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MARKET INTEGRATION AND CONVERGENCE TO THE LAW OF ONE PRICE: EVIDENCE FROM THE EUROPEAN CAR MARKET

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ABSTRACT

This paper exploits the unique experiment of European market integration to investigate the relationship between integration and price convergence in international markets. Using a panel data set of car prices we examine how the process of integration has affected cross-country price dispersion in Europe. We find surprisingly strong evidence of convergence towards both the absolute and the relative versions of Purchasing Power Parity. Our analysis illuminates the main sources of segmentation in international markets and suggests the type of institutional changes that can successfully reduce it.

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1 Introduction

This paper uses the unique experiment of the European integration process to explore the link between integration and price convergence in international markets. Few topics have attracted as much attention and controversy in International Economics as the topic of convergence to the Law of One Price (LOOP). While until a few years ago, one was hard-pressed to find evidence in favor of the convergence hypothesis, the newly emerging consensus in the literature seems to be that Purchasing Power Parity does hold in the long run, with a half-life of shocks of five to six years (see Obstfeld and Rogoff (2000) for a detailed discussion). The new evidence comes primarily from "bigger" data sets — use of panel data sets as in Frankel and Rose (1996), Parslei and Wei (1996), Cecchetti et al (2000), etc., or exploitation of longer time-series data for individual countries (see Taylor (2000a) for an overview) – and methodological advances (Taylor 2000b). Still the slow speed of convergence documented in international markets remains a puzzle. In their excellent study of price dispersion across U.S. cities, Parsley and Wei (1996) report half-lives of shocks of four to five quarters for tradeables, a substantially shorter time than the aforementioned five to six years estimated in cross-country studies. While various explanations have been suggested in the literature – with nominal exchange rate volatility being the primary contender – there is little agreement as to what factors generate international price dispersion in the first place, and what mechanisms can accelerate convergence to the LOOP.

The goal of this paper is to shed light on the above question by focusing on a period that is characterized by a distinct effort to "integrate" national markets in Europe (1970-2000). The progress towards integration took the form of removal of trade barriers, encouragement - within limits - of arbitrage, harmonization of tax rates and other national regulations, increased transparency, monitoring of cross-country price differences, and, with the creation of the European Monetary Union (EMU), reduction of exchange rate volatility in the later years of our sample. To the extent that price dispersion was driven by any of the above factors, we would expect to see accelerated convergence to the LOOP. Moreover, by relating price dispersion (or the reduction thereof) to the timing of institutional changes, we hope to highlight the factors primarily responsible for deviations from the LOOP.

Our approach to the above questions deviates from the traditional convergence literature in that it is a distinctly micro approach. We focus on a particular market, the European automobile market, and exploit a large panel data set that we have put together ourselves over several years, containing observations on car prices and characteristics in five countries over the period 1970-2000. We believe that this approach offers three main advantages.

First, the European car market has been a notorious example of deviations from the LOOP in international markets. The persistent and exceedingly large cross-country price differences, for virtually identical products, have been the focus of intense public debate in Europe. The European Commission has considered the European auto market a test case for integration and ordered several investigations into the sources of these price differences. Furthermore, it has taken concrete steps to integrate the national markets and reduce price dispersion. Hence, the car market is a natural starting point in an investigation of the relationship between market integration and convergence.

Second, while recent studies seem to "converge" in their findings on PPP, the evidence pertains primarily to the relative versions of LOOP or PPP. As pointed out in Goldberg and Knetter (1997), and Knetter and Slaughter (2001), this preoccupation with the relative versions reflects data realities rather than research interests - typically, the data employed in price comparisons are fairly aggregate price data or price indices (Parsley and Wei's use of disaggregate product level data from ACCRA is a notable exception). In general, disaggregate data are easier to obtain for national markets, which is one of the reasons that studies of the absolute version of the LOOP tend to focus on a single country. Disaggregate price data for multiple countries need to be assembled individually, on a product-by-product basis from national industry journals written in many different languages. Even when disaggregate data are available, it is rarely the case that the *identical goods* assumption needed for the absolute version of the LOOP holds. Yet, there is little doubt that *absolute* price differences can be indicative of market segmentation; few of us, for example, would characterize Europe as an "integrated" market if there were a constant \$3,000 difference in the price of a Toyota Corrolla across Belgium and Germany. One of the strengths of our data set - and this is why we had to collect the data ourselves - is that the detail of the information (prices of individual car models plus characteristics) allows us to compare prices of identical products across countries, and hence test not only the relative, but also the absolute version of the LOOP.

Finally, our focus on a particular market allows us a more in-depth analysis of the institutional details. It is the institutional analysis that helps us understand the sources of market segmentation and relate particular measures aimed at integration to actual price convergence.

The remainder of the paper is organized as follows. In the next section we provide a brief overview of the sources of segmentation in the European car market and discuss the steps that have been taken in the last two decades to promote integration. We use this institutional analysis as a basis for forming the hypotheses concerning price convergence that we examine in Section 4. Section 3 discusses the data. Section 4 considers various specifications of convergence equations, and reports our findings. To summarize our results, we find strong evidence in favor of convergence towards both the absolute and the relative versions of Purchasing Power Parity (PPP). To our knowledge, this is the first study documenting convergence towards the absolute version of the Law of One Price in international markets.[1] In comparison to previous studies our estimated speed of convergence seems surprisingly high - the implied half-life of a shock is, depending on the specification, between 1.3 and 1.6 years when we test the relative version, and between 5 and 8.3 years when we test the absolute version of LOOP. Moreover, we find equally high speeds of convergence when we run the regressions country-by-country, thus giving up the cross-sectional dimension of our panel data. This contrasts with the widely held view in the literature that it was the transition from time-series to panel data that allowed researchers to find support for the convergence hypothesis. Finally, our results also seem to contrast with the findings of an earlier paper by Gagnon and Knetter (1995) that focuses on the same market (automobiles), but uses

[1] The closest analog to our study for domestic markets is Parsley and Wei (1996). Their work also documents convergence to the absolute version of LOOP, but in a setting without trade barriers or currency fluctuations.

data from a different set of countries, and finds strong evidence against the relative version of the LOOP. We attribute this surprisingly strong evidence in support of the convergence hypothesis to the progress towards integration in the European market.

2 Segmentation, Price Dispersion, and Integration in the European Car Market

When thinking about cross-country price dispersion, it is useful to distinguish conceptually between two conditions that are required for the existence of price differences. First, price differences require market segmentation. Second, conditional on markets being segmented, we need firms to have reasons to take advantage of this segmentation. Such reasons would include cost differences across markets, or differences in the price elasticities of demand, in which case the price differences are indicative of price discrimination. With this conceptual framework in mind, we now discuss the institutions that generate segmentation in the European car market and the factors that account for the price differences.

2.1 The sources of market segmentation

Since the removal of tariff barriers in 1968, segmentation in the European auto market has been driven by three distinct factors: the differing national systems of type approval, the distribution system, and the requirement of national registration. These factors add to the transportation costs, information costs and language barriers that are also present in many other European industries.

The differing national systems of type approval formed until recently a first major impediment to consumers seeking to purchase a car abroad. Each European country had typically its own set of vehicle requirements. Costly modifications of the imported vehicle were often needed. Moreover, in most countries the job of checking and certifying the conformity of an imported car was entrusted to the official importers. There is no doubt that this procedure enabled them to control and monitor the cross-country trade in the cars they were selling.

The granting of a certificate often took several weeks, involved costly trips, and required fees that bore no relationship to the services provided.[2]

A second major obstacle to cross-border trade stems from the distribution system. During the 1970s and early 1980s many suppliers already instructed their dealers (threatening to withdraw their concessions) not to sell to unauthorized resellers, in particular if the purchase was intended for export. Discrimination against resellers occurred in several subtle forms: excessive delivery lags, high deposit requirements, reservations to provide guarantee outside the country of purchase, and higher prices (see BEUC, 1981 and 1982). Regulation 123/85 subsequently institutionalized these practices as a block exemption to the European competition rules. This regulation was initially approved for 1985-95, but was renewed for another 7 years in 1995. It effectively introduced a system of selective and exclusive distribution, specifying in detail the potentially restrictive arrangements that are legally permitted in agreements between car suppliers and their dealers.[3] Selectivity means that the manufacturer can choose his/her dealers and restrain them from reselling to anyone but end-users or approved sellers. Exclusiveness refers to the right of being the single seller in a designated territory, implying restrictions to engage in active sales promotion outside the territory (or country). Although the system in theory protected the rights to end-users to purchase their cars abroad, many difficulties were encountered. An anonymous dealer survey by BEUC (1986) revealed a refusal to sell to foreign consumers in 20% of the cases; excessive delivery lags for right hand drive cars for the U.K.; and lower discounts to foreigners. These problems need to be added to the high transportation and information costs for unexperienced consumers seeking to purchase abroad. Furthermore, Regulation 123/85 formally erected obstacles against independent commercial importers who attempted to purchase cars in bulk. These were only allowed to act as intermediaries, with a written purchase authorization

[2] For example, the general importer of General Motors in Belgium was convicted in 1975 for demanding excessive fees with the evident intention to discourage parallel imports. BEUC (1982) reports that one importer even charged the difference between the two countries' local prices as a fee for issuing the type-approval certificate.

[3] The regulation was explicitly motivated on the grounds that cars are durable goods, and need as such high quality after-sales-service through an official distribution network.

from their customers. Though the Regulation stated that the European Commission could withdraw the benefits of the Regulation in some instances, for example if price differences between two member states (excluding the high tax countries Danmark and Greece) exceeded 12% over a period of 6 months, or 18% at any point in time, in practice these threats have never been enforced.

A third obstacle to trade between countries has been caused by the system of national registration, which had the effect of limiting trade of foreign, mainly Japanese models. Quantitative restrictions on imports from third countries, in particular Japan, have long existed in various European countries (France, Italy, Portugal, Spain and the U.K.). These restrictions take the form of import quotas or voluntary export restraints. The problem is, of course, that parallel imports from other European countries can undo the national restrictions. The requirement of national registration resolves this problem, since it can control cross-border trade of Japanese cars. In Italy, for example, there existed a tight quota of 3300 cars that could be directly imported from Japan. The total number of Japanese cars that could be officially registered in Italy, including cars from other European countries, was limited to 23000 (slightly more than one percent of the Italian market). When the national quotas were replaced in 1993 by a common import quota for the European Union as a whole, the requirement of national registration continued to maintain unofficial national quotas under various pretexts.

Any remaining doubts about the degree of segmentation in European markets can be dispelled by looking at the magnitude of parallel imports, the goods imported by unauthorized resellers. Table 1 summarizes the evidence collected from various BEUC surveys. It reveals that parallel imports have been quite low in all European countries. They generally do not constitute more than three percent of the total market, and in many countries and years less than one percent. These small numbers are even more remarkable, when one considers that the average price difference between the cheapest and the most expensive European country has been around 30% of the car price.

Given that markets are segmented, it is clear that firms *can* charge different prices in European countries. But why should they want to? Providing an answer to this question is important as it allows us to understand why barriers to arbitrage were erected in the first place. Given that segmentation does not rest on "natural" barriers, but is the result of regulations that reflect firms' lobbying efforts, understanding the incentives of firms to charge different prices in different markets is equivalent to understanding the incentives for preventing arbitrage across markets. This question is investigated in detail in Goldberg and Verboven (forthcoming). In the context of a structural model of the European auto market they identify three main sources of price dispersion in Europe: cross-country differences in costs, differences in the price elasticities of demand generating differences in markups, and import quota constraints. The first source (costs) seems particularly relevant for explaining the high prices in the U.K. (better equipped cars, differences in dealer discount practices) and Germany (catalyzator, environmental regulations); the second source (price elasticities of demand) explains the relatively high prices in Italy, where a strong preference for domestic brands generates market power for the domestic firm (Fiat); quota constraints are relevant explanations for Italy, France and the U.K.. In addition, the authors document local currency price stability that generates large variation in year-to-year price differentials. This stability is attributed primarily to the presence of a local component in marginal costs (around 35% of marginal costs are estimated to be denominated in local currency), and, secondarily, to markup adjustment that is correlated with exchange rate volatility.

2.2 The integration process

Against this background we can think of the integration process in the European car market as having two goals: first, diminish the degree of segmentation, and, second, directly reduce price differences by eliminating sources of cost differences and discouraging price discrimination. An important measure towards reducing segmentation has been the harmonization of so-called "essential requirements" for new car models throughout the European Union. A list of such requirements was set out as early as 1970; yet the process of actually implementing specific changes has been very slow and gradual. For a long time countries had the option of allowing their national type approval standards to co-exist with the European directives. Most countries made use of this option. By 1987, only Italy had adopted the

European directives as the single local standard. The harmonized type approval directives eventually became mandatory, and fully replaced the national systems in 1995. To the extent that these differing national requirements have been responsible for cost differences across countries we would expect cross-country price differentials to decline in absolute terms as a result of integration. To the extent that national regulations have been used as an excuse to prevent arbitrage, we would expect the integration process to have sped up convergence. At any rate, we would expect these changes to show up only gradually given how slow the harmonization process was.

A second step towards integration was the relaxation of the exclusivity of the distribution system when Regulation 123/85 was renewed in 1995; dealers can now advertize outside their territory and carry competing brands. At the same time, there has also been some effort to prevent auto dealers from abusing the selectivity of the distribution system. For example, the explicit condition was added that manufacturers should not restrict consumers, or intermediaries acting on their behalf, to purchase from any dealer. In addition, the European Commission has been carefully monitoring price differences since 1992, and has explicitly stated its preparedness to withdraw the benefits of the selective distribution system if price differences across states exceed 12% (this is the so-called 12% rule). The recent Volkswagen case (1998) has also indicated the Commission's intention to get more serious about preventing dealers from abusing their privileges. Volkswagen was accused and convicted for putting pressure on Italian dealers not to sell to German and Italian customers. This pressure involved threats to 50 dealers to withdraw their licenses, and 12 licenses were effectively withdrawn. The penalties included a 102 million ECU fine (about 10% of Volkswagen's annual profit), the largest fine ever issued by the European Commission to a single firm, and the removal of Volkswagen's rights as set out in the Regulation. Similar investigations are under way against Opel and Mercedes. These investigations and penalties should have the effect of encouraging arbitrage across markets - in fact, parallel imports have been increasing in recent years - and increasing the speed of convergence. In addition, one would also expect manufacturers to be more hesitant to exercise price discrimination - at a minimum, they might try to keep price differences below the 12% benchmark. As a result, we would expect to see lower price differentials across countries - in absolute terms.

Further measures towards integration include tax harmonization and the recent transition to the EMU (1998). As Table 1 indicates, tax rate differences are now much smaller compared to their levels in the past; the diminishing of tax differences should reduce absolute price differentials. To the extent that price differentials reflect local currency price stability, the transition to a system of fixed exchange rates should substantially reduce the year-to-year variation in price differentials. While the transition to the EMU is too recent for us to be able to detect its effects on prices, the fact that Belgium, France and Germany have had a system of quasi-fixed rates in the 1980's and 1990's, allows us to indirectly test the hypothesis that a reduction of nominal exchange rate volatility translates to faster convergence to the LOOP.

In summary, in light of the recent developments in the European markets, one wonders whether absolute price differentials have been reduced and whether the speed of price convergence for the countries in our sample has increased. Nevertheless, the above discussion also suggests that impediments to arbitrage still exist, and that exchange rate volatility is an issue throughout our sample period, especially for the U.K.. Given this, we start by asking the basic question, whether the LOOP holds in our data.

3 A First Look at the Data

The data set we have constructed to examine price convergence is a large three dimensional panel, containing information on approximately 150 vehicle makes per year in five distinct European markets over the period 1970-2000. For each make we have information on sales, list price, and physical characteristics such as engine attributes, dimensions, and performance variables; these characteristics sometimes vary across markets. The five markets included in our analysis are Belgium, France, Germany, Italy and the United Kingdom. We focus our attention on these five countries, both because of data availability constraints, and, more importantly, because they represent the largest markets in Europe: collectively they account for over 85% of total car sales in Europe every year. In addition, these countries represent a large spectrum for several reasons: the size of the market varies from ca. 400,000 units per year in Belgium to almost 3 million cars in Germany; the degree of import penetration ranges from ca. 30% in France and Germany to almost 100% in Belgium; the Japanese penetration varies from ca. 1% in Italy to 20% in Belgium; tax rates vary from 14% in Germany to 33% in France in the early years, and 25% later; and the C1-concentration index ranges from 53% in Italy to 16% in Belgium; throughout our sample period Belgium tends to be the cheapest destination, while the U.K. is associated with the highest prices.

Because our information is at the vehicle make level, our cross-country price comparisons refer to relatively homogeneous products (for example, we are comparing the price of a Honda Civic in Belgium to the price of a Honda Civic in Germany). Nevertheless, to be absolutely sure that we are comparing identical products, we use hedonic price regressions to control for possible variation in characteristics or options of models across countries, and use the residuals of these regressions as the relevant prices in our price convergence regressions.

To obtain a preliminary idea about price dispersion and convergence in our data, it is useful to look at some graphs based on more aggregate data first. To construct aggregate price indices, we ran hedonic price regressions of the form:

$$ln(rp_{i,k,t}^{Euro}) = w_{i,k,t}\gamma + \theta_c + \theta_f + \theta_{s,t} + \theta_{k,t} + \epsilon_{i,k,t}$$

The subscripts i, k and t refer to product i, country k and year t respectively. The variable $rp_{i,k,t}$ refers to the raw, pre-tax price of car model i expressed in a common currency (Euro). The vector $w_{i,k,t}$ consists of physical car characteristics (horsepower, size, etc.) that may vary across markets, while θ_c and θ_f are market segment and firm dummies respectively. In addition, we include a set of source country/time dummies ($\theta_{s,t}$) to control for differences that may be due to a common cost shock facing firms located in a particular country of origin (e.g. an increase in wages facing all Japanese firms). Given this specification, the destination/time effects $\theta_{k,t}$ capture the residual cross-country price differences that cannot be explained by differences in quality or taxation across markets. All differences are measured in percentage terms relative to Belgium.

Figure 1 plots the estimated price indices $\theta_{k,t}$ for the period 1970-2000. The figure documents the same patterns reported in Goldberg and Verboven (forthcoming) for a subperiod of this sample: (1) large and persistent cross-country price differentials; and (2) substantial year-to-year volatility. Belgium appears to be the cheapest country throughout the sample period, while the U.K. is - in most years - the most expensive. These patterns were robust to alternative specifications of the hedonic equation. Moreover, they were robust to the use of more disaggregate price indices. For example, using a similar hedonic price framework as the one described above, we estimated and plotted price indices for each market segment separately (small, large, luxury, sports cars, etc.). The graphs exhibited approximately the same magnitude and same volatility of price dispersion, indicating that the patterns evident in Figure 1 are not driven by aggregation.

Looking at Figure 1, one would be hard-pressed to claim price convergence. What is perhaps most surprising is that, while prices seem to be coming together around 1990-92, they start diverging again after 1992, a development that certainly runs against the idea of the integrated "Europe 1992". A closer examination of the graph reveals that it is the prices in the U.K. and Italy that diverge the most. These two countries however experienced large currency fluctuations in the 1990's that may have affected price convergence. More generally, the price volatility exhibited in Figure 1 immediately brings exchange rates to mind, as there is no other source of price dispersion as volatile as nominal exchange rates. Figure 2 plots the exchange rates of the countries in our sample vis a vis Belgium; the correlation between the evolution of price differences in Figure 1 and the exchange rate fluctuations in Figure 2 is immediately apparent.

Since the existence of price convergence over our sample period does not seem to be an issue that can be settled through graphs or simple statistics, we now turn to a more systematic investigation of price convergence.

4 Results on Price Convergence

This section investigates different versions of price convergence. We start by documenting the persistence of long term price differentials and providing an estimate of the speed of convergence, i.e. how fast deviations from the long-term price differentials are eliminated. Next, we investigate the effects of the integration process; in particular, we examine whether long term price differentials have decreased over time, and whether the speed of convergence has increased. In specifying the dependent variable we face two choices: Define the dependent variable as $\Delta q_{i,k,t}$ where q denotes the log- price *level* of product i in country k at time t; or, alternatively, choose a benchmark country, and define the dependent variable as $\Delta p_{i,k,t}$ where p refers to the log-*difference* in the price of product i in country k relative to the benchmark country. We chose the second approach with Belgium as the numeraire country. Belgium provides a natural benchmark as it is both the country with the lowest car prices in Europe, and the market with the fewest trade restrictions and lowest concentration. In the context of arbitrage, we find it more appealing to focus on bilateral price differences relative to the cheapest country, rather than on deviations from a theoretical cross-country average. A possible criticism of this approach is that the convergence results are not invariant to the choice of the numeraire country (see Papell (1997), Wei and Parsley (1995), Cecchetti et al (2000)). To address this criticism we also estimated convergence equations using different countries as the benchmark (e.g., Germany), and also using the log-price level as the dependent variable.[4] In both cases our results were very similar to the ones reported below, so that we are confident that our conclusions are not due to the particular choice of the base country.

Because some of the vehicle makes are not available for all 31 years in our sample, our panel is unbalanced. To deal with this issue we found it easiest to convert our data to a balanced panel, by using the following procedure: First, we run hedonic price regressions to control for quality, and firm reputation differences across markets. These regressions also include interactions of market segment/country of origin/destination market/time dummies on the right hand side. The coefficients of these dummies represent quality adjusted averages of individual vehicle make prices each year, by market segment, country of origin and destination country. We use these quality adjusted prices to form the dependent variable

[4] In this case we include time effects on the right hand side of the convergence equations. Convergence in this case is understood as convergence to an average across the countries in our sample.

used in the estimation.

4.1 The basic convergence equation

We start by estimating the following basic version of the convergence equation:

$$\Delta p_{i,k,t} = \alpha_{i,k} + \beta p_{i,k,t-1} + \sum_{l=1}^{L} \gamma_l \Delta p_{i,k,t-l} + \varepsilon_{i,k,t} \qquad (1)$$

Our estimation procedure is based on the work of Levin and Lin (1992) on unit root tests with panel data. As noted above, the dependent variable is the log-difference in the price of product i in country k relative to Belgium. The main parameter of interest is β that denotes the speed of convergence. Under the null of no convergence, β is equal to zero. In this case a shock to $p_{i,k,t}$ is permanent. Convergence implies a negative β, with the approximate half-life of a shock to $p_{i,k,t}$ given by $-\ln(2)/\ln(1+\beta)$. Cecchetti et al (2000) also consider an alternative specification (based on work by Im et al (1997)), in which the coefficient β is allowed to vary across countries (β is replaced by β_k in this case); convergence here implies a negative β for *some* countries ($\beta_k < 0$, for some k), as opposed to *all* countries as in Levin and Lin. We chose the Levin and Lin approach as it is the more conservative one - it is unlikely that the behavior of only one or two countries will lead us to reject the unit root hypothesis in this case. We do consider country-specific β's however, later in subsection 4.3, in which we estimate a separate convergence equation for each country pair in our sample.

The dummies $\alpha_{i,k}$ capture product/country fixed effects that account for non-time dependent, product specific price differences across countries. Such effects could be transportation costs (measured as percentages of price differences), unobserved quality differences that vary by destination, or markup differences. The presence of the product/country fixed effects in the estimation indicates that we are testing the relative version of the LOOP. In addition to the speed of convergence β, we are also interested in examining the absolute values of the $\alpha_{i,k}$'s; large values of these product/country specific effects would indicate market segmentation, even if the relative version of the LOOP held in the data. The lags $\Delta p_{i,k,t-l}$ are used to account for possible serial correlation in the error term.[5] As a robustness test on our results, we also estimated unpooled regressions by product, and the results were similar. We therefore only report results from the pooled regressions here.

Table 2, column 1, reports the estimation results for equation (1). The coefficient estimate for β is -0.41, with a t-statistic of -24. Note that in the pooled estimation we have 30 years of data, and approximately 240 product and country specific dummies. The critical values reported in Levin and Lin (1992) for $t = 25$ and $N = 250$ (approximately our panel size) are -21.98, -21.43 and -21.13 at the 1%, 5%, and 10% respectively. Based on these critical values we can reject the null of a unit root (or no convergence). This results contrasts with the findings of Parslei and Wei (1996) or Frankel and Rose (1995) who find it hard to reject the unit root hypothesis when fixed effects are allowed in the panel framework. It is also remarkable that the implied half life of a shock is according to our estimates 1.3 years. This is a much shorter interval than what is traditionally estimated with international data (5 to 6 years); interestingly enough, it corresponds roughly to Parsley and Wei's estimate for tradeable goods in the United States, a market that we would normally consider more integrated than Europe.[6] Note, however, that Parsley and Wei's basic specification does not include destination specific fixed effects, while ours does. As mentioned above, such fixed effects may themselves be indicative of market segmentation. We therefore turn our attention to our estimates of the fixed effects next.

The product/country specific dummies are jointly significant at the 5% level. Rather than reporting the individual product/country fixed effects, Table 2 displays the country *average* fixed effects (i.e. the averages of the $\alpha_{i,k}$ across products by country), and the corresponding standard errors. By dividing these fixed effects by $-\beta$, we obtain the long-term, systematic price differentials across countries. The long-term price differentials take values between 5% (France) and 17% (U.K.) and are all highly significant. They indicate the

[5] The number of lags is determined using Campbell and Perron's (1991) top-down approach. We start by setting $L = 5$; if the absolute value of the t-statistic for $\hat{\gamma}_6$ is less than 1.96 then we reset $L = 4$ and reestimate the equation. We repeat this procedure until the t-statistic of the coefficient with the longest lag is greater than 1.96.

[6] For services, Parsley and Wey find lower convergence rates, with a median of about 4 years.

presence of persistent price differences relative to Belgium - the U.K. estimate, for example, implies that during our sample period, U.K. quality adjusted prices are approximately 17% higher than in Belgium. Price differences of this magnitude seem at odds with the common wisdom view of market integration - despite the fact that the unit root hypothesis is rejected in the data. Comparing our results with the analogous findings of Parslei and Wei for the U.S., it seems that the big difference between Europe and the U.S. lies in the fixed effects. While our estimates of the speed of convergence are very similar, the fixed effects are high and statistically significant in Europe, which is probably not the case in the U.S..

The histogram of Figure 3 provides a more detailed description of the product/country fixed effects. Here the product/country dummies are averaged by market segment. Each bar in the histogram represents the percent price difference of the corresponding market segment in the country of interest relative to Belgium. Note that the pattern of price differences seems relatively robust to different market segments. The only exception is the luxury market segment in Germany which represents the only product group with prices lower than in Belgium.

Columns 3 and 5 of Table 2 also report results based on regressions in which (a) Germany is used as the base country; and (b) there is no numeraire country, but the comparison of price differences is relative to a cross-country average (the specification includes time effects in this case). The basic message of columns 3 and 5 that our conclusions are not sensitive to the choice of the base country; the estimates of the convergence speed are very similar in both cases to the ones obtained with Belgium as the base country.

4.2 The role of exchange rate changes

The literature on the relative version of PPP has suggested that nominal exchange rate volatility in conjunction with short-term price rigidities may be important in explaining international price differences. To investigate the role of exchange rate changes, we also estimated the following equation:

$$\Delta p_{i,k,t} = \alpha_{i,k} + \beta p_{i,k,t-1} + \sum_{l=1}^{L} \gamma_l \Delta p_{i,k,t-l} + \sum_{m=0}^{M} \delta_m \Delta e_{k,t-m} + \varepsilon_{i,k,t} \tag{2}$$

The variable $e_{k,t}$ denotes the log of the exchange rate of country k's currency relative to the Belgian Franc. The lag structure of exchange rate changes is included to capture changes in cross-country price differentials that may result from short-term nominal rigidities. Figure 2 that plots the exchange rates of the four countries in our sample relative to Belgium suggests that this may be an important issue. For example, the decline in the price differential between the U.K. and Belgium in the period 1990-92 coincides with the depreciation of the pound. Without controlling for this depreciation we might be attributing this apparent "price convergence" to institutional changes aimed at fostering integration, when the true source of the change might in fact be just fortuitous movement of exchange rates in the right direction. And vice versa, there might be periods where, despite efforts to increase integration, we may observe a widening of price differentials because of exchange rate changes that are not passed though onto local currency prices in the short run.

The results for the specification that includes exchange rate changes are displayed in Table 2, column 2. In the reported specification we included the exchange rate change and its first three lags to capture pass-through effects that may spread over several years. All variables appearing in equation (2) are stationary - prices by virtue of the results in the previous subsection, while for exchange rate changes we established stationarity separately. There are two things to note in Specification 2. First, our estimate of the speed of convergence hardly changes compared to the specification without exchange rates; the point estimate is -0.38 (t-statistic: -23.3) implying a half-life of a shock of approximately 1.5 years. Nevertheless, the exchange rate change and its first two lags are highly significant. As expected, all coefficients are negative, and declining in absolute value as the lags get longer. The magnitude of $\Delta e_{k,t}$ is striking (point estimate: -0.76, with a t-statistic of -32). It implies that only 24% of an exchange rate change gets passed through (on average) onto local prices in the short run. This is consistent with previous work on exchange rate pass-through that has documented local currency price inertia. Note, however, that the coefficient on the first lag is substantially smaller in absolute value (0.14). The robustness of the estimated speed of convergence to the inclusion of exchange rate changes suggests that, while exchange rate changes and nominal rigidities are important in the short run in explaining cross-country price differentials, our finding of fast relative price convergence is not due just to movements of exchange rates in the right direction.

Of course, a natural objection to the above statement is that two of the countries in our sample (France and Germany) had quasi-fixed exchange rates relative to Belgium for most of our sample period. To investigate whether these quasi-fixed exchange rates may have had an impact on our results, we next turn to bilateral regressions examining the price differentials in each of the countries in our sample relative to Belgium.

4.3 Country pairs

Table 3 reports the convergence coefficients (standard errors in parentheses) obtained by estimating convergence equations for each country pair separately. The first row of numbers was obtained using Belgium as the base country, the second row using France, and so on. The striking feature of this table is that the estimated speeds of convergence are very high for virtually all countries in our sample. While there is some variation in the point estimates of β (it ranges from -0.35 for the Italy/Belgium pair to -0.60 for Germany/France), the coefficient is always statistically significant, and implies relatively short half-lives of price shocks (from 0.75 to 1.6 years).[7] Note that by estimating bilateral regressions, we give up the country dimension in our panel data set - we only exploit the time variation in price differences. In light of this, our results are remarkable. Most previous work on price convergence failed to reject the null of a unit root in the price series when time series data were used. The recent findings on relative price convergence are often attributed to the use of panel data sets which allow the econometrician to exploit the cross-sectional dimension. This explanation,

[7] Note that the relevant critical values for this specification are the ones corresponding to t=25 and N=50, where N here denotes the number of products. These critical values are -10.89, -10.35 and -10.06 at the 1%, 5% and 10% significance levels respectively (Levin and Lin (1992), Table 5). All the t-statistics of the estimated β's in Table 3 are less than -11.

however, does not seem to apply to our case. Of course, we do exploit a richer than usual data set, in the sense that we have detailed data on multiple models.

The results in Table 3 were obtained using a specification that did not include exchange rate changes. Including exchange rate changes leaves the β coefficients virtually unchanged; as before, the coefficients on the exchange rate changes are highly significant. A notable pattern concerning the exchange rate coefficients is that these are substantially higher in absolute value in regressions in which the U.K. is compared to an other base country. For example, in the U.K./Belgium regression, the coefficient on $\Delta e_{k,t}$, where e here denotes the exchange rate between the Belgian Franc and the British Pound, is 0.81 (standard error: 0.04), while the exchange rate coefficients for the other countries range between -0.42 and -0.69. This suggests that nominal exchange rate volatility is more important in explaining price differences in the U.K., relative to the other countries in our sample. This is not surprising given that two out of the three remaining countries in our sample had a system of quasi-fixed exchange rates.

4.4 Progress towards integration?

The previous results established (i) the persistence of long-term price differentials across countries, and (ii) a relatively fast convergence to the long-run equilibrium after price shocks (half-lives of approximately 1.5 years). Our next question concerns the role of the integration process. Our panel data set, that spans a period of 30 years, is ideal for addressing this question. As discussed in Section 2, the European Commission has taken several measures over the past three decades to improve European integration. Since most of these measures have been implemented gradually, we found it most appropriate to use trend variables to capture their effect. We interpret these trend variables as applying only to our sample period: 1970-2000. To make sure that we are capturing the real effects of integration, rather than any nominal shocks, we include exchange rate changes in our specification, as we did previously in equation (2).

Our primary hypothesis is that, to the extent that integration measures have had an effect, the absolute price differentials (the fixed effects) should have declined. To investigate this hypothesis, we interact the product/country fixed effects with time trends. A second question is whether the speed of convergence has changed over time. All else being equal, one would expect integration to speed up price convergence: shocks to prices should be eliminated faster if consumers or intermediaries can more easily engage in arbitrage. However, this expected increase in the speed of convergence may not occur if the absolute price differentials have declined as a result of integration. This is because of the commonly observed non-linearities in the speed of price convergence: large shocks and large price differences tend to be eliminated faster than small differences. If integration reduces price differences across countries, then price shocks may be eliminated more slowly, not because impediments to arbitrage have not diminished, but because the price differences to be eliminated are smaller compared to the pre-integration period. To capture the effect of integration on the speed of convergence we interact the convergence coefficient with a time trend.

Table 4 reports the results. Column 1 considers the effect of integration on the absolute price differentials. The underlying equation is:

$$\Delta p_{i,k,t} = \alpha_{i,k} + \tilde{\alpha}_k * trend + \beta p_{i,k,t-1} + \sum_{l=1}^{L} \gamma_l \Delta p_{i,k,t-l} + \sum_{m=0}^{M} \delta_m \Delta e_{k,t-m} + \varepsilon_{i,k,t} \qquad (3)$$

We focus on a specification where only the country average fixed effects $\tilde{\alpha}_k$ are interacted with a trend, so that our trend coefficient captures the effect of integration on *average* price differentials in each market relative to Belgium. It is important to note here that we use the trend only to capture gradual integration during our sample period (see the institutional discussion in Section 2), and not long-run growth out of sample. The estimated coefficients indicate that the average price levels in France, the United Kingdom and especially in Italy have declined significantly relative to Belgium. The annual declines range from 0.7 percent (France) to 1.5 percent (Italy). In contrast, the average price level in Germany has increased (moderately) relative to Belgium. Yet the country fixed effects show that Germany had a lower price level than France, Italy and the United Kingdom at the beginning of the sample. The change of the fixed effect for Germany thus shows convergence of the German price level to the price levels in the other countries. Overall, these country averages indicate a gradual increase in integration. Nevertheless, it is possible that, while the country averages demonstrate a trend towards price convergence, prices at the product level are still dispersed. To examine this possibility, we tested whether the deviations of the country/product fixed effects from the average country fixed effects were significant. Only 22 percent of these deviations were significant at the 5% level. Most of the deviations fell within the $-3\% + 3\%$ range.

Column 2 of Table 4 considers the effect of integration on the speed of convergence. The underlying equation here is:

$$\Delta p_{i,k,t} = \alpha_{i,k} + \tilde{\alpha}_k * trend + \beta * p_{i,k,t-1} + \tilde{\beta} * trend * p_{i,k,t-1} + \sum_{l=1}^{L} \gamma_l \Delta p_{i,k,t-l} + \sum_{m=0}^{M} \delta_m \Delta e_{k,t-m} + \varepsilon_{i,k,t} \tag{4}$$

It turns out that integration has had little effect on the speed of convergence; if anything, the speed of convergence has decreased (the decrease is significant at the10% level). This may follow from the presence of non-linearities, as suggested above.

In sum, we conclude that integration has led to a gradual reduction in the average price differentials during 1970-2000, yet the speed of convergence in response to shocks has remained more or less unaffected. This is perhaps not surprising given that our estimate of the speed of convergence is comparable to the speed of convergence in the more integrated U.S. market.

4.5 Convergence to the absolute LOOP

So far our discussion has focused on convergence to the *relative* version of the LOOP. As mentioned at the beginning, this has traditionally been the focus of the literature on international price convergence. Next, we turn our attention to the absolute version of the LOOP. The nature of our data (disaggregate product level data) is ideal for testing this version of the LOOP.

The basic equation we estimate to test for convergence to the absolute LOOP is:

$$\Delta p_{i,k,t} = \beta p_{i,k,t-1} + \sum_{l=1}^{L} \gamma_l \Delta p_{i,k,t-l} + \varepsilon_{i,k,t} \tag{5}$$

Note that this equation is similar to equation (1), except for the omission of the product/country fixed effects. The results from this specification are reported in Table 5, column 1. Column 2 of the same table reports results from a specification that includes, in addition to the right-hand side variables in (5), the exchange rate change and its lags. In both columns 1 and 2, the hypothesis of a unit root is easily rejected. The coefficient β is negative, with t-statistics equal to -12 in column 3, and -8.7 in column 4, while the critical values according to Levin and Lin (1992) for T=25, N=250, and no intercepts, are -2.34 at the 1% level, and -1.67 at the 5% level. Note, however, that the implied speeds of convergence are substantially lower compared to our estimates when product/country fixed effects were included in the equation. The β estimate in column 1 implies a half-life of a shock of approximately 5 years, while the convergence coefficient in column 2 implies a half-life of 8.3 years. These numbers seem more in line with the estimates traditionally obtained in the International literature on price convergence. But while the estimates in the literature usually refer to convergence to the relative version (i.e., the half-lives represent the time that elapses until price differentials return to their long-run level), in our case the half-lives refer to convergence to the absolute LOOP (that is the time that elapses until price differentials are eliminated). In this sense, one can claim that our results on convergence are much stronger than the ones previously obtained for international markets.

There is an obvious caveat to the specification (5): the estimation pools data across products. Including product (but not country) dummies reduces the estimated β coefficients to values around -0.20, but in this case there is no correspondence between our specification and the specifications considered in Levin and Lin. Accordingly, the appropriate critical values for testing the unit root hypothesis are not available to us.[8] We therefore employed an

[8] The results from specifications that include product specific, but not country specific dummies, are reported in columns 3 and 4 of Table 5. Given that the critical values are not available to us, we cannot formally test the unit root hypothesis in these two cases. But we can get an idea in which direction the β coefficients change when product dummies are included.

alternative approach and estimated equation (5) on a product-by-product basis. There are too many coefficients to report in this case, but the general picture that emerges from the estimation supports our conclusions from the previous paragraph: the estimated convergence speed is substantially lower when we test for the absolute version, compared to the specification with the country fixed effects. The β coefficients vary from -0.15 to -0.05, implying half-lives between 4 and 13 years. While the majority of the coefficients are statistically significant, the number of the ones that are not, is substantial.

Overall, our results on the absolute version of the LOOP indicate that, while the hypothesis of a unit root is rejected, the results are weaker compared to the tests for the relative version. The fact that the fixed effects estimated in equations (1) and (2) were jointly significant, also argues in favor of the hypothesis that deviations from the absolute LOOP still exist – even if we cannot formally reject convergence when estimating equation (5). This is not surprising given that, as discussed in Section 2, impediments to arbitrage still exist in European markets. Nevertheless, our estimates of the trend variables in the previous subsection in conjunction with the results on absolute convergence suggest that violations of the LOOP are diminishing over time, and are certainly not as pronounced as previously found in studies of international markets.

5 Conclusions

This paper set out to investigate convergence to the LOOP in international markets using detailed product-level data. We view our results as providing strong evidence in favor of both the absolute and relative versions of the LOOP. In particular, there are two features of our findings that distinguish them from those of previous studies: (1) When testing for the relative version of PPP we estimate half-lives of shocks (1.3-1.6 years) that are substantially shorter than the ones estimated in earlier work; (2) We cannot reject the hypothesis of convergence to the absolute LOOP. While our findings regarding the absolute LOOP are not directly comparable to other international studies (as pointed out before, international studies usually focus on relative PPP), it is remarkable that the half-lives of shocks we estimate under absolute PPP (5 to 8 years) correspond roughly to the half-lives estimated by other researchers under relative PPP. A comparison to the results of Parsley and Wei (1996) for the domestic market is also instructive. Our half-life estimates under relative PPP are similar in magnitude to the ones obtained by Parsley and Wei under absolute PPP, while the country/product fixed effects capturing long-term, persistent price differentials across markets, are jointly significant. Under absolute PPP, our half-life estimates are noticeably higher. These results taken together suggest that one important difference between domestic and international markets may be the presence of the fixed effects. While our estimation did account for short-term rigidities associated with nominal exchange rate volatility, we found no evidence that our results on price convergence were driven by exchange rate changes in the right direction.

When interpreting our results it is important to keep in mind that they were obtained using data from Europe, a market that has undergone many changes in the last two decades in order to become more integrated. We are therefore hesitant to generalize our findings to other international markets. Rather, we view them as evidence that the progress towards integration in Europe has had visible effects on cross-country price dispersion that are reflected in tests of the LOOP.

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Table 1: Summary Statistics for the European Car Market[9]

	BE	FR	GE	IT	UK	ALL
1980 value-added tax (in %)	25	33	13	18	23	
1990 value-added tax (in %)	25	25	14	19	24	
Total sales (in 1,000 units)	384.4	1920.3	2508.9	1908.0	1704.1	8412.3
	(48.9)	(192.1)	(359.7)	(293.4)	(248.9)	(892.4)
Parallel imports (in 1,000 units)	N/A	5–40	30–60	10–75	1–50	
Japanese market share (in %)	21.6	3.1	15.5	1.8	11.3	7.7
	(1.9)	(.5)	(1.5)	(1.3)	(.6)	(1.0)
Japanese quota (in %)	—	3.0	15.0	1.0	11.0	
Domestic market share (in %)	2.5	66.6	70.2	58.2	55.1	
	(.4)	(5.1)	(4.0)	(6.2)	(4.0)	
European average (in %)	1.6	24.6	33.4	16.7	12.1	
	(.5)	(2.6)	(1.9)	(1.4)	(1.5)	
C1-ratio (in %)	16.3	33.5	30.2	53.9	28.7	15.7
	(1.8)	(1.7)	(1.2)	(5.2)	(3.3)	(1.6)
	(VW)	(PSA)	(VW)	(Fiat)	(Ford)	(Fiat)

[1] Averages, over 1980-95. Standard deviations in parenthesis.

Table 2: **Results for basic specification with product/country fixed effects**

Dep. Variable: $\Delta p_{i,k,t}$	Base: BE		Base: GE		No Base	
$p_{i,k,t-1}$	-0.41	-0.38	-0.48	-0.42	-0.37	-0.32
	(0.017)	(0.016)	(0.019)	(0.018)	(0.015)	(0.014)
$\Delta e_{k,t}$	-	-0.76	-	-0.66	-	-0.77
		(0.02)		(0.02)		(0.03)
$\Delta e_{k,t-1}$	-	-0.14	-	-0.08	-	-0.08
		(0.03)		(0.03)		(0.03)
$\Delta e_{k,t-2}$	-	0.05	-	0.09	-	0.08
		(0.03)		(0.03)		(0.03)
$\Delta e_{k,t-3}$	-	0.03	-	0.08	-	0.05
		(0.03)		(0.03)		(0.03)
Be	-	-	-0.05	-0.04	-	-
			(0.005)	(0.004)		
Fr	0.02	0.03	-0.02	-0.00	0.02	0.03
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.004)
Ge	0.04	0.03	-	-	0.04	0.03
	(0.005)	(0.004)			(0.005)	(0.004)
It	0.04	0.07	0.00	0.02	0.04	0.07
	(0.005)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
UK	0.07	0.08	0.04	0.04	0.07	0.08
	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)	(0.005)
lags of $\Delta p_{i,k,t}$	yes(3)	yes(3)	yes(3)	yes(3)	yes(3)	yes(3)
prod.-count. dummies	yes	yes	yes	yes	yes	yes
time dummies	no	no	no	no	yes	yes

Table 3: Results for Country-Pairs[2]

	FR	**GE**	**IT**	**UK**
BE	-0.45	-0.56	-0.35	-0.46
	(0.025)	(0.056)	(0.033)	(0.077)
FR		-0.60	-0.50	-0.58
		(0.028)	(0.019)	(0.065)
GE			-0.42	-0.53
			(0.001)	(0.0039)
IT				-0.38
				(0.0034)

[2] The estimated specifications include product fixed effects. The table reports the estimated β coefficients from bilateral regressions, with standard errors in parentheses. For example, the coefficient -0.45 in the upper-left corner corresponds to a regression in which the dependent variable is the first difference of the Belgium-France price differential; the second number in the first row corresponds to the Belgium-Germany regression, etc. The reported specifications did not include exchange rate change lags. The results with exchange rate changes were very similar.

Table 4: The Effects of the Integration Process

(Base Country: Belgium)

Dep. Variable: $\Delta p_{i,k,t}$		
$p_{i,k,t-1}$	-0.45	-0.46
	(0.015)	(0.017)
$p_{i,k,t-1} * trend$	-	0.002
		(0.001)
Fr	0.07	0.07
	(0.005)	(0.005)
$Fr * trend$	-0.003	-0.003
	(0.0003)	(0.0004)
Ge	0.01	0.01
	(0.005)	(0.005)
$Ge * trend$	0.001	0.001
	(0.0003)	(0.0004)
It	0.17	0.17
	(0.007)	(0.007)
$It * trend$	-0.007	-0.007
	(0.0004)	(0.0004)
UK	0.13	0.13
	(0.006)	(0.006)
$UK * trend$	-0.003	-0.003
	(0.0003)	(0.0004)
lags of $\Delta p_{i,k,t}$	yes(3)	yes(3)
exchange rate change and lags	yes	yes
prod.-count. dummies	yes	yes

Table 5: Convergence to the Absolute LOOP?

(Base Country: Belgium)

Dep. Variable: $\Delta p_{i,k,t}$				
$p_{i,k,t-1}$	-0.13	-0.08	-0.28	-0.21
	(0.010)	(0.009)	(0.015)	(0.013)
$\Delta e_{k,t}$	-	-0.81	-	-0.78
		(0.024)		(0.024)
$\Delta e_{k,t-1}$	-	0.05	-	-0.02
		(0.029)		(0.027)
$\Delta e_{k,t-2}$	-	0.26	-	0.19
		(0.027)		(0.027)
$\Delta e_{k,t-3}$	-	0.27	-	0.18
		(0.027)		(0.027)
lags of $\Delta p_{i,k,t}$	yes(3)	yes(3)	yes(3)	yes(3)
prod.-count. dummies	no	no	no	no
only country dummies	no	no	no	no
only product dummies	no	no	yes	yes

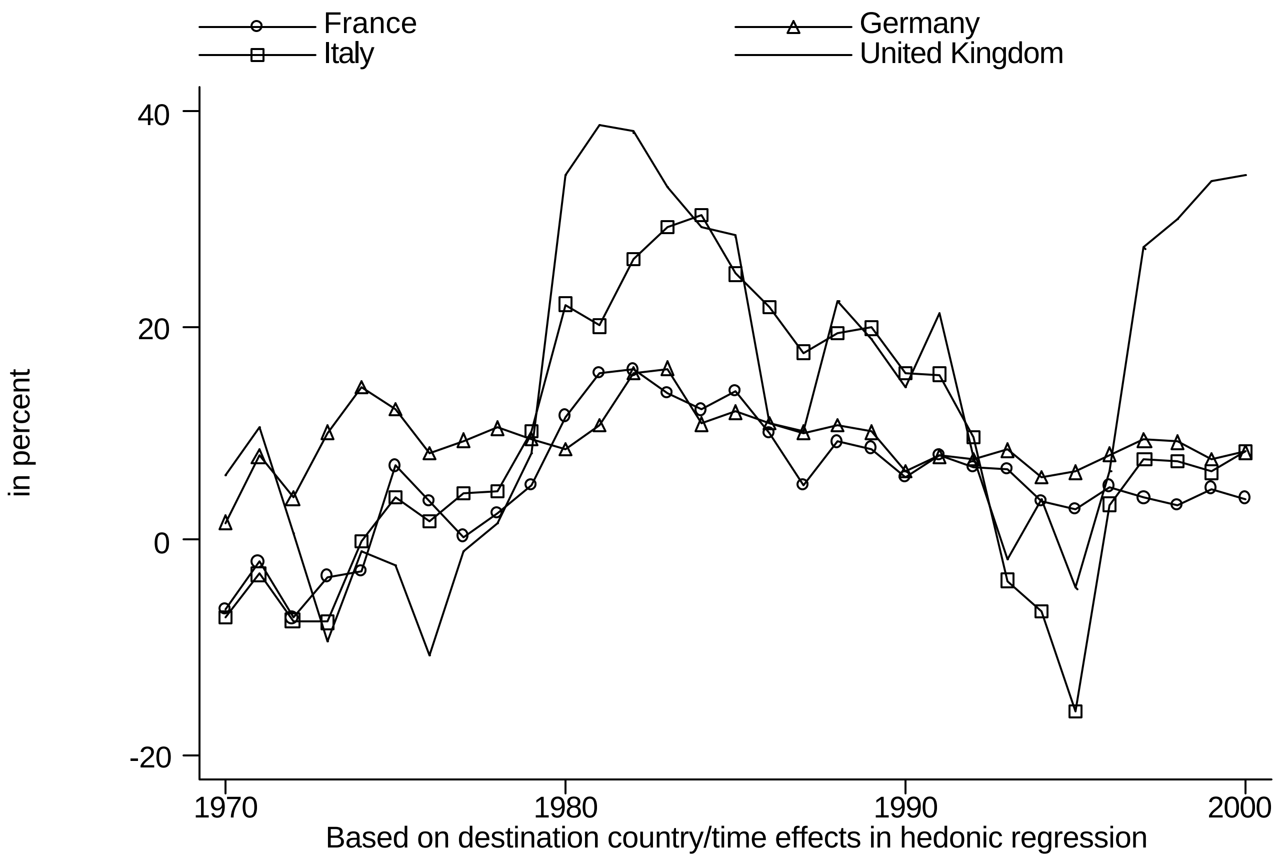

Figure 1: Evolution of car price differentials, relative to Belgium

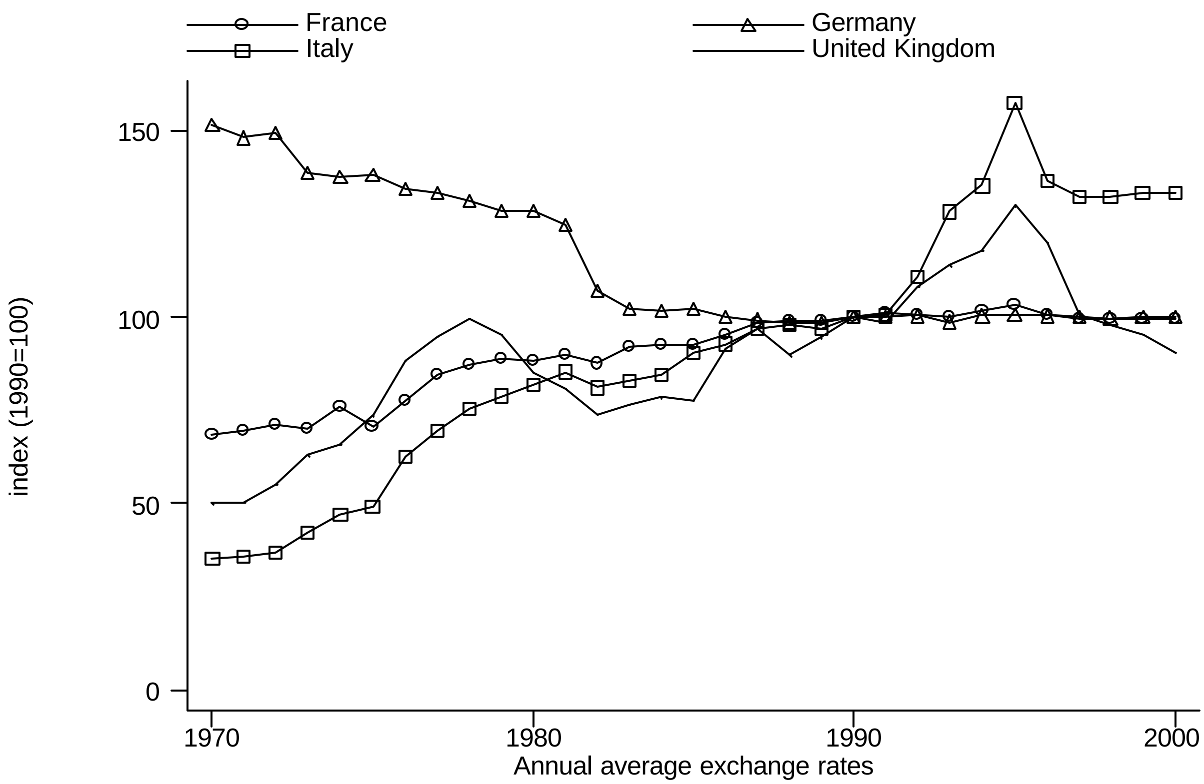

Figure 2: Evolution of exchange rates, relative to Belgium

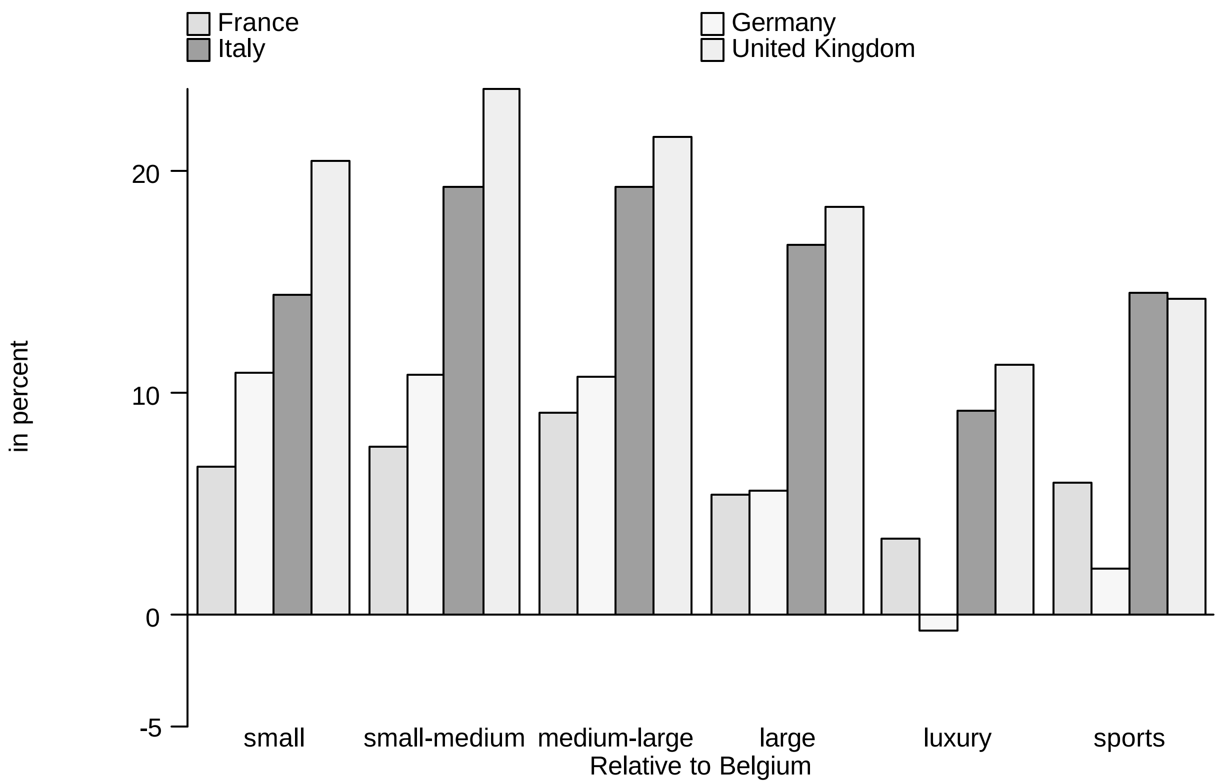

Figure 3: Long term average price differentials by segment, relative to Belgium