* almost all estimates for PPI and GDP follow the signs predicted by theory discussed in section 5.3, i.e. they are positive. The PPI coefficient captures manufacturers' price responses to a change in manufacturing costs not caused by exchange rate changes. The fact that all PPI coefficients but the coefficient for Ireland are positive indicates that an increase in manufacturer costs will induce car producers to increase prices. The PPI coefficient estimates for Spain, France, Ireland, Italy and Sweden are however not significant at a 10 percent level.

Looking at the GDP coefficient, we find negative estimates for France, Ireland, the Netherlands and Austria. A likely explanation is that real prices have been slightly decreasing in these markets at the same time as their GDP growth has been strong relative to the other markets. Another possible explanation is that GDP is not a significant demand shifter in the markets where GDP is negative. For instance, in these markets, the level of savings may determine personal consumption of durable goods to a greater extent than income. Moreover, about half the GDP estimates are not significant at a ten percent level indicating that, during our time period, the variable is a questionable proxy for measurements of demand shifts.

The coefficients of interest in this paper are the exchange rate coefficients. The magnitude of the coefficient captures the degree of pass-through, which is lower than 25 percent on all markets. As can be seen from *Table 1*, all estimates but those for Italy, the Netherlands, Austria and Portugal are significant at a 5 percent level. All coefficients, with the exception of the estimate for the Netherlands, are positive as expected. The magnitude of the Dutch exchange rate coefficient is however small and close to zero.

7.2 The Relation between the Estimated Degree of ERPT and Market Share

After having estimated the degree of ERPT we can now investigate its relation to market share for domestic producers. A table depicting the combined market shares for domestic producers in their respective home market is included below. The only big producer for which price data is missing in our data set is the Swedish producer Saab. Since Saab's market share on the Swedish market is of significant size we have chosen to include it when calculating the market share for Swedish car producers in Sweden. In our opinion this makes the results more in line with practice. Note however, that we have tested not to include the market share of Saab, with only minor impacts on the final curvature between ERPT and market share (the curve is not reported here). Due to the scope of this paper as well as information accessibility problems we have decided to make use of market shares for one year only. The chosen year is 1994 since we were able to find reliable data for this year.

TABLE 2. DOMESTIC PRODUCER MARKET SHARE IN 1994

Destination Market	Domestic Producer Market Share	Domestic Producers
Belgium	0,0000	
Germany	0,5749	Audi, BMW, Opel, Mercedes, Volkswagen
Spain	0,1069	Seat
France	0,6118	Peugeot, Renault, Citroën
Ireland	0,0000	
Italy	0,4520	Fiat, Lancia, Alfa Romeo
Luxembourg	0,0000	
the Netherlands	0,0000	
Austria	0,0000	
Portugal	0,0000	
Sweden	0,3882	Volvo, Saab
United Kingdom	0,1283	Rover (including Landrover)

Source: L´argus de Láutomobile ET DES LOCOMOTIONS, Vol. 45, 1995

The market shares presented in *Table 2* are used in *Figure 3* where the relation between the degree of ERPT and market shares is plotted. The destination markets marked by a triangle are those for which the ERPT coefficient is significant at a five percent level. To make the relation between ERPT and market shares more visible, we have included a trend line through the SPSS chart editor. The line is based on the significant values only. Given the mathematical derivation of Feentra, Gagnon & Knetter (1996) we expect the relation between ERPT and market share to be non linear, and accordingly the included trend line is quadratic in nature. The estimates not significant at a five percent level are marked by a star and are included to give the reader a better understanding for the robustness of the observed pattern.

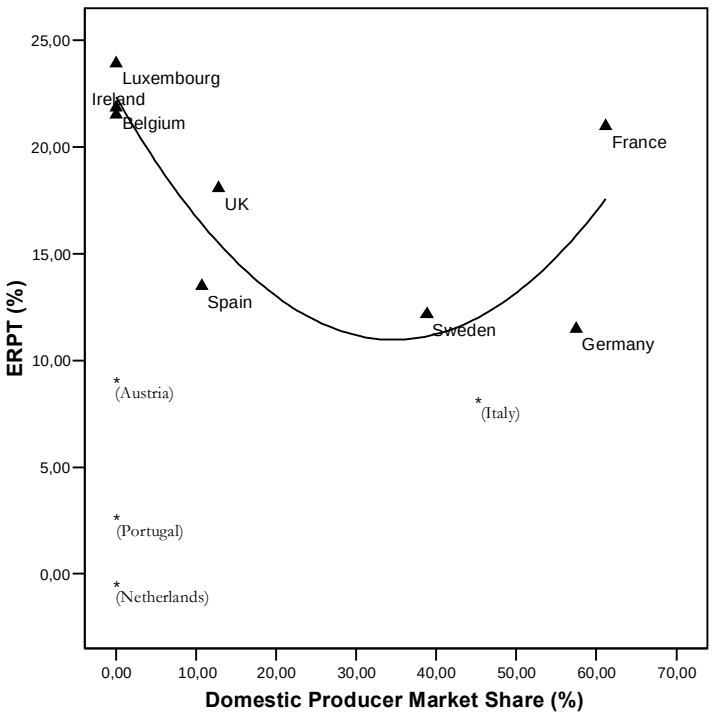


Figure 3. Relation between Estimated Degree of ERPT and Market Shares.

Note: The trend line is based on the significant coefficients marked by triangles.

The curvature of the trend line in *Figure 3* is similar to the inverse of the lower curve suggested by Feenstra, Gagnon & Knetter (1996); see *Figure 2* in section 4.4. A more thorough analysis of the relation between ERPT and market shares follows in the upcoming section 8.

8 Analysis

This section begins with a discussion around the estimated degree of ERPT. Next follows an analysis of the relation between ERPT and market share for domestic producers. The section ends with a brief discussion regarding suggested fields of application.

8.1 Analysis of the Degree of ERPT

The first paragraph entails an analysis of why the estimated pass-through is incomplete. This is followed by a discussion of why ERPT varies across markets. Finally, the magnitude of ERPT is put in relation to previous studies.

8.1.1 Why Pass-Through is Incomplete

In line with our prior expectations, the estimated degree of ERPT is incomplete and lower than the degree found in previous studies. There are a number of reasons for why ERPT is incomplete. First, the conditions for full pass-through, i.e. constant mark ups and constant marginal cost, fail to hold under most market conditions. If price elasticity of demand is not constant, then the optimal pricing strategy faced by car producers is not compatible with the condition of constant mark ups. Price elasticity of demand for cars is likely to increases with price. As such, an increase in price will lead to a greater drop in the number of cars demanded, and a profit maximizing car producer will have to

lower mark ups following an increase in marginal cost caused by a depreciation of the import country's exchange rate. This in turn implies that pass-through will be less than unity.

The other condition for full pass-through states that marginal costs are constant, and as for the condition of constant mark ups, this fails to hold for our sample. It is possible that marginal cost changes with respect to quantity in a given period, which we could not control for due to the lack of firm specific information regarding cost structures. A large share of producer marginal cost and revenues are normally locked into one of the "big" currencies or in the importers currency rather than the exporter currency. In addition production facilities are often located strategically and not simply in the "source country", e.g. production of some Volvo models is mainly located in Belgium. Gron & Swenson (1996) found that firms with greater flexibility in production pass-through a smaller portion of cost increases due to their ability to shift production.[58] We have not accounted for either of these possibilities in our estimation due to the associated complexity, and consequently, the perceived cost shock faced by producers will be higher under our assumptions than it is in practice.

A further example for why ERPT is less than unity considers the very nature of car manufacturing. It is hard to adjust quantity in the short run and car producers can thus be said to compete in a Cournot fashion[59]. Consequently, an exporting car producer may choose not to lower nominal prices to the same extent that the importer's currency appreciates. Put otherwise, even if a foreign car producer could gain market share at the expense of domestic producers by lowering the price, the firm may lack the ability to increase quantity in order to meet the increase in demand. Thus it would be more profitable to instead cash in on the higher mark ups, and again pass-through will be less than unity. A further reason why ERPT is incomplete is the fact that the European car market is not fully integrated. This will be further investigated in the next section.

8.1.2 Logic behind Market Specific Pass-Through

The regression results in *Table 1* show that the estimated degree of pass-through varies between destination markets. An explanation for why pass-through can be incomplete and destination market specific rests on the structure of the European car market as described in section 2. Producers' ability to segment markets, culminating with the 1985 Block Exemption in conjunction with tax differences and market specific demand functions, has enabled producers to price-to-market. The fact that the estimated degree of pass-through differs across markets shows that mark ups and prices are adjusted according to the destination specific characteristics, including among others the destination specific elasticity of demand.

Demand is often biased towards domestic producers indicated by large market shares for producers in their home markets relative to other markets. Car models are positioned and hence perceived differently across member states. Accessibility and quality of after sales service are typically country dependent. Further, the lower the degree of substitutability between domestic and foreign brands, the greater the foreign exporter's power in pricing decisions. Given that the elasticity of substitution can be nation specific, manufacturers' market power, and hence optimal prices, may vary across markets. The finding of destination market specific strategies is further strengthened by the destination specific estimates found for the PPI variable. The findings indicate that cost shocks not caused by exchange rate changes also pass-through differently.

[58] Gron & Swenson (1996), p. 71.
[59] Coumot competition implies adjusting prices instead of quantities in the short run.

Several other factors facilitated producers' ability to segment markets. During the time period of investigation, the integration process of the European Union continued, and was especially significant in the member states aspiring to become members of the European Monetary Union in 1999. The number of parallel imports remained at a low level even after harmonisation in 1995, which can be explained by the competition inhibiting methods used by producers as well as information asymmetries implying that consumers react to the new regulation with a lag. Moreover, according to Friberg (1999), consumers dislike to shop around in other currencies, something economists refer to as bounded rationality. After the advent of EMU in 1999, producer power is likely to have lessened with the adoption of a single currency. As such, car producers' ability to pass-through differently to different EMU member states is likely to have weakened facilitated by the transparency effect, i.e. prices are easier to compare.

8.1.3 Why Pass-Through is lower Compared to Previous Studies

The active use of financial instruments became increasingly common during the 90's, significantly more so than during the 70's and 80's. Increasing understanding and use of these instruments has made costs and revenues less sensitive to currency fluctuations and other shocks. Together with the relatively low exchange rate fluctuations during the 90's, as compared to the decades before, this can explain why the estimates of the ERPT found in this study are smaller than what has been found in previous research. The relative calm in the exchange market throughout our period provides producers with fewer incentives to constantly adjust prices to compensate for shifts in the exchange rate. Costs associated with adjusting prices may simply outweigh the benefits. For instance, consumers often have preferences for a specific car brand. If car producers constantly change prices, they risk losing loyal customers who get disappointed when realizing that the price of their newly bought car dropped significantly shortly after their purchase.

A further explanation for why our estimated pass-though is lower than what has been found in previous studies, is that the latter have utilized prices at the border rather than consumer prices, leading to larger estimated pass-through coefficients. The use of consumer prices also involves the retail level. As such, producers and retailers share the effects of an exchange rate shock since both can adjust their mark ups, and pass-through is likely to be lower.

Another possible explanation for the lower pass-through found in this study, is that we estimate an average ERPT over the entire time period. If a country experiences some periods of negative pass-through the positive and negative values will offset each other and provide a lower degree of average pass-through. The logic behind periods of negative pass-through can be understood intuitively if we consider the product life cycle. Demand for a new car is likely to be stronger when the model is new. Hence producers may take advantage of this higher demand by charging a high initial price and then lowering the price in latter stages of the life cycle to attract the more price sensitive consumers. If such a price decrease occurs in conjunction with a depreciation of the importer's currency ERPT will be spuriously negative. This may serve as an explanation for why the estimated ERPT turns out to be slightly negative for the Netherlands.

8.2 Analysis of the Relation between ERPT and Market Share

According to the mathematical derivation presented by Feenstra, Gagnon & Knetter (1996) the curvature illustrating the relation between ERPT and market share could theoretically take one of the two forms presented in *Figure 2*. As shown by the curves, pass-through should increase with market share when market share is large. For small market shares, pass-through could either increase or decrease with market share. Empirically the authors find evidence for a j-shaped curve, i.e. that pass-

through decreases with market share for small market shares and increases with market share as the market share becomes large. The same empirical evidence is found by Goldberg & Verboven (1998).

With reference to *Figure 3*, we also find evidence of a j-shaped curve[60] even though our estimated degree of ERPT is lower. Note that the shape of the curve is sensitive to the inclusion or exclusion of France. If one of the other countries with a significant observation is removed, the shape of the curve does not change significantly. If the observation for France is removed, the pattern is disturbed, and the curve will be downward sloping, i.e. be similar to the inverse of the *upper* curve in *Figure 2*, rather than j-shaped.

8.2.1 Why ERPT is decreasing in Market Share

A downward sloping curve is in line with theory[61] and can be understood using the following argument. Starting in a scenario of only foreign car producers, i.e. at zero market share for domestic producers, all firms experience a similar change in costs following an exogenous change in the exchange rate. Since foreign car producers combined control the entire market, their power to adjust prices according to their new cost structure is large, even though they still need to account for any changes in demand elasticity caused by an increase in price. As the market share for domestic car producers increases, market power for foreign producers decreases. Thereby foreign car producers' ability to pass-through a positive cost shock not experienced by the domestic producers is lessened. A significant increase in price implies that market share is lost to domestic producers. Also remember from section 8.1.1 that quantity may not easily be adjusted in the short run to meet an increase in demand because of lower prices. Foreign car producers may thereby choose to cash in on higher mark ups rather than increase their market share when their exchange rate is competitive.

8.2.2 Why ERPT increases in Market Share for Large Market Shares

The logic for why pass-through may start to increase with market share when market share reaches a certain threshold level, as is the case in France, is not as intuitive. However, it might be understood when accounting for the nature of French produced cars in conjunction with the dominance of French producers. French produced cars are almost exclusively small personal vehicles, and combined French producers have almost two thirds of the French market. The dominance of domestic producers stems from the French predilection for small cars combined with an extreme home bias effect in demand. The typical French consumer prefers a small car over a larger car and a domestic brand is favoured over a foreign produced brand. Consequently, the degree of substitutability between foreign and domestic brands is low. Consumers who favour a domestic brand will stick to this brand and consumers preferring a foreign produced car will be loyal to the foreign producer. As noted in section 2.1.3, a low degree of substitutability between domestic and foreign car producers implies that the foreign exporter has more power in pricing decisions because a drastic change in car prices will be required to induce a substitution effect in consumption. Consequently, price competition between foreign and domestic brands will be less important. From the perspective of a foreign producer, the closest competitors will be other foreign producers. Since all foreign producers experience a similar exchange rate shock, they have a greater ability to pass-through the change in the exchange rate.

[60] Note however that our curve is the inverse of the j-curve suggested by Feenstra, Gagnon & Knetter (1996) since we look at the market share for domestic producers.
[61] See e.g. Dornbusch (1987) and Feenstra, Gagnon & Knetter (1996).

8.2.3 Robustness of the Relation between ERPT and Market Share

To get a more thorough understanding for the robustness of the observed pattern it is interesting to comment upon how the inclusion of the countries with insignificant ERPT estimates would affect the shape of the curve. As noted, these countries are marked with a star in *Figure 3* and one can easily see that Italy follows the general downward sloping pattern[62]. However, the inclusion of the three non car producing countries with insignificant estimates, i.e. the Netherlands, Austria and Portugal, would disturb the pattern. There is no obvious reason for why the degree of ERPT is much lower in these countries as compared to the other non producing countries with significant values, i.e. Belgium, Ireland and Luxembourg.

Firstly, comparing Belgium and/or Luxembourg with Portugal, one might expect the typical Portuguese to be more price sensitive than consumers in Belgium and Luxembourg and as such, their elasticity of demand may increase more with price. Moreover, looking at the GDP per capita it is clear that the Portuguese purchasing power was lower than the Irish. Thereby, car producers may choose to adjust mark ups to a greater extent in Portugal following an exchange rate shock in order to keep the price faced by consumers stable. Secondly, the price stability in the Dutch market is indicative of an unwillingness to adjust prices to changes in the exchange rate in this market. As in the case for Portugal, this may be explained by the shape of the demand function. Another explanation could be the strategic location of the Netherlands combined with their relatively good language skills, allowing consumers to shop around to a larger extent. Moreover, the relatively large combined markets shares for German brands on the Dutch market in conjunction with a rather stable exchange rate between the Netherlands and Germany can explain the low degree of pass-through on the Dutch market.[63] As noted in the theoretical framework, a producer has lower incentives to pass-through exchange rate changes that are small and expected to be temporary. Cars originating from a country with a more volatile exchange rate will have difficulties to pass-through their exchange rate shock since they then risk loosing market shares to German car producers. This last argument is also a valid explanation for the low estimate found for the Austrian market. The degree of pass-through estimated for Austria would need to be at least ten percent higher to fit the general pattern. The suggestions presented in this paragraph are only speculative.

8.3 Some Suggested Fields of Application

As noted in the introduction, a thorough understanding of ERPT and its relation to market shares is helpful for understanding how market structure may affect pricing decisions following changes in the exchange rate. Knowing the likely relation between pass-through and market share of domestic producers can guide managers as well as policy makers. At the firm level, an understanding of the reaction of competitors to exchange rate changes is of strategic importance. To avoid a price war that is harmful for all producers within a segment, firms are commonly unwilling to lower prices too much. At the same time, if a car producers' increase in price is not accompanied by an increase in the price of competing brands, they are likely to experience a loss in market share. Hence, if the company is familiar with the competitors' plausible reactions, these can be taken into account when determining the magnitude of a price adjustment following a change in the exchange rate, facilitating the firm's ability to make optimal decisions.

[62] Note however that the estimate Italy is significant at a ten percent level.
[63] The difference between the lowest and highest value for the exchange rate between Germany and Austria is only in the order of 0,25 % during out time period.

Knowing the relation between ERPT and market shares is of further use to policymakers attempting to stabilize the economy. One area of interest where an understanding of the ERPT mechanism can be of significant importance is in inflation targeting. To maintain inflation at the desired level, central banks make forecasts of inflation based on information of import prices, domestic prices and indirect taxes and adjust the prime rate thereafter. Exchange rate changes affect inflation through import prices. Intuitively, knowing the magnitude of price adjustments following an exchange rate change will be helpful when making forecasts of the future inflation. Understanding how foreign producers will adjust their prices to exchange rate fluctuations will also be helpful when analysing domestic producers' international competitiveness, in turn determining the country's trade balance.

9 Conclusions

The aim of this study is to estimate the degree of ERPT by using micro-level price data for the European car market from 1993-98, and then relate it to market share of domestic car producers. The number of comparable studies is few, none of which used the detailed data applied in this study. The quality of our data set in conjunction with the lack of research regarding how market structure affects ERPT makes our empirical results interesting and explores new issues.

We find the estimated degree of pass-through to be incomplete and market specific with a magnitude of between approximately 11 percent and 24 percent for countries with estimates significant at a five percent level. For the same countries, when plotting the degree of ERPT against market share for domestic producers we find evidence of the inverse of a j-shaped curve, i.e. ERPT decreases with market share up to a certain threshold level when it starts to increase with market share. However, the j-shape is sensitive to the inclusion or exclusion of France since if the latter is excluded, the curve is downward sloping. The logic behind a downward sloping curve is that as the market share for domestic producers increases, foreign producers face more domestic competition. They are hence less able to pass-through a positive cost shock not experienced by the domestic producers, since a significant increase in price would imply that market share is lost to domestic producers.

In some markets, consumers experience the degree of substitutability between foreign and domestic brands to be low. If this is the case in a market where domestic producers dominate, the curve will be j-shaped and not downward sloping, i.e. ERPT increases with market after a certain threshold level. A low degree of substitutability between domestic and foreign goods gives foreign manufacturers more power to pass-through an exchange rate change because a drastic change in car prices will be required to induce a substitution effect in consumption. The French predilection for small cars combined with an extreme home bias effect in demand may explain why the relation between ERPT and market share is j-shaped for the European car market with the inclusion of France.

More research in the area of ERPT and its relation to market structure would enable one to get a better understanding of whether the relation is universal, i.e. adaptable to other industries and time periods as well as other types of goods and markets. More research could then allow stylized facts to emerge.

10 References

Baltagi B. (2001), *Econometric Analysis of Panel Data*, 2nd ed., John Wiley & Sons Ltd, Chichester.

Burda M. & C. Wyplosz (2001), *Macroeconomics – A European Text*, 3rd ed., Oxford University Press, Oxford.

Cabral L. (2000), *Introduction to Industrial Organization*, The MIT press, Cambridge.

Campa J. M. & L. Goldberg (2002), "Exchange Rate Pass-Through into Import Prices", Working paper no. 8934, IESE Business School & Federal Reserve Bank of New York.

Data on Pre-Tax Car Prices, European Commission, compiled by Dr. Matthias Lutz.

Data on Exchange Rate, Exchange Rate Generator, University of British Columbia. Available [online]: http://fx.sauder.ubc.ca/data.html

Data on Producer Price Index (PPI), SourceOECD Statistical Database. Available [online]: http://caliban.sourceoecd.org/vl=3829277/cl=87/nw=1/rpsv/home.htm

Data on Gross Domestic Product (GDP), Source OECD Statistical Database. Available [online]: http://caliban.sourceoecd.org/vl=3829277/cl=87/nw=1/rpsv/home.htm

Data on Consumer Price Index (CPI), International Financial Statistics (IFS) Database. Available [online]: http://www.imfstatistics.org/imf/ifsbrowser.aspx?branch=ROOT

Degryse H. & F. Verboven (2000), "Car Price Differentials in the European Union: An Economic Analysis", Discussion Paper, Catholic University of Leuven & Centre for Economic Policy Research, London.

Dornbusch R. (1987), "Exchange Rates and Prices", *The American Economic Review*, Vol. 77, No. 1, p. 93-106.

European Commission Press Release (2002), ip/02/1073, Brussels.

Feenstra R., J. Gagnon & M. Knetter (1996), "Market Share and Exchange Rate Pass-Through in World Automobile Trade", *Journal of International Economics*, Vol. 40, p. 187-207.

Friberg R. (1998), "In which Currency Should Exporters set their Prices?", *Journal of International Economics*, Vol. 45, pp. 59-76.

Friberg R. (1999), *Exchange Rates and the Firm: Strategies to Manage Exposure and the Impact of EMU,* MacMillan, London/New York.

Froot K. & P. Klemperer (1989), "Exchange Rate Pass-Through When Market Share Matters", *The American Economic Review*, Vol. 79, No. 4, p. 637-654.

Goldberg P. & M. Knetter (1997), "Goods Prices and Exchange Rates: What have we learned?", *Journal of Economic Literature*, Vol. XXXV, No. 3, p. 1243-1272.

Goldberg P. & F. Verboven (1998), "The Evolution of Price Dispersion in the European Car Market", Working Paper 6818, NBER.

Goldberg P. & F. Verboven (2004), "Cross-Country Price Dispersion and the Euro", forthcoming, Economic Policy.

Gron A. & D. Swenson (1996), "Incomplete Exchange-Rate Pass-Through and Imperfect Competition: The Effect of Local Production", AEA Papers and Proceedings, Vol. 86, No. 2, p. 71-76.

Gujarati D. (2003), *Basic Econometrics*, international edition, 4th ed., Mc Graw Hill, New York.

Haskel J. & H. Wolf (2001), "The Law of One Price-A Case Study", *Scandinavian Journal of Economics*, Vol. 103, No. 4, p. 545-558.

Kirman A. & N. Schueller (1990), "Price Leadership and Discrimination in the European Car Market", *The Journal of Industrial Economics*, Vol. XXXIX, No. 1, p. 69-89.

Lárgus (1995), *Data on Market Shares of Domestic Car Producers*, p. 166-170, Vol. 45 special edition.

Lutz M. (1998a), "Pricing in Segmented Markets, Arbitrage Barriers and the Law of One Price: Evidence from the European Car Market", forthcoming in *Review of International Economics*.

Lutz M. (1998b), "Was Volkswagen Made a Scapegoat? A Note on Price Differentiation in the European Car Market", Discussion paper no. 9804, University of St. Gallen.

Maddala G.S. (2001), *Introduction to Econometrics*, 3rd ed., John Wiley & Sons Ltd, Chichester.

Markusen J., J. Melvin, W. Kaempfer & K. Maskus (1995), *International Trade: Theory and Evidence*, Mc Graw Hill International Editions, New York.

Menon J. (1996), "The Degree and Determinants of Exchange Rate Pass-Through: Market Structure, Non-Tariff Barriers and Multinational Corporations", *The Economic Journal*, Vol. 106, p. 434-444.

Stock J. & M. Watson (2002), *Introduction to Econometrics*, Addison Wesley, Boston.

Verboven F. (2002), Quantitative Study to Define the Relevant Market in the Passenger Car Sector, Catholic University of Leuven.

Wooldridge J. (2002), *Econometric Analysis of Cross Section and Panel Data*, the MIT press, Cambridge.

Appendix A Depiction of Car Models and their Source Country

Model Number	Manufacturer	Model	Source country
1	Alfa Romeo	145, 33	Italy
2	Alfa Romeo	156, 155	Italy
3	Alfa Romeo	166, 164	Italy
4	Audi	A3	Germany
5	Audi	A4, 80	Germany
6	Audi	A6, 100	Germany
7	Audi	A8	Germany
8	BMW	3 series	Germany
9	BMW	5 series	Germany
10	BMW	7 series	Germany
11	Citroën	SAXO, AX	France
12	Citroën	Xsara, ZX	France
13	Citroën	Xsara Picasso	France
14	Citroën	Xantia	France
15	Citroën	Evasion/Syn.	France
16/17/20*	Daihatsu	Charade, Applause	Japan
18	Daihatsu	Gran Move	Japan
19	Daihatsu	Cuore	Japan
21	Fiat	Seicento, Cinquecento	Italy
22	Fiat	Punto, Uno	Italy
23	Fiat	Bravo, Tipo	Italy
24	Fiat	Marea, Tempra	Italy
25	Fiat	Croma	Italy
26	Ford	Fiesta	USA
27	Ford	Focus, Escort	USA
28	Ford	Mondeo	USA
29	Ford	Scorpio	USA
30	Honda	Civic	Japan
31	Honda	Accord	Japan
32	Lancia	Y	Italy
33	Lancia	Dedra	Italy
34	Lancia	K, Thema	Italy
35/36*	Mazda	Demio, 121 new, 121	Japan
37	Mazda	323	Japan
38	Mazda	626	Japan
39	Mercedes	C-class, 190	Germany
40	Mercedes	E-class	Germany
41	Mercedes	S-class	Germany
42	Mitsubishi	Colt	Japan
43/44*	Mitsubishi	Carisma, Galant	Japan
45	Mitsubishi	Pajero	Japan
46	Nissan	Micra	Japan
47	Nissan	Almera, Sunny	Japan
48	Nissan	Primera	Japan

49	Opel	Corsa	Germany
50	Opel	Astra	Germany
51	Opel	Vectra	Germany
52	Opel	Omega	Germany
53	Peugeot	106	France
54	Peugeot	206, 205	France
55	Peugeot	306	France
56	Peugeot	406, 405	France
57	Peugeot	806	France
58	Renault	Twingo	France
59	Renault	Clio	France
60	Renault	Megane, 19	France
61	Renault	Laguna, 21	France
62	Renault	Safrane	France
63	Renault	Espace	France
64	Rover	MGF	Great Britain
65	Rover	111	Great Britain
66	Rover	214 new, 214 SI-old	Great Britain
67	Rover	414i new, 416 4 dr	Great Britain
68	Rover	620	Great Britain
69	Rover	820	Great Britain
70	Landrover	Discovery	Great Britain
71	Landrover	Range Rover	Great Britain
72	Landrover	Freelander	Great Britain
73	Seat	Arosa, Marbella	Spain
74	Seat	Ibiza	Spain
75	Seat	Cordoba	Spain
76	Seat	Leon	Spain
77	Seat	Toledo	Spain
78	Subaru	Legacy	Japan
79	Subaru	Forester	Japan
80/83*	Suzuki	Swift	Japan
81	Suzuki	Baleno	Japan
82	Suzuki	Jimny	Japan
84	Toyota	Avensis, Carina E	Japan
85	Toyota	Starlet	Japan
86	Toyota	Corolla	Japan
87	Volkswagen	Polo	Germany
88	Volkswagen	Golf	Germany
89	Volkswagen	Bora, Vento	Germany
90	Volkswagen	Passat	Germany
91	Volvo	S40, 440 1.8	Sweden
92	Volvo	S70, 850	Sweden
93	Volvo	S 80, 960, 940	Sweden

** Indicative of a model replacement*

Source: Dr. Mathias Lutz at the University of St. Gallen

Appendix B Basis for Selection of Included Car Models

Market / Model	B	D	E	F	IRL	I	L	NL	A	P	S	UK
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1					1				4	4	8	
2	1	1	1	1	1	1	1	1	5	1	5	1
3	2	3	2	2	2	2	3	2	5	3	6	2
5									4	4	4	
6					1				4	5	5	
8					1				4		4	1
9									4		5	
10									4	8	–	
11			1		6				4		–	
12			2		8		3		4		11	
14		1			1		3		4		5	1
15	6	6	6	6	6	6	9	6	6	–	6	8
16			8	2	7	–			4	8	–	1
17	6	6	–	6	–	–	6	6	6	8	–	6
21			1		3				4	1	–	1
22	1	1	1	1	1	1	2	1	5	1	5	1
23					1				4	1	7	1
24	1	1	1	1	2	1	1	1	5		6	2
25	5	5	5	5	–	5	5	5	9	–	9	–
26									4		4	
27									4		4	
28									4		4	
29	2	2	2	2	2	2	2	2	6	2	6	2
30									4		4	
31				4	2				4	7	7	
32					–				4		–	–
33					10				7		–	10
34					10				4		–	10
35			11	3				1	5	9	9	2
37			4			5			4	4	9	
38			–	1		8			4	–	8	
39									4		4	
40					1				4		4	1
41					1				4	1	4	
42	2		8	5	9	5	2		4		10	
43			3	9		5			4	5	4	
44	6	6	9	9	6	6	6	6	6	6	6	6
45	4	4	5	4	4	4	4	9	8	6	–	5
46									4		5	
47			1			6			4		7	
48					3				4		4	
49									4		4	
50									4		4	

Market / Model	B	D	E	F	IRL	I	L	NL	A	P	S	UK
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
51									4		4	
52									4		4	
53					3				4		4	
54	4	4	4	4	4	8	4	4	8	4	11	4
55					1				4		4	
56			3						4		4	
57	5	5	5	5	6	6	5	5	5	8	6	5
58	3	3	3	3	—	3	3	3	4	3	4	—
59									4		10	
60					6				4		8	
61					2				4	3	7	
62	1	1	1	1	2	1	1	1	5	1	—	1
63	1	1	2	1	9	1	1	1	5	5	9	3
64	6	6	6	6	6	6	6	6	6	6	11	6
65	6	9	6	6	6	8	6	6	—	—	—	6
66	2	1	2	2	1	1	2	1	9	1	8	1
67		7	3	5			2	4	5	5	11	
68	2	3	2	3	2	2	2	2	5	5	6	2
69	5	6	8	10	5	—	5	5	9	—	9	5
70	1	1	1	3	1	1	1	1	6	6	10	1
71			2			3			4	5	7	
73					10		1		9	5	9	5
74	1	1			3				4		6	4
75	2	2	2	2	2	2	3	2	4	7	6	4
77									4	2	4	1
78			—			2			4	10	4	
80			6	4	1	5			4	3	—	
81	7	5	5	5	7	5	7	5	5	8	5	5
84						1			4		4	
85			—			—			4		8	
86			9			8			4		4	
87			2						4	2	4	
88									4	1	4	
89	2	2	3	2	3	2	2	2	6	8	6	2
90									5	2	4	
91									4		4	
92									4	3	4	
93	3	3	3	3	3	5	3	3	7	5	7	3

Notes: An empty cell indicates no missing values, — indicates that the model does not exist in the relevant market and a number indicates the number of missing values.

Finland, Denmark an Greece are removed due to lack of car price data and are not presented in the table.

Models 4, 7, 13, 18, 19, 20, 36, 72, 76, 79, 82 and 83 exist for less than half our estimation period and have been removed.

Selection criterion: For countries 1-8, 10 and 12 remove model if more than three observations are missing; For countries 9 and 11 remove model if more than five observations are missing.

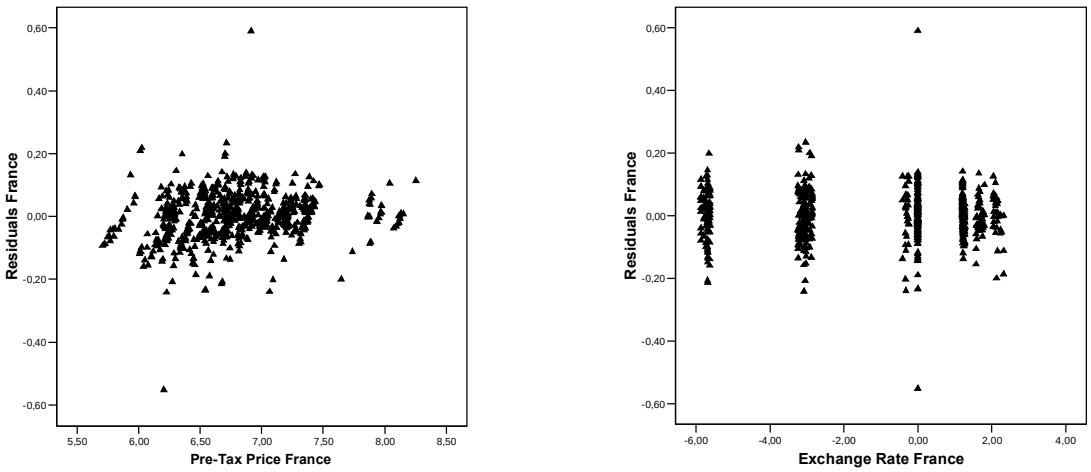
Source: Authors' compilation of dataset received from Dr. Matthias Lutz.

Appendix C Testing the Assumptions of the Fixed Effects Model

The standard Fixed Effects Model used here assumes that (1) all the error terms ε_i have the same variation, i.e they are homoscedastic (2) the error terms ε_i are uncorrelated and (3) there is no perfect relation between included explanatory variables. If these assumptions are not fulfilled then the coefficients may not be accurately measured and the estimators may not be BLUE. To form an understanding of the strength of the model it is important to test the validity of these assumptions.

C.1 Heteroscedasticity

The assumption of homoscedasticity possibly fails when using panel data since the size of cross-sections may differ, causing variation to diverge, i.e. we have heteroscedasticity. Car models differ in their characteristics which might lead to differences in variation. There might also be a problem of heteroscedasticity across time, i.e. that the variation changes with time. If we assume disturbances to be homoscedastic when they in fact are heteroscedastic our estimates will still be consistent but they will not be efficient. Additionally, the standard errors of these coefficients will be biased unless one uses robust standard errors that take the possibility of heteroscedasticity into consideration.[64] One such type of standard errors is White's heteroscedasticity-consistent variances and standard errors. Utilizing these will not alter the coefficients received in the regression results above but it will alter the standard errors and the p-values. However, the small sample properties of White's Heteroscedasticity-Consistent Variances and Standard Errors are not beneficial and hence before using them if is a good idea to test for heteroscedasticity. This can be done by plotting the residuals received from the regression against the included variables in the regression. If heteroscedasticity is present then the magnitude of the residuals will be related to the variable, i.e. the magnitude of the residuals will change as the variable changes. Possible patterns indicative of heteroscedasticity are growing or shrinking funnels. Below we present exemplifying plots for the French market, however the pattern is similar for all included destination markets. As can be seen in *Figure C1*, the value of the residuals seems to be independent of the value of the dependent variable, pre-tax prices, as well as the explanatory variables, exchange rate, PPI and GDP. Hence, we do not seem to have a problem with heteroscedasticity.



[64] Baltagi (2001), p. 77

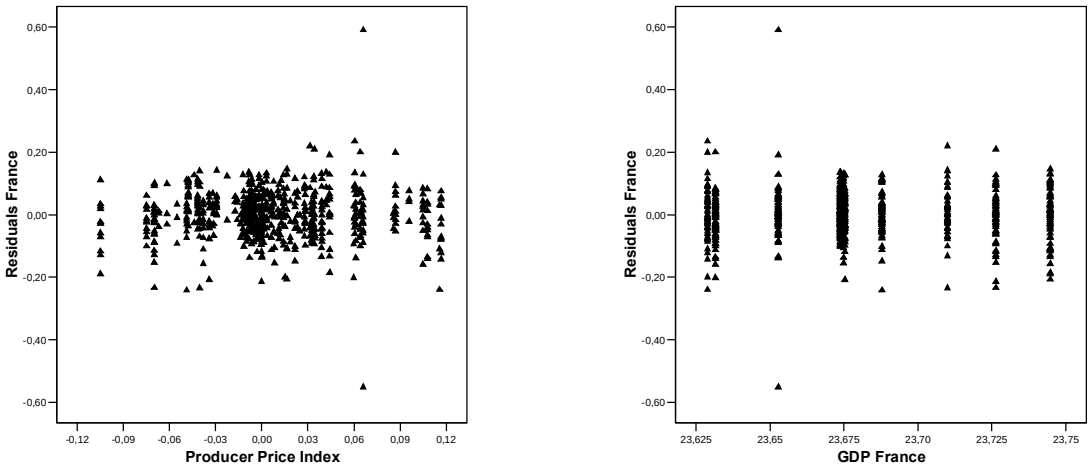
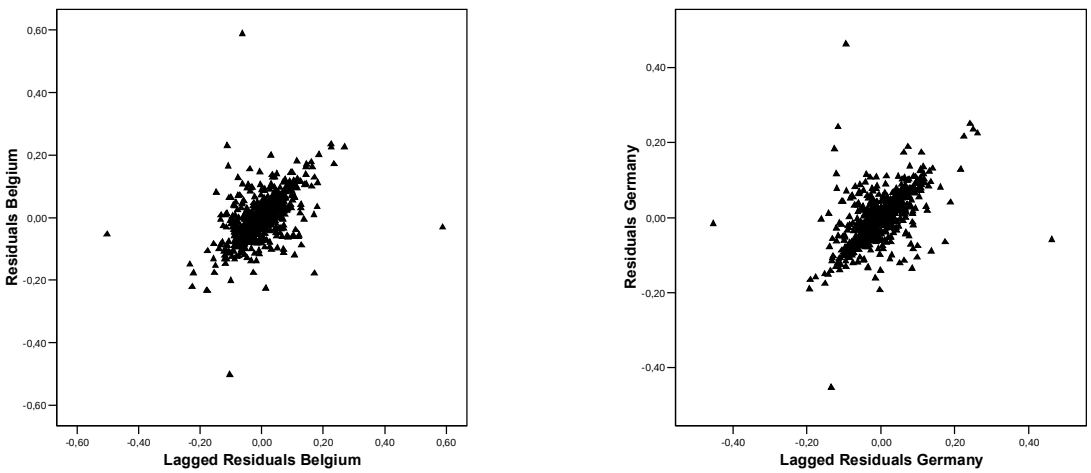


Figure C1. Plots of the Residuals against the Dependent and Explanatory Variables for France

C.2 Autocorrelation

The Fixed Effects Model assumes that the only serial correlation existing in the model is the presence of the same car model across the panel. However, a cost shock now may have impact on future pricing decision leaving the disturbance term serially correlated. If we do not account for this autocorrelation, coefficient estimates will still be consistent but inefficient and standard errors will be biased.[65] To test for autocorrelation we have plotted the residual against the lag of the residual in a scatter plot. If autocorrelation is positive the observations will be along a straight line from the upper right to the lower left corner. If on the other hand it is negative the observations align from the upper left to the lower right corner.[66] As can be seen in *Figure C2*, where we present exemplifying plots for four countries, we seem to have weak positive autocorrelation. The pattern is similar for all included destination markets.



[65] Baltagi (2001), p. 81.
[66] Gujarati (2003), p. 449.

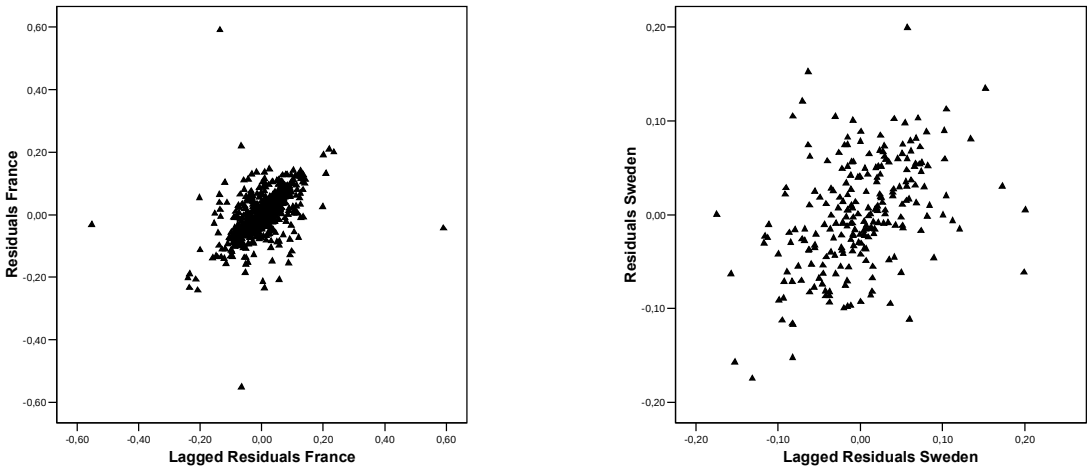


Figure C2. Plots of Residuals against Lagged Residuals for Belgium, Germany, France and Sweden.

Positive autocorrelation might be due to the fact that an exchange rate shock today affects future pricing decision. Following a positive exchange rate shock a car producer may choose to only increase prices slightly in this period and delay the rest of the price increase to the next period. This enables the car producer to slowly adjust prices instead of abruptly increasing them. The latter would surely irritate customers more than the former. Hence, the pricing decision in period two depends on the exchange rate shock experienced in period one. However, there are also other reasons why autocorrelation might be significant. Specification bias is one reason, i.e. if a missing variable has significant impact on the dependent variable one might see a pattern in the residuals. We do not however consider this to be the cause of the autocorrelation. A more plausible reason might be nonstationarity in the residuals.

The positive autocorrelation could thus be due to the weak trends remaining in the deflated values of PPI and GDP. To test if the autocorrelation is severe, we calculate Durbin-Watson statistics, reported in *Table C1*. A statistic lower than 1.738 implies positive autocorrelation, while a statistics between 1.738 – 1.799 means that we are in the zone of indecision. If higher than 1.799 we do not have a problem of positive autocorrelation. These upper and lower limits are taken from Appendix D in Gujarati (2003) and are valid for 3 explanatory variables and more than 200 observations at a 5 percent significance level.

TABLE C1. THE DURBIN-WATSON STATISTIC

	(B)	(D)	(E)	(F)	(IRL)	(I)	(L)	(NL)	(A)	(P)	(S)	(UK)
Durbin-Watson, d	0.96	0.932	1.52	1.032	1.026	1.046	1.012	0.988	1.20	1.308	1.184	0.886

All statistics are lower than 1.738 implying that we have a problem of positive autocorrelation. As mentioned autocorrelation implies that the estimates are consistent but that the significance level and standard errors are inefficient and no longer appropriate. First and foremost we are interested in the magnitude of the coefficient. Even if the significance level would change the estimates will probably still be highly significant. Moreover, the autocorrelation is not extremely strong. Hence, we have decided not to account for the autocorrelation.

C.3 Multicollinearity

Regarding multicollinearity it will almost always be present in economic variables. Intuitively, the variables included in our model are related according to economic theory. For example, a change in the exchange rate is related to the level of GDP in that a currency change may affect a country's terms of trade and hence national income. As long as the degree of multicollinearity is not perfect, i.e. the variables carry exactly the same information, multicollinearity is not a major issue. In this case it is not perfect because if it were it would not be possible to perform the regressions. The estimations are still BLUE but variances will be larger leading to more uncertain inferences.[67]

[67] Gujarati (2003), p. 350.