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Research in Applied Economics

Price Level Convergence under EMU: Empirical Evidence from 1998-2003

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Abstract

This paper examines what effect the introduction of the single currency has had on price dispersion in Europe. The difference-in-difference methodology is applied to price data from two independent datasets spanning the period 1998-2003. The results of the study are consistent with the European Commission's claim that the single currency has caused price convergence in Europe, however, they are statistically insignificant. By including data post-2001, the paper also assesses the impact that the introduction of euro-notes and coins have had on convergence. For some lower priced goods, the rate of convergence increased following 2001, further implying that different national currencies were a barrier to price convergence.

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1. Introduction

In 1999, the exchange rates of eleven countries were irrevocably fixed to the euro - marking the final stage in the creation of European Monetary Union (EMU) and a further step towards economic integration in Europe. Central to the formation of EMU was the principle that increased price transparency would enhance competition and thus lead to price convergence among member states. Five years on, policymakers continue to be occupied with the issue of price convergence, yet despite the apparent overlaps between economic theory and price dispersion, there remain relatively few empirical studies indicating whether or not the single currency has brought about price convergence in Europe.

One of the main reasons for the gap in the empirical literature is due to data limitations – there are only a few datasets that offer disaggregated prices for a number of eurozone countries both before and after 1999. Several studies offer evidence using aggregate consumer price indices (Sosvilla-Rivero & Gill-Pareja 2002), however, these conceal price convergence at the micro level. For those studies that do make use of the limited disaggregated data (Lutz 2003 and Rogers 2001), they do not provide evidence beyond 2001 and thus neglect the potential impact of the introduction of euro notes and coins in 2002.

The purpose of this study is therefore to provide a current perspective on whether the single currency has reduced price dispersion in the eurozone. The empirical analysis is based on two datasets of final goods prices. The primary data-source is unique in the academic literature and is taken from the Dresdner Kleinwort Wasserstein (DrKW) annual European pricing survey, while the secondary source is the more widely used European Commission report on car prices. Both datasets span the 1998-2003 period and thus provide evidence of price dispersion after the introduction of euro notes and coins. In its use of multiple data-sources and the difference-in-differences methodology, this paper is most similar to the work of Lutz (2003).

The structure of the paper is as follows. The next section provides an overview of the issues relating to the euro and market integration, followed by a discussion of the literature on price convergence. Section three describes the data used. Section four outlines the empirical strategy of the paper, and section five presents results. Section six concludes the paper.

2. Issues, Theory and Empirical Applications

A. Issues and Theory

The failure of prices of similar goods to equalise between countries is a sign that markets are not completely integrated. A significant barrier to market integration is the variability of exchange rates since these impose direct costs on firms both in terms of the uncertainty of future exchange rates as well as the transaction costs of currency exchange. The introduction of a single currency reduces these barriers to international trade whilst also improving price transparency. This reduces the scope for price discrimination across national markets by making arbitrage significantly easier.

The European Commission's 1990 report, '*One Market, One Money*', highlights all these issues as potential sources of greater competition and hence reasons to support price convergence in a single currency area. However, the recent literature also provides some other potential sources of price convergence. For example, Devereux et al. (2003) argue that as the euro becomes a vehicle currency for international trade, firms will tend to set prices for the entire euro area. They point to companies such as Ikea, which set the same prices for all fifty US states as evidence to support their argument. The theory behind this combined pricing strategy is that the administrative costs of deriving separate pricing strategies for each US state are too great to warrant price discrimination. In terms of the eurozone, there is already some evidence that companies are setting universal prices for the region. Lutz (2003) notes that *The Economist* has changed its pricing strategy so that purchasers in all euro-members (with the exception of Greece), face the same cover price.

The literature on border effects provides an alternative explanation for price convergence. In their analysis of border effects between the United States and Canada, Engel and Rogers (1996) highlight the importance of sticky nominal prices in explaining price dispersion across borders. They argue that firms that adopt stable price-setting policies[1] in each market may cause high price dispersion between markets, due to nominal exchange rate fluctuations. Coleman and Daglish (1998) provide further evidence to support this theory. Their analysis of border-effects between New Zealand and Australia also concludes that exchange rate volatility is a primary cause of price dispersion between the two nations. Hence, in terms of the single currency area, price dispersion should fall following the introduction of the euro as exchange rates are fixed.

An additional reason for price convergence can be found in the economic growth literature relating to the Balassa-Samuelson (1964) hypothesis. This theory, explains why the price of non-tradable goods as well as tradable goods should converge in a monetary union. The intuition behind this theory relates to productivity level catch-up. Upon entering a monetary union there is likely to be high demand for cheap products from low price economies. If we assume that these low-price economies are also poorer economies[2], then the rise in demand will generate rapid productivity growth in the tradable sector. This will raise both output and wages in the tradable sector. If we further assume that labour is mobile between sectors, then wages in the non-tradable sector will also rise in order to maintain employment. Rising wages imply higher costs to non-tradable producers and hence prices will rise to compensate. Since labour productivity is rising faster in the poorer low-price economies than in the wealthy high-price economies, this will result in price level convergence. This theory suggests another consequence of a single currency area, which is that low-price economies face potentially high levels of inflation.

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[1] Firms may adopt a stable pricing strategy for a number of reasons. Some common examples are if menu costs are particularly high, or if a firm is in a oligopolistic market structure where price changes may be seen as aggressive behaviour and could result in a price war. Another argument is that firms do not wish to change prices too often because it dissuades consumers from purchasing their product due to the uncertainty over price.

[2] Rogers (2001) provides empirical evidence to support this assumption by showing a strong positive correlation between price level and GDP per capita.

Yet, despite the wide array of arguments supporting the European Commission's claim that a common currency reduces price convergence, it is not a foregone conclusion. Market structure and the behaviour of firms also need to be considered. For example, Lutz (2003) notes that if firms respond to a lowering of arbitrage costs by introducing greater arbitrage barriers (such as bundling with non-tradable goods), then the degree of market segmentation increases, which could lead to greater price differences. Furthermore, many firms set prices based on local market conditions rather than across regions as a whole. Hence, differing consumer preferences across countries and across brands give rise to varied price elasticities of demand, which imply the use of differentiated pricing policies. This is in direct contrast to the argument presented by Devereux et al. (2003) mentioned above. Nevertheless there is evidence presented by Bresson and Mathieu (1992) [highlighted in Gaulier and Haller (2000)] that this pattern is empirically relevant to the French car market.

Market concentration is another key issue that can limit the pace of price convergence. In highly concentrated markets, where production is dominated by a few large firms, reductions in arbitrage costs do not act as a sufficient spur to convergence. Indeed, Anderson and Ginsburg (1999) provide evidence to suggest that it is beneficial for a monopolist to continue to price discriminate even if arbitrage takes place. Moreover, institutional and macroeconomic policies can also hinder price convergence. A good example here is non-tariff barriers, which include varying national standards of goods, as well as import quotas. These protectionist measures limit international competition and thus slow the rate of price convergence, although this should not apply within Europe's Single Market.

B. Empirical Applications

The literature contains a number of different approaches that have been used to estimate price convergence in Europe. The first methodology I wish to focus on is that used by Sosvilla-Rivero & Gill-Pareja (2002) in their study of European price convergence between 1975 and 1995. While this study does not cover the euro period at all, the methods used and results generated provide an important historical perspective on price convergence within the European Union. Sosvilla et al. make use of monthly consumer price index data for twelve EU countries. However, instead of using the general price index, they take the 25 component parts[3] of the CPI, thus gaining different measures of price dispersion for different categories of goods. They then regress the price difference between each country and Germany (taking it to be the benchmark country due to its central role in the European Monetary System) using a panel augmented Dickey Fuller regression.

The study reports a significant convergence of prices among tradable goods but little or no effect for non-tradable goods. While these results correspond to those of other studies, (Levin and Lin, 1992), the type of data and methods of analysis used can be critically evaluated to cast doubt on the robustness of the study's results. Two major criticisms can be cited here. Firstly, the use of the component parts of the CPI – although justified by Sosvilla et al. as a means of differentiating between tradable and non-

[3] These consist of 'categories' of consumer goods such as clothing, vehicles, furniture, or tobacco rather than individual goods themselves.

tradable goods – is not strictly valid in terms of a measure of price convergence. This is because each category contains different goods for each of the twelve countries thus resulting in little continuity in comparisons. Other studies have improved upon this model by using disaggregated price level data for individual goods but even these often use goods that are vaguely defined and can vary across countries. The second criticism of the study is its use of Germany as a benchmark country on which to base comparisons. While it is true that Germany took a central role in the European Monetary System, it is not necessarily true that prices will converge towards German levels. Therefore, a more appropriate comparison measure might be to use a weighted average of price levels for all 12 countries.

One study that provides an original way around the continuity problem is that by Gaulier and Haller (2000). Their study determines whether the European car market has experienced price convergence between 1993 and 1999. However, due to incomplete price data for car models spanning the entire sample period[4], they construct a representative price measure for each country, based on car characteristics (these include both technical features such as air-conditioning, as well as market information, such as the share of the market accounted for by each model). This quasi-hedonic approach allows them to use the entire dataset, thus improving the robustness of their conclusions. However, it is important to realise that this methodology is only applicable to certain types of goods for which information on product characteristics is widely available. In terms of more general studies, which attempt to find price convergence across a wide range of goods, this approach would not be feasible due to insufficient data.

In their analysis Gaulier et al. distinguish between two types of convergence, β convergence – where countries with relatively low prices at the beginning of the period experience relatively higher price growth – and σ convergence (the reduction of price dispersion across markets). The study finds evidence of β convergence over the period, thus supporting the Balassa-Samuelson hypothesis, but little evidence of σ convergence. Here the authors point to exchange rate fluctuations as the main hindrance to σ convergence and suggest that the single currency should produce price convergence among member countries.

An additional study by Rogers (2001) provides yet another framework to analyse price convergence. Rogers makes use of the city price dataset supplied by the Economist Intelligence Unit. This is perhaps the most comprehensive data source available for studying price convergence as it offers prices for 168 goods in 28 countries across the world. In addition, Rogers goes to considerable lengths to ensure the continuity of his comparisons by omitting any goods that have missing observations, thus adding considerable weight to his conclusions. On the basis of the EIU data set, Rogers segments each good into one of 12 categories and then weights each category according to country-specific consumption levels. The resulting aggregate index of consumer prices for each country is then compared to the mean index for all eurozone countries. Yet, despite having a significantly more robust methodology than that

[4] Gaulier and Haller (2002) make use of the European Commission's car price data – the same dataset used in this study. However, due to the longer sample period of their study, they note that prices for any given vehicle are rarely available for the entire period – this is because models disappear from producer's best sales lists and so do not appear in the EC report.

of Sosvilla et al., Rogers's study produces remarkably similar results – finding evidence to support price convergence in tradable goods over the period 1990-1999. The major criticism of this study is its failure to include a longer time period after the introduction of the euro and in particular its neglect of the period after the introduction of euro notes and coins. A pertinent study would therefore be to update Rogers' work by considering what has occurred since its publication; however, the availability of the EIU dataset makes this difficult. Other less substantiated criticisms of Rogers's paper highlight the vague definition of some of the goods. In particular, goods such as 'compact car' can vary significantly across countries, due to the characteristics highlighted in Gaulier and Haller's paper (2000). A slight improvement on Rogers's study would therefore be to use more specific definitions of goods, which are clearly comparable across countries.

The final and most recent study that I wish to highlight is that by Lutz (2003), who uses four separate data-sources to examine price convergence as recently as 2001. A significant difference between Lutz's study and those of the previous literature is its application of the difference-in-differences methodology to the issue of price convergence. For each dataset, Lutz compares the effect of the introduction of the euro (the treatment) in EMU countries to an observed counter-factual – the price dispersion of non-EMU countries. This methodology requires that there are no other factors during the treatment period that affect the treatment and control groups differently – a particularly strong assumption that seems unlikely in practice. Yet, while this may bias Lutz's results, it is an acceptable flaw in the study, since a perfect counter-factual is rarely observed.

Unlike the previous studies mentioned above, Lutz finds little evidence of price convergence following the introduction of the euro. The fact that his study contains three years of euro data (1999-2001) could support the argument that the euro has not brought about price convergence. However, there are a number of criticisms of Lutz's study that reduce the severity of his conclusions. A major criticism of the study relates to the data used – particularly to the UBS price data set. Lutz relies on UBS data to provide a range of consumer goods in his study[5]; however, the dataset only includes 13 goods. In addition, these goods are vaguely specified with example goods such as '*men's clothing*' or '*automobile*' warranting considerable concern over the comparability of goods between countries and over time.

Despite the questionable results of Lutz's study, the methodology he uses is the most applicable to my study, given the data I have available. While a more comprehensive analysis with a larger basket of goods would lend itself to Rogers's framework - the variety of different data sources, and limited number of goods that are included in my analysis, mean that the difference-in-differences methodology is most appropriate. Two common criticisms of the literature are its failure to use specifically defined goods and the lack of evidence post 2001. This study attempts to address both these issues.

[5] Lutz (2003) makes use of four data sets: a) the cover price of the Economist; b) the price of a Big Mac; c) The European Commission's car price data; d) the price of a range of goods and services from a publication by UBS. However, only, the UBS dataset provides price data for more than one type of good. Hence, the UBS dataset is most important in determining overall price convergence – unfortunately it is also the least reliable data source.

3. Data Description and Preliminary Analysis

A. Data Description

This paper considers the period from April 1998 to May 2003. This interval was chosen with two criteria in mind i) the period incorporates the introduction of euro notes and coins and ii) a five-year period during which the euro was in use is consistent with the purchasing-power parity literature regarding half-life estimates of price convergence.[6]

The data for analysis comes from two sources. Car price data has been extracted from the report *Car Prices in the European Union* – a bi-annual survey released by the European Commission (EC). Consumer price data is taken from the DrKW annual Euro-price survey. The DrKW data is unique to this study, while the EC's data on car prices has been used extensively in the literature [notably in Gaulier and Haller (2000), Goldberg and Verboven (2001) and Lutz (2003)]. Table 1 describes the basic characteristics of the datasets.

Ideally, a dataset would contain pre-tax price data for a wide range of specifically defined goods across all twelve EMU countries and for a number of other OECD countries (including the three non-EMU countries that are members of the European Union). Unfortunately, no such dataset exists and concessions have to be made.

The DrKW Euro-price survey falls short of the ideal dataset on a number of grounds. The data fails to fully represent the eurozone since six of the twelve EMU countries are absent from the survey. Crucially, this leads to the omission of low price economies such as Portugal and Greece, which could account for a significant amount of price dispersion within the eurozone. In addition, the survey only provides data for three non-eurozone countries. For balance and consistency of comparisons, at least six countries should make up the non-eurozone group, however, due to data limitations this is not possible. The inclusion of Switzerland improves the diversity of the data by providing an example of an OECD country outside the European Union, however, with the absence of Denmark and two other non-eurozone countries, the counterfactual remains far from ideal.

The dataset also suffers from data collection problems. By collecting final goods prices, data is reported post-tax and thus includes varying VAT rates (0-25%), which overstate the degree of price dispersion. In addition, the survey is conducted in European cities rather than across entire nations. Although understandable from a data collection point of view, the use of city data as a proxy for national data may be an inaccurate generalisation. Data availability also limits the number of goods available for analysis. For continuity, this study omits any goods for which data is unavailable for any year 1998-2003 or for any of the nine countries surveyed. This reduces the number of goods available for analysis from over 200, to just 25 – these are listed in Table 2.

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[6] Consensus estimates of the half-life of a deviation from PPP range between 4 and 5 years [Frankel and Rose (1996), Wei and Parsley (1995)], although faster convergence has been recorded in some years Taylor (2002). Thus with a sample period including five years of single currency data, evidence of price convergence should be relatively clear.

Yet, the DrKW survey also has several appealing features. The dataset spans 1998-2003 and thus includes the period after the introduction of euro notes and coins. In addition, the wide variety of goods in the survey provide an adequate basis on which to consider price convergence at the macroeconomic level. But most importantly, the survey includes specifically defined goods such as *'Jeans: Levi's 501 Blue'* that are comparable across countries and over time. The use of specifically defined and often branded goods, which are generic to many European markets, corrects the continuity problem affecting many price convergence studies.

The EC's car price dataset also meets a number of the ideal requirements. Unlike the DrKW dataset, prices are reported pre-tax. This is particularly important for car prices because sales tax rates vary substantially within the EU - ranging from zero in France or Germany to over 200% for some models in Denmark (Gaulier and Haller, 2000). Another improvement over the DrKW dataset is that prices are obtained directly from manufacturers and thus refer to national prices. In addition, like the DrKW dataset, the EC data tackles the continuity problem affecting many studies by using specifically defined goods (e.g. *Ford Fiesta: 1.4 5 Door, Power Steering, Airbags* ...) that are comparable over time and between countries.

However, besides being focused exclusively on cars, the EC's dataset has a number of other limitations. Prior to 1999 the EC only reported car price figures for 12 of the 15 EU countries, omitting Finland, Greece and Denmark. As this study includes data for 1998, all three countries have to be withdrawn from the analysis; meaning data is only available for 10 of the 12-eurozone countries. Furthermore, the absence of Denmark from the dataset leaves only two non-eurozone countries (Sweden and the UK) upon which to make comparisons. This falls far short of the ideal counterfactual and means that very low levels of price dispersion can be reported if prices converge in just two markets. In addition, fluctuating model sales result in some models falling in and out of manufacturers' best sales list, thus leading to gaps in the data set. For continuity, this study only includes those models for which data is available for every year and across all countries. Only 18 models meet these selection requirements - these are listed in Table 3.

For both datasets, the same measure of price dispersion is used. This is the Coefficient of Variation (CV) and is calculated using the following formula[7]:

Coefficient of Variation = Standard Deviation × (100 / Mean)

$$CV = \frac{\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}{\left(N-1\right)} \times \frac{100}{\bar{x}}$$

In this application, x_i refers to the price in a particular country, while $\bar{x}$ is the average price across all N countries in the sample.

[7] The use of the coefficient of variation (CV) as a price dispersion measure is rare in the literature, with the most popular alternative being the standard deviation of logged prices. In order to compare results between studies, this latter measure would be preferable, however, because the 2000 and 2001 DrKW surveys only report CV values for the eurozone and non-eurozone countries (rather than reporting raw-price data for each of the nine countries) this is not possible.

B. Preliminary Analysis

A preliminary analysis of both datasets provides mixed evidence for price convergence in the eurozone. Figure 1 illustrates the mean CV for both series, averaged across models/goods. Looking first at the DrKW dataset, there appears to be a downward trend in price dispersion among the eurozone countries while in the control group there is little visual evidence of price convergence. In contrast, the EC car data indicates a stable level of price dispersion in the eurozone compared with rapid convergence for the control group, particularly after November 2001. What can explain such mixed results? Here it is important to realise that an average measure of price dispersion conceals a great deal of variation among the surveyed goods. Thus, in order to answer this question we must consider how prices for individual goods have varied over time and across regions.

Table 2 reports CV figures for all goods in the DrKW dataset. Although Figure 1 suggests that prices have converged in the eurozone over the period 1998-2003, the disaggregated evidence is far from conclusive. In fact, the *Over-Time* comparison, given in Table 2, indicates that only 14 of the 25 goods had lower levels of price dispersion in 2003 than in 1998. Indeed, the median CV suggests that eurozone prices have barely converged at all over the period. Yet, in relative terms the eurozone has performed well when compared with the control group, which has experienced price divergence between 1998 and 2003. Nevertheless, the *Cross-Sectional* evidence from Table 2 indicates that the majority of goods in both 1998 and 2003 had lower levels of price dispersion outside the eurozone. Thus, even though there has been a relative decrease in price dispersion among the eurozone countries, when compared to the control group, EMU price dispersion has remained higher in absolute terms.

The DrKW data provides mixed evidence for price convergence within the eurozone. There seem to be a number of goods for which prices have converged for both regions, while there are other goods for which price dispersion has remained high or even increased. In order to see whether similar goods follow similar trends, panels A and B of Figure 2 plot the average CV for three categories of goods: non-tradable goods; durable goods; and non-durable goods. Each of the 25 goods in the sample is allocated to a category according to the authors discretion (the composition of each category is outlined in Table 2). As can be seen from panels A and B, non-tradable goods tend to have much higher levels of price dispersion than tradable goods, and their prices fail to converge over time. This is consistent with a number of empirical studies [Rogers (2001) and Sosvilla et al. (2002)] but contradicts the Balassa-Samuelson (1964) hypothesis. Within the tradable sector, durable goods tend to have the lowest levels of price dispersion, presumably because their higher prices reduce arbitrage costs. However, both durable and non-durable goods appear to be responsible for the falling price dispersion in the eurozone.

Panels C and D of Figure 2 provide a similar breakdown for the car price data set, dividing the dataset based on model size. Each model is allocated to one of three categories (small, medium or large) according to the European Commission’s description of each vehicle - Table 3 outlines which models fall into each category. For the eurozone, price dispersion is greatest for the small low-priced segment and least for the high-priced large segment. This is inline with the theory that arbitrage costs fall as the cost of the good increases. However, a similar pattern is not evident in the non-eurozone countries.

In terms of price convergence within the eurozone, both the large and small sector models show falling price dispersion while the medium-sized models are trending upwards. In the non-eurozone countries, convergence is across the board with all three sectors demonstrating falling price dispersion, particularly after 2001. Yet, even this grouped data masks variations for individual models, and so it is necessary to analyse disaggregated car price data.

For the car price dataset, Figure 1 suggests that there is little evidence of price convergence within the eurozone - Table 3 refutes this claim. Looking first at the *Over-Time* comparison it is apparent from both the mean and median measures of dispersion that prices have converged over the period. In terms of individual models, 14 of the 18 sampled have experienced falling levels of price dispersion between 1998 and 2003. This is a substantially higher proportion than the number of goods that experienced falling price dispersion in the DrKW data and is indicative of more widespread price convergence. Nevertheless, it is important to put these findings in context. The control group also reported 14 car models for which price dispersion fell over the period; however, the absolute fall was significantly greater than for the EMU countries. Consequently, the control group has experienced a faster rate of price convergence when compared with the eurozone. The *Cross-Section* comparisons in Table 3 report that in 1998, 14 of the 18 models had higher levels of price dispersion in the non-eurozone countries than within the eurozone. In 2003, however, this situation had changed substantially with only 8 models being able to make the same claim. As a result, despite having significantly higher levels of price dispersion in 1998, the non-eurozone countries have experienced such rapid price convergence that by 2003, they had lower levels of price dispersion than in the EMU.

This surprising result can be largely explained through the inadequacy of the data used. Figure 3 plots average car prices for the two countries that make up the non-eurozone group. As can be seen from the '*actual price*' lines, Swedish prices have risen over the period while UK prices have fallen thus producing the rapid price convergence highlighted in Figure 1. Also included in Figure 3 are two '*hypothetical price*' lines which indicate how British and Swedish car prices would have fluctuated in euro-terms had their UK pound and Swedish kronor levels remained constant i.e. due entirely to exchange rate fluctuations. Hence, despite the implication that there has been rapid price convergence between Sweden and the UK, actual prices have varied relatively little in national currency terms. This highlights the problem of including just two countries in the non-eurozone group and indicates how Sweden and the UK may not be an accurate representation of the non-eurozone region.

In summary, there is some evidence to support the hypothesis that price convergence has increased in the eurozone, however, this preliminary analysis is far from conclusive and does not distinguish between the periods before and after the introduction of euro notes and coins. I now turn to the difference-in-differences approach to test my hypothesis more rigorously.

4. Empirical Methodology

Let X_j^r be the degree of price dispersion among a group of countries where $j \in$ *(EMU, Non-EMU)* and $r \in$ *(≥1999, 1998)*. *EMU* identifies the treatment group (here the 11 original EMU countries), *Non-EMU* refers to the control group of countries outside the eurozone; *≥1999* represents the treatment period (i.e. 1999 and after), *1998* refers to the pre-treatment period before the introduction of the euro.

We want to estimate the effect that the introduction of the single currency has had on price dispersion in the eurozone – denote this 'treatment effect' Δ. Ideally the treatment effect would be estimated by comparing the outcome for the treatment group after receiving the treatment, $X^{EMU}_{\geq 1999} + \Delta$, with the outcome the same group would have experienced had the treatment not occurred, $X^{EMU}_{\geq 1999}$:

$$S^{*} = \left(X^{EMU}_{\geq 1999} + \Delta \right) - X^{EMU}_{\geq 1999} \tag{1}$$

However, the ideal estimate S^{*} suffers from a missing data problem because we cannot simultaneously observe both outcomes for the same group of countries. With non-experimental data, the missing counterfactual, $X^{EMU}_{\geq 1999}$, needs to be replaced by an observable variable that serves as proxy.

The Difference-in-Differences (DD) approach makes use of data for a control group that does not receive the treatment but experiences some or all of the other influences that affect the treatment group. The DD strategy assumes that over time, the no-treatment average outcome for the treated follows the same path as the no-treatment average outcome for the non-treated: $E(X^{EMU}_{\geq 1999} - X^{EMU}_{1998}) = E(X^{Non-EMU}_{\geq 1999} - X^{Non-EMU}_{1998})$. Algebraically the DD estimate can be written:

$$S^{DD} = \left[\left(X^{EMU}_{\geq 1999} + \Delta \right) - X^{EMU}_{1998} \right] - \left(X^{Non-EMU}_{\geq 1999} - X^{Non-EMU}_{1998} \right) \tag{2}$$

By comparing the before-after change in the outcome of the treated with the before-after change in the outcome of the non-treated, the DD approach i) nets out fundamental differences in the two groups; and ii) eliminates common trends in the outcome variable affecting both groups. However, as Meyer (1995) notes, the DD methodology rests on the assumption that there are no other factors during the treatment period which affect the treatment and control groups differently. This is one of the main threats to the validity of inferences from this approach since changes in other laws/policies or macroeconomic conditions are not likely to always influence both groups in the same way. Meyer (1995) also notes that the inclusion of multiple pre-intervention periods or additional control groups can reduce the severity of this threat, but data limitations prevent such measures from being used in this study.

In its simplest form, the DD approach will be implemented in a linear regression framework for each good/car model as shown in Tables 4A/5A.

$$c^{j}_{rt} = \alpha + \beta D_{\geq 1999} + \gamma D^{\mathrm{EMU}} + \delta D^{\mathrm{EMU}}_{\geq 1999} + \varepsilon^{j}_{rt} \tag{3}$$

In the regression above, the dependent variable is the estimated coefficient of variation of common-currency prices for a given group, and i) $D_{\geq 1999}$, ii) D^{EMU} and iii) $D^{EMU}_{\geq 1999}$ are dummy variables equal to one when i) $r = \geq 1999$, ii) $j = EMU$ and iii) $r = \geq 1999$ and $j = EMU$ simultaneously, zero otherwise. The coefficients in eq. (3) are linked directly to those in eq. (2) as highlighted by Lutz (2003):

$$\alpha \rightarrow X^{Non-Euro}_{1998}$$
$$\alpha + \beta \rightarrow X^{Non-Euro}_{\geq 1999}$$
$$\alpha + \gamma \rightarrow X^{Euro}_{1998}$$
$$\alpha + \beta + \gamma + \delta \rightarrow X^{Euro}_{\geq 1999}$$

The dummy variables capture influences that are not directly measured but are specific to the treatment and control groups and/or to periods before and during the treatment. The coefficient β captures time-variant influences that are likely to affect both groups such as improvements in transport technologies.

If β is large in absolute value, it suggests that period-to-period changes in the dependent variable are not unusual and further evidence on its variance over time might be warranted, however, Tables 4 and 5 indicate that β is typically close to zero and insignificant for the majority of goods under study. The coefficient γ captures time-invariant influences that vary between groups such as the distance between markets or whether countries share a common language. Tables 4 and 5 show that γ is also typically close to zero and insignificant, suggesting the treatment and control groups are relatively similar. However, most important is the coefficient δ, as this corresponds directly to the DD effect in eq. (2).

In addition to the simple OLS regression in eq. (3), it is possible to extend the DD methodology by combining observations across goods/models into a grouped panel. DD results for categories of goods can then be produced by running a pooled-OLS regression using the framework below[8] :

$$c_{irt}^{j} = \alpha_i + \beta D_{\geq 1999} + \gamma D^{\text{EMU}} + \delta D_{\geq 1999}^{\text{EMU}} + \varepsilon_{irt}^{j} \tag{4}$$

The appeal of the DD approach comes from its simplicity as well as its potential to circumvent many of the endogeneity problems that typically arise when making comparisons between heterogeneous groups. However, the DD approach also has its limitations.

Bertrand et al. (2003) suggest that the standard DD approach may suffer from a serial correlation problem which produces standard errors that may understate the standard deviation of the DD estimator. This leads to over-rejection of the null-hypothesis that the treatment has no effect. One method of overcoming the serial correlation problem, which is particularly applicable to this study, involves including dummy variables for each post-treatment period as shown in equation (5):

$$\begin{aligned} c_{it}^{j} = \alpha_i &+ \beta_1 D_{1999} + \beta_2 D_{2000} + \beta_3 D_{2001} + \beta_4 D_{2002} + \beta_5 D_{2003} + \gamma D^{\text{EMU}} \\ &+ \delta_1 D_{1999}^{\text{EMU}} + \delta_2 D_{2000}^{\text{EMU}} + \delta_3 D_{2001}^{\text{EMU}} + \delta_4 D_{2002}^{\text{EMU}} + \delta_5 D_{2003}^{\text{EMU}} + \varepsilon_{it}^{j} \end{aligned} \tag{5}$$

In addition to solving the serial correlation problem, this methodology allows the researcher to compare one period with another and thus determine when the treatment effect was largest – for this study, it also makes it possible to see whether the introduction of euro-notes and coins decreased price dispersion. The drawback of this methodology is the number of variables included in the regression. Due to the low number of observations available for each good/car model, this procedure is not applicable to the individual regression that stem from eq. (3). However, the grouped panel datasets used in eq. (4) provide sufficiently high degrees of freedom to make the analysis useful.

Other criticisms of DD estimation revolve around whether the treatment and control groups accurately represent the true population. In this study, Figure 3 provides evidence to support such concerns, however, these issues can only be resolved at the data collection stage. One other prominent concern has been whether DD estimates ever isolate a specific intervention or causal relationship. Advocates have attempted to improve the rigidity of their DD conclusions by including additional control variables and thus isolate a specific intervention. However, due to the large number of potential variables involved, and the negligible results of Lutz (2003), I leave this as an avenue for future study.

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[8] Note: Equations (3) and (4) are identical except that the dependent variable in (4) also varies with respect to individual goods (denoted *i*). The interpretations of the coefficients are the same as for the simple OLS regression

5. Discussion of Results

The results of the DD estimates of the single currency effect are presented in Tables 4-6. First consider Table 4A, which contains estimates for the 25 goods included in the DrKW dataset. Each individual regression consist of just 12 observations and suffers from low degrees of freedom and potential serial correlation[9]. Nevertheless, a significant majority (18 of the 25 goods) report falling price dispersion after the introduction of the single currency. In addition, the median DD estimate for all 25 goods is notably negative thus providing further evidence to support the European Commission's claim that the single currency has reduced price dispersion within the eurozone. However, if we only consider the two statistically significant results, the evidence for price convergence is far from overwhelming - one (shampoo) is consistent with the EC's claim, while the other (camera film) reports price divergence.

At a more aggregate level, Table 4B provides evidence for different categories of goods within the DrKW dataset. Of the three categories, non-tradable goods have experienced the largest fall in price dispersion followed by non-durable goods. In contrast, durable goods experienced a slight rise in price dispersion following the introduction of the euro. These results can be explained by past fluctuations in the levels of price dispersion. As Figure 2 and a number of empirical studies [Rogers (2001) and Sosvilla et al. (2002)] suggest, non-tradable goods tend to have much higher levels of price dispersion than tradable goods. Similarly, durable goods tend to have the lowest levels of price dispersion because their higher prices encourage early arbitrage. Thus, there is greater potential for price convergence among non-tradable goods since prices have converged less in the past. Interestingly, this result differs from both the preliminary analysis and the findings of the other studies mentioned above. Important here is the introduction of euro-notes and coins.

Table 6A indicates that price convergence increased after 2001 for both non-tradable goods and non-durable goods while it fell for durable goods. This may be because durable goods are more expensive and thus tend to be purchased using non-cash payment methods – therefore the introduction of notes and coins would have little effect on durable good purchases. In contrast, the lower-prices of non-tradable and non-durable goods are more readily associated with cash purchases. Thus, when notes and coins were introduced in 2002, more consumers may have become aware of price differences due simply to the physical act of handing over money. This increase in price transparency raises competition between national markets and could causes prices to converge. However, if purchasing methods can explain the disparity in the data, this implies that consumers are suffering from a form of money illusion.

An alternative explanation that preserves the rational consumer hypothesis, relates to price rounding of low value items. Before the introduction of euro notes and coins, goods are sold in national currencies and are subject to rounding conventions. For example, you might have had the 15 franc or 2 DM cup of coffee before the introduction of euro notes and coins. However, once you change from national currencies to a single currency, everybody rounds, say to two euros. This doesn't mean consumers are

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[9] While the DD estimates are not adjusted for the potential serial correlation problem highlighted by Bertrand et al. (2003) a cursory analysis of the ACF combined with the low number of significant results, suggests that serial correlation is not a problem in this dataset. An identical conclusion can be drawn for the car price data from Table 5.

aware of what, say, a coffee costs in other countries, but nevertheless brings about price convergence and is perhaps a more plausible argument than the money illusion hypothesis. An extension of this line of reasoning relates to the pricing strategies of multinational companies. For low price items in particular, it may be more cost effective to adopt the same pricing strategy in different markets e.g. charge the same for a Big Mac or 1.5 litres of Coke whether you are in Paris, Berlin or Athens.

Table 4B also provides a DD estimate that is pooled across all 25 DrKW goods. Although statistically insignificant, the DD estimate implies that price dispersion has fallen 13.2% in the five years following the introduction of the single currency[10]. According to results of the dynamic regressions presented in Table 6A, the rate of convergence has remained relatively stable between 1999 and 2003. Overall then, the DrKW results appear to provide evidence in favour of the price-equalising effects of the euro, although not at statistically significant levels.

Moving to the car price data, it is immediately obvious from Figure 1 and a comparison of Tables 4 and 5 that car prices have significantly lower levels of price dispersion than the goods in the DrKW dataset. There are two potential explanations for this difference: i) cars have already experienced price convergence because they represent a profitable form of arbitrage due to their high prices; ii) the inclusion of taxes in the DrKW dataset may increase price dispersion. Despite the differences in the datasets, Table 5A indicates that the majority of car models (11 out of 18) experienced price convergence during the treatment period. However, unlike the DrKW data, a comparison of the statistically significant results shows 3 models (Seat Ibiza, Volkswagen Golf and Honda Civic) that indicate price divergence, compared with just 1 (Ford Fiesta) corresponding to the price convergence hypothesis.

In terms of car size, Table 5B indicates that large car models have experienced the greatest fall in price dispersion over the treatment period. In contrast the more popular, medium sized models encountered diverging prices while dispersion among the smaller models remained relatively stable. Since prices increase with car size, these findings are not consistent with the result that arbitrage costs fall as the price of the good increases. However, when assessing the profitability of an arbitrage transaction it is also important to consider the quantity demanded. For cars, it is the medium sized models that are most highly demanded, and thus represent the most profitable arbitrage transactions. Presumably then, it is these medium sized models that drove the earlier price convergence found in Gaulier and Haller's (2000) study of car prices between 1993 and 1999. However, as prices converged within the medium sector, arbitrage agents should increasingly focus on the smaller and larger segments where price dispersion remains relatively high. The results from this study suggest that such a move occurred over the period 1999-2003.

Now consider the broader DD estimate measured across all car models - shown in Table 5B. This result indicates that price dispersion increased by 3.9% for the five years since the introduction of the single currency. While this contradicts the EC's claim of price convergence under the single currency, it carries little weight due to the very low statistical significance of the result – indicated by a t-value that

[10] See Mathematical Appendix for the calculation used to come to this result.

is very close to zero. However, the dynamic analysis in Table 6B also casts doubt over the price convergence hypothesis. The results show that prices tended to converge between 1999 and 2001 but then diverged following the introduction of euro-notes and coins in 2002. Since cars are rarely purchased using cash, the introduction of tangible notes and coins should have produced little discernable effect on the rate of price convergence. Yet, the price divergence observed in 2002 and 2003 is surprising. Once more, the reliability of data for the control group can be used to explain such results. As has already been indicated in Figure 3, much of the rapid price convergence within the non-eurozone group can be accounted for by exchange rate movements. Nevertheless, after 2001, price convergence in the eurozone group is not nearly as fast as the control group and so relative price dispersion increased.

In summary, the car price data provides mixed evidence of price convergence within the eurozone. If we consider both datasets together, the majority of goods (29 out of 43) produced negative DD estimates – indicative of price convergence. In contrast if we consider only the statistically significant results the inference swings towards price divergence with 4 out of 6 reporting positive DD estimates.

6. Conclusion

The results in this papers suggest that the single currency has led to a widespread narrowing of price differences across a range of goods, albeit at statistically insignificant levels. This suggests that the use of different currencies was a barrier to further economic integration in the European Union, thus supporting the European Commission's claim. In addition, the results indicate that for some lower priced goods, the introduction of euro-notes and coins did act as a further spur to price convergence, suggesting consumers may not be perfectly rational but instead suffer from a form of money illusion.

The results of this paper are consistent with the conclusions of the majority of other studies regarding price dispersion in common currency areas, yet they differ to those of Lutz (2003) whose work this study most closely resembles. Differences in data can be used to explain at least some of this contrast. One could argue that the inclusion of a wider range of goods make the results of this study more indicative of general macroeconomic price trends. In addition, the use of five years of post-treatment data as opposed to just three, make this study more likely to pickup on price convergence patterns than Lutz's work. However, it is possible that the data and empirical strategy used in this paper are unrepresentative of true conditions. Therefore it is important to assess the validity of results.

The first criticism of this study relates to the basis on which its conclusions have been drawn. Unlike Lutz (2003), this study bases its conclusions on the sign (±) of all DD estimates, rather than focusing on just the statistically significant results. This was justified on the grounds that each regression had very low numbers of observations and thus were unlikely to produce statistically significant results. However, the disadvantage of this method is that it produces less reliable conclusions. Indeed, if this study followed the lead of Lutz and focused on just significant results, then its conclusion would be one of price divergence rather than convergence.

Clearly, the robustness of the study's conclusions are sensitive to the data used, and hence to its reliability. Unfortunately, as section (3) of this study indicates, the data used is far from ideal. Therefore, a simple method of improving the strength of results would be to use a dataset that contains more of the ideal properties described in (3). Here, the Economist Intelligence Unit's dataset represents a considerable improvement. By including a wider range of goods, the EIU's data is likely to be more representative, whilst the inclusion of a greater number of countries make comparisons between multiple control groups possible – thus adding considerable weight to conclusions.

The methodology used in this paper can also be criticised as it fails to address one of the key issues relating to price convergence – inflation. While other studies have shown that inflation among low price economies was responsible for price convergence, the DD methodology can only conclude that price convergence has occurred and provides no evidence to substantiate the Balassa-Samuelson hypothesis. This is a notable downfall of the DD methodology since policymakers remain concerned about the inflation effects of joining the single currency.

Nevertheless, this paper has shown that over the five years since the introduction of the euro, prices have converged quite steadily. However, this pattern is unlikely to continue indefinitely, since even in a perfect monetary union, there will be a limit to price convergence. In the UK for example, large price differences still exist - supermarkets in Newcastle and London charge very different prices. This is partly because consumers do not have perfect information, but even if they did, price dispersion would still exist due to transport costs. One useful source of further study might therefore be to compare price convergence in border areas with those inland. However, until data becomes available to make such comparisons possible, policymakers will continue to discuss the long term impacts of the single currency on price convergence.

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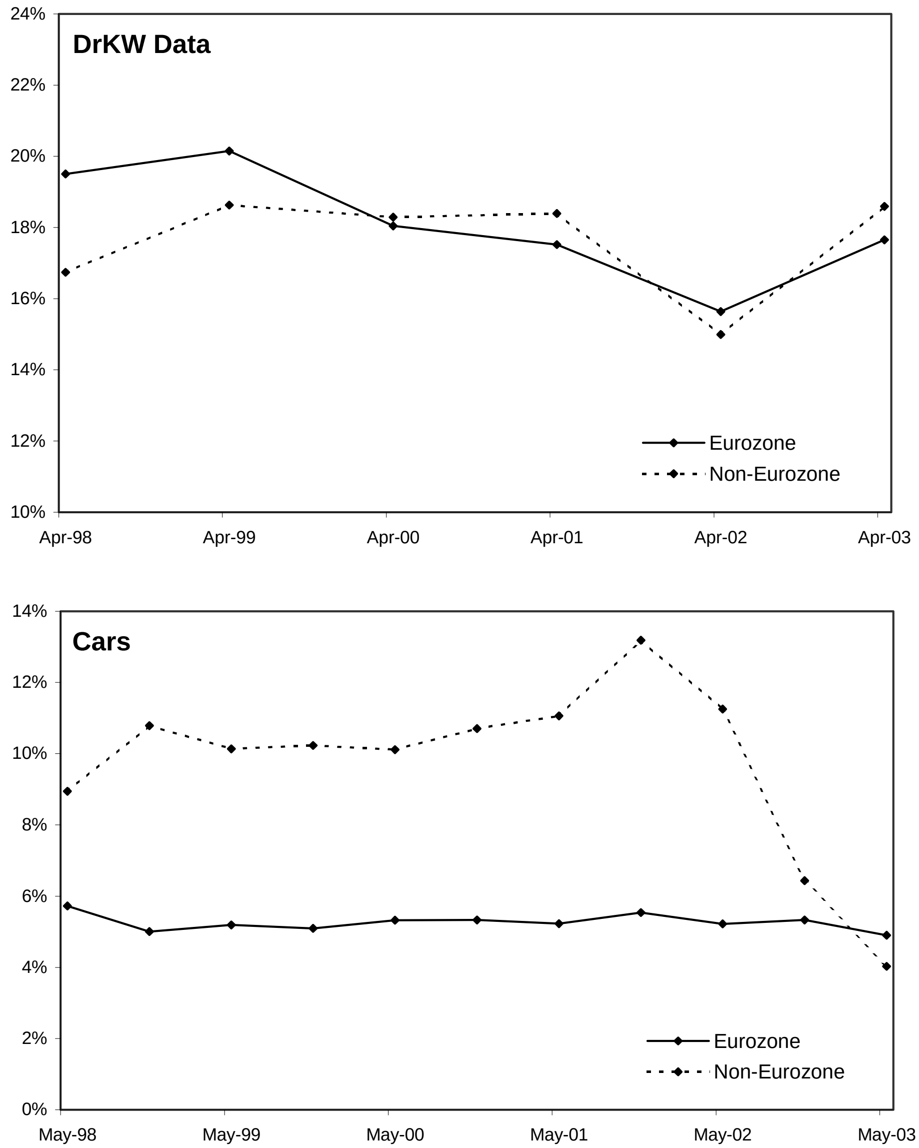
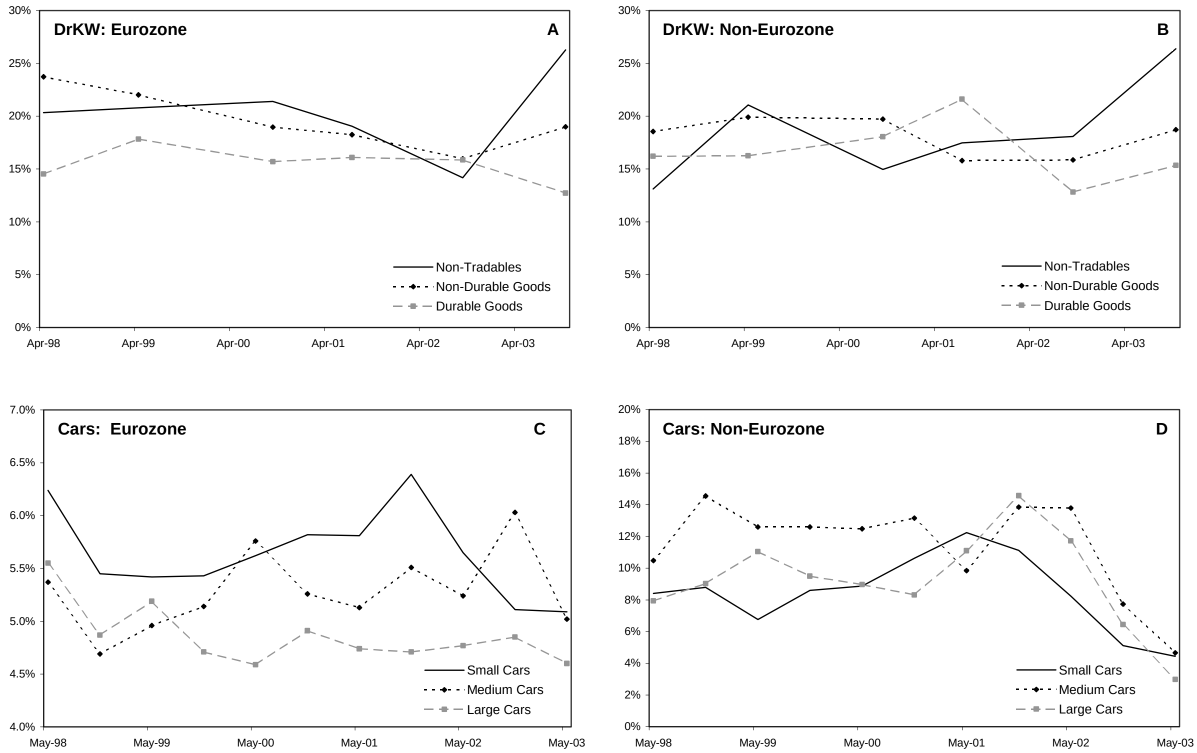
Figure 1: Mean Coefficient of Variation Over Time



Notes:
The above panels represent the coefficient of variation for the DrKW and car price data sets. For the top panel, the data is calculated by averaging the coefficient of variation of 25 consumer goods. For the bottom panel the data is calculated is calculated by averaging across 18 car models.

Figure 2: Mean Coefficient of Variation Over Time – Category Breakdown



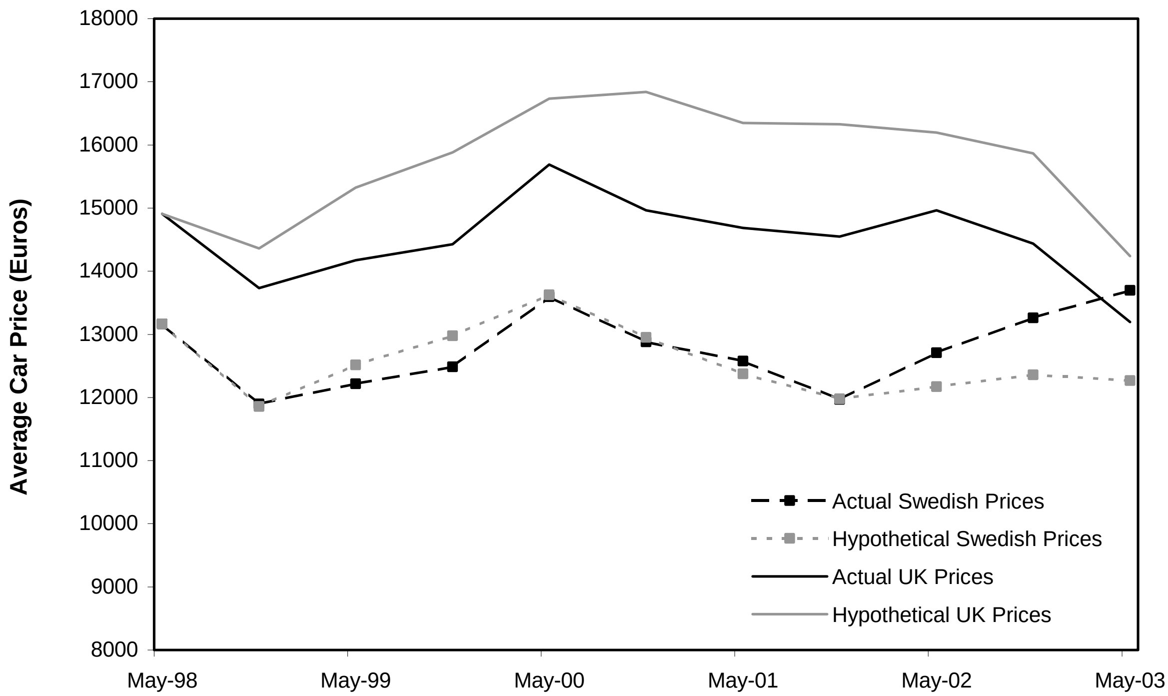
Notes:

[1] Panels A-D divide the car price and DrKW data sets into three separate categories. For each category, the figures reported are the mean coefficient of variation across the selection of goods included in the category.

[2] Panels A and B divide the DrKW dataset into: Non-Tradable goods and services (NT), Non-Durable goods (ND) and Durable goods (D). Each of the 25 goods from the DrKW dataset is allocated to a category according to the authors discretion. Table 2 identifies which goods are included in each category.

[3] Panels C and D separate the 18 models included in the car price data set, according to the size of each vehicle - small (S), medium (M) or large (L). Following the European Commission's guidelines, which separate cars into six categories A-F, this study defines small cars as those in categories A-B, medium sector cars as those in category C, and large sector cars as those in categories D-F. Table 3 identifies which models are included in each category.

Figure 3: The effect of exchange rate movements on average car prices in Sweden and the UK



Notes:
[1] Actual prices are calculated by taking raw data from the European Commission's Report 'Car Prices Within the European Union' and averaging across the 18 models included in this study – see Table 3 for model details.
[2] Hypothetical prices are calculated by taking the average car price for each country in May 1998 and then adjusting by the euro/pound or euro/kronor exchange rate for each period. Exchange rate data is taken from *DataStream* and refers to mid-month levels. The hypothetical price plots indicate how British and Swedish car prices would have fluctuated in euro-terms due to changes in exchange rate levels only.

Table 1: Description of Data Sets

	Cars[1]	DrKW Data[2]
Source	European Commission	DrKW Euro-price survey
Period	1998-2003	1998-2003
Frequency	Bi-annual (1 May; 1 November)	Annual (usually second quarter)
Number of Series	18	25
EMU Countries	Austria, Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain	Belgium (Brussels), France (Paris), Germany (Frankfurt), Italy (Rome), Netherlands (Amsterdam), Spain (Madrid)
Non-EMU Countries	Sweden, United Kingdom	Sweden (Stockholm), Switzerland (Zurich), United Kingdom (London)

Notes:

[1] All EU Manufactures report car price data for best selling models to the European Commission on a bi-annual basis. Although, Finland, Greece and Denmark are now included in the EC's study, they were omitted from the 1998 report and are thus left out of this study. Crucially, car prices are reported pre-tax. This is significant since taxes on cars vary substantially across the European Union, and because pre-tax prices are the necessary measure when considering arbitrage. For the 1998 surveys, prices have been converted into ecus using the exchange rates given in each report.

[2] Data is gathered on an annual basis by a small number of data collectors in nine European cities. This data is reported in the DrKW Euro Price Surveys of April 1998, April 1999, September 2000, July 2001, September 2002 and October 2003 from which this analysis is drawn. Despite the variation in publication dates, all data is collected on an annual basis in the second quarter of each year – prior to summer discounting. All prices are reported in euros and where necessary are converted using mid-month exchange rates from *DataStream*.

Table 2: Coefficient of Variation Comparisons Over Time and Across Regions - DrKW

		Over-Time		*Cross-Section Comparisons*			
	Category of Good[1]	Eurozone 1998[2] (CV)	Eurozone 2003 (CV)	Eurozone 1998 (CV)	Non-Eurozone 1998[3] (CV)	Eurozone 2003 (CV)	Non-Eurozone 2003 (CV)
Café Coffee (Tall Café Latte)	NT	10.81	24.83	10.81	20.43	24.83	22.61
Cinema Entry	NT	33.85	38.60	33.85	3.22	38.60	45.05
McDonald's Big Mac	NT	23.06	5.94	23.06	17.21	5.94	6.06
Milk Local Brand	NT	13.62	35.73	13.62	11.58	35.73	31.80
Bottled Water (Evian 1.5 Litre)	ND	44.42	31.13	44.42	44.84	31.13	21.13
Coca Cola (1.5 Litre)	ND	11.73	18.30	11.73	10.24	18.30	29.76
Instant Coffee (Nescafe Gold Blend 200g)	ND	25.80	31.62	25.80	18.48	31.62	29.80
Jam: Bonne Maman Strawberry (370g)	ND	13.69	11.91	13.69	7.46	11.91	15.27
Kellogg’s Cornflakes (500g)	ND	19.09	17.49	19.09	19.37	17.49	14.89
Mars Bars (58g)	ND	36.05	4.65	36.05	27.97	4.65	5.42
Ariel Detergent Powder Normal (1.5Kg)	ND	34.44	23.30	34.44	3.83	23.30	20.72
Camera Film (Kodak 36 Exp Film)	ND	14.82	24.18	14.82	42.45	24.18	15.91
Deodorant (Lynx/Axe)	ND	21.17	9.03	21.17	17.46	9.03	16.80
Nappies: Pampers Newborn (28 Pack)	ND	17.50	26.83	17.50	8.41	26.83	22.20
Shampoo (3 Brands)	ND	22.36	10.45	22.36	3.45	10.45	14.00
Jean's (Levi 501 Blue)	D	12.71	17.37	12.71	8.88	17.37	14.81
Timberland Boots (Yellow with brown top)	D	12.95	9.67	12.95	11.68	9.67	8.26
Trousers: Plain Work Style	D	18.72	12.34	18.72	63.32	12.34	14.68
T-Shirt Plain White	D	6.45	12.62	6.45	7.22	12.62	21.55
Books (Paperback Top 10)	D	27.20	23.97	27.20	2.57	23.97	46.65
CD's (Sample from top 10)	D	9.75	12.30	9.75	11.84	12.30	9.98
Iron (Rowenta PPP2)	D	11.30	2.75	11.30	4.34	2.75	7.60
Shavers (Braun Flex & Philishave Coolskin)	D	19.87	8.65	19.87	19.17	8.65	7.45
Video Games (Sample of 4 games)	D	9.50	4.86	9.50	13.38	4.86	4.52
Videos (Sample of films Top-Ten)	D	16.80	22.68	16.80	19.70	22.68	17.98
Mean		19.51	17.65	19.51	16.74	17.65	18.60
Median		17.50	17.37	17.50	11.84	17.37	15.91

Notes:

[1] Each good is allocated to a category according to the authors discretion. The three categories are Non-Tradable goods and services (NT), Non-Durable goods (ND) and Durable goods (D).

[2] Eurozone coefficient of variation figures are calculated by taking the standard deviation of prices across six countries (Belgium, France, Germany, Italy, Netherlands and Spain) and dividing by the average price over all six countries.

[3] Non-eurozone figures are calculated by taking the standard deviation of prices across three countries (Sweden, Switzerland and the UK) and dividing by the average price for those countries.

Table 3: Coefficient of Variation Comparisons Over Time and Across Regions - Cars

		Over-Time		*Cross-Section Comparisons*			
	Category of Good[1]	Eurozone 1998[2] (CV)	Eurozone 2003 (CV)	Eurozone 1998 (CV)	Non-Eurozone 1998[3] (CV)	Eurozone 2003 (CV)	Non-Eurozone 2003 (CV)
Ford Fiesta[4]	S	10.62	5.61	10.62	7.09	5.61	1.62
Opel Corsa	S	5.53	3.31	5.53	2.51	3.31	3.24
Renault Clio	S	5.19	4.29	5.19	9.75	4.29	12.62
Nissan Micra	S	5.35	5.08	5.35	6.11	5.08	0.17
Fiat Punto	S	5.12	7.00	5.12	10.02	7.00	1.22
Seat Ibiza	S	5.62	5.23	5.62	14.98	5.23	7.74
Ford Focus	M	7.82	7.00	7.82	2.04	7.00	1.87
Opel Astra	M	3.15	4.62	3.15	8.55	4.62	6.30
Peugeot 306/307	M	5.74	4.43	5.74	15.43	4.43	4.59
Renault Megane	M	5.50	4.27	5.50	0.53	4.27	6.43
Volkswagen Golf	M	3.50	4.76	3.50	16.37	4.76	5.83
Honda Civic	M	6.53	5.06	6.53	19.97	5.06	2.93
Audi A4	L	3.93	3.54	3.93	6.41	3.54	2.12
BMW 318i	L	3.61	3.38	3.61	7.89	3.38	2.88
Ford Mondeo	L	9.08	6.97	9.08	9.57	6.97	0.65
Renault Laguna	L	5.31	7.46	5.31	11.74	7.46	0.30
Opel Vectra	L	5.84	4.37	5.84	7.99	4.37	4.89
Mercedes C180	L	2.25	1.91	2.25	4.07	1.91	7.10
Mean		5.54	4.90	5.54	8.95	4.90	4.03
Median		5.43	4.69	5.43	8.27	4.69	3.09

Notes:

[1] Each good is allocated to a category according to the European Commission's description of each vehicle. The three categories are Small-sector cars (S), Medium-sector cars (M) and Large-sector cars (L). All figures relate to May of each year, as published in the European Commission's study of car prices in the European Union.

[2] Eurozone coefficient of variation figures are calculated by taking the standard deviation of prices across ten countries (Austria, Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain) and dividing by the average price over all ten countries.

[3] Non-eurozone figures are calculated by taking the standard deviation of prices across just two countries (Sweden and the UK) and dividing by the average price for those countries. This means that very low levels of price dispersion can be reported, if manufacturers haves set similar prices just for just the UK and Swedish markets and therefore may not be indicative of the non-eurozone region as a whole . Unfortunately, this cannot be avoided due to the lack of data for other non-eurozone countries. In terms of the above data, this may account for the low CV figures reported for the following models: Nissan Micra, Renault Megane, Ford Mondeo and Renault Laguna.

[4] Each car model is specifically defined to make comparisons over time and across countries robust. For example the Ford Fiesta in this study relates to the 1.4 5Dr version, with power steering, airbags and two years warranty as standard.

Table 4: Difference-in-Differences Estimates - DrKW Data

A. Individual Regressions

n = 12

$$c_{rt}^{j} = \alpha + \beta D_{\geq 1999} + \gamma D^{\text{EMU}} + \delta D_{\geq 1999}^{\text{EMU}} + \varepsilon_{rt}^{j}$$

		α		β		γ		δ	
Café Coffee (Tall Café Latte)	NT	0.204*	(2.43)	-0.047	(0.51)	-0.096	(0.81)	0.157	(1.21)
Cinema Entry	NT	0.032	(0.25)	0.209	(1.50)	0.306	(1.70)	-0.292	(1.48)
McDonald's Big Mac	NT	0.172*	(2.16)	-0.008	(0.09)	0.059	(0.52)	-0.107	(0.87)
Milk Local Brand	NT	0.116	(1.40)	0.105	(1.16)	0.020	(0.17)	-0.017	(0.14)
Bottled Water (Evian 1.5 Litre)	ND	0.448*	(4.37)	-0.129	(1.15)	-0.004	(0.03)	0.007	(0.05)
Coca Cola (1.5 Litre)	ND	0.102	(1.53)	0.079	(1.08)	0.015	(0.16)	-0.026	(0.25)
Instant Coffee (Nescafe Gold Blend 200g)	ND	0.185*	(2.54)	0.046	(0.58)	0.072	(0.71)	-0.074	(0.65)
Jam: Bonne Maman Strawberry (370g)	ND	0.075*	(1.79)	0.048	(1.04)	0.062	(1.05)	-0.038	(0.58)
Kellogg’s Cornflakes (500g)	ND	0.194*	(4.52)	-0.043	(0.92)	-0.003	(0.05)	0.007	(0.11)
Mars Bars (58g)	ND	0.280*	(2.41)	-0.115	(0.91)	0.081	(0.49)	-0.077	(0.43)
Ariel Detergent Powder Normal (1.5Kg)	ND	0.038	(0.41)	0.120	(1.18)	0.306*	(2.31)	-0.225	(1.55)
Camera Film (Kodak 36 Exp Film)	ND	0.425*	(4.98)	-0.227*	(2.43)	-0.276*	(2.29)	0.255*	(1.93)
Deodorant (Lynx/Axe)	ND	0.175*	(3.45)	0.006	(0.11)	0.037	(0.52)	-0.052	(0.67)
Nappies: Pampers Newborn (28 Pack)	ND	0.084	(0.80)	0.100	(0.87)	0.091	(0.61)	-0.123	(0.76)
Shampoo (3 Brands)	ND	0.035	(0.86)	0.056	(1.26)	0.189*	(3.32)	-0.135*	(2.16)
Jean's (Levi 501 Blue)	D	0.089*	(1.80)	0.020	(0.37)	0.038	(0.55)	-0.041	(0.53)
Timberland Boots (Yellow with brown top)	D	0.117	(1.38)	0.048	(0.51)	0.013	(0.11)	-0.070	(0.53)
Trousers: Plain Work Style	D	0.633*	(3.66)	-0.339*	(1.79)	-0.446*	(1.82)	0.350	(1.31)
T-Shirt Plain White	D	0.072	(0.43)	0.152	(0.83)	-0.008	(0.03)	-0.012	(0.05)
Books (Paperback Top 10)	D	0.026	(0.24)	0.246*	(2.08)	0.246	(1.61)	-0.228	(1.36)
CD's (Sample from top 10)	D	0.118*	(2.35)	0.026	(0.47)	-0.021	(0.29)	-0.027	(0.34)
Iron (Rowenta PPP2)	D	0.043	(0.32)	0.099	(0.66)	0.070	(0.36)	-0.021	(0.10)
Shavers (Braun Flex & Philishave Coolskin)	D	0.192*	(2.44)	-0.057	(0.67)	0.007	(0.06)	-0.034	(0.28)
Video Games (Sample of 4 games)	D	0.134*	(4.53)	-0.068*	(2.09)	-0.039	(0.93)	0.032	(0.71)
Videos (Sample of films Top-Ten)	D	0.197*	(3.75)	-0.066	(1.15)	-0.029	(0.39)	0.101	(1.25)
Median		0.118		0.026		0.020		-0.034	
Results > 0 (Significant Results > 0)								7	(1)
Results < 0 (Significant Results < 0)								18	(1)

B. Grouped Panel Regressions

$$c_{irt}^{j} = \alpha_i + \beta D_{\geq 1999} + \gamma D^{\text{EMU}} + \delta D_{\geq 1999}^{\text{EMU}} + \varepsilon_{irt}^{j}$$

	n	α		β		γ		δ	
All DrKW Goods	300	0.167*	(5.86)	0.010	(0.41)	0.028	(0.90)	-0.027	(1.01)
Non-Tradable Goods (NT)	48	0.131*	(4.02)	0.065	(1.29)	0.072	(0.99)	-0.065	(0.80)
Non-Durable Goods (ND)	132	0.185*	(4.46)	-0.005	(0.17)	0.052	(1.27)	-0.044	(1.26)
Durable Goods (D)	120	0.162*	(3.09)	0.006	(0.13)	-0.017	(0.33)	0.005	(0.12)

Notes:
[1] Absolute t-values are shown in parentheses. Significant estimates (at the 10% level or lower) are marked with an asterisk (*).
[2] The Difference-in-Differences estimate for each regression is given in the final column δ.
[3] The number of observations included in each regression is denoted ‘n’. For all regressions on individual goods only 12 observations are available, while in the grouped panel regressions, the observations on different goods are pooled together.

Table 5: Difference-in-Differences Estimates - Car Data

A. Individual Regressions

n = 22

$$c_{rt}^{j} = \alpha + \beta D_{\geq 1999} + \gamma D^{\text{EMU}} + \delta D_{\geq 1999}^{\text{EMU}} + \varepsilon_{rt}^{j}$$

		α		β		γ		δ	
Ford Fiesta	S	0.059*	(2.89)	0.030	(1.34)	0.037	(1.28)	-0.063*	(1.97)
Opel Corsa	S	0.022	(0.72)	0.037	(1.08)	0.027	(0.61)	-0.033	(0.69)
Renault Clio	S	0.118*	(8.50)	0.003	(0.22)	-0.068*	(3.43)	0.007	(0.33)
Nissan Micra	S	0.091*	(2.66)	0.010	(0.26)	-0.037	(0.77)	-0.021	(0.40)
Fiat Punto	S	0.071*	(2.44)	0.029	(0.90)	-0.024	(0.57)	-0.015	(0.33)
Seat Ibiza	S	0.155*	(9.12)	-0.118*	(6.27)	-0.100*	(4.18)	0.119*	(4.48)
Ford Focus	M	0.070*	(3.03)	0.035	(1.38)	-0.007	(0.21)	-0.040	(1.10)
Opel Astra	M	0.091*	(5.59)	-0.054	(0.00)	-0.077	(0.05)	0.020	(0.78)
Peugeot 306/307	M	0.159*	(5.45)	0.013	(0.42)	-0.100*	(2.43)	-0.020	(0.44)
Renault Megane	M	0.056	(1.64)	0.058	(1.55)	-0.006	(0.12)	-0.052	(0.97)
Volkswagen Golf	M	0.160*	(7.64)	-0.089*	(3.87)	-0.126*	(4.26)	0.101*	(3.10)
Honda Civic	M	0.216*	(6.69)	-0.095*	(2.67)	-0.157*	(3.44)	0.088*	(1.74)
Audi A4	L	0.060*	(2.86)	0.049*	(2.11)	-0.022	(0.76)	-0.054	(1.65)
BMW 318i	L	0.100*	(5.52)	0.002	(0.08)	-0.059*	(2.29)	-0.008	(0.28)
Ford Mondeo	L	0.112*	(4.15)	-0.025	(0.83)	-0.033	(0.85)	0.017	(0.40)
Renault Laguna	L	0.141*	(4.16)	-0.002	(0.04)	-0.085*	(1.78)	0.008	(0.14)
Opel Vectra	L	0.056*	(3.36)	0.012	(0.64)	-0.001	(0.06)	-0.003	(0.13)
Mercedes C180	L	0.040*	(3.24)	0.019	(1.41)	-0.013	(0.75)	-0.023	(1.22)
Median		0.091		0.011		-0.035		-0.012	
Results > 0 (Significant Results > 0)								7	(3)
Results < 0 (Significant Results < 0)								11	(1)

B. Grouped Panel Regressions

$$c_{irt}^{j} = \alpha_i + \beta D_{\geq 1999} + \gamma D^{\text{EMU}} + \delta D_{\geq 1999}^{\text{EMU}} + \varepsilon_{irt}^{j}$$

	n	α		β		γ		δ	
All Car Models	396	0.099*	(8.42)	-0.002	(0.16)	-0.046*	(3.84)	0.002	(0.13)
Small Cars (S)	132	0.086*	(4.95)	-0.002	(0.07)	-0.028	(1.39)	-0.001	(0.04)
Medium Cars (M)	132	0.125*	(5.36)	-0.013	(0.55)	-0.075*	(3.19)	0.016	(0.67)
Large Cars (L)	132	0.085*	(5.83)	0.009	(1.01)	-0.036*	(3.06)	-0.011	(1.13)

Notes:
[1] Absolute t-values are shown in parentheses. Significant estimates (at the 10% level or lower) are marked with an asterisk (*).
[2] The Difference-in-Differences estimate for each regression is given in the final column δ.
[3] The number of observations included in each regression is denoted 'n'. For all regressions on individual models only 22 observations are available, while in the grouped panel regressions, the observations on different models are pooled together.

Table 6: Dynamic Difference-in-Differences Estimates

A. DrKW Data

$$c_{it}^{j}=\alpha_i+\beta_1 D_{1999}+\beta_2 D_{2000}+\beta_3 D_{2001}+\beta_4 D_{2002}+\beta_5 D_{2003}+\gamma D^{\text{EMU}}+\delta_1 D_{1999}^{\text{EMU}}+\delta_2 D_{2000}^{\text{EMU}}+\delta_3 D_{2001}^{\text{EMU}}+\delta_4 D_{2002}^{\text{EMU}}+\delta_5 D_{2003}^{\text{EMU}}+\varepsilon_{it}^{j}$$

Group	Coefficient	(Year)[1]	All DrKW Goods (n = 300)		Non-Tradable Goods (n = 48)		Non-Durable Goods (n = 132)		Durable Goods (n = 120)	
Non-Eurozone	α_i	1998	0.167*	(5.86)	0.131*	(4.02)	0.185*	(4.46)	0.162*	(3.09)
	β_1	1999	0.019	(1.42)	0.080*	(2.80)	0.014	(0.80)	0.000	(0.02)
	β_2	2000	0.016	(0.48)	0.018	(0.24)	0.012	(0.30)	0.018	(0.30)
	β_3	2001	0.017	(0.48)	0.044	(0.90)	-0.028	(0.70)	0.054	(0.78)
	β_4	2002	-0.017	(0.59)	0.050*	(1.79)	-0.027	(0.61)	-0.034	(0.64)
	β_5	2003	0.019	(0.47)	0.133	(1.33)	0.002	(0.04)	-0.009	(0.13)
Eurozone	γ	1998	0.028	(0.90)	0.072	(0.99)	0.052	(1.27)	-0.017	(0.33)
	δ_1	1999	-0.012	(0.68)	-0.075*	(2.92)	-0.031	(1.64)	0.033	(0.95)
	δ_2	2000	-0.030	(0.75)	-0.008	(0.06)	-0.060	(1.35)	-0.007	(0.10)
	δ_3	2001	-0.036	(1.02)	-0.057	(0.63)	-0.027	(0.52)	-0.038	(0.67)
	δ_4	2002	-0.021	(0.61)	-0.111	(1.54)	-0.051	(1.05)	0.047	(0.86)
	δ_5	2003	-0.037	(0.99)	-0.073	(0.80)	-0.049	(1.00)	-0.009	(0.14)

B. Car Data

$$c_{it}^{j}=\alpha_i+\beta_1 D_{1999}+\beta_2 D_{2000}+\beta_3 D_{2001}+\beta_4 D_{2002}+\beta_5 D_{2003}+\gamma D^{\text{EMU}}+\delta_1 D_{1999}^{\text{EMU}}+\delta_2 D_{2000}^{\text{EMU}}+\delta_3 D_{2001}^{\text{EMU}}+\delta_4 D_{2002}^{\text{EMU}}+\delta_5 D_{2003}^{\text{EMU}}+\varepsilon_{it}^{j}$$

Group	Coefficient	(Year)	All Car Models (n = 396)		Small Models (n = 132)		Medium Models (n = 132)		Large Models (n = 132)	
Non-Eurozone	α_i	1998	0.099*	(8.42)	0.086*	(4.95)	0.125*	(5.36)	0.085*	(5.83)
	β_1	1999	0.003	(0.36)	-0.009	(0.41)	0.001	(0.10)	0.018*	(2.42)
	β_2	2000	0.005	(0.38)	0.001	(0.36)	0.003	(0.13)	0.002	(0.09)
	β_3	2001	0.023	(1.36)	0.031	(0.92)	-0.007	(0.21)	0.044*	(3.22)
	β_4	2002	-0.010	(0.68)	-0.019	(1.12)	-0.018	(0.45)	0.006	(0.56)
	β_5	2003	-0.058*	(4.39)	-0.042*	(2.64)	-0.079*	(3.02)	-0.055*	(2.35)
Eurozone	γ	1998	-0.046*	(3.84)	-0.028	(1.39)	-0.075*	(3.19)	-0.036*	(3.06)
	δ_1	1999	-0.004	(0.46)	0.005	(0.21)	-0.001	(0.06)	-0.018*	(1.79)
	δ_2	2000	-0.005	(0.33)	-0.013	(0.39)	0.002	(0.07)	-0.003	(0.20)
	δ_3	2001	-0.021	(1.24)	-0.028	(0.78)	0.009	(0.31)	-0.046*	(3.09)
	δ_4	2002	0.010	(0.67)	0.015	(0.72)	0.024	(0.61)	-0.007	(0.64)
	δ_5	2003	0.055*	(3.80)	0.034*	(1.75)	0.078*	(3.12)	0.052*	(1.97)

Notes:
[1] Both the year and group that each coefficient refers to, appears adjacent to the coefficient in order to clarify their meaning. The interpretation of each coefficient can also be derived from the equation included in the table.
[2] The Difference-in-Differences estimates for each regression are given by the δ_i coefficients – these highlight the change in price dispersion within the eurozone for a particular year.
[3] The limited number of observations for each good/car model mean that this dynamic analysis cannot be performed on the individual series due to very low degrees of freedom.
[4] Absolute t-values are shown in parentheses. Significant estimates (at the 10% level or lower) are marked with an asterisk (*).

Mathematical Appendix: Percentage Change in Price Dispersion

Construct the missing counterfactual $X^{EMU}_{\geq 1999}$ by assuming the ideal estimate (S^*) equals the DD estimate (S^{DD}).

$$S^* = S^{DD}$$
$$\left(X^{EMU}_{\geq 1999} + \Delta\right) - X^{EMU}_{\geq 1999} = \left[\left(X^{EMU}_{\geq 1999} + \Delta\right) - X^{EMU}_{1998}\right] - \left(X^{Non-EMU}_{\geq 1999} - X^{Non-EMU}_{1998}\right)$$
$$X^{EMU}_{\geq 1999} = X^{EMU}_{1998} + \left(X^{Non-EMU}_{\geq 1999} - X^{Non-EMU}_{1998}\right)$$
$$X^{EMU}_{\geq 1999} = \left(\alpha + \gamma\right) + \left(\alpha + \beta\right) - \left(\alpha\right)$$
$$X^{EMU}_{\geq 1999} = \alpha + \beta + \gamma$$

This represents the level of eurozone price dispersion for the treatment period if the single currency not been introduced. Recall the treatment effect: $S^{DD} = \delta$. Thus, the percentage change in price dispersion caused by the treatment is given by:

$$\%\text{Change in Price Dispersion} = \frac{\left(X^{EMU}_{\geq 1999} + \Delta\right)}{X^{EMU}_{\geq 1999}} - \frac{X^{EMU}_{\geq 1999}}{X^{EMU}_{\geq 1999}} = \frac{\delta}{\alpha + \beta + \gamma}$$

Example: All DrKW Goods

$$c^j_{irt} = \alpha_i + \beta D_{\geq 1999} + \gamma D^{\text{EMU}} + \delta D^{\text{EMU}}_{\geq 1999} + \varepsilon^j_{irt}$$
$$\widehat{c}^j_{irt} = 0.167 + 0.010 D_{\geq 1999} + 0.028 D^{\text{EMU}} - 0.027 D^{\text{EMU}}_{\geq 1999}$$

$$\%\text{Change in Price Dispersion} = \frac{-0.027}{0.167 + 0.010 + 0.028} = -13.17\%$$

Note: This measure rests on the assumption that $S^* = S^{DD}$ which is a potential source of criticism. However, the value of a tangible number with which to make comparisons, makes the calculation worthwhile, and clarifies the implication of the result.