Exchange Rates and Prices under Fixed and Flexible Exchange Rates

James R. Lothian*

Abstract: Purchasing power parity is the theoretical lynchpin of international finance and open-economy macroeconomics. It posits a relationship linking the exchange rate between two countriesô currencies and their price levels that has major implications for economic behavior under systems of both fixed and floating exchange rates. This chapter reviews the history of the purchasing-power-parity theorem and presents unique evidence on its empirical performance both in recent decades and over the very long term.

* Gabelli School of Business, Fordham University, 160 West 62nd Street, New York, NY 10023, USA; lothian@fordham.edu

I. Introduction

The floating exchange rate regime is now close to a half century old. Before its inception, however, critics claimed that it simply would not work. "Individual foreign exchange traders and bankers would have an almost impossible task in groping for a going rate that could take all these conflicting influences into account,ò Robert Roosa, a former Fed and U.S. Treasury official asserted (Friedman and Roosa, 1967, p.49). The result, he claimed, was that ñtrade would be throttled and ... capital misdirected.ò

Both prognostications turned out to be completely wide of the mark. It took a bit of time but the foreign exchange market eventually began to grow and then it did so by leaps and bounds. Today it is huge in size and highly liquid ï an average daily turnover of more than $5 trillion in April 2016, two thirds of it in forward-looking instruments like foreign exchange swaps, foreign exchange futures and options and outright forwards that allow economic agents to hedge exchange risk. (BIS, 2016). International trade during this period has increased too and international financial markets have become much more integrated.[1]

Exchange rates, moreover, in the end have behaved as theory suggested. Despite considerable volatility over short periods, they have changed in sync with movements in relative price levels over the long term. Purchasing power parity (PPP) over such horizons has held remarkably well. Nevertheless close to three decades elapsed before that became widely realized and even today doubts persist.

Those are the issues upon which this chapter focuses. In it, I present evidence on the behavior of exchange rate and purchasing power parity across countries under floating rates and compare that behavior to behavior over the very long term historically. This first body of evidence is a direct follow up on the earlier study by Lothian and Simaan (1998) ï a replication of that experiment. The second body of evidence comes from a study now being completed by

---

[1] International Monetary Fund data show a near tenfold increase in worldwide real exports and imports from 1971 to 2016 (*International Financial Statistics*, 2017). Lothian (2002), Goldberg et al (2003) and Obstfeld and Taylor (2004) present evidence on the increase in financial integration.

Lothian and Devereux that uses data for the Netherlands and the UK spanning the ultra-long period 1590 to 2010 (Lothian and Devereux, 2016).

2. Theoretical issues

The theory of purchasing power parity offers a simple, empirically tractable explanation of exchange-rate behavior under floating exchange rates and of international price behavior under fixed exchange rates. In periods of high exchange-rate variability and of widespread disturbances in prices and incomes internationally, it has repeatedly surfaced

In the first instance, purchasing power parity is an application of the law of one price, not in the usual sense as applied to individual goods and securities, but on an aggregate level. Viewed solely from that perspective, however, PPP is somewhat questionable, if not implausible. Textbook presentation generally have a laundry list of reasons why aggregate price indices for different economies can differ from one another ï changes in the relative prices of traded and non-traded goods, differences in the market baskets of goods in different countries and so forth. Many of these objections seem quite compelling theoretically. If that were the whole story, moreover, it would be relatively simple to dismiss PPP. The interesting question, therefore, is why in light of these problems, PPP has been thought to make sense.

That gets us to a second rationale for PPP ï as a position of long-run monetary equilibrium. The ratio of relative prices of traded vs. non-traded goods, and other such factors in this view are regarded as nuisance parameters, their behavior perhaps of greater empirical importance in the transition from one steady-state equilibrium to another, but in general not very germane to the issue of those equilibria themselves. Such factors are treated in much the same way that distributional effects are treated in single-economy applications of the quantity theory.

This is a perspective that has been of great importance in the development of PPP, historically. After outlining the theory of PPP, I turn to an overview of this earlier literature. I focus on three contributions to this literature, the first by the late scholastic writers associated with the University of Salamanca in the sixteenth century, who were the first to posit the PPP relationship, the second by the Bullionists in nineteenth century Britain, as represented by John Wheatley, and the third by the American economist Irving Fisher at the turn of the last century.

To see the link between money and exchange rates and the potential differences in economic behavior under different exchange-rate regimes consider the following long-run two-country model.[2] The model takes the form of two equilibrium money-price relations and a purchasing-power-parity relation. The first two have their roots in the quantity theory of money; the third is a variant of the law of one price. The money-price relations for the domestic and foreign countries can be written as:

$$m = p^{d} + k \tag{1a}$$

and

$$m^{F} = p^{dF} + k^{F} \tag{1b}$$

where m is the logarithm of the nominal supply of money, m^d is the logarithm of the real amount of money demanded, assumed here for simplicity to be constant, and p is the logarithm of the price level and the superscript F denotes the foreign country.

The purchasing power parity relation takes the form:

$$s = p - p^{F}, \tag{2}$$

where s is the logarithm of the nominal exchange rate ï the price in domestic currency of a unit of the foreign currency.

In the floating-exchange-rate case, in contrast, monetary policies in the two countries will be independent and under control of the respective central banks and price levels are determined by (1a) and (1b). If monetary policies differ, so too will price levels. In this instance, the exchange rate will adjust to preserve purchasing power parity and move against the country with the more

[2] The model is consistent both with the verbal formulations of the theory by the Salamancans, Wheatley and Fisher and with much of the literature of the last 50 years, e.g. Friedman and Schwartz (1963, Lucas (1982), Darby and Lothian (1989), Evans and Lothian (1993) and Evans (2011).

expansive monetary policy.[3] In the fixed-exchange-rate case, *s* does not change so the domestic and foreign price levels, *p* and will converge. Money supplies in the two countries then will adjust to differences in the quantities of real money balances demanded.

3. The historical development of the concept of PPP

The tie-in of PPP with the quantity theory of money is explicit in the analyses of the individuals associated with what has come to be called ñthe School of Salamancaò in sixteenth century Spain. Priest-professors of moral philosophy, moral theology and the law they wrote on a broad spectrum of questions relevant to the European society of their time.

The prominent names here include: Francisco de Vitoria (c.1492-1546), initially a professor at the Sorbonne and later at Salamanca; Domingo de Soto (1495-1560) his student in Paris and later also a professor at Salamanca; Martín de Azpilcueta, known as Navarrus (1493-1586), an eminent canon lawyer and professor first at Salamanca and subsequently in Portugal; Luís de Molina (1535-1600), a theologian and civil lawyer; Juan de Mariana (1535-1624), a theologian cum political philosopher and historian; Francisco Suárez (1548-1617) a theologian who taught first at Salamanca, and then at other universities in Spain and Portugal as well as in Rome and Leonard Lessius (1554-1623), a Belgian theologian and student of Suárez in Rome who later taught at Louvain.

The motivation for their excursions into monetary theory was moral philosophy and theology and not economic analysis *per se*. They were trying to make sense of the phenomena that they were observing in the Europe of that era ï the price increases in Spain and elsewhere and depreciation of the Spanish currency that accompanied the inflows of specie, particularly silver, from the mines of the New World and the developments that were taking place in finance. A major question at issue was whether these price increases and the associated currency depreciation were morally justifiable. Their answer was ñyesò and in order to reach that conclusion they came up with what for the time was a highly sophisticated analysis.

---

[3] To see this, combine (1a), (1b) and (2) to get $s = (m - m^d) - (m' - m^{d\prime})$.

A particularly clear, and often-quoted statement is that of Azpilcueta writing in 1556. He wrote (quoted in Grice-Hutchinson, 1978, p. 104):

> [O]ther things being equal, in countries where there is great scarcity of money all other saleable goods, and even the hands and labor of men, are given for less money than where it is abundant. Thus we see by experience that in France, where money is scarcer than in Spain, bread, wine, cloth and labor are worth much less. And even in Spain, in times when money was scarcer, saleable goods and labor were given for very much less than after the discovery of the Indies, which flooded the country with gold and silver. The reason for this is that *money is worth more where and when it is scarce than where it is abundant* [my emphasis].

What we see here is a succinct statement of both the quantity theory of money and the monetary approach to exchange rates with PPP, the link between the two, lurking in the background. Similar statements can be found in the work of de Bañez and de Luego (Grice-Hutchinson, 1952, 1978, 1993)

Now fast forward three centuries to the period of the Napoleonic Wars and the Bullionist debate. Britain, as also Ireland which had its own currency, suspended specie payment in 1797 in the midst of paper money inflations. The sterling and the Irish pound, which had been rigidly linked at a rate of 1.0833 Irish pounds per pound sterling, were decoupled. Bank note issuance in both countries increased and currencies depreciation ensued, the Irish currency initially by more than the British. The debate at the time was whether the domestic inflations and the currency depreciations were linked. Arguing for the affirmative were the Bullionists: Henry Thornton, David Ricardo, Francis Horner and John Wheatley.

Wheatley, though not the most prominent of the group, provided a statement of the Bullionist position that was, as Thomas Humphrey put it, ñin some respects the most original of the group.ò In his first work on the subject, his *Remarks on Currency and Commerce* published in 1803 he stated the position succinctly:

> Almost all the nations of Europe have augmented their currency by some addition of paper. The course of exchange is the best criterion how far the currency of one is increased beyond the currency of another. By the recent

state of our unfavourable exchanges it is evident that our currency has been augmented in greater proportion than any.

In back of this view and developed further in his two volume work *An Essay on the Theory of Money and Principles of Commerce* (1807 and 1822) were three propositions: a strict quantity theory in which money was neutral and in which it alone determined the price level, purchasing power parity in absolute form and model of inter-country adjustment in which the activities of speculators in foreign exchange rather than trade-related specie flows were a rapid equilibrating force.[4] In the face of an incipient disequilibrium, speculators engaged in arbitrage in the market for bills of exchange and thus brought money supplies and price levels back to equilibrium under a specie standard and moved exchange rates into line with differences between price levels under a paper-money standard. Wheatleyôs grasp of international monetary theory was further apparent in his discussion of money-supply behavior under floating exchange rates. He argued that, contra their usual behavior under paper-money standards, exchange rates could in fact remain relatively constant provided the countries involved had similar rates of money-supply growth. What Wheatleyôs lacked in theoretical nuance ï unlike Thornton, no discussion of the velocity of money and, unlike Hume, no distinction between short- and long-run effects of monetary changes ï he made up for in his analysis of equilibrium.5

Now we turn to Irving Fisher writing in America a century later. At the heart of Fisherôs monetary analysis are clear statements with regard to macroeconomic equilibrium that embody PPP and that rely on its conditions for

---

[4] See Humphrey (1994) and Officer (1982, pp. 53-61) for discussions of Wheatley's contribution to international monetary economics. The latter cites a passage in the first volume of Wheatley's *An Essay on the Theory of Money and Principles of Commerce* (1807), calling it "the clearest exposition of the PPP theory ... made prior to the 20th century." (Officer, p. 58).

[5] In the second volume of *An Essay on the Theory of Money and Principles of Commerce* (1822), Wheatley switched theoretical gears and went on to discuss the short-run non-neutrality of money. The motivation for his doing so was the decline in output in Britain following the monetary disinflation necessitated by Britain's resumption of specie payments at the 1797 parity.

the adjustment of prices among economies. PPP in rate of change form is also implicit in his analysis of interest rates under different monetary standards. In his analysis both of the money-price relation and of interest-rate behavior, his discussion of the role of expectations has a decidedly modern ring (Lothian, Pownall and Koedijk, 2011).

> In *The Purchasing Power of Money* (1911, p. 91) he wrote:
>
> > If all countries had their irredeemable paper money, and had no money acceptable elsewhere there could be no international adjustment of monetary matters. Price levels in different countries would have no intimate connection . . . [b]ut where two or more nations trading with each other use the *same* standard, there is a tendency for the price levels of each to influence profoundly the price levels of the other.

Fisher then went on to trace the links between price levels and money supplies in different economies, first using the example of Connecticut vis-à-vis surrounding states and then countries adhering to gold. With regard to U.S states, he wrote:

> > If the level of prices Connecticut falls below that of the surrounding states, . . . the effect is to cause an export of money from those states to Connecticut, because people will buy goods wherever they are cheapest and sell them wherever they are dearest. With its low prices Connecticut becomes a good place to buy from, but a poor place to sell in. But if outsiders buy of Connecticut, they will have to bring money to buy with. There, therefore, will be a tendency for money to flow to Connecticut until the level of prices there rises to a level which will arrest the influx.

In the new equilibrium, relative, rather than absolute, PPP will prevail according to Fisher. In this connection, he stated that:

> > [I]t must not be inferred that prices of various articles or even the general level of prices will become precisely the same in different countries. Distance, ignorance as to where the best markets are to be found, tariffs and costs of transportation help to maintain price differences.

He added later:

> But, although international and local trade will never bring about exact uniformity of price levels it will, to the extent that it exists, produce an adjustment of these levels toward uniformity by regulating in the manner already described the distribution of money.
>
> And since the *quantity of money itself* affects prices for *all* sorts of commodities, the regulative effect of international trade applies not simply to the commodities which enter into that trade, but to all others as well.

In his empirical analysis of both price behavior and interest-rate behavior, Fisher relied heavily on comparisons under different monetary standards ï price levels of countries on gold vis-à-vs one another, price levels of countries on gold versus price levels of countries on silver and with irredeemable paper currencies, and yields on bonds redeemable in gold versus yields on similar bonds redeemable in silver and paper currencies.[6]

Overlapping with Fisher was the man who actually coined the phrase "purchasing power parity," the Swedish economist Gustav Cassel (Cassel, 1918). Cassel went on to publish a raft of articles and books on the subject (e.g., Cassel, 1916, 1918, 1922, 1928a, 1928b). Cassel sought to revive interest in the concept of PPP in the context of the debate over whether and how the major currencies should return to the gold standard, which had been suspended during the First World War, and more specifically in the context of the rate at which sterling should return to gold.

With the rise of Keynesian economics, the fixed-price models of *The General Theory* became the principal engine of macroeconomic analysis, one result of which was de-emphasis of PPP. The PPP concept did, however, remain a key element in the quantity-theory analysis that developed at the University of Chicago in the post-WWII years and that formed the theoretical backbone of Friedman and Schwartz's (1963) *A Monetary History of the United States*. Although they uncovered sizable variations in the PPP relation over various subperiods, the two nevertheless remained impressed by its relative stability over

[6] See Fisher (1907) with regard to interest rates and UIP and Fisher (1918, 1934) with regard to international price behavior.

the bulk of their sample period. Friedman and Schwartz (pp. 678 679) wrote, "One striking example of the stability of basic economic relations is the stability of relative prices in the United States and Great Britain adjusted for changes in the exchange rate between the dollar and the pound [i.e. the reciprocal of the real exchange rate]." Their view was not at all atypical (see, e.g., Galliot, 1970).}

When the United States and other developed countries shifted to floating exchange rates at the start of the 1970s, PPP took on a new life. Some economists at the time became excessively optimistic with regard to its empirical applicability, viewing it as holding not just in the long run but in the very short run too. The papers in Frenkel and Johnson (1976) are prominent examples. A scant decade later, many researchers had reached a completely opposite conclusion. According to one observer, PPP had "collapsed" (Frenkel, 1981). Such inferences were, however, based on less than a decadeôs worth of data and soon began to prove fragile.

As somewhat more data for the float became available and researchers examined those and other data more thoroughly, it started to become apparent that the PPP relation might in fact provide a useful characterization of exchange-rate and international price behavior over the long run. Lothian (1985) showed this using cross-country data for a group of 20 developed countries in the period 1956 to 1980. Frankel (1986) and Edison (1987) showed the same thing using historical time-series data. Over the next three decades, studies of PPP proliferated. The conclusions that came out of this research reinforced those of the three studies just cited, that PPP held quite well when viewed in the context of a century or more of data ï two centuries in the case of Lothian and Taylor (1996) ï and that during the floating-rate period itself it appeared to do so too, though here doubts continue to be voiced.[7]

4. Empirical evidence from cross-country panel data

Now let me turn to some additional empirical evidence. The first body of evidence to be considered comes from annual data for the United States and a

[7] See the papers in Part II, Real Exchange Rates and Purchasing Power Parity in my *Essays in International Money and Finance* (Lothian, 2017). For evidence on the floating-rate period up until the early 1990s, see Frankel and Rose (1996), Lothian (1997) and Lothian and Simaan (1998.

group of 21 other OECD during the period 1995 to 2015. This evidence is interesting in its own right, but what make sets it apart is that it is close to a direct replication of the earlier study by Lothian and Simaan for the same group of countries over the period 1974 to1994.

The form of the PPP relation used here is between the rates of inflation in the foreign countries dp^{for} and the exchange rate adjusted rate of inflation in the United States, the sum of the actual US rate of inflation, dp^{US}, and the change in the log of the respective foreign to US exchange rate, ds_i:

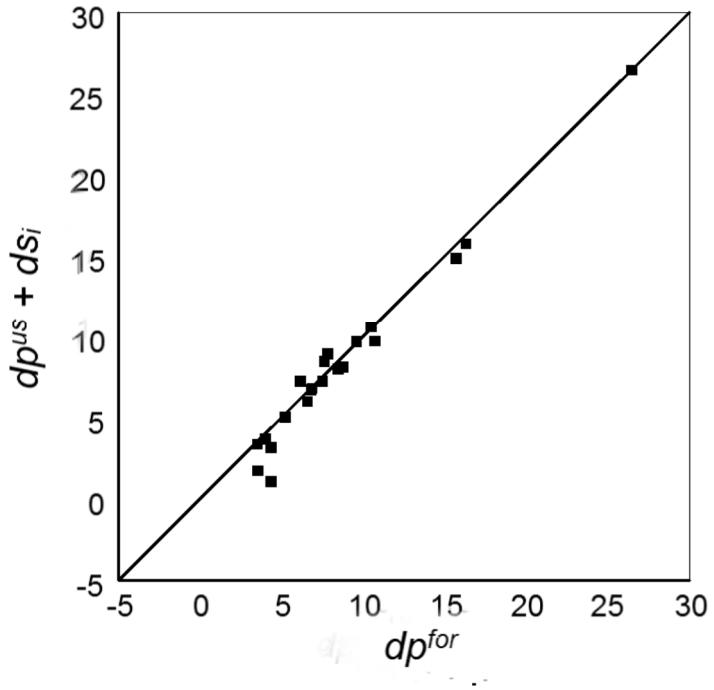
$$\square\square_{\square}^{\square\ \square} + \square\square_{\square\square} = \square + \square\square\square_{\square\square}^{\square\square\square} + \square_{\square}, \qquad (3)$$

where Ŭand ɓ are coefficients to be estimated, e_t is an error term and the subscripts i and t denote the country and time period respectively. If PPP holds rigidly, Ŭwill be 0 and ɓ will be 1. In that case, the change in the real exchange rate, the algebraic sum of the three variables in (3), will be 0.

Shown in Figure 1 is a scatter plot of the exchange rate adjusted rate of inflation in the United States against the inflation rates for the other OECD countries. The data are 21-year averages of yearly observations for the 1995 to 2015 sample period. Drawn in as a frame of reference is a 45-degree line through the origin. While the points are not literally on the line they are clustered around it and thus indicative of a close to one-to-one relation between the variables.

The results of the corresponding regressions presented in Table 1 bear this out. These regressions are run two ways to account for errors-in-variables problems, first as in equation (1) with the sum of dp^{US} and ds_i as the dependent variable and dp^{for} as the independent variable and then in reverse form with dp^{for} as the dependent variable and $dp^{US} + ds_i$ as the independent variable. The slope coefficients in these regressions of .89 and 1.07 bracket the theoretical value of unity. They average .98. The coefficient of determination is .95 and the standard errors of the regression both close to one percentage point.

Figure 1. Exchange-rate adjusted US inflation vs. foreign inflation, averages for 1974-1994, OECD sample



Note: dp^{US} - ds_i: is the exchange-rate adjusted rate of inflation in the United States; is the sum of the actual rate of inflation rate in the United States, dp^{US}, and the foreign vs. US exchange rate, ds_i .

Table 1. Regressions of foreign-country and exchange-rate adjusted US inflation, OECD sample. 21-year averages of yearly data, 1995-2015 and 1974-1994

Dep. variable.	Constant	π_i^{CPI}	$dp^{US} + ds_i$	R^2/SEE
1995 to 2015				
$dp^{US} + ds_i$	0.644	0.889		0.952
	0.263	0.045		1.056
	2.450	19.874		
π_i^{CPI}	-0.544		1.071	0.952
	0.306		0.054	1.159
	-1.778		19.874	
1974 to 1994				
$dp^{US} + ds_i$	-0.949	1.068		0.989
	0.330	0.025		0.985
	-2.871	41.939		
π_i^{CPI}	0.991		0.926	0.989
	0.291		0.022	0.917
	3.405		42.091	

Note: $dp^{US} + ds_i$ is the exchange-rate adjusted US rate of inflation and π_i^{CPI} is the foreign rate of inflation.

Table 2 contains regressions with $dp^{US} + ds_i$ as the dependent variable using yearly data, 3-year averaged and 7-year averaged data along with the regression using 21-year averaged data already reported. Two things should be noted here. The first is the near unity coefficients in all of the regressions. Clearly there is at least a semblance of the PPP relation even in the yearly regressions. But notice the second thing ï the substantial improvement in the fit of the regressions as the data are averaged. The standard error is close to halved in going from yearly data to 3-year and 7-year averages and reduced close to 80 per cent again in going from 7-year to 21-year averages. The difference between long run and short run does indeed matter. That in turn may explain some of the difficulty researchers

had in the early years of the float in detecting the PPP relation in the scanty data then available.

Table 2. Regressions of $dp^{US} + ds_i$ on Δp_i^{yearly} yearly data and various averages of yearly data, OECD sample, 1995-2015

	Constant	Δp_i^{yearly}	R^2/SEE
yearly	0.766	0.899	0.326
	0.460	0.060	9.067
	1.666	14.903	
3-year	0.774	0.896	0.601
	0.445	0.059	5.055
	1.738	15.127	
7-year	0.609	0.938	0.633
	0.659	0.089	4.966
	0.924	10.505	
21-year	0.639	0.889	0.952
	0.263	0.045	1.058
	2.425	19.832	

Note: $dp^{US} + ds_i$ is the exchange-rate adjusted US rate of inflation and Δp_i^{yearly} is the foreign rate of inflation

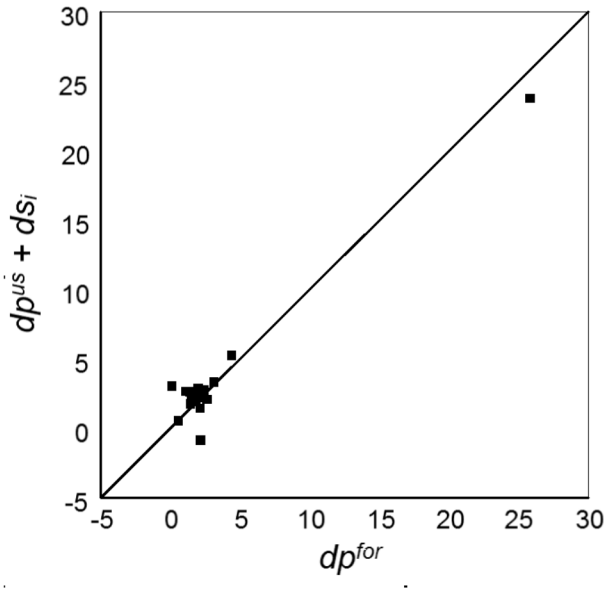
Table 2 contains regressions with $dp^{US} + ds_i$ as the dependent variable using yearly data, 3-year averaged and 7-year averaged data along with the regression using 21-year averaged data already reported. Two things should be noted here. The first is the near unity coefficients in all of the regressions. Clearly there is at least a semblance of the PPP relation even in the yearly regressions. But notice the second thing ï the substantial improvement in the fit of the regressions as the data are averaged. The standard error is close to halved in going from yearly data to 3-year and 7-year averages and reduced close to 80 per cent again in going from 7-year to 21-year averages. The difference between long run and short run does indeed matter. That in turn may explain some of the

difficulty researchers had in the early years of the float in detecting the PPP relation in the scanty data then available.

The decrease in variability that comes with averaging very likely has two sources. The first and more obvious is the mitigation of the effects of measurement error, both in the price series and the exchange rate series. The second is the canceling out of the effects of other stochastic factors that influence real exchange rates over shorter, but not longer, periods.

As stated above, the findings that I have just reported come from what in effect is a partial replication of my earlier with Yusif Simaan (Lothian and Simaan, 1998). Figure 2 presents a scatter diagram similar to Figure 1 but for the preceding 21 years 1974 to 1994, which was the period that Simaan and I studied. It looks almost the same as Figure 1. The observations again are scattered tightly

Figure 2. Exchange-rate adjusted US inflation vs. foreign inflation, averages for 1995-2015, OECD sample



Note: dp^{US} - ds_i: is the exchange-rate adjusted rate of inflation in the United States; is the sum of the actual rate of inflation rate in the United States, dp^{US}, and the foreign vs. US exchange rate, ds_i .

around the 45-degree line pointing again to a close to one to one relationship between the two series. The results of the two regressions reported in the lower half of Table 1 provide confirmation of these visual findings. The two slope coefficients are again both close to unity and on average equal unity.

These are powerful results. Replications are few and far between in economics which lacks the laboratories available in the physical sciences. Replications that lead to near identical findings are I suspect fewer still. When they do occur, however, they greatly strengthen oneôs degree of belief in the theoretical relationship under investigation.

4. Empirical evidence from cross-country panel data

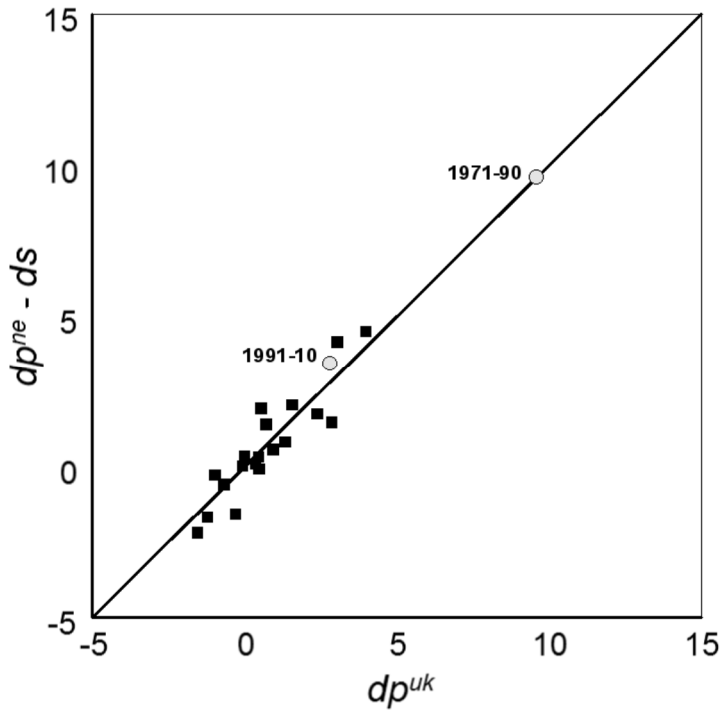
The final bit of evidence comes from ultra-long annual time series data that John Devereux and I have compiled for a study of the Dutch guilder- British pound sterling exchange rate for the period 1590 to 2010 (Lothian and Devereux, 2016). For purposes of comparability with the results reported above, I focus principally on results based on 20-year averages of these data. Shown in Figure 3 is a scatter plot of the exchange-rate adjusted Dutch inflation rate against the UK inflation rate. Here I have singled out the two observations for the floating-rate period.

Table 3 reports corresponding regression results. Table 4 contains a comparison of the 20-year average results with those from regressions using yearly data and 5-year and 10-year averages of the yearly data.

The results across the board are virtually identical to those obtained with the OECD data for the floating-rate. Consistent with theory, we see a close to one-to-one positive relationship between the exchange-rate adjusted Dutch inflation rate, dp^{NE}- ds, and the UK inflation rate, dp^{UK}, in the chart. It is clear, moreover, that this relationship is in no way different for the floating-rate years. One observation is almost literally on the 45-degree line. The other is exceedingly close to it.

The regression results reported Table 3are fully consistent with what we see in the chart. The estimated slope coefficients in the regressions are .89 and 1.04 for an average of .97. The R^2 is .92 and the standard errors less than one percentage point.

Figure 3. **Exchange-rate adjusted Dutch inflation rate vs. UK inflation rate. 20-year averages, 159- 2010**



Note: dp^{NE}- *ds* is the exchange-rate adjusted Dutch inflation rate and dp^{UK} is the UK inflation rate,

Table 4 reports the results of regressions of the one inflation rate on the other for the yearly data and for the three bodies of averaged data. The estimated slope coefficients in all four regressions are positive and statistically significant. The relationship in the yearly data, however, is very weak, an R^2 of .13 and an estimated slope coefficient of .41. But with averaging the picture improves markedly. The slope coefficients and R^2s progressively increase and the standard errors of estimate progressively decrease. In the regressions using five year averages, the R^2 rises to .56 and the estimated slope coefficients to .90 while the standard error falls to less than 40 per cent of its value in the yearly regression. In the regressions using ten-year and twenty-year averages, the results improve further. The estimated slope coefficients are both close to unity. The R^2s are .84 and .92, respectively. The standard errors of the regressions in going from the

five-year to the ten-year to the twenty- year averages are halved and then almost halved again.

Table 3. Regression results, adjusted Dutch inflation and British inflation. 20-year averages of yearly data. 1590-2010

Dep. Variable.	Constant	dp^{NE}- ds_i	dp^{UK}	R^2/SEE
dp^{UK}	0.136	0.891		0.923
	0.167	0.059		0.688
	0.815	15.135		
dp^{NE}- ds_i	-0.045		1.036	0.923
	0.183		0.068	0.742
	-0.248		15.135	

Note: the exchange-rate adjusted Dutch inflation rate, dp^{NE}- ds_i, and dp^{UK} is the UK inflation rate,

Table 4 reports the results of regressions of the one inflation rate on the other for the yearly data and for the three bodies of averaged data. The estimated slope coefficients in all four regressions are positive and statistically significant. The relationship in the yearly data, however, is very weak, an R^2 of .13 and an estimated slope coefficient of .41. But with averaging the picture improves markedly. The slope coefficients and R^2s progressively increase and the standard errors of estimate progressively decrease. In the regressions using five year averages, the R^2 rises to .56 and the estimated slope coefficients to .90 while the standard error falls to less than 40 per cent of its value in the yearly regression. In the regressions using ten-year and twenty-year averages, the results improve further. The estimated slope coefficients are both close to unity. The R^2s are .84 and .92, respectively. The standard errors of the regressions in going from the five-year to the ten-year to the twenty- year averages are halved and then almost halved again.

Table 4. Regression results for adjusted Dutch inflation on British inflation, yearly data and averages of yearly data, 1590-2010

	Constant	dp^{UK}	R^2/SEE
yearly	0.735	0.412	0.127
	0.374	0.053	7.551
	1.965	7.803	
5-year	0.119	0.904	0.562
	0.332	0.088	2.869
	0.360	10.259	
10-year	0.014	0.988	0.837
	0.227	0.069	1.359
	0.063	14.350	
20-year	-0.045	1.036	0.923
	0.183	0.068	0.742
	-0.248	15.135	

Note: the exchange-rate adjusted Dutch inflation rate, dp^{NE}- ds_i, and dp^{UK} is the UK inflation rate,

These results are remarkable from two standpoints. The first is that the PPP relation holds as well as it does over this exceedingly long and exceedingly diverse period and shows no signs of temporal instability. The second is the substantial similarity between these results and the results for the float. If the two sets of scatter plots and regressions had been left unlabeled, a reader would have a hard time distinguishing between them, yet they come from such different bodies of data and with only a short overlap from two very different time periods.

4. Conclusions

Purchasing power parity is a fundamental economic relation with an intellectual lineage extending back to the middle of the sixteenth century. According to one line of thinking, however, it lost most, if not all, of its power when floating exchange rates came into being following the breakdown of the Bretton Woods system of pegged exchange rates in the early 1970s.

What the empirical evidence has increasingly shown, however, is that whatever else has gone on under floating exchange rates, purchasing power parity has continued to hold quite well over the longer term. The results presented in this chapter here add substantially to that evidence.

This has important implications for how we think both about exchange-rate behavior and about exchange-rate systems in our theorizing and in our practical day-to-day analysis. It implies, for example, that theories that focus exclusively on the effects of real variables on exchange rates miss a major portion of the picture. It implies further that purchasing power parity as an equilibrium condition is an important constraint, one that cannot be ignored either by policy makers or the business community.

References

BIS Triennial Central Bank Survey of foreign exchange and OTC derivatives markets in 2016 **http://www.bis.org/publ/rpfx16.htm**

Cassel, Gustav. (1916). ñThe Present Situation of the Foreign Exchanges.ò *Economic Journal*, **26,** 62ï 65.

Cassel, Gustav. (1918). ñAbnormal Deviations in International Exchanges.ò *Economic Journal,* **28**, 413ï 415.Cassel, Gustav. (1922). *Money and Foreign Exchange after 1914.* Constable, London.

Cassel, Gustav. (1928). *Foreign Investments – Lectures of the Harris Foundation*. University of Chicago Press, Chicago.

Cassel, Gustav. (1928b). *Post-War Monetary Stabilization*. Columbia University Press, New York.

Darby, Michael R. and James R. Lothian (1989). ñInternational Transmission Afloat,ò in M. Bordo (ed.), *Money, History and International Finance: Essays in Honor of Anna J. Schwartz*, 203ï 236, University of Chicago Press for the National Bureau of Economic Research, Chicago.

Edison, H. (1987). ñPurchasing Power Parity In The Long Run: A Test of the Dollar/Pound Exchange Rate (1890ï 78),ò *Journal of Money, Credit, and Banking*, **19**, 376ï 387.

Evans, Martin D. D. (2011). *Exchange-Rate Dynamics*. Princeton University Press , Princeton.

Evans, Martin D. D. and James R. Lothian (1993). ñThe Response of Real Exchange Rates to Permanent and Transitory Shocksò, *Journal of International Money and Finance*, **12**, 563ï 586.

Fisher, Irving. (190). *The Rate of Interest*. Macmillan, New York.

Fisher, Irving. (1918). *The Purchasing Power of Money: Its Determination and Relation to Credit, Interest and Crises*. MacMillan, New York,.
Fisher, Irving. (1934). *Are Booms and Depressions Transmitted Internationally Through Monetary Standards*? New Haven, [a second printing from Sect. 2. Rapp. XXII session de l'Institut international de statistique, London,]
Frankel, J. (1986). ñInternational Capital Mobility and Crowding out in the U.S. Economy: Imperfect Integration of Financial Markets or Goods Markets?ò in R. Hafer (ed.), *How open is the US economy.* 33ï 67. Lexington Books, Lexington.
Frankel, Jeffrey A. and Andrew K. Rose (1996). ñA Panel Project on Purchasing Power Parity: Mean Reversion within and between Countries.ò *Journal of International Economics* **40**, 209ï 224.
Frenkel, Jacob A. (1981). ñThe Collapse of Purchasing Power Parities during the 1970s,ò *European Economic Review*, **16**, 145ï 165.
Frenkel, Jacob A. and Harry G. Johnson (1976). *The Monetary Approach to the Balance of Payments*, Allen & Unwin, London.
Friedman, Milton, Roosa, Robert V. (1967).*The Balance of Payments: Free Versus Fixed Exchange Rates*. American Enterprise Institute for Public Policy Research Washington, DC.
Friedman, Milton and Anna J. Schwartz (1963). *A Monetary History of the United States: 1867–1960*, Princeton University Press, Princeton.
Gailliot, Henry J. (1970). ñPurchasing Power Parity as an Explanation of Long-Term Changes in Exchange Rates,ò *Journal of Money, Credit and Banking,* **2**, 348ï 357.
Goldberg, Lawrence G., James R. Lothian and John Okunev (2003). ñHas International Financial Integration Increased?ò *Open Economies Review*, **14**, 299ï 317.
Grice-Hutchinson, Marjorie. (1952*). The School of Salamanca: Readings in Spanish Monetary Theory, 1544-160*5. Clarendon Press, Oxford.
Grice-Hutchinson, Marjorie. (1978). *Early Economic Thought in Spain, 1177-1740,* Allen and Unwin, London.
Grice-Hutchinson, Marjorie (1993).. *Economic Thought in Spain: Selected Essays* (edited and with an introduction by Laurence S. Moss and Christopher K. Ryan. Edward Elgar, Brookfield, Vt.
Humphrey, Thomas M. (1994), ñJohn Wheatleyôs Theory of International Monetary Adjustment.ò Federal Reserve Bank of Richmond, *Economic Quarterly*, **80**, 69-96.
International Monetary Fund. (2017). *International Financial Statistics*, CD ROM version
Lothian, James R. (1985). ñEquilibrium Relationships between Money and Other Economic Variables,ò *American Economic Review*, **75**, 828ï 835.

Lothian, James R. (1997). ñMulti-country Evidence on the Behavior of Purchasing Power Parity under the Current Float,ò *Journal of International Money and Finance*, **16**, 19ï 35.
Lothian, James R. (2002). ñThe internationalization of money and finance and the globalization of financial markets,ò *Journal of International Money and Finance*, **21**, 699ï 724.
Lothian, James R., John Devereux (2016). ñ Exchange Rates and Prices in the Netherlands and Britain over the Past Four Centuries. ò unpublished working paper, Fordham University.
Lothian, James R., Rachel A.J. Pownall and Kees G. Koedijk (2013). ñI Discovered the Peso Problem: Irving Fisher and the UIP Puzzle,ò *Journal of International Money and Finance*, **38**, 5ï 17.
Lothian, James R. and Yusif Simaan (1998). ñInternational Financial Relations under the Current Float: Evidence from Panel Data.ò *Open Economies Review*, **9**, 293ï 313.
Lothian, James R. and Mark P. Taylor (1996). ñReal Exchange Rate Behavior: The Recent Float from the Perspective of the Past Two Centuries,ò *Journal of Political Economy*, **104**, 488ï 510.
Lucas, Robert E. Jr. (1982). ñInterest Rates and Currency Prices in a Two-country World.ò *Journal of Monetary Economics*, November, **10:** 335-359.
Maurice Obstfeld and Alan M. Taylor. (2004). *Global capital markets: Integration, crisis, and growth*. Japan-U.S. Center Sanwa Monographs on International Financial Markets. Cambridge University Press, Cambridge.
Officer, Lawrence H. (1982), *Purchasing Power Parity and Exchange Rates : Theory, Evidence and Relevance* . JAI Press, Greenwich, Conn.
Wheatley, John. (1803). *Remarks on Currency and Commerce*. Cadell and Davies, London.
Wheatley, John, (1807, 1822). *An Essay on the Theory of Money and Principles of Commerce*. Printed for T. Cadell and W. Davies, by W. Bulmer and Co., London.