Understanding European Real Exchange Rates

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We study good-by-good deviations from the Law-of-One-Price (LOP) for over 1,800 retail goods and services between all European Union (EU) countries for the years 1975, 1980, 1985, and 1990. We find that for each of these years, after we control for differences in income and value-added tax (VAT) rates, there are roughly as many overpriced goods as there are underpriced goods between any two EU countries. We also find that good-by-good measures of cross-sectional price dispersion are negatively related to the tradeability of the good, and positively related to the share of non-traded inputs required to produce the good. We argue that these observations are consistent with a model in which retail goods are produced by combining a traded input with a non-traded input.

The LOP states that identical goods 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; similar baskets of goods should cost the same once expressed in common units. Each of these propositions is essentially a statement about the *cross-sectional* distribution of international relative prices. Due to data limitations, however, most empirical work has examined the *time-series* distribution of international relative prices. That is, because most data take the form of index numbers, most of what we know about LOP and PPP deviations involves the volatility and persistence of *changes* in relative prices. We know relatively little about the absolute relative prices themselves. This is particularly troublesome given that economic theory places much starker restrictions on absolute LOP deviations than on their changes.

This paper uses a novel dataset on absolute LOP deviations to bridge this gap. Our data are local-currency retail prices for a broad set of goods and services in all EU 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 that are as similar as possible.

We focus on the cross-sectional distribution of the LOP deviations from this dataset. For each good, the deviation is defined relative to that good's intra-European average price. We have two sets of results, the first relating to the mean of the distribution and the second relating to the variance. For the mean, we compute the average LOP deviation across goods for each country. We find that, after controlling for national income and VAT differences, most of the means are close to zero. In only four of 47 cases is a mean greater than 10 percent in absolute value. This phenomenon is quite stable over the time period we study. In simple terms, if we consider most pairs of EU countries with similar incomes and VATs, at any point in time between 1975 and 1990, there are roughly as many overpriced goods as there are underpriced goods.

Our results about the mean go against the grain of many previous studies, which have emphasized large and persistent deviations from PPP. Most of these studies, however, have involved the U.S. dollar and have involved time-series variation over short (i.e., quarterly)

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horizons. Our results, in contrast, apply only to intra-European prices and are characteristic of absolute price dispersion at four different points in time (1975, 1980, 1985, and 1990). They are also consistent with several independent data sources (documented below). Our main point is that one should be wary of extrapolating the "consensus" about real-exchange rate behavior. "Large and persistent deviations from PPP" is not a good description of Europe between 1975 and 1990.

While the mean is across goods for each country, the variance is across countries for each good. That is, we focus on good-by-good dispersion in the absolute LOP deviations. We find that much of this dispersion can be attributed to two classic characteristics of goods: how tradeable they are, and how tradeable the inputs required to produce them are. For example, the average amount of price dispersion in our data is 28 percent. The average is 25 percent versus 40 percent, however, for traded versus non-traded goods. Similarly, the average is 25 percent versus 32 percent for goods requiring a below-average versus an above-average share of non-traded inputs. Combining these effects in a regression framework, we find that if we consider a non-traded good with the maximum share of non-traded inputs, the predicted price dispersion is 43 percent. In contrast, the prediction for the most-traded good, requiring the lowest share of non-traded inputs, is just 12 percent. The difference of 31 percent is large, relative to both the unconditional amount of dispersion in the data, 28 percent, and the range of the good-specific dispersion measures, 2 percent to 82 percent. Interestingly, our estimates suggest that the lion's share of the price dispersion is attributable to the tradeability of inputs, not tradeability of the final good.

Our results stand on their own as empirical facts. In order to provide a tighter link between facts and theory, however, we begin our paper by outlining a simple model of retail price determination. Retail goods are produced by combining a traded input with a non-traded input. LOP deviations are a convex combination of input cost deviations. This simple theory provides a coherent economic context for the motivation and interpretation of our regressions. It also provides functional form restrictions, which we test. We find that, while the explanatory variables suggested by the theory are supported by the data, the functional form restrictions are not. We discuss reasons for the latter and what it suggests about future research directions.

Our work is most closely related to a large body of empirical work on the international comparison of microeconomic prices. Most data either take the form of index numbers across relatively broad sets of goods, or absolute prices across a very narrow sets of goods. Examples of the former are Charles Engel (1993), Engel and John H. Rogers (1996), Alberto Giovannini (1988), Peter Isard (1977), Rogers and Michael Jenkins (1995), and J. David Richardson (1978). Examples of the latter are Robert E. Cumby (1996), Harry Flam (1992), Kenneth Rogoff et al. (1995), Atish R. Ghosh and Holger C. Wolf (1994), Jonathan Haskel and Wolf (2000), Michael M. Knetter (1989, 1993), Matthias Lutz (2004), and David C. Parsley and Shang-Jin Wei (2000). Our data, in contrast, are distinguished by absolute prices across a very broad set of goods. This allows us to say something akin to absolute PPP and also to relate absolute price dispersion to the characteristics of goods in the cross section.[1]

The remainder of the paper is organized as follows. We begin in Section I by outlining a conceptual framework, both in terms of data objects and economic theory. Section II describes our data. Our analysis is organized around understanding the mean and the variance of the cross-sectional distribution of the LOP deviations from this data. Section III examines the mean and Section IV examines the variance. Section V concludes.

I. Conceptual Framework

Before describing our data, it is useful to develop a conceptual framework with which to

[1] Some recent work that has used a broad cross-sectional dataset on absolute prices from the Economist Intelligence Unit includes Crucini and Mototsugu Shintani (2004), Engel and Rogers (2004), Parsley and Wei (2003), and Rogers (2001). These data are quite broad in terms of countries, but lack the detail and, to some extent, the comparability, of the goods in our Eurostat (the Statistical Agency of the European Community) source. It also covers a more recent time period, 1990–present. In addition Collin Crownover et al. (1996) use data on price levels from Internationaler Vergleich der Preise fur die Lebenshaltung, published by the German Statistical Office. The data are annual from 1927 to 1992 and cover six major industrialized countries.

organize it. The price data we seek to understand are denoted P_{ij}: the price of good i in country j, expressed in units of some numeraire currency. None of our analysis will depend on what this numeraire currency is. We transform the price data into log deviations from the geometric-average European price, which we denote q_{ij}:

$$(1) \qquad q_{ij} \equiv \log P_{ij} - \sum_{j=1}^{M} \log P_{ij}/M$$

where M is the number of countries. Note that q_{ij} is independent of the numeraire.

Most of our paper attempts to relate dispersion in q_{ij}, across countries j, to economically meaningful characteristics of the goods i. Following Bela Balassa (1964), William J. Baumol and William G. Bowen (1966), Paul A. Samuelson (1964), Wilfred Ethier (1979), Irving B. Kravis and Robert E. Lipsey (1983), and Alan C. Stockman and Linda L. Tesar (1995), we focus on two characteristics: the international tradeability of the good and the amount of non-traded inputs required to produce the good. To be concrete, consider a typical non-traded good, a taxi ride. As is often asserted, all retail goods involve significant amounts of non-traded inputs, such as labor. A taxi ride is no exception. Less well appreciated, however, is the fact that all non-traded goods involve traded inputs, in this case the automobile and gasoline. We use the following simple framework to organize this view of what distinguishes goods in different locations.

We view retail goods as being produced by combining a non-traded input with a traded input. With perfect competition, Cobb-Douglas technology and constant returns to scale, we have

$$(2) \qquad P_{ij} = W_j^{\alpha_i} T_{ij}^{(1-\alpha_i)}$$

where W_j is the cost of the non-traded input in country j (e.g., the wage rate), α_i is the share of the non-traded good required to produce good i, and T_{ij} is the cost of the traded input for good i in country j. Inherent in the notation are two standard assumptions. The first is that factor mobility is much higher across sectors within a country than across countries; W_j is country-specific, not good-specific. The second is that retailers in all countries produce good i using the same production technology; α_i is good-specific, not country-specific.

Taking logs of equation (2) and subtracting the geometric average (across j) gives

$$(3) \qquad q_{ij} = \alpha_i w_j + (1 - \alpha_i) t_{ij}$$

where, following equation (1), w_j and t_{ij} denote log differences from the cross-country geometric average. Equation (3) says that deviations from LOP should be related to cross-country differences in non-traded and traded factor input costs, as well as differences in the production share attributable to each. Differences in non-traded input costs are the crux of the classic Balassa-Samuelson hypothesis, with w_j being positive for countries with higher productivity in the traded sector relative to the non-traded sector. Differences in traded costs are often thought of as deriving from transport costs, with t_{ij} being positive for an importer of good i and negative for an exporter.

Our empirical work is organized around equation (3). In Section III we begin by examining the country-specific cross-sectional means, which we denote $E(q_{ij}|j)$. These variables are close cousins of real exchange rates. We find that w_j is important in the sense that the mean is negative for relatively poor countries. We also find that, having controlled for income differences, $E(q_{ij}|j)$, is often quite close to zero for most European countries. The interpretation offered by equation (3) is that t_{ij} changes sign a lot across goods. In other words, countries import some goods, export others, and on average the effects on LOP deviations cancel out.

In Section IV we examine the cross-sectional variances, denoted $Var(q_{ij}|i)$. That is, we examine how cross-country dispersion in LOP deviations varies across goods. According to equation (3),

$$(4) \qquad Var(q_{ij}|i) = \alpha_i^2 Var(w_j) + (1 - \alpha_i)^2 Var(t_{ij}|i) + 2\alpha_i(1 - \alpha_i) Cov(w_j, t_{ij}|i).$$

We estimate a cross-sectional regression (across i) corresponding to this equation. We use industry-level data on the share of non-traded inputs required for production as a proxy for α_i. We use industry-level data on the tradeability of the final good—as measured by international trade flows divided by total output—to proxy for $Var(t_{ij}|i)$. We find that an economically important portion of the price dispersion across goods can be accounted for by tradeability and non-traded input cost shares.

Having laid out our data requirements, we now describe our data.

II. The Data

Corresponding to equation (1), we begin by describing our data on local currency prices, P_{ij}, of goods i in countries j.

Our price data are from a series of publications of Eurostat (1975–1990).[2] The publications contain the results of four surveys of retail prices in the capital cities of EU countries for each of the years 1975, 1980, 1985, and 1990.[3] For our purposes it is sufficient to treat the surveys as four separate cross sections. It is important to note, however, that the goods in each cross section maintain a high degree of comparability, across both locations and time. Table 1 presents basic information about what these cross sections entail. The 1975 survey covers nine EU countries. Greece, Portugal, and Spain were added in 1980. Austria was added in 1985. The number of goods also grows over time, from 658 items in 1975 to 1,896 items in 1990. Finally, a substantial fraction of goods are labeled as "branded goods." The importance, for our purposes, is in terms of comparability of goods. In many cases we are literally talking about the same automobile, portable radio, or type of cheese.[4]

TABLE 1—SCOPE OF THE PRICE SURVEYS

	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 branded goods	31%	42%	48%	54%
Panel B: After eliminating goods with insufficient data and 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 branded goods	31%	28%	33%	38%

Notes: The countries are Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, and United Kingdom (all years), Greece, Portugal, Spain (added in 1980), and Austria (added in 1985). In panel B, we eliminate any observation that has a relative price more than or less than five times that of the EU median. Then we eliminate goods for which there are more than four missing observations in 1975, five in 1980, and six in 1985 and 1990 (this ensures that, for each good, we have data for at least half of the countries). The category "Proportion of branded goods" refers to the proportion of goods for which two or more brands exist in the price survey. Explicit descriptions of the goods are available at http://www.e-aer.org/data/june05_app_crucini.pdf.

[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.

As Table 1 indicates, there are a great number of missing observations in the price surveys: 13 percent in 1975, an abrupt increase in 1980 to 36 percent, and a similar level in 1985 and 1990. This increase does not reflect a discrete change in the data collection procedure, but instead (we hypothesize) the inclusion of lower-income countries which tend to consume fewer items of the survey's basket of goods. The number of missing observations also differs systematically across countries from a low of about 9 percent to a high of about 55 percent. Belgium is consistently the country with the fewest missing 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 that has an insufficient number of cross-country observations, which we define as four in 1975, five in 1980, and six in 1985 and 1990. The increments reflect the fact that the number of countries in the sample increases over time.

[2] The data were not made available to us by Eurostat. We obtained hard-copies of the publications from various libraries and had the data entered into an electronic format by a professional data-entry firm.

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

[4] A comprehensive list of the goods is available at http://www.e-aer.org/data/june05_app_crucini.pdf. The raw data will also be made available at this location in the future.

TABLE 2—SAMPLE RECORDS FROM PRICE SURVEY

Code	Good description	Units	AUS	BLG	DEN	FRF	GER	GRC	IRL	ITL	LUX	NET	POR	ESP	UK
11111	Long grn rice, carton	500 g	26	50	48	52	52	42	51	35	52	36		39	32
11251	Chicken-fresh, 70% pres	1.2 kg	107	204	207	203		115	159	163			88		148
11421	Cond. milk 9–10% b.f.	410 g		48			56	31				54	56	42	42
11621	Dried almonds	100 g	28	54		61	34	28	43	35	54	49	37	49	50
11911	Ground blended coffee	1 kg	234	439	425	350				586		355	451	437	446
13112	Liqueur—s.b.	0.7 L		579	1294	542	599	589	980	414	502	599	1152	491	910
21112	Man's k-way jacket	1 nb	1584	544	1596	1022	824	1373	1331	872	996	1196	904	713	
22121	Ladies boots, box caf	1 pr	3720	4027	4095	3733	3692	2645	2362		4422	2615	2745	2951	3176
41112	Chest of drawers	1 nb	2834	6988	2192	11400	4889	2904	5078	7186	3990	7742	3529	4630	4065
42111	Spring mattress: s.b.	1 nb	4070		3923	3253	2674					3803			
43121	Dishwasher: s.b.	1 nb		23480						23548			22705	22823	
43161	Iron: steam, s.b.	1 nb	2436		2201	1925	2089	3018		1916	1745	1810	2495	2450	1485
45111	Washing powder: s.b.	700 g	414	299		337	316		310		313				
52211	Hearing aid: s.b.	1 nb				29528	25976					23343	17734	19134	26054
61113	Car: 1200–1700 cc, s.b.	1 nb	357298		524411	341213						346786	356516		
61212	Bicycle: racing, s.b.	1 nb				15147	19314				18000	17788			15238
63111	Bus fare, 6 km, no transf	1 tik	52	30	50	58	43	9	41	12	25	39	17	16	33
71131	Record player, s.b.	1 nb	7091	5190		5158	4172	10955		4719	4848	4861	4194	7828	
71311	Cassette for game: s.b.	1 nb	873	850		1299			948	1072	1066	400			764
72221	Rental of television	1 mo		2296	1340	1631	1191	2962	1382	1285	3136	1490	1670	1795	1487

Notes: Sample of 20 records from the original 1,805 records of the 1985 survey. Currency units are Belgian francs. Countries are Austria (AUS), Belgium (BLG), Denmark (DEN), France (FRF), Germany (GER), Greece (GRC), Ireland (IRL), Italy (ITL), Luxembourg (LUX), the Netherlands (NET), Portugal (POR), Spain (ESP), and the United Kingdom (UK). Branded goods are denoted 's.b.' (selected brand). Prices are rounded to the nearest franc, although the raw data (and our analysis) are in units of francs and centimes. Blank entries denote missing data.

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 five 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 the remaining data, the proportion of missing observations never exceeds 25 percent. 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 represent the various categories of goods and services 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 include such taxes as VAT (we control for VAT below). The prices are averages of the surveyed prices across different city-wide sales points.[5]

As is evident from the sample of goods reported in Table 2, the surveys are as comprehensive as those used to construct national consumer price indices. We see food items, clothing, major appliances, automobiles, services, and so on. Although Eurostat reports the prices in local currency units, Table 2 presents prices in Belgian francs to facilitate comparisons. The deviations we see from the LOP are suggestive of what is to come. The rental cost of a television, for example, varies widely across countries, whereas the dispersion in the cost of rice is considerably smaller.

The goods-descriptions published by Eurostat 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 Table 2) and those without such a designation. The reason provided by Eurostat 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. It is important to note, however, that the survey is explicitly designed to assure comparability of goods across locations.

One last issue 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 are collected in a

[5] 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.

sequence of surveys. In what we call "1985," for example, the prices of most services were collected in September and October 1985, while prices of most clothing items were collected in December 1984. The nominal exchange rate data, with which we convert prices into a common currency, take explicit account of this timing, taking the form of averages of daily data over the relevant time intervals.

A. *Supplemental Data*

Following the discussion in Section I, we supplement our retail price data with data on tradedness 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.

The variable α_i in equation (4) is the non-traded input share for good i. We measure this as the ratio of non-traded input costs to total cost where both numbers are computed from the 1988 input-output tables of the United Kingdom.[6] Table A1 of the Data Appendix (available at http://www.e-aer.org/data/june05_app_crucini.pdf) contains the cost shares of non-traded intermediate inputs by industry. The values range from a low of 4.6 percent for tobacco to a high of 31.8 percent for forestry and fisheries.

The other variable in equation (4), $Var(t_{ij}|i)$, is the cross-sectional variance (across locations j for each good i) in the traded input cost. We proxy this with the tradeability of the final good, measured 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.[7] The (admittedly coarse) idea is that, at the retail level, the intermediate input is often very similar to the final good itself. A seller of computers combines labor with computers and sells computers. The same applies to the seller of furniture. Since computers are more tradeable than furniture, however, the cross-sectional dispersion in the "intermediate input cost" for computers should be lower than that for furniture. Table A2 of the Data Appendix reports the trade shares. Among traded goods, average shares for the period 1974 to 1990 range from a low of 13 percent for tobacco products and 15 percent for printing, publishing, and allied industries, to highs of 122 percent for professional goods and 121 percent for office and computing machinery. The average trade share across goods for this period is a substantial 53 percent.

Comparing some of the numbers in Tables A1 and A2 suggests that the distinction between tradeability and trade in "middle products" is important. Leather products, for instance, are highly tradeable in the sense that their trade share is high and their non-traded input share is low. The exact opposite is true of most service-related goods. Forestry products (telecommunications), in contrast, are quite tradeable (non-tradeable), yet they require a large (small) amount of non-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 empirical analysis is designed to identify these two economic effects separately.

The remaining supplemental data we use are data on European nominal exchange rates, national income, and VAT rates. Details are provided in the Data Appendix.

III. LOP Deviations: The Mean of the Distribution

Figure 1 summarizes the empirical distribution of deviations from the LOP, q_{ij} defined in equation (1). The figure contains one chart for each country. Each chart reports one kernel estimate of the density of q_{ij} for each available year. We see four striking features. First, and most obviously, LOP deviations can be large, with the support of most of the densities being on the order of ± 100 percent. Second, there is a clear income effect. The densities of the relatively poor countries—Greece, Portugal, and

[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.

[7] We use the actual trade share whenever trade data are 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.

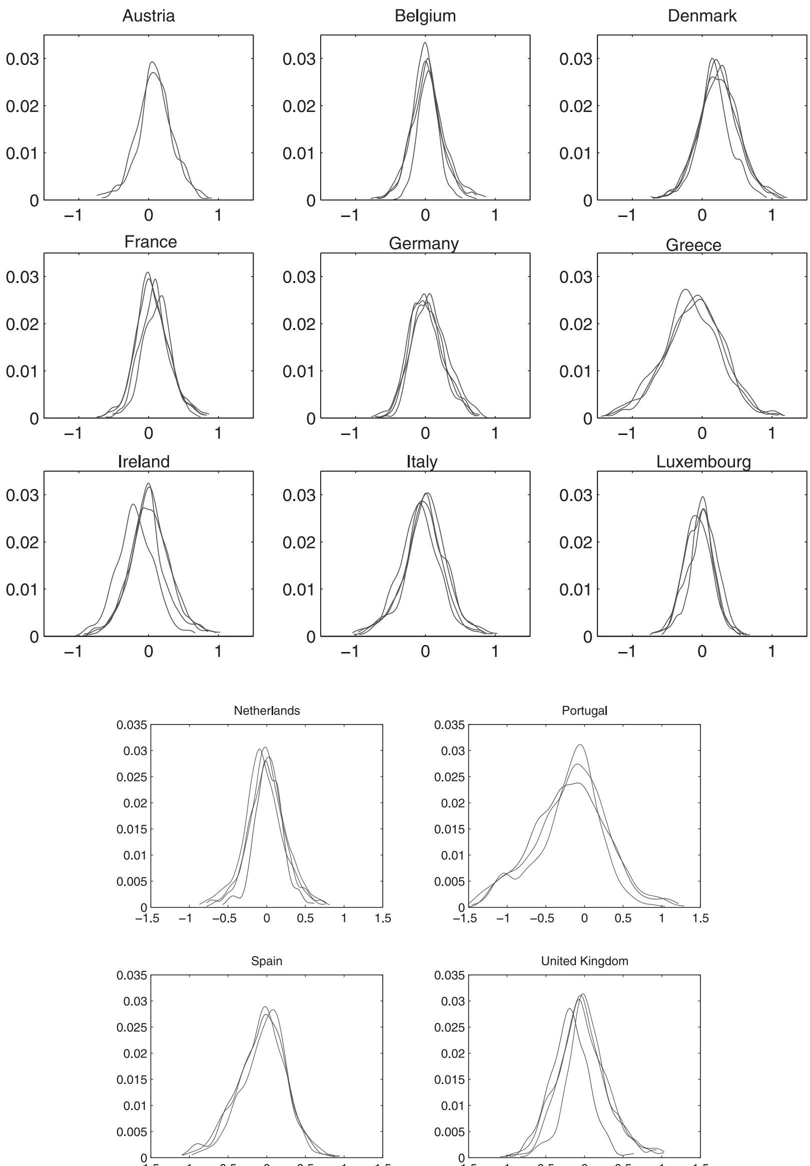

FIGURE 1. EMPIRICAL DISTRIBUTIONS OF LOP DEVIATIONS

Notes: Each line represents an estimate of the density of good-by-good deviations from the LOP, relative to the European average price, for each of the years 1975, 1980, 1985, and 1990. The exceptions are Austria, where we do not have data for 1975 and 1980, and Greece, Spain, and Portugal, where 1975 is missing.

Spain in particular—seem to be located farther to the left. Third, for the other (relatively wealthy) countries, most of the densities seem to be located near zero. That is, there seem to be roughly as many overpriced goods as underpriced goods. Finally, this latter phenomenon seems quite stable over time. In spite of many relatively large nominal exchange rate movements, the location and

TABLE 3—AVERAGE (ACROSS GOODS) LOP DEVIATION

Panel A: Without VAT adjustment

		Without income adjustment				With income adjustment			
Country	z_j	1975	1980	1985	1990	1975	1980	1985	1990
Luxembourg	0.299	−0.009	0.030	−0.043	−0.027	−0.097	−0.045	−0.137	−0.165
Denmark	0.260	0.177	0.215	0.222	0.219	0.081	0.132	0.125	0.155
Netherlands	0.126	0.023	0.018	−0.055	−0.007	−0.031	−0.022	−0.088	−0.030
France	0.126	0.119	0.112	0.075	0.072	0.084	0.072	0.034	0.039
Belgium	0.122	0.042	0.044	0.067	0.053	0.006	0.002	0.032	0.023
Germany	0.105	0.066	0.089	0.013	0.053	0.046	0.055	−0.028	0.028
Austria	0.096			0.096	0.078			0.065	0.049
Italy	0.061	−0.055	−0.087	−0.007	0.034	−0.050	−0.105	−0.030	0.014
U.K.	0.035	−0.200	0.050	−0.001	−0.037	−0.213	0.054	−0.011	−0.038
Spain	−0.192		−0.100	−0.082	−0.067		−0.018	0.013	0.015
Greece	−0.257		−0.170	−0.170	−0.173		−0.098	−0.067	−0.023
Ireland	−0.323	−0.195	−0.029	0.048	0.012	−0.052	0.104	0.170	0.102
Portugal	−0.457		−0.213	−0.174	−0.254		−0.046	0.008	−0.114
Std. Dev.	0.232	0.129	0.123	0.109	0.118	0.094	0.077	0.083	0.083

Panel B: With VAT adjustment

		Without income adjustment				With income adjustment			
Country	z_j	1975	1980	1985	1990	1975	1980	1985	1990
Luxembourg	0.299	0.029	0.056	−0.020	0.018	−0.035	0.002	−0.089	−0.082
Denmark	0.260	0.143	0.108	0.124	0.144	0.074	0.048	0.053	0.098
Netherlands	0.126	0.024	−0.001	−0.073	−0.012	−0.015	−0.031	−0.097	−0.029
France	0.126	0.074	0.065	0.041	0.056	0.049	0.036	0.011	0.032
Belgium	0.122	0.016	0.015	0.036	0.046	−0.011	−0.016	0.010	0.024
Germany	0.105	0.078	0.077	−0.002	0.060	0.063	0.053	−0.031	0.042
Austria	0.096			0.044	0.050			0.021	0.028
Italy	0.061	−0.042	−0.097	−0.028	0.032	−0.039	−0.110	−0.045	0.017
U.K.	0.035	−0.152	0.056	0.016	0.007	−0.161	0.059	0.009	0.005
Spain	−0.192		−0.018	0.003	−0.048		0.041	0.072	0.012
Greece	−0.257		−0.088	−0.083	−0.169		−0.036	−0.009	−0.061
Ireland	−0.323	−0.200	−0.060	0.035	0.029	−0.096	0.037	0.123	0.094
Portugal	−0.457		−0.134	−0.087	−0.251		−0.013	0.044	−0.150
Std. Dev.	0.232	0.111	0.078	0.060	0.103	0.076	0.050	0.062	0.069

Notes: The variable z_j denotes average log income differences, 1975–1990, relative to the EU average. The remaining data are equally weighted averages of LOP deviations, across goods i, for each country j: $E(q_{ij}|j)$. Standard errors were reported in the previous version of the paper (available at http://www.e-aer.org/data/june05_app_crucini.pdf) but are omitted here for space considerations. All standard errors are between 0.01 and 0.02 with the exception of those from Greece, Portugal, and Spain which are between 0.015 and 0.025. Income and VAT adjustment are described in the text and the Data Appendix. For these calculations we eliminate multiple brands of the same good.

shape of the densities don't seem to move around much.[8]

To be more precise, Table 3 reports the sample means, $E(q_{ij}|j)$, of the density estimates from Figure 1. The countries are organized from richest to poorest. The values in the left-most columns of panel A confirm what we see in Figure 1; many of the means for the relatively rich countries are within the interval ± 10 percent. There are, however, some exceptions, most notably Denmark. With this in mind, the remainder of the table makes the following adjustments.

(a) First, we use industry/year-specific data on VAT rates to reduce each price in our

[8] There are several glaring exceptions but, interestingly, they go against the notion that movements in the distribution are driven by movements in nominal exchange rates. Between 1975 and 1980, for instance, average prices in Ireland and the United Kingdom increased substantially relative to Europe (see also Table 3), yet their currencies actually *devalued* relative to Europe.

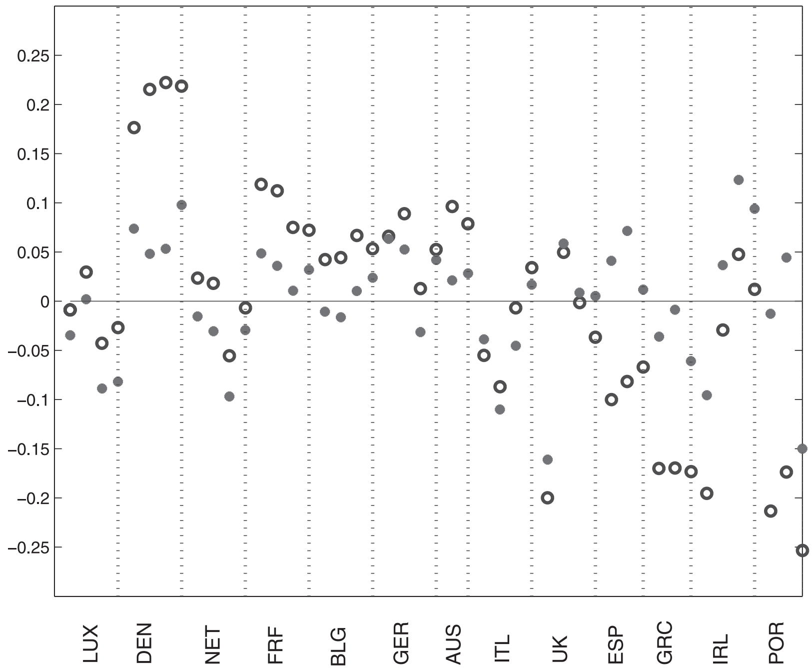

FIGURE 2. AVERAGE LOP DEVIATIONS
(Raw data (circles) and income/VAT adjusted (filled circles))

Notes: Each point is the average LOP deviation for a particular country/year. Vertical dashed lines delineate countries. Each point between these dashed lines is one particular year for that country. Thus, the first four points represent Luxembourg for 1975, 1980, 1985, and 1990, the next four represent Denmark for the same years, and so on. The countries are organized from lowest to highest income, as in Table 3. Finally, open circles represent unadjusted data (i.e., the means from Table 3 in the left-most columns of panel A), whereas filled circles represent means which have been adjusted for income and VAT differences (i.e., from the right-most columns of panel B in Table 3).

dataset to be a before-VAT rate. The VAT data are described and documented in the Data Appendix. Note that Denmark is by far the highest VAT country. We then recompute the values q_{ij} and their cross-good averages. The results are reported in Table 3, in the left-most columns of panel B.

(b) Second, we adjust the means for relative income differences via the regression

$$(5) \quad E(q_{ij,t}|j, t) = a + bz_{j,t} + \text{residuals}$$

where $z_{j,t}$ denotes the (log) per-capita income difference between country j and the EU average in date t, and (as above), and $E(q_{ij,t}|j)$ denotes the (cross goods i) average LOP deviation for country j relative to the EU average at date t.[9] The results are reported in the rightmost columns of Table 3.

Net of these adjustments, the average deviations from LOP are substantially reduced and are quite small in magnitude. Out of 47 average LOP deviations, only four are outside the interval ±10 percent. The standard deviations of the averages (across countries), shown in the final row of each panel, are reduced by almost half. Figure 2 provides emphasis by plotting the av-

[9] The time subscript is included here to indicate that, in our relative income adjustments, we incorporate the important changes that occurred during 1975–1990 (e.g., Ireland).

TABLE 4—AVERAGE (ACROSS GOODS) LOP DEVIATION BY TRADEDNESS

	1975			1980			1985			1990		
	All	Traded	Non-traded	All	Traded	Non-traded	All	Traded	Non-traded	All	Traded	Non-traded
Luxembourg	−0.035	0.006	−0.273	0.002	0.009	−0.031	−0.089	−0.064	−0.239	−0.082	−0.043	−0.318
Denmark	0.074	0.082	0.020	0.048	0.067	−0.064	0.053	0.063	0.001	0.098	0.101	0.083
Netherlands	−0.015	−0.023	0.016	−0.031	−0.055	0.109	−0.097	−0.108	−0.027	−0.029	−0.049	0.094
France	0.049	0.045	0.063	0.036	0.026	0.098	0.011	0.001	0.068	0.032	0.038	−0.005
Belgium	−0.011	−0.012	−0.003	−0.016	−0.034	0.094	0.010	0.008	0.026	0.024	0.018	0.067
Germany	0.063	0.049	0.137	0.053	0.040	0.128	−0.031	−0.046	0.051	0.042	0.022	0.149
Austria							0.021	0.010	0.083	0.028	0.015	0.124
Italy	−0.039	0.000	−0.247	−0.110	−0.097	−0.186	−0.045	−0.026	−0.165	0.017	0.039	−0.108
U.K.	−0.161	−0.151	−0.222	0.059	0.036	0.184	0.009	−0.026	0.217	0.005	−0.056	0.326
Spain				0.041	0.044	0.028	0.072	0.079	0.017	0.012	0.015	−0.020
Greece				−0.036	−0.010	−0.160	−0.009	0.007	−0.111	−0.061	−0.035	−0.278
Ireland	−0.096	−0.115	0.017	0.037	−0.002	0.261	0.123	0.085	0.351	0.094	0.059	0.298
Portugal				−0.013	0.026	−0.222	0.044	0.076	−0.133	−0.150	−0.117	−0.301
Std. Dev.	0.076	0.076	0.151	0.050	0.047	0.153	0.062	0.059	0.158	0.069	0.058	0.211

Notes: See notes to Table 3. Data here are identical (income/VAT adjusted) except for the distinction between traded and non-traded goods. A non-traded good is defined as having a trade share equal to zero according to Table A2 of the Data Appendix.

erage LOP deviations before and after income/VAT adjustment.[10]

What does the simple model of Section I have to say about these results? First, the interpretation of the income adjustment is obvious; it represents cross-country variation in w_j in the manner of Balassa-Samuelson. Second, the fact that (net of VAT) the remaining average price differences are small suggests that t_{ij} changes sign a lot across goods. Countries import some goods, export others, and on average the effects on LOP deviations cancel out.

Further evidence is provided in Table 4, where we distinguish the averages $E(q_{ij}|j)$ by the tradedness of the goods across which the average is taken. We see that average prices for traded goods tend to be much closer to zero than for non-traded goods. While this is interesting in and of itself, our model suggests two possibilities. First, cross-sectional variation in the α_i's for non-traded goods could bias our income adjustment, which (in Table 4) is done based on the *average* traded/non-traded LOP deviation. Second, it could be the case that, among the set of non-traded goods for a particular country, there is less "averaging out" associated with some traded inputs being exported and others imported. Our supplementary data are not yet rich enough to distinguish between these possibilities.

IV. LOP Deviations: The Variance of the Distribution

We now examine good-by-good price dispersion which, as in equation (4), we measure as the variance of q_{ij} across countries j: $\sigma_i^2 \equiv Var(q_{ij}|i)$. Figure 3 plots kernel estimates of the density of σ_i for each year. We see that different goods can have substantially different amounts of price dispersion, with the sample standard deviations ranging from 2 percent to 80 percent. While it might seem that price dispersion increased after 1975, this is instead an artifact of the sample of countries expanding in 1980 to include lower-income countries.

Table 5 reports means of the distributions from Figure 3 broken down by year, tradeability, and the fraction of non-traded inputs required for production. We see strong evidence that these variables are important determinants of good-by-good price dispersion. Average price dispersion across traded goods is 25 percent versus 40 percent for non-traded goods. The average for goods with above-average share of non-traded inputs is 32 percent versus 25 percent for goods with a below-average share.

[10] In a previous version of the paper, available at http://www.e-aer.org/data/june05_app_crucini.pdf, we show that CPI expenditure share weighted averages tell very much the same story as the equally weighted averages reported here. In addition, we perform a number of consistency checks on our data using different data sources. We show that (a) before income/VAT adjustment, our estimates of (absolute) average LOP deviations are quite similar to the absolute PPP data available from the OECD and from the Penn World Tables (PWT); and (b) when we first-difference our data (necessarily over five-year intervals), the implications for correlations between changes in real and nominal exchange rates (e.g., Michael Mussa, 1986) are consistent with those from the PWT, the OECD, and the national CPI data contained in the International Financial Statistics (IFS).

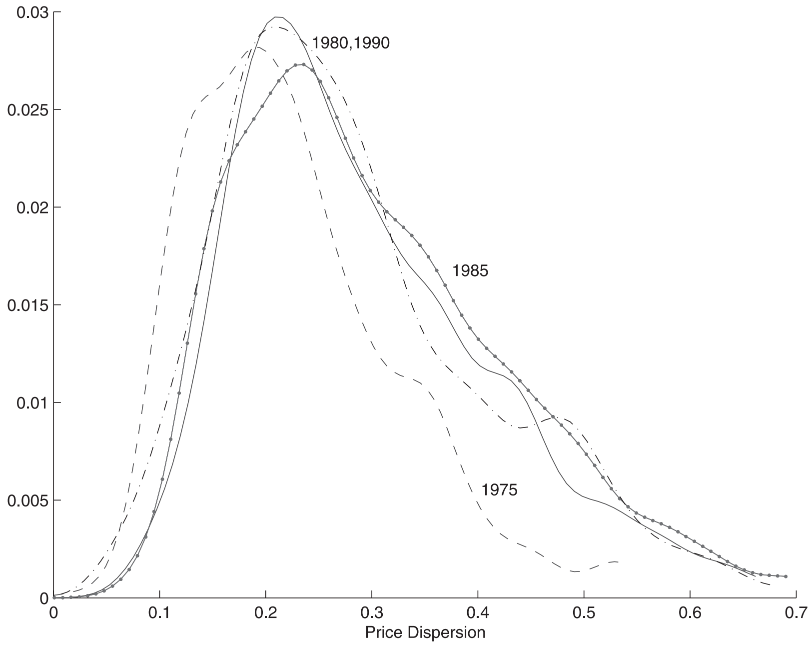

FIGURE 3. EMPIRICAL DISTRIBUTIONS OF $Var(q_{ij}|j)^{1/2}$

Note: Each line represents an estimate (for each year) of the density of $Var(q_{ij}|i)^{1/2}$, the standard deviation of the LOP deviation for good i across countries j.

Next we consolidate this information in a regression framework.

A. *Regressions*

We begin by slightly rewriting our model of price dispersion, equation (4), as

$$(6) \qquad \sigma_i^2 = \alpha_i^2 Var(w_j) + (1 - \alpha_i)^2 x_i$$

where, for notational simplicity, we define $x_i \equiv Var(t_{ij}|i)$. Recall that, as is discussed in Section II A, we do not have direct data on t_{ij}. Instead, we proxy x_i itself with a measure of the tradeability of the final good. We also assume that the conditional covariance from equation (4) is zero.[11] Based on this, Table 6 reports estimates of the parameters of the following regression:

$$(7) \qquad \sigma_i^2 = a + b\alpha_i^2 + c(1 - \alpha_i)^2 x_i + \text{residuals}.$$

We see that the coefficients are all highly significant and that the regression function explains a significant portion of the cross-sectional variation in our data on price dispersion. Moreover, the coefficients are economically significant. For example, if we consider the good with the smallest share of non-traded inputs α_i, and the smallest x_i (the latter meaning that the good is highly traded), the predicted price dispersion (based on the pooled regression) is 0.12 (in standard deviation). The opposite case—the good requiring the most non-traded inputs with the highest x_i (lowest tradeability)—gives a value of 0.43. The increase of 0.31 is substantial, both relative to the unconditional (average) dispersion in the data (standard deviation of roughly 0.28), as well as the range of σ_i which is 0.02 to 0.82.

[11] We do not have data that allow us to identify variation in $Cov(w_j, t_{ij}|i)$ across goods i. Given this, the only alternative is to assume a constant instead of zero. The difference, however, is minor, resulting in only a slightly more complex quadratic function via the inclusion of the term $\alpha_i(1 - \alpha_i)$. Moreover, when we do this, we find that (a) the hypothesis that the coefficient on the additional variable is zero cannot be rejected; and (b) the economic implications of the remaining parameter estimates are almost identical to those of equation (7).

TABLE 5—AVERAGES OF GOOD-SPECIFIC MEASURES OF PRICE DISPERSION

	1975	1980	1985	1990	Average
All goods	0.2290	0.2941	0.3024	0.2855	0.2777
Non-traded goods	0.3138	0.4146	0.4252	0.4537	0.4018
Traded goods	0.2164	0.2750	0.2846	0.2596	0.2589
Above avg. share of services	0.2619	0.3372	0.3464	0.3378	0.3208
Below avg. share of services	0.2116	0.2703	0.2779	0.2551	0.2537

Notes: Values are averages of good-specific measures of price dispersion. Each value is the average (across goods i) of $Var(q_{ij}|i)^{1/2}$, the good-by-good sample standard deviation, where the standard deviation is across countries j.

What does theory add here? There are two main differences between the regression (7) and the (obvious) reduced-form regression of σ_i^2 on α_i and x_i. The first is the quadratic functional form. This is a relatively uninteresting artifact of our choice of price-dispersion measure, the variance. Empirically, it turns out to be of little importance. The second difference relates to economics. The essence of the interaction term, $(1 - \alpha_i)^2 x_i$, is that the explanatory power of the tradeability variable, x_i, should diminish for goods requiring a high share of non-traded inputs, α_i. If most of the cost of a taxi ride is labor, then the relative price of gasoline shouldn't matter much.

We examined the importance of the interaction term in several ways. All of them indicated that this restriction is inconsistent with our data. For example, if one writes out equation (4) as a quadratic function of five variables, two of those will be α_i and x_i. In no case were we able to reject the hypothesis that the coefficients on the remaining variables were equal to zero. Similarly, if we add the interaction term to the simple linear specification involving α_i and x_i, we cannot reject the hypothesis that its coefficient is zero. Finally, we took a subsample of goods with relatively high non-traded input shares and regressed the price dispersion measures from this subsample on our tradeability measure. We found strong evidence that the opposite is true. That is, the tradeability measure x_i has more explanatory power conditional on high non-tradedness, not low non-tradedness.

Overall, the message is that α_i and x_i have strong explanatory power for cross-sectional price dispersion, but that the functional-form restrictions from our theory are not an important part of this. This could represent a limitation of the theory. It could also represent a limitation of our data on the characteristics of individual goods. One limitation is that we are forced to use industry-level data to try to explain good-specific price dispersion. More important, in our view, is our use of the trade share as a proxy for trade costs. As is well known, the volume of trade depends upon not only trade costs, but also comparative advantage and the elasticity of substitution between domestic and foreign goods. Carolyn L. Evans (2003), for example, shows how a traditional gravity model of trade predicts that bilateral trade flows depend

TABLE 6—REGRESSION ESTIMATES

$\sigma_i^2 = a + b\alpha_i^2 + c(1 - \alpha_i)^2 x_i$ + residuals					
Year	a	b	c	R_a^2	R_d^2
1975	0.083	0.299	0.090	0.433	0.120
	(0.006)	(0.115)	(0.013)		
1980	0.099	0.921	0.051	0.291	0.107
	(0.007)	(0.143)	(0.012)		
1985	0.115	0.791	0.059	0.319	0.106
	(0.006)	(0.118)	(0.008)		
1990	0.122	1.033	0.100	0.537	0.291
	(0.005)	(0.106)	(0.008)		
Pooled	0.102	0.868	0.062	0.417	0.129
	(0.003)	(0.064)	(0.005)		

Notes: Estimates of the parameters of the regression are based on equation (7) in the text. σ_i^2 denotes our good-specific measure of price dispersion: the sample variance of q_{ij} from equation (1) in the text. α_i denotes the non-traded input share for good i and x_i is (the negative of) the trade share of good i (see Section II A for details). Standard errors are in parentheses. Because our explanatory variables are averaged across different numbers of goods within industry groups, the residuals will be heteroskedastic. We therefore use a feasible GLS estimator (details are provided in the Data Appendix). R_a^2 denotes the regression R^2 that results in averaging the dependent variable in the same manner as the explanatory variables. R_a^2 denotes the regression R^2 from the "raw regression" where, necessarily we are trying to account for variation in σ_i^2 using variables that have (potentially) had some of their explanatory variation averaged away.

(negatively) upon the trade cost multiplied by the elasticity of substitution. Thus, higher trade shares could reflect lower elasticities of substitution, higher trade costs, or both. Future work should concentrate on developing additional microeconomic data on the characteristics of individual goods, including elasticities of substitution.

V. Concluding Comments

A considerable body of empirical and theoretical work in international economics attempts to answer two basic questions. The first question is: What determines whether a deviation from the LOP will be large or small? The second question is: What determines whether a deviation from the LOP will be enduring or short-lived?

The empirical literature on the first question is very limited due to a paucity of absolute price data on comparable goods across international locations. The theoretical literature, in contrast, is well-developed and offers a number of potential answers. The models of Bernard Dumas (1992) and Piet Sercu et al. (1995) emphasize the magnitude of shipping costs in consumption goods and physical capital, respectively. The models of Paul R. Krugman (1987) emphasize imperfect competition. The models of Balassa (1964) and Samuelson (1964) emphasize productivity differences across traded and non-traded goods. The models of Ethier (1979) and Ronald W. Jones and Kalyan K. Sanyal (1982) emphasize that much of international trade takes place in intermediate inputs, not final goods and services. In each case, the first-order restrictions from theory are on absolute LOP deviations. Our paper represents the development of better data to test these restrictions. What we find is encouraging from the perspective of theory. An economically important part of the heterogeneity across goods in LOP deviations is related to the tradeability of the good and the share of non-traded inputs required to produce the good.

The empirical literature on the second question is vast, in part because persistence may be studied using relative versions of the LOP and PPP, thus eliminating the need for absolute price data. The consensus is that the half-lives of deviations from parity last between three and five years.[12] The theoretical literature, however, has focused almost exclusively on the adjustment (or lack of adjustment) of domestic-currency prices to changes in the nominal exchange rate. In particular, the sticky-price models, which have followed Maurice Obstfeld and Rogoff (1995), are distinguished by assumptions of when firms can change their prices and, therefore, impose first-order restrictions on changes in LOP deviations. Given the persistence of the deviations, most economists believe that sticky prices, in their various forms, cannot account for the observed persistence in real exchange rates.

Is there an important link between these questions? We think so, in spite of the fact that the two bodies of literature addressing them have evolved more or less independently. To understand this, consider the "PPP Puzzle" posed by Rogoff (1996); the persistence and conditional volatility in PPP and LOP deviations are too large to be consistent with sticky-price models in conjunction with data on price-setting behavior. Models of goods-market arbitrage and non-traded inputs, in contrast, restrict the unconditional volatility of PPP and LOP deviations. This is where the link lies. If the unconditional volatility restrictions are supported by the data—as our study suggests—then we are led to rethink our interpretation of the time-series evidence. Rogoff (1996), for instance, interprets the evidence as suggesting, "International goods markets, though becoming more integrated all the time, remain quite segmented, with large trading frictions across a broad range of goods." Our view is that this is too broad a brush. While it is certainly true for Big Macs, the set of goods for which it is suspect goes beyond gold bullion. Moreover, theory is informative for which goods are in the set and which are not. A promising avenue for future work involves further integration of arbitrage-based models—which impose absolute bounds on LOP deviations—with models which describe behavior within the bounds, such as sticky-price models and models where most trade is at the level of intermediate inputs, not final products.

[12] See, for example, Jeffrey A. Frankel and Andrew K. Rose (1996), Christian J. Murray and David H. Papell (2003), and Rogoff (1996).

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