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THE LAW OF ONE PRICE - A CASE STUDY

Jonathan Haskel
Holger Wolf

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ABSTRACT

We use retail transaction prices for a multinational retailer to examine the extent and permanence of violations of the law of one price (LOOP). For identical products, we find typical deviations of twenty to fifty percent, though there is muted evidence for convergence over time. Such differences might be due to differences in local costs. If so, relative prices of similar products (round versus square mirrors) should be equal across countries. In fact, relative prices vary significantly across very similar goods within a product group; indeed, the ordering of common currency prices often differs for similar products. The finding suggests that differences in local distribution costs, local taxes, and probably tariffs do not explain the price pattern, leaving strategic pricing or other factors resulting in varying markups as alternative explanations for the observed divergences.

Jonathan Haskel
Department of Economics
Queen Mary and Westfield College and CEPR
Mile End Road
London E1 4NS
United Kingdom
j.e.haskel@qmw.ac.uk

Holger Wolf
Department of Economics
George Washington University
2201 G Street, NW
Washington, DC 20052
and NBER
hwolf@gwu.edu

1. Introduction

The law of one price (LOOP), and PPP in its aggregation, is a cornerstone assumption in much of international economics. While most empirical studies have rejected strict PPP[1], a lively recent literature suggests that deviations from PPP may be bounded, and that, once thresholds are taken into account, mean reversion is in fact fairly fast.[2] Most papers in this literature invoke arbitrage as explanation for the mean reversion, with arbitrage costs defining the corridors of inaction [O'Connell and Wei (1997), Obstfeld and Taylor (1997)].

This interpretation is however subject to several caveats. First, the cited studies are based on price indices, mean reversion thus does not imply reversion to absolute PPP, nor does it map naturally into arbitrage cost arguments. Second, estimates of the price elasticities of trade, particularly for intra-OECD trade, are typically quite low; indeed, trade flows do not seem to display any discontinuity around points of pronounced mean reversion in the real exchange rate [Campa and Wolf (2000)].

Aggregation issues make it difficult to resolve these issues at the macro level. One potential avenue of progress is to study actual prices of individual products across countries. Recent studies in this vein include examinations of the price of hamburgers [Cumby (1996)], of magazines [Ghosh and Wolf (1994), Knetter (1998)] as well as of broad group of consumer items [Crucini, Telmer and Zachariadis (1998)]. By and large, these studies have found substantial violations of the law of one price at a point in time, though Cumby (1996) and Ghosh and Wolf (1994) also find some evidence for mean reversion over time for hamburgers and magazines.

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[1] A very partial list of recent work, with different conclusions, includes Cumby (1996), Engel, Hendrickson and Rogers (1997), Frankel and Rose (1996), Papell (1997), O'Connell and Wei (1997), Obstfeld and Taylor (1997), Parsley and Wei (1996), Weber (1997). Froot and Rogoff(1995) and Rogoff (1996) provide an overview of the literature

[2] Benninga and Protopapadakis (1988), Coleman (1995), Dumas (1992), Obstfeld and Taylor (1997), O'Connell and Wei (1997), Williams and Wright (1991), Campa and Wolf (2000).

We follow this tradition by examining absolute prices for more than 100 identical goods sold in twenty-five countries by IKEA, a Swedish furniture retailer. The data set has a number of promising properties. First, we use the actual local currency transaction prices for identical goods, allowing a direct computation of absolute and proportional violations of the law of one price. We thus avoid two of the major problems facing studies comparing international index numbers, the lack of an absolute baseline, and the likelihood of differences in the composition of the basket underlying the index.[3] Second, unlike hamburgers and magazines, household furnishings are both highly traded and highly tradable: IKEA sources from fifty countries and sells in almost thirty countries.[4] Third, the dataset is three-dimensional, with a country, a product and a time dimension, allowing us to study not only the presence of violations of the law of one price, but also changes in these violations over time.

Abandoning price indices for actual transaction prices comes at a cost: by necessity, any group of products selected has some "special" characteristics that may limit the extent to which findings for that group can be generalized. Arguably, however, lamps, kitchen utensils, chairs and other relatively cheap household items are in fact quite "typical" of the generic differentiated traded good sold in an imperfectly competitive environment. While product designs are unique to IKEA, in most cases designs are similar to products offered by a number of similarly sized competitors.[5]

We begin by documenting common currency price divergences both across products and across country pairs. We find that substantial divergences, of the order of twenty to fifty percent, are typical. There are two ready explanations. First, there may be strategic pricing or other factors leading to differences in

[3] Comparability problems even arise in the case of Hamburgers (which use local ingredients with slight variations across countries) and magazines (which carry different advertisements and, in some cases, have slightly different content).

[4] About 80% of products are sourced from Europe, primarily from the Nordic countries (30%) and Eastern Europe, notably Poland. Most of the remaining products are sourced in east Asia. (Die Zeit, 27.8.98:23)

[5] Including Pinault-Printemps-Redoute and Great Universal Stores in Europe (with 26,779 and 62,842 employees, versus IKEA's 36,400 employees, and 278% and 80% of IKEA's sales, respectively); Heilig-Meyers (23.100 employees and 36% of IKEA's sales), Ethan Allan, Pier 1 Imports and others in the United States.

markups. Second, divergences may simply reflect differences in the local "nontraded" component of the transaction price (local distribution costs, tariffs, taxes etcetera).

We differentiate between these explanations by examining the ordering of prices. If price differences reflected differences in local distribution costs, than the ordering of prices between two locations should be the same for similar goods, such as round versus square wooden-frame mirrors. Consequently, the law of one price should hold for the relative price of two "similar" products, that is, the relative price of round to square mirrors in country A should be the same as the relative price of round to square mirrors in country B even if the absolute common currency prices for both mirrors differ between country A and B. The data unambiguously reject this hypothesis: the ordering of prices across products between two countries displays no simple pattern, suggesting that strategic pricing, or other factors leading to differences in markup, need to be invoked to explain the observed price pattern. We do, however, find that relative prices display a tendency towards convergence, with faster convergence for large divergences.

The remainder of the paper is structured as follows. We begin with a brief description of the dataset. We then turn to a discussion of the price setting process followed by IKEA, based on communications with store managers. Next, we present stylized facts on common currency prices before examining causes of cross-sectional differences in relative price divergences.

2. Data

The study is based on the local currency catalogue prices of IKEA stores. IKEA sells in a total of 140 stores[6] in twenty-nine countries. We were able to obtain catalogs for twenty-five of these, located in western and eastern Europe, the Americas, Asia and Australia.[7] The dataset spans the catalogue years 1995 to 1998, with a small number of catalogues for the first two years and a near complete set for the last two years.

IKEA sells a total of about 12,000 products. We selected a subset of 119 products, drawn from six categories: mirrors, lamps, rugs, chairs, chests of drawers, and kitchen utensils, as well as a single high price item, a leather sofa. The subgroups were selected to cover a range of transportability, average prices and design intensity; within the subgroups, items were chosen based on availability for the largest set of countries. The sample is thus fairly diverse, ranging from low price items such as forks, typically selling at the equivalent of about $2, to the leather sofa, selling at the equivalent of more than $500. The prices are valid for one year starting from the publication of the catalogue and are actual transaction prices.[8] Coverage differs across countries and years. The sample contains 220 transaction prices for 1995, 268 for 1996, 1,421 for 1997 and 1,200 for 1998.[9] Relative price observations number around four hundred for the first two sample years, and around ten thousand for the two later years. Common currency translations (into the

[6] There is a single price for a product applicable to all stores within a country.

[7] The countries are Austria, Australia, Belgium, Canada, Czech, Denmark, Finland, France, Germany, Italy, Hong Kong, Hungary, Kuwait, Malaysia, Netherlands, Norway, Poland, Singapore, Slovakia, Spain, Sweden, Switzerland, UAE, UK, and the USA. We were unable to obtain catalogs for the four remaining locations: China, Iceland, Saudi Arabia and Taiwan.

[8] IKEA does not rely to a large degree on coupons, and has quite infrequent sales events. In consequence, most transactions occur at the posted catalogue price. We have no data on whether all products were continuously available during a given calendar year.

[9] We used the 1997 catalogs to select the products. The lower number of price observations for 1998 reflects the discontinuation of some products.

Swedish Krona, except where stated otherwise) were undertaken using the average June bilateral exchange rate, reflecting the mailing date of the catalogs.[10]

3. Price Setting

A sizable literature relates the optimal price setting behavior of multinational enterprises such as IKEA to the strategic behavior of competitors [Dornbusch (1987), Aw (1993), Knetter (1993, 1994), Gron and Swenson (1996)], the importance of menu and adjustment costs [Delgado (1991), Kasa (1992)], the expected permanence of cost, demand and exchange rate shocks, the presence of fixed entry and exit costs [Dixit (1989)], the importance of distribution networks, market share considerations [Froot and Klemperer (1989), Feenstra, Gagnon and Knetter (1996)], arbitrage pressures and other factors.[11] To gauge which of these factors are of primary importance to IKEA; we sent inquiries to several stores requesting information about pricing strategy.

According to the responses received, prices are set locally for each country, subject to a shared low price business strategy. While the IKEA head office provides a price ladder indicating where a product is situated relative to other products, it generally does not suggest prices. The general pricing strategy aims to create a consumer expectation that IKEA prices will be substantially below those of local competitors for virtually all products. According to the responses, the low price strategy dominates margin considerations in the short run; attempts to raise margins focus on lowering sourcing costs. As an implication, exchange rate passthrough --- zero by definition during the one year validity of the catalogue --- is also constrained in the longer run, as the following quote from a store manager illustrates: "*The exchange rate has a very big effect on our profitability, but very little on the pricing process […] At times when exchange rates do put pressure on the profits we have to work harder to reduce our production costs. The price the customer pays is very*

[10] To allow for possible lags in the production and mailing of catalogues, we recomputed some results using the March rate, with no marked differences (see below).

rarely affected." The statements we received are of course anecdotal snapshots. If indeed representative of price setting behavior, they suggest that the prices of domestic rather than international competitors are the primary guidepost; IKEA price setters apparently feel unconstrained by direct international retail arbitrage (either narrowly defined to include only identical IKEA products purchased abroad, or more broadly defined to also include close substitutes). International common currency price differences would thus be expected to affect IKEA prices only if local competitors exploit such differences to reduce their domestic prices.

4. Static Deviations From The LOOP

We begin by assessing two key properties of prices: the divergence of common currency prices of a given product across countries, and the divergence of relative prices across products for a given country pair. Table 1 provides an illustrative example, the 1998 prices of two mirrors in the European IKEA stores, translated into US dollars. The simple law of one price clearly provides an inappropriate description for this price pattern. Column 1 reports prices for the Alg mirror, a simple square mirror tile. These vary from the equivalent of $12 in Norway to $32 in Spain. Column 2 reports prices for the Krabb mirror, a more original wavy mirror tile with a distinct design element. Prices range even wider for this mirror, from the equivalent of $20 in the Netherlands to $51 in neighboring Germany. Column three reports the ratio of the two mirrors, ranging from equal prices in Netherlands, to a 60% differential in Denmark.

[11] Menon (1995), Rogoff (1996) and Goldberg and Knetter (1997) provide recent surveys.

Table 1: European Prices (1998, in US$)

	Alg Mirror *[1]*	*Krabb Mirror* *[2]*	*Ratio of Alg to Krabb* *[3]*	*Guldros Mirror* *[4]*
Netherlands	20	20	1.00	101
Spain	32	34	0.94	112
United Kingdom	25	30	0.83	115
Belgium	22	28	0.78	111
Finland	15	21	0.71	107
Switzerland	19	27	0.70	67
France	21	33	0.63	100
Sweden	15	24	0.62	94
Italy	23	44	0.52	79
Austria	24	48	0.50	113
Norway	12	27	0.44	82
Germany	22	51	0.43	97
Denmark	13	34	0.38	119

Notes*: Alg*: Square Mirror, 45x60cm, Tiles. *Guldros:* Round mirror, 59x78cm, Beveled glass, *Krabb:* Designer mirror, 44x40cm. Source: IKEA

It might be supposed that the bilateral price differences have an important systematic component across products, reflecting differences in local distribution costs. While we return to this point in more detail below; Table 1 already provides a suggestion as to why such differences are unlikely to fully explain price setting. If differences in local costs were the main explanation, and if, as seems likely, such differences were fairly similar for similar products such as different types of mirrors, the ranking of absolute prices between two countries would be the same across types of mirrors. A comparison of columns 1, 2 and 4 (the latter adds prices for the Guldros mirror, a fairly standard design round mirror with a higher average prices, and a range from $67 in Switzerland to $119 in Denmark) reveals that not to be the case. For example, both the Alg and the Krabb mirror are more expensive in Austria compared to Denmark, yet the Guldros mirror is more expensive in Denmark compared to Austria. The reverse ranking holds for Spain.

4.1 Common Currency Price Differences: Products

We next examine the overall distribution of relative common currency prices. For each product, we first construct the set of all independent relative prices. For each country pair, the relative price is constructed by dividing the larger by the smaller price; thus the relative price distribution is bounded below by one. To assure reasonable sample size, we drop all products for which fewer than fifty relative prices were available. For some products, there are a few extreme values of the relative price (and thus obvious violations of the law of one price (LOOP)), which would by themselves have a significant impact on distribution statistics and would lead to the rejection of the LOOP with high statistical significance. This would however not rule out the possibility of the LOOP holding for most goods and most country pairs most of the time, and thus to still be a useful description of international price setting. To allow for this possibility, we sort observations by the relative price and drop the top and bottom decile, before computing the distribution statistics for the interior deciles.

Table 2 reports the maximum and median relative price as well as the coefficient of variation. Under the strict null of the law of one price without differences in local distribution costs, the maximum and median relative price should be equal to one, and the coefficient of variation should be equal to zero. The reported statistics unambiguously rejects the LOOP hypothesis. The price difference (in common currency) between the cheapest and the most expensive store exceeds fifty percent for most goods, and ranges up to nine hundred percent for some goods. The (less variable) median difference in the common currency price ranges between twenty and thirty percent for most goods.

The table also reveals substantial differences across product groups. Mirrors appear to be fairly similarly priced across countries: only for two mirrors does the maximum price deviation exceed one hundred percent, while the coefficient of variation is generally quite low. In sharp contrast, the maximum price differentials for lamps, rugs, chairs and kitchen utensils frequently exceed one hundred percent.

The divergences are consistent with two explanations. First, it might be the case that the LOOP holds for ex-factory gate prices, but is rejected for the retail prices because of differences in local distribution costs etc. Second, the price divergences might reflect strategic pricing decisions or other causes of differing markups. To illustrate, suppose that the retail price of an item *k* produced in country *j* and sold in country *i* reflects production costs, local distribution costs, tariffs etc. as well as differences in markups. Denoting the source country currency cost of product *k* by C^j_k, the exchange rate between the source country and the destination country as S_{ij}, the local price of the product can be written as:

$$(1) \qquad P^i_k = [S_{ij}C^j_k(1+\delta^i_k)(1+\tau^i_k)](1+\pi^i_k)$$

where π^i_k denotes the markup, δ^i_k denotes the local distribution cost and τ^i_k denotes any other cost, such as tariffs. Deviations from the LOOP may thus reflect differences in markups, but they may also reflect differences in distribution costs or tariffs, which would lead to price deviations even if markets were otherwise integrated. Without precise information about local distribution costs and tariffs, it would appear that little additional inference is feasible. However, at the cost of two additional assumptions, two further tests of the law of one price can be derived. The first is based on the ranking of relative common currency prices across products for a given country pair; and the second on the size and variability of the ratio of relative prices of similar products across countries.

Table 2: Common Currency Relative Prices By Products

Mirrors	**Max**	**Min**	**CofV**		**Max**	**Min**	**CofV**
Alg 2 Pack	2.04	1.25	0.20	Krabb	1.83	1.26	0.17
Alg 4 Pack	1.82	1.19	0.17	Biscaya	1.38	1.11	0.09
Bjorn 75x118	1.19	1.06	0.04	Bjorn 75x75	1.47	1.15	0.11
Bonnett	1.68	1.20	0.13	Brok	1.41	1.15	0.09
Fiffig	1.60	1.19	0.14	Fjord	1.34	1.14	0.07
Flagg	1.26	1.07	0.06	Guldros	1.49	1.15	0.10
Kloster	1.23	1.11	0.05	Micky	1.49	1.17	0.10
Narvik	1.37	1.12	0.08	Octagon	1.59	1.20	0.13
Pejla	1.53	1.16	0.11	Piral	1.43	1.14	0.09
Ratt	1.64	1.16	0.13	Sill	1.90	1.21	0.17
Spatta	1.62	1.19	0.13	Stirr	1.50	1.19	0.11
Tunga	1.71	1.25	0.15	Uddebo	4.84	1.32	0.41
Ulk	1.51	1.10	0.12	Vimma	1.42	1.15	0.09
Lamps							
Antifoni	1.95	1.25	0.17	Bor	7.28	1.20	0.80
Glimt	9.83	2.98	0.68	Glittra	4.38	1.18	0.45
Gospel	1.41	1.15	0.09	Ilmenit	4.22	1.27	0.55
Kyrolit	3.74	1.26	0.25	Kvartett	5.26	1.24	0.68
Kvinet	6.57	1.39	0.75	Kvintol	1.88	1.21	0.17
Mystik	5.48	1.27	0.53	Rimfrost	3.55	1.24	0.30
Skyfall	5.88	1.26	0.76	Smog	6.58	1.24	0.72
Rugs							
Bro	8.99	1.27	1.00	Karby	6.31	1.16	0.75
Klampen	3.38	1.32	0.28	Mjang	8.53	1.24	0.85
Ollerup	6.13	1.16	0.71	Saltnes	7.07	1.22	0.84
Stuby	3.29	1.32	0.30	Vasby	9.71	1.25	0.94
Chairs							
Abo	1.85	1.16	0.14	Albert	9.58	1.22	0.91
Bobbi	4.90	1.25	0.59	Dora	7.62	1.25	0.88
Hogmo	2.42	1.28	0.20	Hornsby	5.19	1.30	0.51
Ivar	2.14	1.25	0.18	Jussi	1.87	1.24	0.16
Kronvik	1.86	1.21	0.15	Mans	7.31	1.26	0.86
Ogla	2.06	1.28	0.18	Oglett	1.50	1.14	0.10
Ringo	2.11	1.29	0.19	Terje	1.87	1.20	0.16
Ticho	5.71	1.22	0.56	Tomas	9.62	1.34	0.98
Tuna	8.52	1.37	0.87	Vebster	1.81	1.19	0.15
Drawers							
Fjord 80x80	1.93	1.21	0.15	Fjord 125x80	1.75	1.22	0.15
Fjord 58x80	1.79	1.14	0.14	Kurs-A	1.84	1.20	0.16
Kurs-D	2.49	1.22	0.25	Kurs-F	2.08	1.20	0.16
Kurs-G	1.72	1.16	0.13	Kurs-I	5.70	1.19	0.58
Narvik 2 drawers	4.92	1.18	0.49	Narvik 3 drawers	1.90	1.23	0.18
Narvik 5 drawers	1.79	1.09	0.13	Narvik 6 drawers	1.86	1.18	0.15
Kitchen Utensils							
Fanfar 7 piece set	6.23	1.24	0.78	Fanfar Pasta Pan	3.43	1.18	0.34
Grunka Skimmer	5.90	1.28	0.60	Grunka Ladle	7.51	1.25	0.71
Grunka Spoon	2.68	1.23	0.23	Grunka Soup Ladle	3.93	1.25	0.25
Grunka Spaghetti Server	3.93	1.25	0.26	Grunka Carving Fork	5.00	1.24	0.50
Grunka Spatula	2.95	1.25	0.24	Heat Cork mats	7.65	1.34	0.67
Kontrol Saucepan	9.32	1.30	0.96	Kontrol 6.3l casserole	5.07	1.20	0.72
Kontrol Saucepan	7.21	1.15	0.94				
Easy Chairs/Sofa							
Arstad	5.71	1.25	0.47	Boana	5.74	1.31	0.70
Kimsta	2.04	1.18	0.18	Pixbo	2.03	1.22	0.17
Sofa Halland	1.57	1.13	0.10				

Source: Author's calculations based on IKEA catalogues.

4.2 Common Currency Price Differences: Country Pairs

If it is assumed that differences in local distribution costs between two countries primarily reflect factors such as wage differences which apply to all products in a country, rather than product specific factors, such as tariff rates, then the ranking of common currency prices should be the same across products for a given country pair if the LOOP holds net of distribution costs. For example, if unit labor costs in Germany are higher than in the UK, and if this difference is the sole reason for price differences between the UK and Germany, then we should that German prices exceed UK prices (measured in a common currency) for all products. To test this weaker version of the LOOP, we construct, for each country pair, the set of all independent relative prices (for all products for which prices for both countries are available). To avoid potential small sample bias, we drop all country pairs for which less than fifty relative prices were available, leaving 132 country pairs. For each product, the relative price is constructed by dividing the price in the first country by the price of the second country; thus the relative price distribution is bounded below by zero. The data are then sorted by size. As before, we drop the top and bottom decile to focus on the "typical" observations (thus lowering the hurdle for the LOOP hypothesis). The results provide little support for this weaker version of the LOOP. For 123 out of the 132 country-pairs, the minimum relative price is less than unity while the maximum relative price is above unity. Country specific differences in distribution costs applicable to all products thus do not provide a full explanation of the observed price pattern. If differences in local costs are indeed the explanation, the ordering of these costs in common currency must thus differ across goods for given country pairs. Similarly, if differences in tariffs are the explanation, the ordering of tariffs must change across goods for a given country pair. The results presented above do not rule out such product-varying distribution costs. The presence of very similar products in the sample however permits a closer look at the likely importance of this possibility.

4.3 Double Relative Prices

If one is willing to assume that differences in local costs and tariffs are pronounced between product groups (mirrors versus chairs) but small between items in a given product group (forks versus spoons)[12]; then a comparison of the ratio of two items within a group in country A with the same ratio in country B should not be affected by local cost differences. Specifically, if $[(1+\delta^i_{k1})(1+\tau^i_{k1})] = [(1+\delta^i_{k2})(1+\tau^i_{k2})]$ for all items k1 and k2 within the same category in country i (and likewise in country j); and if there is a single source for each good, with a single foreign currency price; than the ratio of the two prices in country i reduces to:

$$(2) \qquad R^i = P^i_{k1} / P^i_{k2} = [C^j_{k1} / C^j_{k2}] \, [(1+\pi^i_{k1})/(1+\pi^i_{k2})]$$

while the double relative price, $DRP^{i,j} = R^i / R^j$ reduces to the double relative markup:

$$(3) \qquad DRP^{ij} = [(1+\pi^i_{k1})/ (1+\pi^i_{k2})]/[(1+\pi^j_{k1})/(1+\pi^j_{k2})]$$

A double relative price of one is thus a necessary condition for perfect market integration. It is, however, not sufficient as proportional non-zero markups will generate a double relative price of one as well. To implement the test, we define all goods within a given category (mirrors, chairs, chest of drawers, lamps, kitchen utensils, rugs) as "near identical". We then compute all independent double relative prices within the category, always placing the larger relative price in the numerator. Table 3 reports the resulting percentile distribution.

[12] The validity of the assumption is open to debate, and may be more valid for local distribution costs than for tariffs, which occasionally vary significantly between very similar products [Bovard (1991)].

Table 3: Percentile Distribution of Double Relative Prices

	Mirrors	*Lamps*	*Rugs*	*Chairs*	*Drawers*	*Kitchen Utensils*	*Easy Chairs*
1.0 to 1.1	24.4	24.8	19.5	25.5	36.0	39.0	18.2
1.1 to 1.2	19.6	19.2	18.3	21.1	23.9	13.1	18.6
1.2 to 1.3	15.0	14.4	12.8	15.4	13.9	12.5	13.4
1.3 to 1.4	10.8	9.8	10.6	10.5	8.1	7.8	12.0
1.4 to 1.5	7.8	7.2	6.8	7.3	4.9	5.3	8.4
1.5 to 1.6	5.9	4.4	5.0	5.0	3.1	3.8	5.8
1.6 to 1.7	3.9	3.2	3.7	3.5	1.8	3.3	5.2
1.7 to 1.8	2.8	2.2	2.8	2.4	1.3	1.5	3.0
1.8 to 1.9	1.9	1.6	2.1	1.6	0.9	2.0	2.2
1.9 to 2.0	1.5	1.1	2.0	1.1	0.6	1.5	1.8
> 2.0	6.0	11.6	15.9	5.9	4.9	9.8	10.9
Observations	38,568	9,535	2,851	25,109	15,105	11,426	931

The divergences reported earlier are replicated. For all product groups except chests of drawers and kitchen utensils, more than half of the relative prices differ by more than twenty percent across country pairs, for the latter two groups, the share is above forty percent. For all product groups, a significant portion of double relative prices exceeds two, with rugs (almost 16% of all relative prices) and lamps (almost 12%) having the highest fraction of large deviations. Conditional on the validity of the adjunct hypothesis that intra-group differences in proportional local costs are negligible, the results strongly suggest that differences in local costs or tariffs do not provide a full explanation of the observed price pattern.

4.4 Mean Reversion

The characteristics of the distribution of relative prices casts doubt on the usefulness of the law of one price for describing this dataset, which arguably contains products which are fairly representative of the prototypical differentiated manufacturing good. As a final test of (weak) arbitrage, we turn to the time series dimension to examine whether the divergences identified above persist or diminish over time. Such shrinkage or "mean reversion" might reflect arbitrage if other stores set prices below the posted IKEA prices for those products priced particularly high by IKEA, and IKEA, in accordance with the strategy described

above, responds by reducing the prices in the next catalogue. Estimating the standard mean reversion regression of the log change in relative prices between period t and t+1 on the log level in period t for the entire sample yields:

$$(4)\ \Delta RP^{ij}_k(t) = -0.89\ RP^{ij}_k(t-1) \qquad R^2 = 0.627$$

where $RP^{ij}_k(t-1)$ includes all observations of the relative common currency price in period t-1 of a good k in countries i and j for which the same relative price is also available in period t, with a total of 3214 observations.[13] The regression suggests significant mean reversion, a finding consistent with results for more aggregate price indices. A number of authors have argued that this regression may be mis-specified: if arbitrage is costly, it will only commence once the relative price divergence exceeds a threshold defined by the cost of arbitrage.[14] The presence of thresholds can be examined within a modified mean reversion regression allowing for interactive effects. Estimating the upper and lower thresholds by a grid search yields the following threshold mean reversion regression:

$$\Delta RP^{ij}_k(t) = \underset{(4.53)\ **}{-\ 0.19\ RP^{ij}_k(t-1)} \underset{(16.63)\ **}{-\ 0.78\ U^*\ RP^{ij}_k(t-1)} \underset{(16.45)\ **}{-\ 0.74\ L^*\ RP^{ij}_k(t-1)}$$

with an R2 of 0.659. The upper threshold equals 0.95, U is set equal to one for all observations exceeding 0.95, to zero otherwise. The lower threshold equals –0.75, with L set equal to one for all observations below –0.75, and to zero otherwise. For small initial deviations from the LOOP mean reversion is thus present, but quite slow, while for larger deviations relative prices exhibit more rapid mean

[13] As a robustness test, we dropped the two early years with few observations (going from 3214 to 2802 observations), and used the March exchange rate to allow for a longer lag between price setting and the mailing of the catalogues. The results are highly robust to these changes, the coefficient on the lagged relative price is unchanged (-0.89), and the R2 increases from 0.627 to 0.872.

[14] Benninga and Protopapadakis (1988), Coleman (1995), Dumas (1992), Obstfeld and Taylor (1997), O'Connell and Wei (1997).

reversion.[15] The same conclusion is suggested by a scatterplot of the lagged level versus the change (Figure 1), revealing a clear negative relationship coupled with a cluster around zero. These results are thus supportive of longer-term mean reversion. In interpreting the results, it must however be remembered that a finding of mean reversion is not sufficient to infer effective arbitrage as mean reversion may for example simply reflect a nominal exchange rate re-alignment caused by other factors.

5. Conclusion

The law of one price provides a cornerstone of international macroeconomics. To explore its validity, we examined a panel of local currency transaction prices of identical products sold by the same company in a large group of countries. The products are arguably representative of the "typical" differentiated manufactured good.

We found significant common currency price divergences across countries for a given product and across products for a given country pair. The distribution properties of the price divergences suggest that they cannot be attributed to differences in local costs, tariffs or taxes. The exclusion of these factors points to the existence of sizable differences in markups and thus to a failure of effective arbitrage, the driving force of the law of one price in the Casselian form. We did, however, find weaker evidence consistent with the view that actual or potential arbitrage at least influences the size --- if not the existence --- of violations of one price, and may also lead to a gradual reduction of these differences over time. While, in this sense, the results from this micro-level study thus conform with recent findings on threshold mean reversion for

[15] Since transportation costs depend primarily on volume and distance shipped, it may however be inappropriate to assume that the same threshold applies for all country-pairs and all products. To allow for this possibility, we estimated the threshold equations separately for three price ranges (below 50 Swedish Kronor (SK), between 50 and 250 Sk and above 250 SK) and for three distance ranges (below 500 KM, between 500 KM and 1000 KM, and above 1000 KM). No consistent pattern emerged from these regressions, however. Specifically, controlling for the price range of the product, neither the threshold nor the speed of mean reversion displayed a consistent relationship with distance, vice versa, controlling for distance, neither the threshold nor the speed of mean reversion was systematically linked to the price range of the product, arguing in favor of pooling across distance and price ranges.

aggregate price indices, they clearly also demonstrate that substantial violations from the law of one price are pervasive features of individual goods prices.

Bibliography

Aw, Bee-Yan (1993); "Price Discrimination and Markups in Export Markets"; Journal of Development Economics; December, 42:2: 315-36.

Benninga, S. and A. Protopapadakis (1988); "The Equilibrium Pricing Of Exchange Rates And Assets When Trade Takes Time"; Journal of International Money and Finance; 7: 129-49.

Bovard, James (1991); The Fair Trade Fraud; St. Martin's Press, London.

Campa, Jose and Holger Wolf (1997); "Is real exchange rate mean reversion caused by arbitrage?"; NBER Working Paper Series No. 6162, September.

Coleman, A.M. (1995); "Arbitrage, Storage and the "Law Of One Price"; Mimeo, Princeton University.

Cumby, Robert (1996); "Forecasting Exchange Rates and Relative Prices with the Hamburger Standard"; NBER Working Paper No. 5675.

Crucini, Mario, Chris Telmer and Marios Zachariadis (1998); "What Can We Learn From Deviations From The Law Of One Price?"; Mimeo.

Davutyan, N. and John Pippenger (1990); "Testing Purchasing Power Parity: Some Evidence On The Effects Of Transaction Costs"; Econometric Reviews; 9: 211-240.

DeVries, Casper (1989); "International Trade and the Arbitrage Principle"; Erasmus University Discussion Paper No.8910.

Delgado, Francisco (1991); "Hysteresis, menu costs, and pricing with random exchange rates"; Journal of Monetary Economics; 28, 461-84.

Dixit, Avinash (1989); "Hysteresis, Import Penetration and Exchange Rate Passthrough"; Quarterly Journal of Economics; May, 205-28.

Dornbusch, Rudiger (1987); "Exchange Rates and Prices"; American Economic Review; March, 93-106.

Dumas, Bernard (1992); "Dynamic Equilibrium And The Real Exchange Rate In A Spatially Separated World"; Review of Financial Studies ; 5: 2: 153-80.

Engel, Charles, M. Hendrickson and John Rogers (1997); "Intra-National, Intra-Continental and Intra-Planetary PPP"; Journal of the Japanese and International Economies; 11:480-501, December.

Engel, Charles and John Rogers (1996); "How Wide Is The Border?"; American Economic Review; December: 86: 1112-25.

Feenstra, Robert, Joseph Gagnon and Michael Knetter (1996); "Market Share and Exchange Rate Pass-Through in World-Automobile Trade"; Journal of International Economics; 40:187-207, February.

Frankel, Jeffrey, Ernesto Stein and Shang-Jin Wei (1995); "Trading Blocs and the Americas'; Journal of Development Economics; June: 47: 1: 61-96.

Frankel, Jeffrey and Andrew Rose (1996); "A Panel Project On Purchasing Power Parity"; Journal of International Economics; 40: February: 209-225.

Fraser, Patricia, Mark Taylor, and Alan Webster (1991); "An empirical examination of long-run purchasing power parity as theory of international commodity arbitrage"; Applied Economics; 23: 1749-59.

Froot, Kenneth and Kenneth Rogoff (1995); "Perspectives on PPP and Long Run Real Exchange Rates"; in Gene Grossman and Kenneth Rogoff (eds.) Handbook of International Economics; Vol. 3.

Froot, Kenneth and Paul Klemperer (1989); "Exchange Rate Pass-Through When Market Share Matters"; American Economic Review, September, 79:637-654.

Ghosh, Atish and Holger Wolf (1994); "Pricing in International Markets: lessons from The Economist"; NBER Working Paper Series No. 4806, July.

Goldberg, Pinelopi and Michael Knetter (1997); "Goods Prices And Exchange Rates"; Journal of Economic Literature; 35:1243-72, September.

Gron, Anne and Deborah Swenson (1996); "Incomplete Exchange Rate Pass-Through and Imperfect Competition: The Effect of Local Production"; American Economic Review; May: 71-76.

Isard, Peter (1977); "How Far Can We Push The Law Of One Price?"; American Economic Review; 67: 942-48.

Kasa, Kenneth (1992); "Adjustment Costs and Pricing-to-Market: Theory and Evidence"; Journal of International Economics; February, 1-27.

Knetter, Michael (1993); "International Comparisons of Pricing-to-Market Behavior"; American Economic Review, 83: 473-486.

Knetter, Michael (1994); "Is Export Price Adjustment Asymmetric?"; Journal of International Trade and Finance; 13: 55-70.

Knetter, Michael (1997); "The segmentation of international markets: evidence from the Economist" NBER Working Paper No. 5878, January.

Menon, Jayant (1995); "Exchange Rate Pass-Through"; Journal of Economic Surveys; Vol. 9: 2: 197-231.

Michael, Panos; A. Robert Nobay and David Peel (1997); "Transaction Costs And Non-Linear Adjustment In Real Exchange Rates"; Journal of Political Economy; 105:862-79, August 1997

Obstfeld, Maurice and Alan Taylor (1997); "Nonlinear Aspects Of Goods-Market Arbitrage And Adjustment: Heckscher's Commodity Points Revisited"; Journal of the Japanese and International Economies; 11:441-79, December.

O'Connell, Paul and Shang-Jin Wei (1997); "The Bigger They Are, The Harder They Fall"; NBER Working Paper No. 6089, July.

Papell, David (1997); “Search for stationarity: purchasing power parity under the current float”; Journal of International Economics; 43:[313]-32, November.

Parsley, David and Shang-Jin Wei (1996); “Convergence To The Law Of One Price Without Trade Barriers Or Currency Fluctuations”; Quarterly Journal of Economics; 108: 1211-1236.

Prakash, G. and Alan Taylor (1997); “Measuring Market Integration”; NBER Working Paper No. 6073, June.

Rauch, James (1996); “Trade and Search”; NBER Working Paper No. 5618, June.

Rogoff, Kenneth (1996); “The Purchasing Power Parity Puzzle”; Journal of Economic Literature; 34: June: 647-668.

Weber, Axel (1997); “Sources of purchasing power disparities between the G3 economies”; Journal of the Japanese and International Economies; 11:548-83, December.

Webster, Alan (1987); “Purchasing Power Parity As A Theory Of International Arbitrage In Manufactured Goods”; Applied Economics; 19: 1433-1456.

Wei, Shang-Jin (1996); “Intra-National Versus International Trade”; NBER Working Paper No. 5531, April

Williams, J. and B. Wright (1991); Storage And Commodity Markets; Cambridge, Cambridge University Press.

Die Zeit (1998); “Mit Stolz und Reue”; 27.August 1998, page 23.

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