How Far Can We Push the "Law of One Price"?

By PETER ISARD*

Students exposed to the pure theory of international trade have been seduced by visions of an imaginary world with few goods, each typically produced by several countries but nevertheless homogeneous. In the assumed absence of transport costs and trade restrictions, perfect commodity arbitrage insures that each good is uniformly priced (in common currency units) throughout the world—the "law of one price" prevails.

In reality the law of one price is flagrantly and systematically violated by empirical data. This paper presents evidence that exchange rate changes substantially alter the relative dollar-equivalent prices of the most narrowly defined domestic and foreign manufactured goods for which prices can readily be matched. Moreover, these relative price effects seem to persist for at least several years and cannot be shrugged off as transitory. In other words, for manufactured goods selected from the most disaggregated commodity lists for which *U.S.* and foreign prices can be matched, the products of different countries exhibit relative price behavior which marks them as differentiated products, rather than near-perfect substitutes.

To clarify discussion it is useful to distinguish two contexts in which the law of one price is valid from a third context in which the law of one price does not hold. First, in a comparison of *U.S.*, European, and Japanese prices of various well-defined steel items (plate, galvanized sheet, cold-rolled sheet, and hot-rolled sheet) c.i.f. for delivery in a common port, Laurence Rosenberg found that relative dollar prices charged by different countries were fairly constant over time and were not significantly affected by exchange rate realignments. The dollar prices of primary commodities are also generally considered to be fairly independent of country of origin.[1] These are cases in which the products of *different* countries are close to identical, or near-perfect substitutes, so that any price disparities would be rapidly eliminated by commodity arbitrage. Second, in the absence of restrictions on commodity arbitrage, a product of any *single* country sold competitively in two different markets (foreign or domestic) would also obey the law of one price in the sense that its dollar-equivalent prices in the two markets could not differ by more than the cost of transportation between these markets.

Many *U.S.* manufactured goods do not have near-perfect substitutes on the lists of products manufactured abroad, however, and in this third context the law of one price is denied as an empirical proposition. Agricultural tilling machinery produced in the United States, for example, is apparently not a close substitute for agricultural tilling machinery produced in Germany. More generally, the most disaggregated groupings of manufactured goods for which both *U.S.* and German prices are readily available are dominated by products for which German dollar price indexes diverge over time from *U.S.* dollar price indexes[2] in a manner that is strongly correlated with exchange rate movements. This divergence is evident in comparisons of *U.S.* wholesale transactions prices and German export transactions prices for various 2- and 3-digit sectors of the *WPI* industry breakdown (Section I),

*Division of International Finance, Board of Governors of the Federal Reserve System. The opinions expressed herein do not necessarily represent the views of the Federal Reserve System. I am grateful to Lance W. Girton, Peter Hooper, and Jeffrey R. Shafer for helpful discussions.

[1]This may not be the case when sellers of primary commodities have monopoly power and/or enter into long-term marketing agreements with their customers, as do *U.S.* copper producers, for example.

[2]This divergence should come as no surprise to anyone familiar with the work of Irving Kravis and Robert Lipsey.

in comparisons of *U.S.* and German export transactions prices for various 4- and 5-digit *SITC* machinery categories (Section II), and in comparisons of *U.S.* export unit values with unit values of *U.S.* imports from Canada, Germany, and Japan for various 7-digit Schedule A and B commodity groups (Section III).

The denial of the law of one price in this context—at the most disaggregated product level for which price data can be readily matched—provides a strong presumption that it is impossible to assemble available data into aggregate price indexes which can be expected to obey the law of one price (except, perhaps, when product coverage is restricted to primary commodities). Obversely, the notion that aggregate indexes of export or tradeable-goods prices will exhibit purchasing power parity—that is, that relative home currency prices of different countries will stay in line with exchange rates—cannot validly lean on the law of one price for support.

I. Comparative Movements of *U.S.* and German Industrial Prices

The adjustment mechanism alleged to police the law of one price is commodity arbitrage. Under free trade, if products were marketed competitively, commodity arbitrage would prevent disparities between the f.o.b. transactions prices associated with export and domestic sales of the same product—that is, export and wholesale transactions prices would be equal f.o.b. International tests of the law of one price would be insensitive to whether the comparisons were between international wholesale prices, export prices, or a mix of both.

Discriminating monopolies and tariffs, subsidies, or other trade restrictions create disparities between export and wholesale prices. Provided that trade restrictions do not change substantially during the data period, however, international comparisons of any mix of export and wholesale prices can validly test the law of one price by focussing on whether any initial disparities change substantially over time. Evidence that disparities between the common currency prices of different countries are systematically correlated with exchange rates, rather than randomly fluctuating over time, is a strong denial of the law of one price for the products being compared.

The United States, Germany, and Japan publish data on export transactions prices. The coverage of *U.S.* data is restricted mainly to various 4- and 5-digit *SITC* machinery items, collected only once a year (in June) prior to 1974 and four times a year beginning in 1974. German and Japanese data are available monthly for a broad list of items; but for many items Japanese prices are sticky. These considerations have led us to first compare monthly time-series of *U.S.* wholesale prices and German export prices for a variety of industries over the 1968–75 period, and to then compare June data on *U.S.* and German export prices for various machinery categories over the 1970–75 period.[3]

The first set of industry price comparisons is described by Figure 1 and Tables 1 and 2. The exchange rate is measured in dollars per mark (1970 = 100),[4] and relative price indexes are German mark prices multiplied by the exchange rate and divided by *U.S.* dollar prices (and then converted to 1970 = 100). The figure presents strong evidence that relative dollar prices of apparel and paper products have not fluctuated about constant levels during the eight-year data period under examination, but rather have been influenced heavily by exchange rate movements. Interpreted casually, the figure suggests that the relative price of apparel is explained almost entirely by the

[3]The first comparison extends a similar study of the 1968–73 period, which I have described elsewhere. This comparison focuses on 2- and 3-digit sectors of the 8-digit *WPI* industry breakdown, and does *not* consider the most narrowly defined industries for which price comparison is possible. The comparisons of machinery export prices (Section II) and *U.S.* import and export unit values (Section III), however, *are* restricted to the most narrowly defined products for which such prices can readily be compared.

[4]For December 1968–September 1969 the exchange rate is set 4 percent above the actual spot rate to reflect the effective exchange rate for German exports under the 4 percent export tax levied between late November 1968 and the mark revaluation in October 1969.

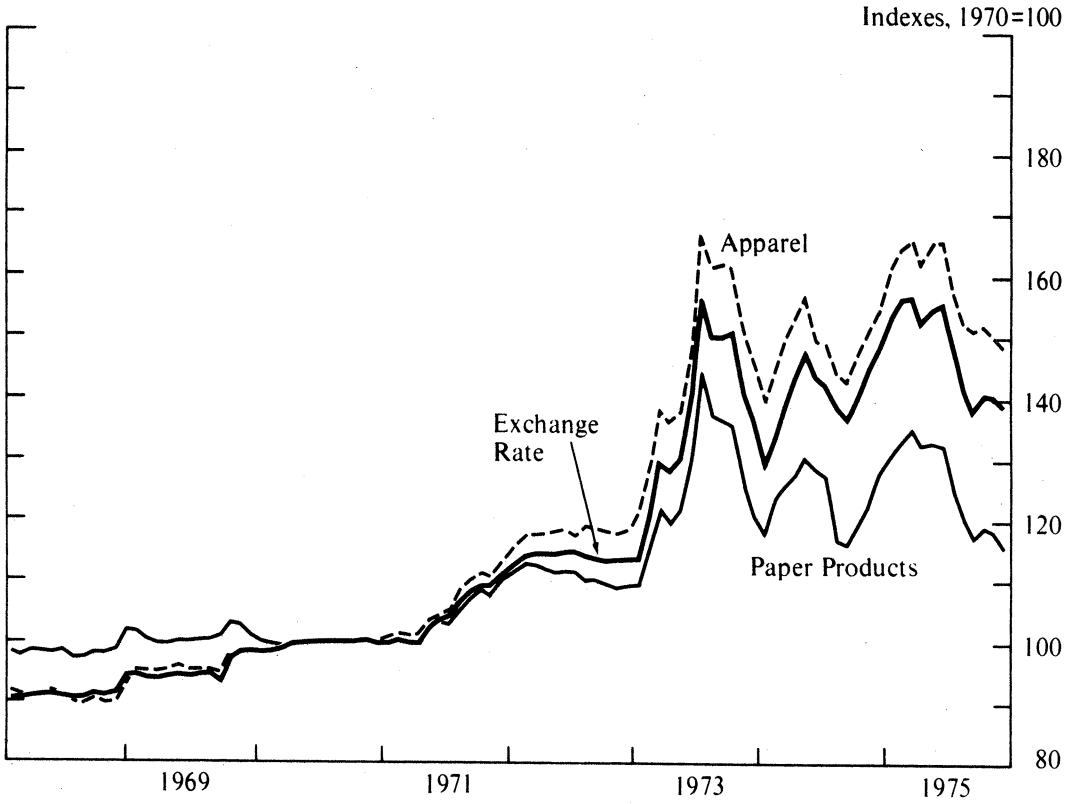

FIGURE 1

TABLE 1—PERCENTAGE CHANGES IN EXCHANGE RATES AND RELATIVE DOLLAR PRICE INDEXES BETWEEN SELECTED PERIODS

	Jan.–Mar. 1968 to June–Aug. 1969	June–Aug. 1969 to Feb.–Apr. 1971	Feb.–Apr. 1971 to July–Sept. 1972	July–Sept. 1972 to Aug.–Oct. 1973	Aug.–Oct. 1973 to Aug.–Oct. 1974	Aug.–Oct. 1974 to Feb.–Apr. 1975	Feb.–Apr. 1975 to Oct.–Dec. 1975	Jan.–Mar. 1968 to Oct.–Dec. 1975
Exchange rate (dollars/mark)	4.07	5.85	14.14	31.33	−7.70	12.11	−9.90	53.94
German dollar price/ *U.S.* price								
Apparel	4.57	6.15	16.73	36.26	−10.52	13.61	−8.47	64.29
Industrial chemicals	6.17	3.36	9.91	43.92	−15.01	−13.47	−16.04	7.18
Agricultural chemicals	8.39	−4.51	9.02	37.36	14.37	−10.26	−27.05	16.06
Plastic materials	10.73	10.90	14.93	28.96	−20.23	−10.13	−13.11	13.37
Paper products	2.08	0.86	9.35	23.57	−14.12	13.92	−12.00	19.78
Metalworking machinery	10.68	20.66	14.23	33.52	−14.98	11.08	−12.04	69.18
Electrical industrial equipment	5.36	7.85	15.04	34.08	−5.06	8.88	−11.85	59.71
Home electronic equipment	10.99	8.07	10.87	38.32	−5.68	12.69	−9.22	77.51
Glass products	−0.47	−3.66	19.54	38.97	−11.61	4.44	−13.26	27.55

Source: U.S. price data are from U.S. Department of Labor, *Monthly Labor Review.* German price data are from Statistisches Bundesamt. A detailed data appendix is available from the author upon request.

TABLE 2—CUMULATIVE PERCENTAGE CHANGES IN EXCHANGE RATES AND RELATIVE DOLLAR PRICE INDEXES

	June–Aug. 1969	Feb.–Apr. 1971	July–Sept. 1972	Jan.–Mar. 1968 to Aug.–Oct. 1973	Aug.–Oct 1974	Feb.–Apr. 1975	Oct.–Dec. 1975
Exchange rate (dollars/mark)	4.06	10.16	25.73	65.13	52.41	70.86	53.94
German dollar price/ *U.S.* price							
Apparel	4.57	11.00	29.57	76.55	57.98	79.49	64.29
Industrial chemicals	6.17	9.73	20.61	73.58	47.53	27.66	7.18
Agricultural chemicals	8.39	3.50	12.83	54.99	77.27	59.09	16.06
Plastic materials	10.73	22.79	41.13	82.00	45.18	30.48	13.37
Paper products	2.08	2.96	12.59	39.14	19.49	36.12	19.78
Metalworking machinery	10.68	33.55	52.56	103.69	73.16	92.34	69.18
Electrical industrial equipment	5.36	13.63	30.72	75.26	66.40	81.17	59.71
Home electronic equipment	10.99	19.95	33.00	83.96	73.50	95.53	77.51
Glass products	−0.47	−4.11	14.63	59.30	40.80	47.05	27.55

Source: See Table 1.

exchange rate, whereas the relative price of paper products adjusts almost entirely to exchange rate changes in the short run while moving back slowly toward its initial level over time.

In Tables 1 and 2 we have selected 8 three-month periods during which the exchange rate was fairly stable. Table 1 compares movements in exchange rates and relative prices during the successive intervals between these 8 periods, while Table 2 shows cumulative changes. The first interval in Table 1 starts at the beginning of the data period and ends just prior to the German revaluation in October 1969. The second interval includes this revaluation and ends just prior to the start of the German float in May 1971. The third interval spans the German float, the Smithsonian Agreement in December 1971, and the three quarters following the Smithsonian. This interval ends prior to the early signs of the pressures that brought the realignment in February 1973. The fourth interval includes the realignments of first-quarter 1973 and the floating period thereafter, ending when the mark was at its peak in summer 1973. The fifth interval ends a year later, after the mark had fallen to a trough in January 1974, risen to a new peak in May, and then depreciated to a summer 1974 trough. The sixth interval ends with the mark at its next peak in spring 1975. The seventh interval spans the dollar appreciation in the second half of 1975.

For most of these intervals, changes in the exchange rate are paralleled fairly closely by movements in five of the nine relative price indexes—those for apparel, metalworking machinery, electrical industrial equipment, home electronic equipment, and glass products—although relative prices of metalworking machinery and home electronic equipment show "unexplained" upward shifts in the first two intervals while the relative price of glass products shows unexplained downward shifts. The relative price of paper products moves up proportionately less (or down proportionately more) than the exchange rate in six out of seven intervals; while relative prices of industrial chemicals, agricultural chemicals, and plastic materials parallel exchange rates fairly closely for the first half of the sample period and then fall sharply during the second half.

The conclusions drawn from this informal analysis are 1) that exchange rate movements are associated with substantial short-run changes in relative dollar price indexes

TABLE 3—EXCHANGE RATES AND RELATIVE EXPORT PRICE INDEXES FOR SELECTED MACHINERY CATEGORIES[a]

	German Dollar Price/*U.S.* Dollar Price						
	Exchange Rate	Internal Combustion Engines	Agricultural Tilling Machinery	Office Calculating Machines	Metalworking Machinery	Pumps	Forklift Trucks
June 1970	100	100	100	100	100	100	100
June 1971	103.4	104.1	108.9	110.3	110.4	106.2	111.1
June 1972	114.6	119.8	116.6	114.4	125.2	121.2	125.6
June 1973	140.9	155.5	136.2	139.3	153.8	144.7	159.7
June 1974	143.9	147.7	138.1	146.0	144.3	151.7	145.1
June 1975	155.2	148.1	122.5	147.7	141.8	139.3	139.1

Source: *U.S.* price data are from U.S. Department of Labor, *U.S. Export and Import Price Indexes.* German data are from source listed under Table 1.

[a]1970 = 100.

for all industrial categories considered here, and 2) that in most cases a major share of the short-run relative price change persists for at least several years. Careful econometric studies of data for a longer sample period might indeed find that the relative price changes associated with any particular exchange rate movement are completely offset over long periods of time. But in reality exchange rates are rarely stable over long periods of time. Thus, for practical purposes, products at this level of disaggregation are not sufficiently close substitutes to preclude substantial and persistant changes in relative common currency prices.

II. Comparative Movements of *U.S.* and German Export Prices for Selected Machinery Categories

The *U.S.* and German export transactions prices for various 4- and 5-digit *SITC* machinery categories allow relative price comparisons at a finer level of commodity disaggregation than the industry groups considered above. Prior to 1974, *U.S.* data were collected only once a year, in June. Table 3 compares relative prices for six machinery categories with the exchange rate in June of each year during the 1970–75 period. The conclusions of the previous section extend to this finer level of disaggregation. Machinery items at the 4- and 5-digit *SITC* level of disaggregation are not sufficiently close substitutes to preclude substantial and persistent changes in relative common currency prices.

III. Comparisons of *U.S.* Export Unit Values with Unit Values of *U.S.* Imports from Canada, Germany and Japan

The *U.S.* export price data are available at a still finer level of product disaggregation in the form of unit value indexes for 7-digit Schedule B export commodities. These export unit values can be compared with 7-digit Schedule A import unit values for products distinguished by country of origin.[5,6] Unlike the process of collecting transactions price data, however, the process of collecting unit value information does not hold constant the mix of items within each commodity group whose prices are sampled. Thus, on the one hand, there is no strong presumption that the law of one price will be more evident in these unit value data than it is in the export and

[5]The Schedule A and Schedule B classifications differ, but a reasonably close matching is possible at the 7-digit level.

[6]It is not appropriate to dismiss this comparison on the grounds that countries rarely export the exact same products that they import. The relevant issue is whether products selected from disaggregated lists of *U.S.* manufactured goods have close (not exact) substitutes on lists of goods manufactured abroad, and this is an empirical question which should be addressed in each of the few contexts for which matching data are available.

wholesale price data previously examined for less disaggregated commodity groups. But on the other hand, there is no presumption that shifts in commodity composition will generate "noise" in relative export and import unit values that is strongly correlated with exchange rate movements.

Because our only access to these unit value data was by hand copying, we limited our sample size to five commodity groups and constructed unit values on a quarterly basis, rather than monthly, from first-quarter 1968 through first-quarter 1975. Our focus is on unit values of exports to all importing areas combined and unit values of imports from three selected countries: Canada, Germany and Japan. The five commodity groups are soaps, tires (pneumatic passenger car), wall paper, ceramic tile (floor and wall), and steel bars. Export unit values are generally f.a.s. at the *U.S.* port of export, based on the transactions price, including inland freight, insurance and other charges incurred in placing the merchandise alongside the carrier at the *U.S.* port of exportation. Import unit values are c.i.f. beginning in 1974; prior to 1974 c.i.f. values are not available and import value is defined generally as "the market value in the foreign country."

These unit value data fluctuate so erratically that it is difficult to reach any conclusions about the law of one price by looking casually at plots analogous to Figure 1, or at information analogous to that provided in Tables 1–3. Accordingly I have relied on regression analysis to determine if any part of the variation in ratios of import unit values to export unit values is related systematically to fluctuations in exchange rates.

The notation I have used is:

t = index of quarterly time periods

R_t = ratio of *U.S.* import unit value by

TABLE 4—REGRESSION RESULTS FOR HYPOTHESIS (1)

	a_0	a_1	a_2	ρ	$\bar{R}^2$	*D.W.*
Canada						
Tires	−4.16	.0588	−.317	.859	.737	2.33
	(−.832)	(1.16)	(−1.15)	(8.87)		
Wallpaper	−.406	.0118	.361	.186	.656	1.89
	(−.462)	(1.31)	(4.50)	(1.00)		
Steel bars	.852	−.00292	.418	.0930	.553	1.94
	(.935)	(−.312)	(4.82)	(.494)		
Germany						
Soap	.726	.0938	−.791	.120	.148	1.60
	(.607)	(2.35)	(−1.35)	(.641)		
Tires	−.0828	.0437	−.142	.758	.728	1.66
	(−.152)	(2.72)	(−.816)	(6.15)		
Wallpaper	.316	.0264	−.0401	−.0974	.163	1.96
	(.885)	(2.21)	(−.223)	(−.518)		
Japan						
Soap	−.582	15.49	.921	.113	.0674	1.87
	(−.137)	(1.12)	(.740)	(.604)		
Tires	−.940	6.28	.244	.461	.869	2.11
	(−2.90)	(6.04)	(2.95)	(2.75)		
Wallpaper	−.720	6.79	1.07	.153	.901	2.04
	(−1.83)	(5.30)	(9.40)	(8.17)		
Ceramic tile	.0242	2.32	.428	.125	.693	1.74
	(.0826)	(2.43)	(4.99)	(.665)		
Steel bars	.183	1.39	.148	.508	.672	2.42
	(.825)	(1.95)	(2.71)	(3.12)		

Source: U.S. Department of Commerce.

Note: Numbers in parentheses are *t*-values. Critical values for the one-tailed *t*-test are 1.71 (95 percent confidence) and 2.48 (99 percent confidence).

country of origin to *U.S.* export unit value, in period t

S_t = exchange rate in period t: the *U.S.* dollar price of one unit of the currency of the country of origin of *U.S.* imports

D_t = dummy variable: 0 from 1968 Q1 to 1973 Q4; 1 from 1974 Q1 to 1975 Q1

where D_t is introduced to adjust for the shift as of first-quarter 1974 in the method of valuing imports.

The first regression hypothesis that we tested is

$$(1) \quad R_t = a_0 + a_1 S_t + a_2 D_t + e_t + \rho e_{t-1}$$

which allows for first-order autocorrelation. We also tested the hypothesis

$$(2) \quad \Delta R_t = b_1 \Delta S_t + b_2 \Delta D_t + u_t + \sigma u_{t-1}$$

which allows for a different pattern of serial correlation.[7] In each case we used the Cochrane-Orcutt procedure. The empirical results argued in favor of hypothesis (1) on two counts: the Durbin-Watson statistics were closer to 2.0 for six out of eleven pairs of commodities and countries of origin,[8] while corrected R^2 statistics were consistently higher.[9]

Table 4 presents the regression results for hypothesis (1). Ratios of German dollar prices to *U.S.* dollar prices and ratios of Japanese dollar prices to *U.S.* dollar prices are seen to be significantly and positively dependent on *U.S.* dollar prices of the mark and yen, respectively, for almost all commodity groups under consideration. A similar finding does not emerge in the Canadian case, perhaps because the exchange rate between the *U.S.* and Canadian dollars showed little variance and no abrupt changes during the sample period. The significance of exchange rate levels in the German and Japanese cases, however, suggests again that substantial changes in exchange rates typically have substantial and persistent effects on the relative common currency prices of closely matched manufactures produced in different countries.

[7]Other patterns of serial correlation are more difficult to take into account and have been implicitly assumed not to exist.

[8]Four of the fifteen pairs were discarded because *U.S.* imports from the country of origin were zero or negligible, so that unit values could not be computed, in one or more quarters of the sample period.

[9]It is worth noting, however, that b_1 was judged to be significantly greater than zero with at least 95 percent confidence in five of the eleven estimates of equation (2).

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