Understanding European Real Exchange Rates*

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Abstract

We study good-by-good deviations from the Law-of-One-Price for over 5,000 goods and services between European Union countries for the years 1975, 1980, 1985 and 1990. We find that between most countries there are roughly as many overpriced goods as there are underpriced goods. Equally-weighted and CPI-weighted averages of good-by-good relative prices generate relatively accurate predictions of most nominal cross-rates, as purchasing power parity (PPP) would suggest. These findings are robust across years, in spite of relatively large movements in nominal exchange rates. Variation around the averages is large but is found to be related to economically meaningful characteristics of goods such as international tradeability, non-tradedness of factors of production and the competitive structure of the markets in which the goods are sold. Using data on product brands, we find that product heterogeneity is at least as important as geography in explaining relative price dispersion. Overall, our data provide strong evidence that international goods markets are segmented, but (i) the evidence relies on absolute deviations from the Law-of-One-Price, not deviations from PPP, (ii) some markets are much more segmented than others, with the distinctions being consistent with economic theory.

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1 Introduction

The Law-of-One-Price states that identical goods which are sold in different countries should have identical prices, once the prices are expressed in common currency units. Purchasing Power Parity (PPP) is the notion that this should hold on average, across goods: similar *baskets* of goods should cost the same once expressed in common units. Knowing the extent to which data support these propositions is important for understanding nominal exchange rate behavior, international industrial organization, the pricing of international financial assets, and a host of other questions in international economics.

Surprisingly, relatively little empirical research has actually tested either of The Law-of-One-Price or PPP. Instead, most previous work has tested their implication: *changes* in international relative prices should equal zero. The main reason has been data limitations. Aside from a handful of counterexamples, most of the data available outside of the national statistical agencies takes the form of index numbers.[1] Data in the form of absolute prices — prices in dollars, pounds, yen and so on — has been hard to come by, particularly for the broad baskets of goods and services required to assess purchasing power. This has been an important impediment to our understanding, in particular our understanding of the well-known rejections of the propositions in their various forms. Do we reject PPP because most international goods markets are highly segmented? Or, are some markets segmented while other markets are integrated, with prices behaving in such a way that the latter dominate the former?[2]

Our paper attempts to fill this void and answer these questions. We use data on retail prices — prices denominated in local currency units — for a broad set of goods and services in all Europe

[1] Exceptions are Robert Cumby (1996) who studies Big Mac hamburgers, Kenneth A. Froot, Michael Kim and Kenneth Rogoff (1995) who study wheat, butter and charcoal, Atish R. Gosh and Holger C. Wolf (1994) who study the Economist Magazine, Jonathan Haskel and Wolf (1998) who study IKEA furniture, and Mattias Lutz (2001) who studies automobiles. Recent work by Collin Crownover, John Pippenger and Douglas G. Steigerwald (1996), David C. Parsley and Shang-Jin Wei (2000) and John H. Rogers (2001) involve more extensive cross-sections.

[2] For example, Engel and Rogers (1999) find that, across U.S. cities, the variability of changes in relative prices is larger for traded goods than for non-traded goods. Is this evidence of segmented markets? Or are markets for traded goods well integrated while prices for non-traded goods just don't move around very much? As Engel and Rogers (1999) note, it is difficult to know without data on absolute price levels. A relatively small amount of (geographic) dispersion in the relative prices of traded goods, for instance, would be supportive of integrated markets for traded goods, in spite of the fact that their relative prices might display higher time series volatility than that of non-traded goods.

Union countries over five-year intervals between 1975 and 1990. The data are quite comprehensive, covering most CPI categories, and are collected with the explicit goal of generating cross-country comparisons of individual goods and services which are as similar as possible.

We begin by considering the cross-sectional distribution (*i.e.*, good-by-good) of deviations from The Law-of-One-Price across bilateral country pairs. Using Belgium as the numeraire, we find, somewhat surprisingly, that although the deviations can be very large, they tend to average to zero. That is, in most countries (relative to Belgium) there tends to be as many overpriced goods as there are underpriced goods. This phenomenon is robust across all four time periods, in spite of relatively large swings in nominal exchange rates. Moreover, when we weight the good-by-good deviations according to CPI expenditure shares — thus constructing the 'real exchange rate' in absolute units — we find that deviations from PPP are not large in most cases. The exceptions almost all involve the relatively poor countries, Spain, Ireland, Greece and Portugal. PPP, therefore, seems to describe intra-European aggregate prices reasonably well, at least during the years 1975, 1980, 1985 and 1990. Our data provide strong evidence of segmented goods markets but, interestingly, the evidence is in terms of absolute price dispersion, not deviations from PPP as has been the case in many previous studies.

The remainder of our paper is dedicated to relating good-by-good, cross-country price dispersion to the economic characteristics of goods. For example, consider two bottles of beer, one served on Las Ramblas, in Barcelona, and one served in the Squirrel Hill Cafe, in Pittsburgh. Each good obviously contains a location-specific component: most people have preferences over Barcelona versus Pittsburgh. Similarly, the production of each good requires non-tradeable inputs such as labor. On the other hand, beer is an internationally tradeable commodity, suggesting, in addition to location specificity, some sort of good-specificity. We try to understand price dispersion in terms of the characteristics which might govern where a particular good lies in this location-good space. We take guidance from a large theoretical literature — including papers by George Alessandria (1999), Caroline Betts and Timothy Kehoe (1999), Bela Balassa (1964), William J. Baumol and William G. Bowen (1966), Paul R. Krugman (1987), Paul A. Samuelson (1964), Wilfred J. Ethier (1979), and Alan C. Stockman and Linda L. Tesar (1995) — which suggests the importance of tradeability, production structure, the industrial organization of the markets in which the goods are sold, and so on.

We find that such theories have much to say about the price dispersion we observe in Europe. Dispersion among non-tradeable goods is roughly 10% higher than that of tradeables (*i.e.*, dispersion of 32% versus 22%). Goods which require lots of non-tradeable inputs to produce exhibit relatively high dispersion. Combining the two, we find that if we consider a non-tradeable good with the maximum share of non-traded inputs, and compare it to a traded good with the minimum share of non-traded inputs, cross-country price dispersion falls from 32.6% for the former to 16.8% for the latter. We also find that price dispersion is higher for services and heavily taxed goods such as alcohol and tobacco, and that identical goods across countries exhibit roughly the same degree of dispersion as do differentiated goods (different brands of similar goods) within a country.

Our work is related to an extensive empirical literature that studies the time-series behavior of nominal and real exchange rates. At the aggregate level, numerous papers have shown that deviations from PPP based upon consumer price indices can be large and persistent with half lives in the neighborhood of three to five years (see Froot and Rogoff (1995) for a survey of this literature). Much of this literature involves currencies vis-a-vis the U.S. dollar. We find that the story is different for intra-European real exchange rates. While bilateral real and nominal exchange rates across the U.S. and individual European countries have been shown to have high positive correlation and comparable variability, intra-European real exchange rates have considerably lower variability than nominal exchange rates and the two are actually negatively correlated. We show that OECD and Penn World Table estimates of real exchange rates tell a similar story.

Another body of papers — including Charles Engel (1993), Engel and Rogers (1996, 1999), Froot, Kim and Rogoff (1995), Alberto Giovannini (1988), Peter Isard (1977), Parsley and Wei (2000), Rogers and Michael Jenkins (1995) and David C. Richardson (1978) — examine less aggregated prices. They show that economically large deviations from PPP are not a mere artifact of examining CPI baskets of questionable comparability. International borders seem to represent something special for the determination of relative prices. The papers by Engel and Engel and Rogers map this into a geographic metric, and argue that international borders are very 'wide.' Their results are based on *time-series variation* in the prices of similar goods within and across countries. Our results are based on *cross-sectional variation.* We show that, for the average good, cross-country dispersion in the deviation from the Law-of-One-Price is 25%. We also show that, if real exchange rates are highly persistent, this measure of cross-sectional variance is consistent with Engel and Rogers' measures of time series variance. We do not have data on intra-European price dispersion. Parsley and Wei (2000), however, find that average absolute dispersion across U.S. and Japanese cities is roughly 15%. Therefore, a rough measure of border width, based on cross-sectional variation, is that price dispersion increases (on average) from 15% to 25%.

The remainder of the paper is organized as follows. We begin in Section 2 by describing the structure and scope of our data. In Section 3 we present some basic descriptive statistics to illustrate the considerable range of Law-of-One-Price deviations across goods and the tendency for these deviations to average to zero across goods. We relate this second property of the data to PPP by weighting our micro-data by consumption expenditure shares. Section 4 contains the main results of the paper. Here we compute a measure of price dispersion across countries for each good in our sample and relate this dispersion measure to features of the good. We also explore the potential for brand differentiation and geographic price discrimination to explain price variance within and across countries using data on brands. Section 5 concludes with remarks about the implications of our findings for the large and growing theoretical literature on the dynamics of international relative prices.

2 The Data

The original source of our price data is a series of publications by Eurostat, the statistical agency of the European Community, each containing the results of an extensive retail price survey conducted in various capital cities of Europe.[3] Table 1 presents basic information about what our cross-sections entail. We have detailed retail prices at five year intervals between 1975 and 1990. In 1975 the survey covers nine European countries, in 1980 Greece, Portugal and Spain are added while in 1985 Austria is added. The number of goods included in the survey also grows over time from 658 items in 1975 to 1,896 items in 1990.

As Table 1 indicates there are a great number of missing observations in the price surveys, 13% are missing in 1975 and the number increases abruptly in 1980 to 36% and remains at about that level. The number of missing observations differs systematically across countries from a low of about 9% to a high of about 55%. Belgium is consistently the country with the fewest missing

[3] Exceptions are the survey data for Germany and the Netherlands in 1980, 1985 and 1990 in which case the prices are averages across cities within each country.

observations while Ireland is consistently the country with the most missing observations.

Since our main focus is on explaining price dispersion across countries we eliminate any good which has an insufficient number of cross-country observations, which we define as 4 in 1975, 5 in 1980, and 6 in 1985 and 1990. The increments to our criteria reflect the fact that the number of countries in the sample increases over time. We also control for gross measurement error by eliminating goods for which the common-currency price differs from the good-specific median by a factor of 5 or more. These filters reduce our sample of goods from a total of 5,449 to 3,545 with the details for individual years provided in Panel B of Table 1. Of these remaining data, the proportion of missing observations never exceeds 25%. For calculations which require a numeraire to be defined, we use Belgium for the simple reason that it has the fewest missing observations. Our survey data also contain a large number of brand-name goods, typically accounting for about one-third of the goods that we utilize.

Table 2 reports a number of individual records from the 1985 survey with the goods chosen to be representative of the various overall categories contained in our dataset. All the surveys have a similar structure involving a Eurostat code, a detailed description of the particular good, the units of measure and columns of price data. The retail prices are cash prices paid by final consumers and therefore will include taxes, such as VAT. The prices are themselves averages of the surveyed prices across different city-wide sales points.[4]

As is evident from the sample of goods reported in this table, the surveys are as comprehensive as those used to construct national consumer price indices. In the sample presented we see food items, clothing, major appliances, automobiles, services, and so on. Although Eurostat reports the prices in local currency units, Table 1 presents prices in Belgian francs to facilitate comparisons. The deviations we see from the Law-of-One-Price are suggestive of what is to come. The rental cost of a television, for instance, varies widely across countries whereas the dispersion in the cost of rice is much smaller.

The descriptions that Eurostat publishes are abbreviated versions of those used by the statistical agency to compile the data. The level of detail in the published version also varies across goods. In particular, goods can be placed into two categories: those indicated as selected brands (s.b. in

[4]The procedure for selecting sales points follows the practice used to construct national consumer price indices. Sales points are selected by the national statistical offices so that the sample is representative of the distribution of prices in the city with more observations collected for goods having greater price dispersion within the city.

Table 2) and those without such a designation. The reason given for the selected brand designation is the need for confidentiality. While we might like to know which automobiles are Mercedes and which are Volvos the record does not provide us with the necessary details. However, the survey is explicitly designed to assure comparability of goods across locations.

One last important issue regarding the price data is the exact timing of the surveys. While we find it convenient to refer to our cross-sections by year, in reality the price data for each cross-section is collected in a sequence of surveys. The nominal exchange rate data with which we convert prices into a common currency takes explicit account of this timing, taking the form of averages of daily data over the relevant time intervals.

Much of our paper attempts to relate international price dispersion to economically meaningful characteristics of goods. Toward this end, we supplement our retail price data with information on trade and production structure. Because these variables are unavailable at the level of the individual good we assign each good to an industry and use the industry-level measure in place of the good-specific measure.

We define tradeability of a good as the ratio of the total trade among the countries in our sample in a particular industry divided by total output of that industry across the same countries.[5] Among traded goods, the trade shares range from a low of 15.1% for printing, publishing and allied industries to a high of 129.5% for professional goods (see Table 3). The average trade share is very substantial, equalling 54.3%.

We also consider the share of non-traded inputs into the production of a good. We define this as the ratio of non–traded inputs to total cost where both numbers are computed from the 1988 input-output tables of the United Kingdom.[6] Table 4 contains the cost share of non-traded intermediate inputs by industry. The values range from a low of 4.6% for tobacco to a high of 31.8% for forestry and fisheries.

Comparing some of the numbers in Table 3 and 4 it is obvious that the distinction between tradeability and trade in 'middle products' is important. As is often asserted, all retail goods involve

[5]We use the actual trade share whenever trade data is available and assign an index of zero otherwise. The industries assigned zero trade shares are: restaurants and hotels, transport, storage and communication, inland transport, maritime transport, communication, financing, insurance, real estate and community, social and personal services.

[6]Non-traded inputs are assumed to include: utilities, construction, distribution, hotels, catering, railways, road transport, sea transport, air transport, transport services, telecommunications, banking, finance, insurance, business services, education, health and other services.

significant amounts of non-traded inputs (the cross-industry average share of non-traded inputs is 14.1%). Less well appreciated is the fact that all non-traded goods involve some traded inputs. From an economic standpoint it is unclear whether a 'non-traded' good with substantial traded inputs will exhibit more or less price dispersion than a 'traded good' with substantial non-traded inputs. Our analysis is explicitly designed to separately identify these two economic effects.

3 Deviations From the Law-of-One-Price

We denote p_{ij} as the local currency price of good i in country j. The numeraire country is denoted n and the nominal exchange rate for country j's currency in units of country n's is e_j. We define $q_{ij} = \log(e_j p_{ij}/p_{in})$, as the law-of-one-price deviation for good i between country j and n. If q_{ij} is positive, good i is more expensive in country j than country n, the numeraire.

Figure 1 summarizes the empirical distribution of deviations from the Law-of-One-Price. The figure contains one chart for each country for which we have four cross sections of data. Each chart reports four kernel estimates of the density of q_{ij}, one estimate for each of the 1975, 1980, 1985 and 1990 cross sections. The numeraire is Belgium. The chart in the lower right corner pools all countries together, thus characterizing the distribution of all prices (across goods and countries) relative to Belgium.

Figure 1 exhibits three striking features. First, most of the densities are centered at zero. That is, there are roughly as many overpriced goods as there are underpriced goods in a given country compared to Belgium. Second, this phenomenon is relatively stable over time. In spite of relatively large movements in nominal exchange rates over the period, the location of the density estimates doesn't move around very much. Finally, the variance of law-of-one-price deviations across goods is large, with the support of many of the densities being on the order of plus or minus 150%.[7]

The first feature – the locations of the densities – suggests that law-of-one-price violations average out in the aggregate. Table 5 reports the estimated means and their standard errors. For most countries and time periods the average law-of-one-price deviation is statistically different from

[7] Luxembourg, which has a fixed exchange rate with Belgium, is an interesting special case. Figure 1 shows that dispersion is substantially smaller for Luxembourg than for the remaining countries. In 1985, for example, roughly 40% of Luxembourg's prices were within 10% of those from Belgium, whereas only 20% (on average) satisfy the same criteria for the other countries. While geographical distance might seem a likely reason, it's important to note that Luxembourg is roughly as close to Brussels as it is to Amsterdam and Paris. This points to the nominal exchange rate regime as an obvious candidate for explaining the cross-country differences.

zero, however the differences are often quite small. In 24 of 32 cases the average is less than 10% in absolute value (we ignore the poor countries in Table 5 for now). If we exclude Denmark — which has a relatively high VAT — this is true for 24 of 28 cases.

The fact that there are roughly as many overpriced as underpriced goods, and that this persists over time, is interesting. It suggests that, over five year periods, changes in nominal exchange rates do not simply shift the distribution of relative prices around. It is also suggestive of purchasing power parity. In the next section we examine the latter more closely.

3.1 Purchasing Power Parity

The right-most columns of Table 5 ask to what extent our data indicate that CPI-type baskets of goods cost the same in different locations. This is accomplished by taking consumption expenditure-weighted averages of the good-by-good real exchange rates depicted in Figure 1.[8] For the most part, we see only minor differences between the expenditure-share weighted and equally weighted PPP measures. The mean absolute deviation between the two is just 4.5% and only four values differ by more than 10% (Portugal in 1980 and 1985, and Greece in 1980 and 1990). The reasons are (i) the two weighting schemes are not as different as one might think (*e.g.*, perishable goods are purchased often but cost little, whereas durable goods are purchased infrequently and cost a lot),[9] and (ii) there is little tendency in our data for large expenditure share goods to be systematically over or under-valued.

CPI weighting, therefore, tells much the same story as equal weighting discussed in the previous section. Denmark is roughly 20% more expensive than Belgium in all years. Purchasing power never deviates by more than 10% across Austria, France, Germany, and Luxembourg while the deviations from PPP in Ireland, Italy, the Netherlands, and the United Kingdom exceed 10% in only a single year. In contrast, price levels in Greece, Portugal and Spain are substantially lower than Belgium, ranging from 14% to 46% lower depending on the country and time period.

Table 5 suggests two candidates for interpreting what we observe. First, the table lists countries

[8] Specifically, if we denote the average expenditure share on good i between countries j and n as w_i, then the relative cost of the aggregate consumption basket (in percent) is $\sum_i w_i(e_j p_{ij}/p_{in}) - 1$. Our analysis is based on $\sum_i w_i q_{ij}$, which is approximately the same (and has the usual statistical benefits). Data on consumption expenditure shares are taken from the International Comparison Project. Further details are given in the data appendix.

[9] For example, the 1990 German price index gives a weight of 2.4% to "meat and fish" and a weight of 2.6% to passenger automobiles.

by income level, from highest to lowest. Consistent with many previous papers — the pioneering work of Irving B. Kravis and Robert E. Lipsey (1983) for instance — the poorer countries clearly tend to have lower price levels. The correlation between price levels and income is roughly -0.80 regardless of the year or measure used. Second, the table documents the year of entry into the European Union, the idea being that the poorer countries entered the European Union later and should be expected to have different relative prices. There are, however, two problems with this explanation. First, if trade barriers were the explanation we would expect convergence in real exchange rates across the original members and late entrants and there is no evidence of this in Table 5. Second, if we compute real exchange rates across traded and non-traded goods the differences are much larger for non-traded goods than for traded goods, consistent with the Balassa-Samuelson hypothesis. Table 6 presents additional evidence related to this last point, breaking down our real exchange rate estimates into traded and non-traded goods. We see that most of the variation across countries is due to variation in non-traded goods prices, not traded goods prices. This pattern is evident for each time period and each country. There is also some evidence of convergence over time for traded goods, particularly from 1975 to 1985. A natural explanation is the elimination of formal tariff barriers across member countries and the quadrupling of intra-EU trade over the period.

3.2 Relationship with Other Evidence

An important issue is the extent to which our results and data are consistent with previous work and alternative datasets. This section addresses this using absolute price data from the OECD and Penn World Tables (PWT) as well as the more commonly-used national CPI index number data. We focus on the properties of the aggregate, CPI-weighted real exchange rates as in Table 5.

Beginning with absolute price data, Figure 2 organizes countries by income level and then plots our real exchange rate estimates (from Table 5) and their confidence intervals alongside analogous estimates from the OECD. In spite of the cross-section of goods and services being quite different (at least conceivably), we see that in many cases the real exchange rates are quite similar. The pairwise, mean absolute deviation is 7% and the correlation is 0.85. The figure also reiterates the main message of Table 5; deviations from PPP are often quite small for high income countries and there is a negative correlation between price levels and national income.

Turning to CPI index-number data, any comparison must be in terms of time-series properties. That is, we must transform our data from absolute units into changes. We focus on the prominent finding of Mussa (1986), who concluded that the correlation between changes in nominal exchange rates and CPI-based real exchange rates is very high, on the order of 0.90. Mussa's data frequency was quarterly. Our Eurostat data is available only at the five-year interval, so direct comparisons are obviously limited. We can, however, ask two questions. First, the alternative sources for absolute prices — the OECD and PWT data — are available annually. We can therefore compare changes in these data to changes in CPI data (implicitly, Mussa's data), and rely on the fact that the Eurostat data seem quite similar to the OECD data (Figure 2). Second, we can simply make comparisons at the five-year frequency.

Table 7 examines annual changes. The table shows correlations between changes in (log) nominal and CPI-based real exchange rates using three different numeraires — the U.S., Belgium and Germany — as well as the average correlation across all possible numeraires. It also shows the implications of PWT and OECD data. By and large, the story is a somewhat muted version of Mussa's. The correlations are all in the range of 0.65 to 0.78. There does not appear to be a strong numeraire effect with the exception of the U.S., which increases the correlation from roughly 0.70 to 0.80.

Table 8 examines five-year changes. The correlations are uniformly lower than their annual counterparts, sometimes by a substantial amount. Most notably, the Eurostat sample generates values which are roughly zero and this is consistent across data-sources. Incorporating the missing time periods (Row 2) increases the correlations, but they are still relatively low compared to the sample which includes the U.S.. At the five-year frequency, then, the U.S. data has a substantial positive effect which is less apparent at the annual frequency. This is a feature of both the CPI data and the absolute-price data, so the difference cannot be easily attributed to non-comparable CPI baskets between the U.S. and Europe.

To summarize, we take two lessons from this section. First, at the five-year frequency, nominal and real exchange rates are less correlated within Europe than between Europe and the U.S.. Second, and more important for this paper, a consistency check on our data is satisfied. The Eurostat data appear quite consistent with alternative data sources in terms of real exchange rate behavior. This is encouraging for the main focus of our paper: dispersion in the relative prices which make up the (aggregate) real exchange rate.

4 Understanding International Price Dispersion

The basic building block of our measure of international price dispersion is the percentage deviation of the price of good i in country j from the cross-country average price of the same good:

$$z_{ij} = \frac{e_j p_{ij}}{\overline{p}_i} - 1, \tag{1}$$

where $\overline{p}_i \equiv \sum_{j=1}^{M_i} e_j p_{ij}/M_i$ and M_i is the number of countries for which we have price observations on good i. This measure of the deviation from the Law-of-One-Price is independent of the numeraire, Belgium, for which $e = 1$. We measure the cross-country price dispersion of good i as,

$$y_i = mad(z_{ij}), \tag{2}$$

where $mad(\cdot)$ is the mean absolute deviation, which is less sensitive to large outliers than the standard deviation. The vector, y, of mean absolute price deviations, good-by-good, is what we seek to explain.

4.1 Descriptive Statistics

Figure 3 summarizes the empirical distributions of our dispersion measure, good-by-good. Each line in the figure is a kernel estimate of the density of y_i for one of the annual cross-sections. Focusing on the 1980, 1985 and 1990 cross sections – for which we have basically the same cross-section of countries – the distributions look very similar, both in location and shape.[10]

The location of these densities tells us something interesting about the overall importance of national borders for price dispersion. Consider the hypothesis that the countries in our sample constitute a 'common market.' If this were literally true we would expect the densities to be located near the origin – how close is difficult to say, but existing estimates of intranational price dispersion provide a valuable benchmark. David Parsley and Shang-Jin Wei (2000) estimate that price dispersion across cities within Japan and the United States equalled 13% and 14.5%, respectively in 1985. The average amount of price dispersion in our European sample in the same year is 24.2%.

One explanation for the higher dispersion of international relative prices compared to that observed within countries is exchange rate variability in the presence of prices that are sticky in

[10] The lower dispersion for 1975 is largely due to the omission of Greece, Portugal and Spain from the cross section.

domestic currency terms, another is higher arbitrage costs internationally compared to intranationally. Because the sticky-price explanation does not rely on heterogeneity in price dispersion across individual goods, we can evaluate its explanatory power as a 'country effect' in accounting for variation in the variables z_{ij} from equation (1). For example, the deutschemark appreciated against the Belgian franc by 25% between 1980 and 1985. If all nominal prices in Germany are fixed, then all of the percentage deviations, z_{iG}, will increase by 25 percent and all of the variation relative to other countries will be attributable, not to good-specific factors, but to the German country factor alone. Table 9 shows that while these country effects are economically important, they explain only between 10 and 20 percent of the variation in our data. Moreover, this number will tend to overstate country effects due to nominal exchange rate movements once we control for the wealth effects discussed in Section 3.

Table 10 reports the conditional mean of price dispersion for various types of goods. When we treat goods as being either traded or non-traded we find price dispersion for non-traded goods is considerably higher, 32.9% compared to only 22.9% for traded goods (using 1985 results). We also see that price dispersion is 5.8% higher for goods that utilize more than the average amount of non-traded inputs, 29.2% versus 23.4%. One unexpected finding is that branded goods exhibit substantially less price dispersion than non-branded goods, 20.1% compared to 26.2%.

While the broad implications of Table 10 will hold up to further scrutiny in the next section, we stress the limitations of drawing conclusions from the conditional means alone. One obvious problem is that the groupings are not mutually exclusive. For example, traded goods also tend to be goods with lower than average non-traded input shares. Are the conditional means for these two categorizations really picking up independent sources of variation? We also observe that branded goods have much higher trade shares than non-branded goods. Do branded goods really have less price dispersion than non-branded goods or are we picking up the impact of tradeability yet again? We deal with these issues by adopting a formal regression framework and by separating our analysis into two parts. The first part analyzes the relationship between price dispersion and the characteristics of goods and the second focuses on market structure using only our brand data.

4.2 Price dispersion and goods characteristics

We work with the following linear specification:

$$y_i = \alpha + x_i \cdot \beta + u_i \ , \quad i = 1, ...N \tag{3}$$

where y_i is price dispersion of good i across countries, x_i is a vector of explanatory variables and u_i is an error term assumed to be *i.i.d.*

What prevents us from estimating equation (3) is that our observations on x are aggregated to a larger extent than those on y. Take for example, our measure of tradeability. While we have data on price dispersion for virtually every electronic good from a coffee mill to a color television set, our measure of tradeability is limited to a few aggregative categories of electronic goods. In a nutshell, the variable we seek to characterize — good-specific price dispersion — is observable at a much 'finer' level than the variables we seek to characterize it with. This type of aggregation has important consequences for statistical inference.[11]

Our solution is to estimate,

$$y_{ig} = \alpha + \bar{x}_g \cdot \beta + (x_{ig} - \bar{x}_g) \cdot \beta + u_{ig} \ , \tag{4}$$

which is a regression of y onto $\bar{x}_g$, the within-group sample mean for x_i (i.e. whereas x_{ig} might be the trade share for a cell phone, $\bar{x}_g$ is the trade share for all electronic goods, the group to which cell phones belong). The error term in this regression is now $(x_{ig} - \bar{x}_g) \cdot \beta + u_{ig}$, which is heteroskedastic in the presence of within group variation in x. We take two approaches to estimating equation (4), each of which turn out to yield qualitatively similar results. First, we estimate α and β using generalized least squares (GLS), having characterized the exact form of the heteroskedastic covariance matrix for the errors. Second, we average our disaggregate data, y, within groups, g, dictated by our aggregative data, x, and estimate,

$$\bar{y}_g = \alpha + \bar{x}_g \cdot \beta + \bar{u}_g \ , \tag{5}$$

where the sample averages, $\bar{y}_g$ and $\bar{u}_g$ are defined in the obvious way and are understood to depend explicitly on the number of observations with a group, which we denote N_g. Estimates based on

[11] The statistical appendix (available upon request from the authors) provides details of our statistical framework and shows how we obtain consistent, efficient estimates of β, it's standard errors, and meaningful goodness-of-fit measures.

equation (5) are also obtained using feasible GLS, given our knowledge of the covariance matrix of $\bar{u}$, which is a simple function of the values N_g. The main disadvantage of equation (5) is that it averages variation in y. The advantages are a simpler form of the covariance matrix and a more easily interpretable goodness-of-fit, due to the fact that we are not trying to explain variation in y with variation in x, which, by definition has had much of its variation averaged away.

The regressors we use are the trade share, the share of non-tradeable inputs discussed in section 2 and dummy variables for large cars and vice goods (alcohol and tobacco products). The first two are motivated by international trade theory while the latter two reflect more practical considerations. The European automobile industry is afforded a number of important exemptions from the European Union's competition policy which Harry Flam (1992) argues is responsible for enormous variation in automobile prices across countries (for example, a Mercedes 190 D sells for 36% more in Portugal than Germany even after controlling for differences in VAT). The dummy variable for vice goods is intended to control for the significant differences in national excise taxes on alcohol and tobacco products.

Table 11 reports our estimates. The coefficients on the explanatory variables are all of the expected sign and are all statistically significant. Goods from sectors with high trade shares exhibit less price dispersion across countries, as do goods which require smaller amounts of non-traded inputs. Large cars and vice goods both have significantly higher price dispersion after controlling for trade and cost structure.

The impact of each regressor is economically important as well. Taking the results for 1985, for example, the coefficient on the trade share suggests that if we consider two goods, both with a minimum amount non–traded inputs (0.10), one non-tradeable and one with a high level of tradeability (0.75), price dispersion will fall from 25.3% to 20.3%. The coefficient on non-traded inputs implies that, for a non–traded good, if the share of non-tradeable inputs doubles – from 10% to 20% – price dispersion rises from 25.3% to 29%.

Together these two factors account for much of the variation in price dispersion across goods. Averaging across the four time periods we account for at least one-third of the heterogeneity in price dispersion across goods. The R^2 from the GLS regression ranges from a low of 0.28 in 1980 to a high of 0.49 in 1990.[12] To make this more concrete, consider two goods, a desk-top computer and a

[12]We also report the fraction of variance explained based on the raw data, which is not as informative since it

haircut. Based on our measures, these particular goods have very different economic characteristics. A desk-top computer, being drawn from the office, computing and accounting machinery sector, has a high trade share and a low non-traded input share. In contrast, a haircut, being drawn from the community, social and personal service sector, is a non-traded good with a high share of non-traded inputs into production. Based on our regression model, if we move from a desk-top computer to a haircut, price dispersion is predicted to double, rising from 16.8% to 32.6%.

In summary, we find that theories distinguishing goods by the extent of their tradeability and the transformation of traded goods to final goods account for a significant fraction of cross-country price dispersion. The last factor we consider is market structure.

4.3 Price dispersion and market structure

Arthur Pigou (1920) defined price discrimination as being present when different groups of consumers pay different prices for identical goods. In the "pricing to market" literature (see Krugman (1995) and Robert C. Feenstra (1995) for comprehensive reviews) price discriminating oligopolistic suppliers use their market power to sustain price differences across national boundaries. Identical goods, then, could sell at different prices across countries even when converted to a common currency. Alternatively, the goods might not actually be identical in which case monopolistically competitive firms could charge different prices depending on the elasticity of substitution between them. Assuming that international goods are homogenous when in fact they are different varieties of the same good would, under monopolistic competition, lead to unfounded rejections of the Law-of-One-Price.

Our panel data is sufficiently rich that we can shed light on these two alternative views of the microeconomic structure of goods markets. The procedure boils down to a two-way analysis of variance. The first dimension of the variance captures price differences across brands of the same good within a country. We refer to these as brand effects: the price differences domestic consumers pay for differentiated brands of the same good. The second dimension captures the differences in price of the same brand across countries. We refer to these as country effects: the price differences international consumers pay for identical brands of a particular good. We gauge the relative importance of product heterogeneity and geographic price discrimination by comparing

primarily reflects the different levels of aggregation of the regressors and regressand.

their contributions to total price variance.

Specifically, we estimate:

$$y_{ij}^h = \alpha_i + d_j \cdot \beta_j + d_h \cdot \delta_h + \varepsilon_{ij}^h \tag{6}$$

where y_{ij}^h is the log of the price of brand h of good i, in country j expressed in a numeraire currency while d_j and d_h are country and brand dummy variables, respectively. The equation is estimated for each good for which we have a sufficient number of country and brand observations (as discussed below).[13]

The sub-sample we use consists of those goods for which prices are collected for multiple brands of otherwise homogeneous products. Due to the sparseness in available data for some individual brands or entire categories of goods we have adopted the following criteria for selecting data into this part of our analysis. First, we exclude a good if the price survey contains less than four different brands since this would limit out ability to infer the variance of price across brands for that good. Second, we exclude a brand when price observations are available for less than four countries for the analogous reason. Third, due to the inherent ambiguity in what constitutes a good versus a brand, we partition brands of a particular good into 'high-priced' and 'low-priced' whenever a sufficient number of observations exist to do so and treated them as separate goods.

To avoid reporting 140 individual variance decompositions, good-by-good, we average the results across goods using a classification that conveys the same basic message as a full table of results.[14] The groupings are: appliances, automobiles, automotive services, electronic goods, other manufactures and vice goods. Table 12 presents the Eurostat descriptions of the goods organized in this fashion. While the Eurostat descriptions vary somewhat in detail, all items in this table are defined up to the make and model or exact brand (details which Eurostat does not publish).

Table 13 presents the results of the variance decomposition along with a few additional summary statistics. The categories are ordered from those with the largest country effects to those with the smallest country effects. Beginning with the overall averages we see the brand and country effects are of equal importance. Based on this metric, monopolistic competition and geographic price

[13] For most goods data is missing for some brands in some countries. The implication is that the dummy variables will not be orthogonal and the variance decomposition will not be unique. In the statistical appendix (available upon request) we describe how we deal with this problem when constructing and reporting our variance decompositions.

[14] Results of the variance decomposition good-by-good for each year are available from the authors by request.

discrimination are of comparable importance in accounting for price dispersion. However, the averages are not very representative of the results for the underlying categories. At one extreme, we see vice goods and automotive services, both with virtually all of the price variation accounted for by country effects (80% when we average across years). At the opposite end of the continuum are appliances where the bulk of price variation comes in the form of brand differentiation.

In the case of vice goods, we suspect that most of the country effect is due to variation in national excise taxes across countries. The large country effect for automotive services is exactly what we would expect for a classic non-traded good. Among manufactured goods, automobiles are of interest for a number of reasons. First, the automobile industry has attracted a great deal of interest in the international trade literature that studies the pass-through of exchange rate fluctuations to trade prices from source to destination markets. Knettner (1989, 1993) finds more evidence of pricing to market in the automobile industry than in others that he studies. Interestingly, automobiles are the last category of goods in Table 13 where country effects dominate brand effects. The large country effects cannot be dismissed as reflecting differences in excise taxes or trade barriers. These factors do play a role, but only for particular countries and import sources. For example, Flam (1992) emphasizes very high value-added taxes on automobiles in the case of Denmark and Greece, and import restrictions imposed on Japanese models by Portugal and the United Kingdom.[15] Most likely, the European automobile industry has large country effects because it is allowed exemptions from EU competition policy that are not enjoyed by other industries represented in our table.

Of the remaining categories, there is little to distinguish electronic goods from other manufactures. Both categories have considerable amounts of price variation across brands within countries and across countries for a given brand. Appliances, as one might expect, have the largest brand effects.

We conclude that the ability of firms to price discriminate across countries is no greater than their ability to differentiate their products within a country. When this conclusion fails to hold, we can point to other factors that account for the difference: in the case of vice goods, excise taxes; in the case of services, no trade; in the case of automobiles, a combination of factors (excise taxes, import restraints, and exemptions from EU competition policy).

[15] See also Lutz (2001) for a very detailed and interesting study of automobile price dispersion in Europe by make and model.

4.4 Relationship with other evidence

Maurice Obstfeld and Rogoff (2001) recently proposed that models distinguished by goods-market arbitrage costs can explain many features of the data. In terms of our good-by-good log deviations from the Law-of-One-Price, q_{ij}, this implies the no-arbitrage restriction:

$$-\tau_i \leq q_{ij} \leq \tau_i \quad . \tag{7}$$

The theory states that when a good is traded internationally, q_{ij} equals $\pm\tau_i$ (the 'transaction cost'). Thus, if we observe a law-of-one-price deviation of 15% for a particular traded good, the implication is that transactions costs equal 15% with the price being that much higher at the destination compared to the origin. When goods are not traded, the theory predicts that q_{ij} will lie strictly within the arbitrage bands and, therefore, understate the magnitude of arbitrage costs.

Because most existing studies use price indices, researchers have focused on the time-series variance or persistence properties of q_{ij} (or its first-difference), and not its cross-sectional mean or variance. Understanding how time series and cross-sectional properties are related, in the context of an arbitrage model, helps to relate our findings to those of previous studies, in addition to offering some new insights.

For example, Rogers and Jenkins (1995) study very dissaggregated consumer price data across Canada and the United States (in index number format) and find little to distinguish real exchange rate behavior for traded versus non-traded items in terms of persistence. In contrast, we find absolute price dispersion to be substantially lower for traded goods than for non-traded goods. These observations, of course, are not necessarily at odds with one another. Equation (7) places no restrictions on the persistence of q_{ij}, rather it restricts the support of the distribution of the absolute deviations which is presumed to be smaller for traded goods than for non-traded goods. Our findings of large absolute deviations for haircuts and small deviations for fuel oil, therefore, are not necessarily inconsistent with Rogers and Jenkins inability to reject a unit root either case.

Engel (1993) and Engel and Rogers (1996, 1999) focus on time series variability and ask the question 'How Wide is the Border.' They estimate the width of the national border by examining how changes in international relative prices are related to changes in intranational relative prices.

The essence of their approach is the ratio of inter to intra-national relative price variability:

$$\frac{stdev(\Delta q_{ij})}{stdev(\Delta q'_{ij})} = \frac{\{var(\Delta p_{ij} - \Delta p_{in}) + var(\Delta e_j) + cov(\Delta e_j, \Delta p_{ij} - \Delta p_{in})\}^{1/2}}{stdev(\Delta p'_{ij} - \Delta p'_{in})} \tag{8}$$

where *stdev* and *var* denote standard deviation and variance, Δ denotes the change in a variable, and the superscript '$\prime$' indicates that locations j and n are *within* the same country. The term in the denominator is the variance of the inflation differential across regions, within a country. The terms in the numerators are the variance of the inflation differential across countries, the variance of the change in their nominal exchange rate, and the covariance between the two. Typically, this ratio is a large number. Using annual European CPI data, for example, Engel and Rogers (1999) estimate an average $stdev(\Delta q_{ij})$ of 7.2% and an average $stdev(\Delta q'_{ij})$ of roughly 1%, so the ratio is 7.2. Most of this is due to high nominal exchange rate variability: $stdev(\Delta e_j) = 7.3\%$. With monthly data, they report a ratio of 4.0. Using Canada-U.S. data they report more moderate values, in the neighborhood of 2. Engel and Rogers map these ratios into more economically meaningful metrics — geographical distance — and argue persuasively that they imply very 'wide' international borders relative to within-country borders.

One common interpretation of their findings – dating back to at least Mussa (1986) – is that local currency prices are unresponsive ('sticky') to changes in nominal exchange rates. This 'explains' a large value for equation (8) by reducing it (approximately) to the square root of $1 + var(\Delta e_j)/var(\Delta p'_{ij} - \Delta p'_{in})$. Empirically, the denominator is small and the numerator is large (nominal exchange rates are highly variable), so we get a big ratio, at least during the post-Bretton Woods era. While the 'sticky price' interpretation is surely true over a sufficiently short time horizon, our results cast doubt for longer horizons. The density estimates in Figure 1 don't move around with changes in nominal exchange rates. Changes in real exchange rates are half as variable as changes in nominal exchange rates. The two are negatively correlated. Price dispersion varies with goods characteristics according to economic theory.

How wide do our data say the border is? Before answering this, it's worth asking if our data on absolute price dispersion are consistent with Engel and Rogers' numbers based on changes. Suppose that deviations from the Law-of-One-Price, q_{ij}, follow a first-order autoregression with autocorrelation φ. Across goods, the average amount of international price dispersion we observe is a mean-absolute deviation of roughly 25% (*i.e.*, the mean of the distributions in Figure 3. This provides an estimate of the unconditional standard deviation q, so an estimate of the conditional variance is $0.25^2(1-\varphi^2)$. The variance of the change in q, $var(\Delta q)$, provided that $\varphi < 1$, is the conditional variance multiplied by $(1+(\varphi-1)^2/(1-\varphi^2))$. Engel and Rogers estimate, for Europe, that $stdev(\Delta q)$ is roughly 7 percent. If $\varphi = 0.96$, then our estimates coincide with theirs.

Highly persistent real exchange rates, then, reconcile our estimates of unconditional variability with Engel and Rogers' estimates of conditional variability. Which estimates are more relevant for understanding the effects of international borders, however, depends on the question one has in mind. The arbitrage-cost model, equation (7), clearly requires some comparison of absolute price dispersion within and across countries. We don't have data on intranational European dispersion, but Parsley and Wei (2000) report an average of roughly 15% based on within-country U.S. and Japanese data. If we assume that Europe is similar (admittedly a strong assumption), a meaningful measure of 'border width' is that it increases goods-market arbitrage costs from 15 to 25 percent.

5 Conclusion

The richness of our cross-sectional data allowed us to venture where studies based on more aggregative data have not: a characterization of what determines the good-by-good dispersion in absolute deviations from the Law-of-One-Price. We find that, with the exception of the relatively poor countries, EC currencies had comparable purchasing power in 1975, 1980, 1985 and 1990. In contrast, dispersion around these averages is large, implying, for example, that someone living in Germany faces a distinct set of relative prices vis-à-vis someone living in France. The bulk of our paper is dedicated to characterizing this dispersion in terms of factors emphasized by economic theory: tradeability, non-traded inputs into production, brand differentiation and price discriminations across locations. Taken as a whole, our evidence suggests that a substantial fraction of what determines dispersion in real exchange rates is attributable to these types of factors. In a nutshell, while there is certainly some degree of location specificity to what defines 'a good,' there is also an important degree of good specificity which links prices across national markets in a manner which is consistent with basic microeconomic principles.

Our findings have a number of implications for recent theoretical work on the determination of real exchange rates. Currently there are three branches of the literature at various stages of development. The first branch of the literature introduces price rigidities into dynamic equilibrium models (V. Chari, Patrick Kehoe and Ellen McGratten (1998), for example). These models were developed to study monetary policy over the short to medium run and they have proven useful for that purpose. We doubt, however, that such models provide a plausible mechanism for sustaining deviations from the Law-of-One-Price of the magnitude observed in our data. What they do provide is a possible way to reconcile our results with those based upon the time series properties of aggregative price indices. At the risk of oversimplifying, suppose that all prices are fixed in terms of home currency for only one period but the exchange rate adjusts to maintain covered interest parity. In such an environment the entire distribution of real exchange rates will shift with the nominal exchange rate, creating perfect collinearity between the nominal and real exchange rate within the period. The fact that much of the time series literature fails to find differences in the behavior of real exchange rates across goods may reflect this collinearity at high frequencies.

A second strand of literature builds microfoundations of the price adjustment process by considering the role of imperfect competition in sustaining price differences across countries. These models have the ability to distinguish the behavior of real exchange rates across industries based on their industrial structure and may generate sustained deviations from the Law-of-One-Price. Our analysis of the international pricing of brand goods provides support for this approach provided some discipline is imposed on the classification of the goods. For example, allowing for the same amount of market power in all goods markets is a very inadequate description of the level of competition across industries. Our findings indicate that even among brand name goods, where market power is arguably the greatest, substantial geographic price discrimination appears to be isolated to a subset of goods such as automobiles. While automobiles are large ticket items, they receive a weight of only 5% in the U.S. CPI, roughly equal to that for food consumed outside the home. The practical importance of drawing an accurate dividing line between sectors with different industrial structures is emphasized in a recent paper by Betts and Michael Devereux (2000).

Finally, a third strand of literature incorporates transportation costs. These models predict that real exchange rates will vary within the limits of arbitrage bounds. Provided the arbitrage costs are interpreted broadly, to include transportation and other costs of bringing goods to final markets, our results tend to favor this approach which has been used in international finance by Raman Uppal and his co-authors in a series of papers (see for example, Piet Sercu, Uppal and C.

Van Hulle (1995)).

Determining which of these three models will emerge as the work-horse of international macroeconomics remains uncertain. Perhaps each will serve a different purpose. What is certain is the need for more absolute price data to effectively assess their relative merits.

Data Appendix

National retail price data. The retail price data were compiled and published by Eurostat, the statistical agency of the European Community, in cooperation with the national statistical agencies of the countries that participated. While all of the price data is published we are unaware of available electronic copies. All prices refer to cash prices paid by final consumers, including taxes, both VAT and any others paid by the purchaser. Sales points are selected is such a way that the sample selected is representative of the distribution in the capital city. Prices are collected at different locations so that the average price is representative of the distribution within the city. These data were not available electronically so we had a private firm key-punch the commodity codes, commodity descriptions and prices into a spreadsheet.

Consumption expenditure weights. The consumption expenditure weights were graciously provided by Charles Engel. The original source is the International Comparison Project. The weights are available for 151 categories in both 1975 and 1980 while 139 categories are available for 1985, and 200 categories are available for 1990. Each individual retail price was assigned to a unique consumption expenditure category and this was done separately for each year and each country. We renormalized each country's weights to sum to unity over the available consumption survey.

Aggregate real exchange rates. We define the aggregate real exchange rate for country j relative to Belgium (our numeraire) as:

$$q_j = \sum_{i=1}^{N} \gamma_{ij} q_{ij} \ , \qquad \text{(A-1)}$$

where γ_{ij} are weights which sum to unity. We use either equal weights or consumption expenditure weights. Consumption expenditure weights equal $\gamma_{ij} = \theta_{kj}/H_{kj}$, where θ_{kj} is the share of expenditure by consumers of country j on goods falling into category k in the ICP dataset and H_{kj} is a count of the number of goods in our dataset that fall into consumption category k. This is equivalent to estimating the mean real exchange rate using a simple average of the real exchange rates of each good in a particular category and applying the weight to this relative price in estimating the aggregate real exchange rate. For each bilateral calculation we include all goods prices for which we have an observation for both countries. However, to avoid double counting similar items, we eliminate multiple brands. That is, given some good for which we have multiple brands, we keep the good which has the maximum number of observations across the countries. In the event of a tie, we randomly choose which good to keep.

Data Reconciliation. In order to explain the price dispersion across goods that exists in our data we constructed measures of tradeability and the costs of non–traded inputs into production. The constructed variables for tradeability, and non–traded inputs from input-output tables are available at different levels of detail. For this reason, and in order to make the most of the information available for each of these factors, we matched the retail price data with each of the variables using two-digit, three-digit, and four-digit classifications depending on the level of detail available for each of the variables rather than attempting to match all variables using the same level of detail. The input-output data are also available at a three-digit level of detail that extends to four-digits for some industry groups. In order to reconcile the data as accurately as possible, we used the ISIC codes and descriptions available in the User Guide of the OECD International Sectoral Database.

Tradeability. We obtained data on imports, exports, and gross output for the period 1973 to 1990 from the 1994 edition of the OECD STAN Database. We use thirty-two non-overlapping subdivisions of manufacturing for which sufficient data are available and to the extent that they are relevant to the commodities in our price dataset. We also constructed additional tradeability indices for agriculture (sector 1) and electricity, gas, and water (sector 4) using the 1994 edition of the OECD Sectoral Database, which provides value-added instead of gross output data. Unfortunately, we only have this data for six countries: Belgium, Denmark, France, Germany, Italy, and the United Kingdom. We assigned a zero trade share to the following industries: restaurants and hotels, transport, storage and communication, inland transport, maritime and air transport, communication, financing, insurance, real estate and business services, community, social and personal services. Otherwise, our measure of tradeability is calculated as:

$$\theta_k = \frac{\sum_{j=1}^{m_k}(X_{kj} + M_{kj})}{\sum_{j=1}^{m_k} Y_{kj}} \tag{A-2}$$

where for each sector k we sum over all countries j which have data for that sector. X_{kj} (M_{kj}) stands for exports (imports) of sector k from country j and Y_{kj} stands for the gross output of sector k by country j.

Input–Ouput Data. We use the input-output matrix for the United Kingdom in 1988. These data were compiled by Keith Maskus and Allan Webster (1995). We thank Tom

Prusa for suggesting this data source, which is available at the National Bureau of Economic Research home page. Non–traded inputs are assumed to include: utilities, construction, distribution, hotels, catering, railways, road transport, sea transport, air transport, transport services, telecommunications, banking, finance, insurance, business services, education, health and other services. We compute the cost share of non–traded intermediate inputs computed as,

$$\Phi_k = \sum_{s=1}^{S} \phi_{ks} \ , \tag{A-3}$$

where ϕ_{ks} is the share of non–traded intermediate input s in the total cost of the output of sector k.

A statistical appendix and more extensive data appendix are available from the authors upon request.

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TABLE 1 – SCOPE OF THE PRICE SURVEYS

Item	1975	1980	1985	1990
Panel A: Raw survey data				
Number of countries	9	12	13	13
Number of goods	658	1090	1805	1896
Proportion missing	13%	36%	38%	44%
Least missing[a]	9%	23%	25%	32%
Most missing[a]	27%	47%	53%	55%
Proportion of brand goods	31%	42%	48%	54%
Panel B: Data after eliminating outliers				
Number of countries	9	12	13	13
Number of goods	594	686	1164	1101
Proportion missing	10%	17%	19%	23%
Least missing[a]	4%	3%	7%	9%
Most missing[a]	22%	28%	37%	34%
Proportion of brand goods	31%	28%	33%	38%

Note: Proportion of brand goods means "proportion of goods for which two or more brands exist in the price survey." In order of appearance in the surveys, the countries are: Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Netherlands, United Kingdom (all years) Greece, Portugal, Spain (added in 1980) and Austria (added in 1985).

[a]Belgium is the country with the least number of missing observations in every year and Ireland is the country with the greatest number of missing observations in each year except for 1990 in which case the United Kingdom has the most missing.

TABLE 3 – TRADE SHARES

Industry	Trade share
Agriculture, hunting, forestry and fishing	0.403
Food	0.281
Beverages	0.266
Tobacco	0.171
Textiles	0.576
Wearing apparel	0.552
Leather products	0.667
Footwear	0.634
Furniture and fixtures	0.254
Paper and paper products	0.494
Printing and publishing	0.151
Industrial chemicals	0.806
Other chemicals	0.468
Chemical products, n.e.c.	0.498
Misc. products of petroleum and coal	0.416
Rubber products	0.533
Plastic products, n.e.c.	0.272
Pottery, china etc.	0.261
Non-metal products, n.e.c.	0.200
Iron and steel	0.450
Non-ferrous metals	0.682
Fabricated metal products, except machinery and equipment	0.354
Office and computing machinery	1.280
Machinery and equipment, n.e.c.	0.586
Electrical machinery	0.486
Radio, television and communication equipment	0.588
Electrical apparatus, n.e.c.	0.467
Shipbuilding and repairing	0.431
Motor vehicles	0.618
Motorcycles and bicycles	0.635
Professional goods	1.295
Other manufacturing n.e.c.	1.276
Electricity, gas and steam and water	0.856

Source: OECD Sectoral Database and OECD STAN Database.

Note: The following industries have been assigned a zero trade share: restaurants and hotels, transport, storage and communication, inland transport, maritime and air transport, communication, financing, insurance, real estate and business services, community, social and personal services.

TABLE 4 – NON-TRADED INPUT COST SHARES

Category	Input share	Category	Input Share
Agriculture	0.144	Glass	0.195
Forestry and fishing	0.318	Clay refractories	0.201
Milk and milk products	0.080	Cement, concrete	0.259
Meat, fruit, veg, fish processing	0.096	Iron and steel; plant	0.111
Oils and fats, grain products	0.124	Non-ferrous metals	0.092
Bread, biscuits etc	0.104	Metal castings etc	0.119
Sugar, confectionery	0.139	Office machinery, computers etc	0.103
Foods, nes	0.174	Other machinery	0.116
Alcoholic drink	0.097	Telecommunication etc equipment	0.120
Soft drink	0.160	Domestic electric appliances	0.135
Tobacco	0.046	Electronic consumers goods etc	0.113
Woven textiles	0.095	Electronic components	0.147
Hosiery and other knitted goods	0.097	Electric lighting equipment	0.106
Carpets etc	0.112	Shipbiulding and repairing	0.134
Clothing and furs	0.096	Motor Vehicles and parts	0.090
Leather and leather goods	0.073	Other vehicles	0.110
Footwear	0.086	Instrument engineering	0.149
Wood furniture	0.107	Other manufacturing	0.122
Paper and board products	0.135	Utilities	0.157
Printing and publishing	0.211	Hotels, catering etc	0.144
Synthetic resins, man made fibers	0.134	Railways	0.272
Paints, dyes etc	0.154	Road transport etc	0.151
Soap and toiletries	0.226	Air transport	0.253
Chemicals nes	0.133	Transport services	0.204
Mineral oil processing	0.054	Telecommunications and posta	0.124
Rubber and plastic products	0.127	Business services etc	0.134
		Other services	0.304

Source: National Bureau of Economic Research and author's calculations.

TABLE 5 –LOG REAL EXCHANGE RATES

	GNP	Equally weighted				Consumption expenditure share weighted			
Country[a]	(1990 $)	1975	1980	1985	1990	1975	1980	1985	1990
Luxembourg	16,399	-0.051	-0.019	-0.092	-0.074	-0.112	-0.097	-0.128	-0.116
(1957)		(0.011)	(0.010)	(0.011)	(0.012)				
Germany	14,478	0.020	0.043	-0.048	-0.004	0.012	0.017	-0.025	0.010
(1957)		(0.014)	(0.016)	(0.013)	(0.014)				
France	13,931	0.077	0.067	-0.001	0.015	0.114	0.076	0.047	0.019
(1957)		(0.012)	(0.014)	(0.014)	(0.015)				
Denmark	13,802	0.140	0.176	0.166	0.163	0.181	0.201	0.195	0.234
(1957)		(0.017)	(0.018)	(0.018)	(0.019)				
United Kingdom	13,066	-0.240	0.010	-0.062	-0.087	-0.209	0.053	0.012	-0.032
(1973)		(0.019)	(0.019)	(0.016)	(0.021)				
Netherlands	12,858	-0.025	-0.019	-0.109	-0.057	-0.035	0.007	-0.080	-0.029
(1957)		(0.012)	(0.014)	(0.014)	(0.014)				
Austria	12,849			0.029	0.020			0.050	0.072
(1995)				(0.015)	(0.017)				
Italy	12,555	-0.094	-0.128	-0.077	-0.035	-0.126	-0.137	-0.080	0.009
(1957)		(0.019)	(0.019)	(0.019)	(0.018)				
Spain	11,020		-0.152	-0.165	-0.129		-0.212	-0.193	-0.124
(1986)			(0.021)	(0.019)	(0.019)				
Ireland	9,067	-0.239	-0.074	-0.025	-0.040	-0.303	-0.074	0.025	0.027
(1973)		(0.020)	(0.020)	(0.019)	(0.018)				
Greece	6,678		-0.208	-0.253	-0.237		-0.258	-0.289	-0.138
(1981)			(0.025)	(0.022)	(0.023)				
Portugal	6,520		-0.280	-0.264	-0.320		-0.408	-0.403	-0.332
(1986)			(0.029)	(0.024)	(0.024)				

Note: Entries in columns 3 to 10 are q_j, the weighted average for country j of good-specific log relative prices. For these calculations we eliminate multiple brands of the same good. The numbers in parentheses are standard errors of the equally-weighted means.

[a] The year the country joined the European Union is in parentheses. Strictly speaking the term European Union subsumes the history of various forms of institutional arrangements. The European Economic Community (EEC) was formally established by one of the Treaties of Rome in 1957 and the European Community was established in 1967 as the merger of the EEC, the European Coal and Steel Community and the European Atomic Energy Community.

TABLE 7 – CORRELATION OF ANNUAL CHANGES IN REAL AND NOMINAL EXCHANGE RATES

	Data-source and Numeraire					
	CPI				PWT	OECD
	U.S.	Belgium	Germany	Avg	Avg	Avg
Sample						
Eurostat Sample	0.78	0.65	0.65	0.67	0.67	0.67
				(0.07)	(0.08)	(0.09)
Eurostat Countries	0.77	0.68	0.68	0.68	0.68	0.69
				(0.06)	(0.08)	(0.07)
Include U.S.	0.77	0.76	0.75	0.74	0.74	0.75
				(0.04)	(0.09)	(0.04)

Notes: Values are correlations between annual changes in real and nominal exchange rates over the period 1975-1990. CPI data are obtained from the IFS. PWT denotes absolute price data from the Penn World Tables (http://datacentre.chass.utoronto.ca/cgi-bin/pwt/) which have been transformed into log changes. OECD denotes analogous data from the OECD (http:/www.oecd.org/std/ppp/pps.htm). Columns 1–3 use the U.S., Belgium and Germany as the numeraire, respectively. Columns 4-6 report the average correlation over all possible numeraires, with the standard deviation across numeraire choices reported in parentheses. Row 1 uses the exact sample of countries and time periods included in the Eurostat survey which underlies this paper. Row 2 uses the same set of countries, but includes time periods for which the Eurostat survey has missing data. Row 3 adds the U.S. to the sample of countries/time-periods in Row 2.

TABLE 8 – CORRELATION OF FIVE-YEAR CHANGES IN REAL AND NOMINAL EXCHANGE RATES

	Data-source and numeraire							
	CPI				PWT	OECD	Eurostat	Eurostat
Sample	U.S.	Belgium	Germany	Avg	Avg	Avg	Belgium	Avg
EUROSTAT Sample	0.20	0.12	−0.04	0.09	0.33	0.13	−0.19	−0.06
				(0.18)	(0.13)	(0.19)		(0.13)
EUROSTAT Countries	0.37	0.34	0.20	0.26	0.40	0.29		
				(0.11)	(0.08)	(0.12)		
Include U.S.	0.37	0.58	0.47	0.49	0.57	0.50		
				(0.08)	(0.07)	(0.09)		

Values are correlations between five-year changes in real and nominal exchange rates over the period 1975-1990. CPI data are obtained from the IFS. PWT denotes absolute price data from the Penn World Tables which have been transformed into log changes. OECD denotes analogous data from the OECD. Columns 1–3 use the U.S., Belgium and Germany as the numeraire, respectively. Columns 4-6 report the average correlation over all possible numeraires, with the standard deviation across numeraire choices reported in parentheses. Row 1 uses the exact sample of countries and time periods included in the Eurostat survey which underlies this paper. Row 2 uses the same set of countries, but includes time periods for which the Eurostat survey has missing data. Row 3 adds the U.S. to the sample of countries/time-periods in Row 2.

TABLE 9 – COUNTRY EFFECTS

Country	1975	1980	1985	1990
Austria	n.a.	n.a.	0.077	0.070
	n.a.	n.a.	(0.008)	(0.010)
Belgium	0.020	0.002	0.025	-0.003
	(0.007)	(0.009)	(0.009)	(0.008)
Denmark	0.189	0.240	0.251	0.267
	(0.013)	(0.015)	(0.012)	(0.015)
France	0.109	0.073	0.043	0.037
	(0.009)	(0.011)	(0.009)	(0.009)
Germany	0.039	0.055	-0.024	0.009
	(0.010)	(0.012)	(0.008)	(0.008)
Greece	n.a.	-0.090	-0.083	-0.073
	n.a.	(0.017)	(0.014)	(0.014)
Ireland	-0.167	-0.029	0.043	0.018
	(0.012	(0.013)	(0.013)	(0.012)
Italy	-0.034	-0.086	-0.004	0.012
	(0.012)	(0.012)	(0.011)	(0.011)
Luxembourg	-0.027	-0.020	-0.085	-0.072
	(0.007)	(0.009)	(0.007)	(0.007)
Netherlands	0.007	0.000	-0.066	-0.026
	(0.008)	(0.010)	(0.008)	(0.008)
Portugal	n.a.	-0.132	-0.102	-0.160
	n.a.	(0.019)	(0.016)	(0.012)
Spain	n.a.	-0.057	-0.065	-0.043
	n.a.	(0.013)	(0.011)	(0.010)
United Kingdom	-0.167	0.020	0.001	-0.025
	(0.011)	(0.013)	(0.011)	(0.014)
Percent Explained	20.90	10.13	9.13	11.53
Percent Unexplained	82.60	91.46	93.10	92.17
Residual	-3.49	-1.59	-2.23	-3.70

Note: Entries represent the average, across goods for a particular country, of the percent by which each price deviates from its good-specific mean. Specifically, given the price of the ith good in the jth country, and the nominal exchange rate, e_j, the means are calculated as

$$\text{Mean} = \frac{1}{N_j} \sum_{i}^{N_j} \left(\frac{e_j p_{ij}}{\sum_{j=1}^{M_i} e_j p_{ij} / M_i} - 1 \right).$$

The residual associated with the variance decomposition is due to missing observations or, equivalently, an unequal number of observations, N_j, for each country, j.

TABLE 10 – PRICE DISPERSION SUMMARY STATISTICS

	1975	1980	1985	1990
Overall price dispersion	0.188	0.236	0.242	0.229
Dispersion by characteristic:				
Non-traded	0.253	0.321	0.329	0.325
Traded	0.178	0.223	0.229	0.214
Above average share of services	0.214	0.287	0.292	0.306
Below average share of services	0.183	0.228	0.234	0.219
Branded goods	0.153	0.211	0.201	0.191
Non-branded goods	0.204	0.246	0.262	0.252

Notes: Authors calculations.

TABLE 11 – PRICE DISPERSION AND THE CHARACTERISTICS OF GOODS

Variable	1975	1980	1985	1990
Intercept	0.208	0.187	0.217	0.236
	(0.011)	(0.011)	(0.009)	(0.009)
Trade share	-0.108	-0.049	-0.067	-0.093
	(0.015)	(0.011)	(0.008)	(0.008)
Non-tradeable inputs	0.106	0.461	0.365	0.284
	(0.055)	(0.059)	(0.048)	(0.046)
Dummy variables:				
Large cars	0.036	0.098	0.115	0.061
	(0.044)	(0.028)	(0.03)	(0.018)
Vice goods	0.046	0.101	0.113	0.071
	(0.016)	(0.016)	(0.014)	(0.013)
R^2 (aggregated)	0.42	0.28	0.37	0.49
R^2 (dissaggregated)	0.14	0.16	0.17	0.23

Note: The table presents the coefficients of estimating regression equation (4) in the text. R^2 (aggregated price data) is the R^2 measure of fit from the GLS regression. R^2 (raw price data) is the fraction of variance explained based on the raw data which is necessarily lower because we cannot explain intrasectoral dispersion in prices given the more aggregate nature of our explanatory variables.

TABLE 13 – VARIATION DECOMPOSITION FOR BRANDED GOODS AND SERVICES

			Variance decomposition			Number of:		
Good category	Period	Variance	Country	Brand	Residual	Goods	Brands	Obs.
	1975	n.a.	n.a.	n.a.	n.a.	0	n.a.	n.a.
	1980	5.02	0.83	0.09	0.08	1	5	60
Vice goods	1985	5.52	0.72	0.06	0.22	3	18	144
	1990	3.62	0.87	0.06	0.07	3	16	128
	All years	4.64	0.80	0.06	0.13	7	39	332
	1975	7.89	0.10	0.76	0.14	1	4	36
	1980	10.30	0.74	0.16	0.11	4	18	152
Automotive services	1985	13.09	0.84	0.03	0.13	6	29	326
	1990	13.05	0.91	0.01	0.08	6	36	390
	All years	12.11	0.80	0.10	0.11	17	87	904
	1975	0.95	0.52	0.45	0.03	3	12	60
	1980	8.24	0.66	0.31	0.03	5	34	315
Automobiles	1985	5.19	0.66	0.30	0.04	8	72	717
	1990	10.18	0.67	0.25	0.08	8	107	1289
	All years	6.96	0.65	0.30	0.05	24	225	2381
	1975	3.48	0.39	0.51	0.09	6	26	184
	1980	8.03	0.24	0.58	0.19	6	32	250
Other manufactures	1985	5.37	0.34	0.48	0.18	11	59	482
	1990	6.90	0.34	0.46	0.20	13	89	812
	All years	6.05	0.33	0.49	0.17	36	206	1728
	1975	1.51	0.32	0.59	0.10	2	10	60
	1980	2.10	0.35	0.48	0.17	3	16	89
Electronic goods	1985	6.66	0.28	0.58	0.13	13	81	592
	1990	5.01	0.30	0.53	0.17	18	122	1126
	All years	5.17	0.30	0.55	0.15	36	229	1867
	1975	1.48	0.29	0.59	0.13	6	29	159
	1980	3.16	0.29	0.66	0.05	3	17	94
Appliances	1985	6.62	0.13	0.81	0.07	4	31	273
	1990	3.60	0.22	0.65	0.13	7	51	361
	All years	3.58	0.20	0.68	0.12	20	128	887
	1975	2.51	0.32	0.57	0.11	18	81	499
	1980	6.88	0.47	0.41	0.11	22	122	960
All goods	1985	6.86	0.45	0.42	0.13	45	290	2534
	1990	6.83	0.45	0.41	0.14	55	421	4106
	All years	6.29	0.44	0.43	0.13	140	914	8099

Note: The details of estimation are explained in a statistical appendix, which is available upon request. Statistics in columns (3)-(6) are averages of the good-by-good results.

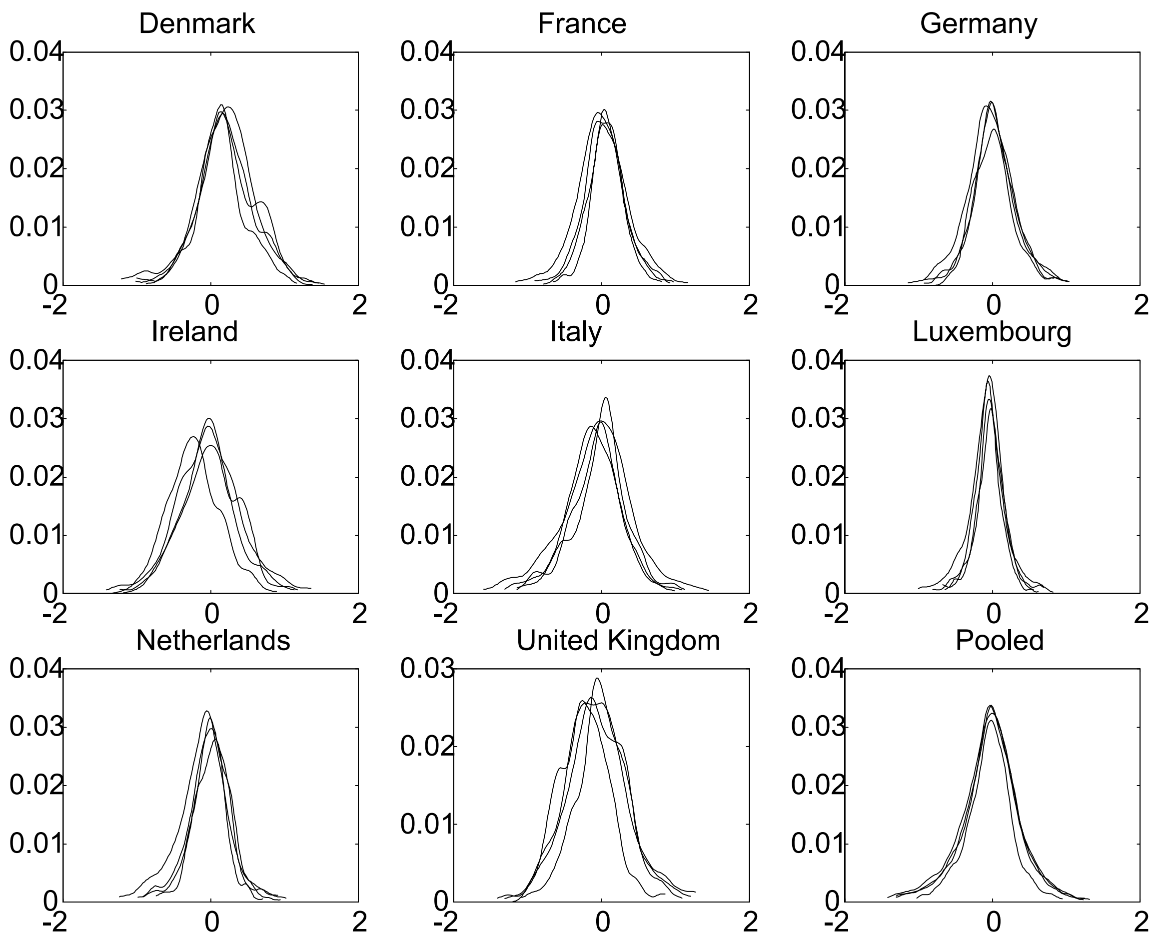

Figure 1: Empirical distributions of law-of-one-price deviations

Each line represents an estimate of the density of good-by-good deviations from the Law-of-One-Price between Belgium (the numeraire) and some other EC country. More specifically, each line is an estimate of the density, for country j, of $q_{ij} = \log(e_j p_{ij}/p_{in})$, where p_{ij} is the price of good i in country j, denominated in domestic currency and e_j is the spot exchange rate between country j and Belgium. Each chart contains a bilateral comparison between Belgium and one other EC country for each year in our panel. We present the individual country densities only for those countries with 4 years of available data. However, the lower right-hand chart presents an estimated density for each year (1975, 1980, 1985 and 1990), pooled across all countries with data available for the year under examination.

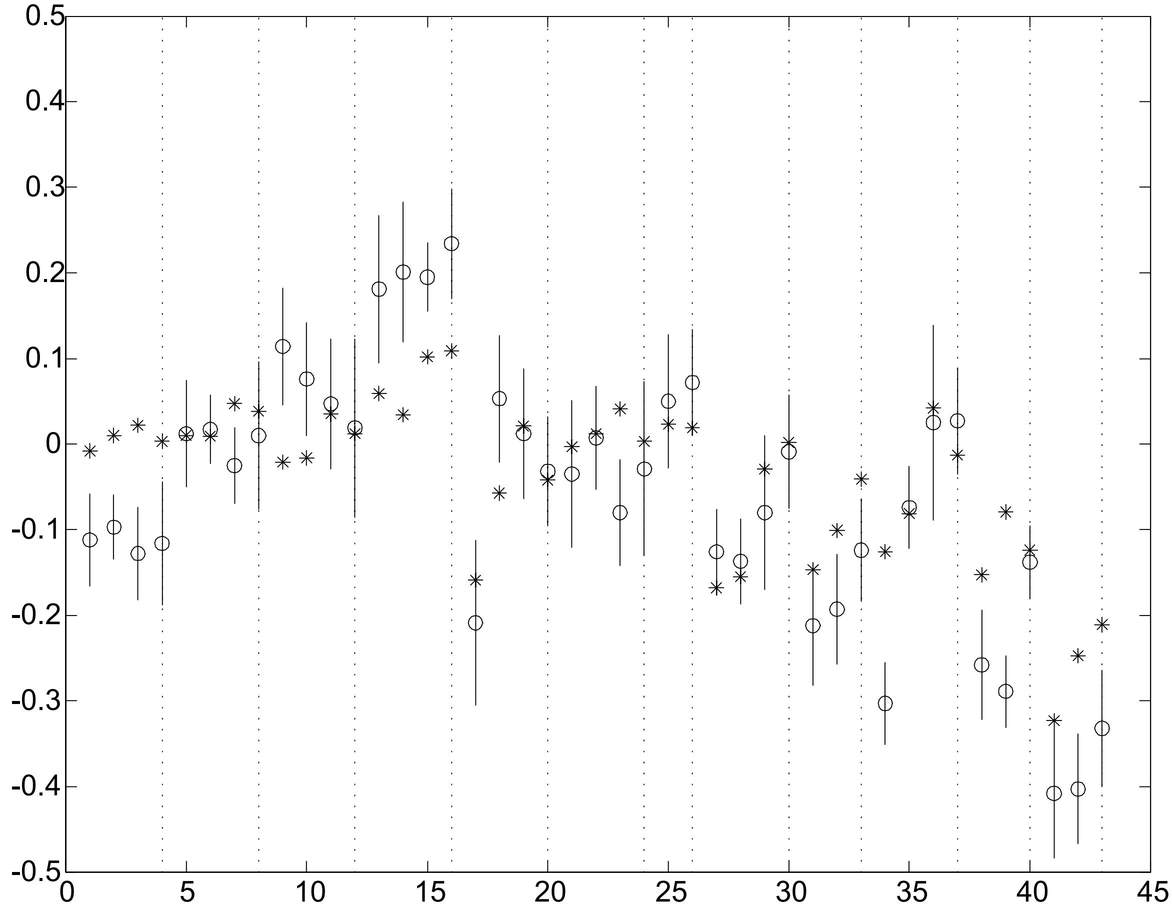

Figure 2: Alternative estimates of purchasing power parity.

Each point in the figure represents an estimate of purchasing power parity for a particular country in a particular year. The dashed lines delineate the switch from one country to the next (countries are ordered from left to right based on declining per capita income). The circles represent our CPI-weighted estimates of PPP and the bars through them are 95% confidence intervals. The asterisks are PPP estimates produced jointly by the OECD and Eurostat.

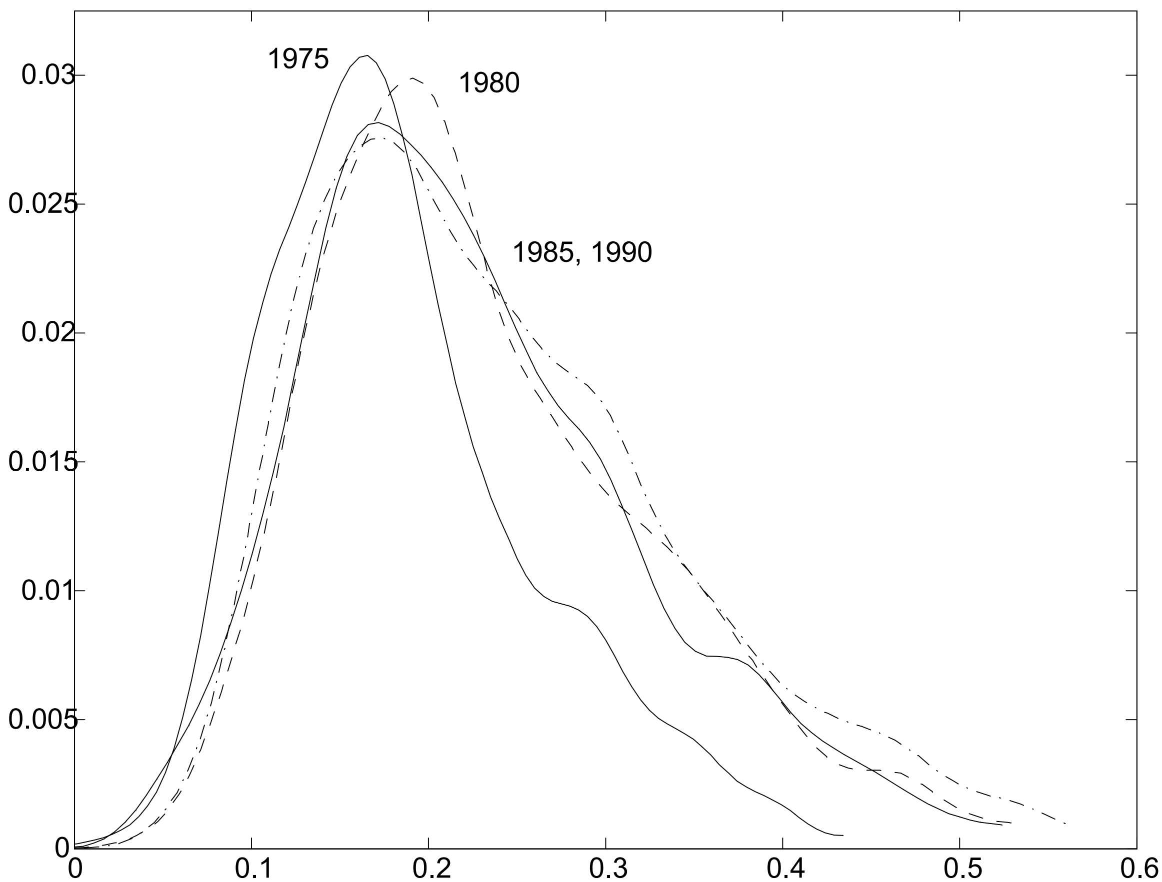

Figure 3: Empirical distributions of good-by-good cross-country price dispersion.

Each line represents an estimate of the density of the mean absolute deviation of national prices compared to the cross-country mean, good-by-good, for a particular year in the cross-section. Specifically, the dispersion measure is defined as: $y_i = mad(z_{ij})$, where $z_{ij} = \frac{e_j p_{ij}}{\sum_{j=1}^{M_i} e_j p_{ij}/M_i} - 1$.