The Behavior of Prices and Nominal Exchange Rates across Exchange-Rate Regimes: Three Natural Experiments

James R. Lothian*

First draft May 2007; this draft February 2008

Schools of Business
Fordham University

Abstract: The evidence presented in this paper shows that as a long-run proposition PPP is indeed a very useful approximation. We see this in long historical data and in panel data for the three episodes – the classical gold-standard period, the interwar period and the varied monetary regimes of the post-WWII era. Low frequency movements of exchange rates and relative price levels are highly correlated and more often than not bear a close to one-to-one relation to one another. Price-level behavior across countries differs in the way that PPP suggests when monetary arrangements differ and is highly similar when monetary arrangements are themselves similar.

* Graduate School of Business, Fordham University, 113 West 60th Street, New York, NY 10023, USA, tel., 1 212 636-6147, emails, lothian@fordham.edu; jrmlothian@aol.com. I want to thank Caitlin Leary for help in data collection, Luis Catão for generously providing me with his data for the gold-standard era. Rachel Campbell, John Devereux, Iftekhar Hasan, Christian Wolff and participants at the 11th the International Conference on Macroeconomic Analysis and International Finance at the University of Crete.

I. Introduction

The literature on purchasing power parity is both voluminous and continuing to grow.[1] Why has this topic generated so much interest, not just in recent decades but historically?

There are, I believe, two reasons. One is obvious: PPP offers a simple, empirically tractable explanation of exchange-rate behavior that when all is said and done has no major competitor. In periods of exchange-rate variability, PPP has, therefore, repeatedly surfaced. The other reason economists have deemed PPP to be useful is because of its implications for price behavior and the transmission of disturbances under regimes of fixed and pegged exchange rates. The two are, so to speak, simply two sides of the same coin.

In the first instance, PPP is an application of the law of one price, not in the usual sense as applied to individual goods or securities, but on an aggregate level. Viewed solely from that perspective, however, PPP appears rather questionable, if not implausible. Any textbook presentation has a laundry list of reasons why aggregate price indices for different economies can differ from one another – 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 are 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 repeatedly thought to make sense.

That gets us to a second reason – PPP as a monetary equilibrium condition. Viewed from this perspective, PPP is a long-run proposition, with empirical implications for the behavior of nominal exchange rates and price levels over time and across different economies. 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

---

[1] Surveys of this literature include Edison et al. (1997), Rogoff (1996), Sarno and Taylor (2002) Taylor and Taylor (2004).

treated in much the same way that distributional effects are treated in single-economy applications of the quantity theory.

This is, I believe, the perspective that has been of great importance in the theoretical development and empirical application of PPP, historically. It is the approach that I adopt here. I, therefore, begin with a brief overview of this earlier literature. I focus, in particular, on three contributions to this literature, the first by the Salamancan writers of 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 Irving Fisher.[2]

I follow this discussion of the history of economic thought as it pertains to PPP with an outline of a bare-bones equilibrium model that is consistent with both these historical discussions of the theory and modern recent theoretical analysis. I then turn to the data, initially to very long-term data that I have used elsewhere, and then to three sets of multi-country panel data. The first body of multi-country data is for the period 1870-1914, the era of the classical gold standard; the second for the interwar period from 1921 to 1939 and the third and last for the Bretton Woods and post-Bretton Woods era. What all three have in common are differences over both time and space in underlying monetary regimes and in the behavior of money supplies, whence the term "natural experiments. My focus here is on the longer-term behavior of price levels among countries on the same and on different monetary standards and on the relation of price levels of countries to nominal exchange rates. In both the long-term historical data and in the data for these individual episodes, I concentrate on low-frequency movements in the variables of interest and hence on PPP as a description of long-term equilibrium.

The evidence in the main is that at this level of abstraction PPP performs tolerably well. In each instance, the important differences in price behavior that theory suggests we ought to see in the data we do in fact see. Longer term changes in relative price levels, moreover, are highly correlated with longer-

[2] See Officer (1982) for a more broad-based review of the historical PPP literature.

term changes in nominal exchange rates.

The notion that PPP has totally broken down at one time or another that periodically has been advanced in connection with these episodes, therefore, receives no credence in these data. The results also speak to the related question of the applicability of PPP under different exchange rate regimes. A typical objection to studies of PPP that rely on long-term time series data is one of aggregation bias.[3] These data suggest that this is a nonissue as it pertains to the *long-term* performance of PPP.[4]

II. PPP and Monetary Equilibrium: An Historical Overview

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 "the School of Salamanca" in sixteenth century Spain. Priest-professors, and philosophers, moral theologians and jurists, 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 and called the Father of the Hispanic Scholastics; 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; Domingo de Bañez (1527-1624), professor of theology at Salamanca and friend and confessor of St. Theresa of Avila; and Tomás de Mercado (1500-1575); 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; Leonard Lessius (1554-1623), a Belgian theologian and student of Suárez in Rome who later taught at Louvain; and Cardinal Juan de Luego (1583-1660), the last of the

---

[3] For a direct test of this hypothesis see Lothian and McCarthy (2002).

[4] As Mussa (1986) much earlier showed and others have corroborated, differences in regime do matter empirically at shorter time horizons.

Spanish late scholastics.

Their motivation for their excursions into monetary theory was not economic analysis per se but moral philosophy and theology. They were trying to make sense of the phenomena that they were observing in the Europe of that era – the price increases and depreciation of the Spanish currency that accompanied the inflows of specie, particularly silver, from the mines of the New World. The question at issue was whether these price increases and the currency depreciation were morally justifiable. Their answer was "yes" and in order to reach that conclusion they came up with what for the time was a highly sophisticated analysis. A particularly clear, and often-quoted statement is that of Azpilcueta. 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 let me fast forward three centuries to the period of the Napoleonic Wars and the Bullionist debate. Britain, as also Ireland, which had its own currency the Old Irish Pound, suspended specie payment in 1797 in the midst of paper money inflations that The Old Irish Pound, which had been rigidly linked to sterling at a rate of 1.0833 Irish pounds per pound sterling, and sterling became decoupled. Bank note issuance in both countries increased and the currencies depreciated, the Irish initially by more than the British. The debate at the time was whether these phenomena 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 Humphrey has put it, "in some respects the most original of the group." 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 Humean specie flows provided were the rapid equilibrating force. 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. Wheatley's 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 Wheatley's lacked in theoretical nuance – unlike Thornton, no discussion of velocity and, unlike Hume, no distinction between short- and long-run effects of monetary changes – he made up for in his analysis of equilibrium.[5]

Now let me turn to Irving Fisher. Fisher, for whatever reason, is seldom mentioned in

---

[5] 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)

It is interesting to note that in the second volume of that work (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.

connection with international monetary economics and, to my knowledge, is never mentioned in connection with PPP.

This is curious, to say the least. At the heart of Fisher's monetary analysis are clear statements with regard to macroeconomic equilibrium that embody PPP and that rely on its conditions for the adjustment of prices among economies. PPP in rate of change form, moreover, is 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 (Campbell, et al., 2007).

In *The Purchasing Power of Money* (p. 91) he writes:

> 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 goes 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 writes:

> 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 states 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 goes on to say 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 both of price behavior and interest-rate behavior, Fisher relied heavily on comparisons under different monetary standards – 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]

III. Theoretical Considerations

To see the potential differences in economic behavior under different exchange-rate regimes and floating exchange rates and the role played by the purchasing-power- parity condition, consider the following simple long-run, two-country equilibrium model.[7] One country, the "domestic economy," is a small country whose trade and financial markets are completely open; the other, the "foreign country" is large and also fully open economy.

The model as it pertains to the domestic economy 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 second is a variant of the law of one price. The money-price relations can be written as:

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

and

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

[7] The model is both consistent with the verbal formulations of the theory by the Salamancans, Wheatley and Fisher and with much of the more recent literature, e.g. Friedman and Schwartz (1963), Johnson (1969), Lucas (1982) and Darby and Lothian (1989).

$$m' = m^{d}' + p' , \tag{1b}$$

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 where a prime signifies the foreign country.

The purchasing power parity relation takes the form:

$$p = p' + s , \tag{2}$$

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

In the fixed-exchange-rate case, s does not change by definition so p, the domestic price level, will take whatever value is consistent with p', the foreign-country price level. Money supplies in the two countries then will adjust to differences in the quantities of real money balances demanded.

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 while 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 expansive monetary policy.[8] The key to these differences between the two exchange-rate regimes, therefore, is purchasing power parity. If purchasing power parity holds, price behavior will be similar in countries adhering to fixed exchange rates and different in countries pursuing floating rates, provided of course that their monetary policies do in fact differ.

IV. Empirical Evidence: Long-term Data

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

The first body of evidence I want to consider comes from long-term historical time-series data that I have used in previous research (Lothian, 1990, 1991; Lothian and Taylor, 1996, 2006).

Shown in the three panels of Figure 1 are plots of the logs of the price levels of France, Japan and the US, respectively, along with a plot of the log of the U.K. price level and the log of the corresponding foreign-U.K. real exchange rate. What immediately strikes the eye in all three charts are the differences between the behavior of the price levels and the real exchange rates. While there is a good deal of variation in the real exchange rates over shorter periods, the variations over the full sample periods are dramatically dwarfed when compared to the variations in national price levels. The price levels in all four instances show a substantial upward drift. The real exchange rates, in contrast, appear mean reverting, or in the case of Japan, where following earlier work (Lothian, 1990, 1991) I have allowed for a deterministic trend, trend-reverting.[9] On this purely visual level, therefore, the principal implications of purchasing power parity appear to be borne out.

The other thing to notice here is the difference in behavior of the various price series over time. During periods when the four countries were on the gold, or in the case of France earlier, a bimetallic standard, these series generally move closely together. Divergences become most evident when the standards differ – France and the US vs. the UK during the Napoleonic Wars, the US vs. the UK during the American Civil War, Japan before it went on gold in 1897, France and Japan vs. the UK in the interwar years, and then in World War II and the decades that followed.

What also is apparent in these charts is the rather dominating influence that the shift from commodity to fiat money had in all four countries. These differences across regimes account for such a large proportion of the variance of price levels and nominal exchange rates that we have as it were, many fewer effective degrees of freedom than two hundred or more observations would seem to indicate.

To mitigate this problem, I computed non-overlapping decadal average rates of change of

[9] The rationale for doing so was to allow for Harrod-Balassa- Samuelson productivity-growth effects that appeared potentially important both in the decades following the Meiji restoration and the decades immediately following World War II.

nominal exchange rates and relative price levels for all three countries relative to the UK. These are plotted for the three countries combined in Figure 2; corresponding regression results for both these pooled data and for the individual -country data are given in Table 1. Given the errors that are likely to exist in the prices series, in earlier years particularly, I ran these regressions both in the usual form as:

$$) s_{it} = a_1 + b_1 \;) (p_{it} - p_{ukt}) + e_{1it}, \tag{4}$$

and in reverse form as

$$) (p_{it} - p_{ukt}) = a_2 + b_2 \;) s_{it} + e_{2it}, \tag{5}$$

where s_i is the log nominal exchange rate of country i relative to the U.K. and p_i and p_{uk} are the respective log price levels. The first would be appropriate if the exchange rate were the only variable subject to measurement error; the second, if only price levels were subject to measurement error.

. It is clear from both the plot of these data in Figure 2 and the regressions reported in Table 1 that there is a strong relationship between the two variables. This is particularly so in the cases of France and Japan Consistent with theory, the slope coefficients in the regressions, in most instances are close to unity and many not significantly different from unity, while the intercepts generally are small in absolute value and in all instances not significantly different from zero.

V. Empirical Evidence: The Three Natural Experiments

I now will turn to what I have termed "the three natural experiments" in the title of this paper. They are, in historical order, the classical gold standard era from 1870-1913; the interwar period from 1921-1939, and the post-World War two era from 1957 to 1998.

The three are different from one another in a number of respects. Nevertheless they have two important features in common from the standpoint of exchange-rate analysis – differences across time and

space both in monetary regimes and in the behavior of money supplies.

The first, when viewed in retrospect, was in most ways an era of relative economic stability – substantial and continual real growth through much of the industrial world and its appendages, and a high degree of economic and financial integration, characterized by free trade and unprecedented capital flows from the core countries in Europe to the colonies and former colonies in the rest of the world. The second, which after the hyper-inflations and other post-WWI dislocations appeared for a short time in the 1920s to be returning to the pre-1913 status quo ante, is remembered instead for the Great Depression and the disruptions to trade and the statist policies that followed in its wake. The third, which like its predecessor, began on a high note with the post-WWII recoveries in Europe and Japan and the economic ascendancy of the United States, was by the mid-1960s starting on a path to what a decade and a half later received the appellation "the Great Inflation."

In all three, there were changes in the stocks of money in the various countries involved that in the first instance were largely unrelated to developments in the foreign exchange market. It is, therefore, possible to trace the effects of those movements on price levels and nominal exchange rates and to see how well PPP worked.

V. A. The Period 1870-1913

I have collected annual data for 25 countries for the years 1870 to 1913 for price levels – for the most part consumer price indices – and for exchange rates relative to the U.S. dollar exchange rates.[10] By 1875, the majority of these countries were on the gold standard , with the Untied States joining in 1879 and Belgium, Finland and France joining in 1880. Four countries – China, India, Japan and Mexico were, however, on silver standards for much of the period. Eight others – three in Latin America, Argentina,

[10] The countries listed by group are as follows: (silver) China, India, Japan, Mexico; (Latin America paper currencies) Argentina, Brazil, Chile; (European paper currencies) Austria-Hungary Greece, Italy, Portugal, Spain, Russia; (core) France, Germany, the United Kingdom and the United States and (other) Australia, Belgium, Canada, Denmark, Egypt, Finland, the Netherlands, New Zealand, Norway, Sweden, and Turkey. The source of most of these data was Catão and Solomou (2005).

Brazil and Chile and five in Europe, Greece, Italy, Portugal, Russia and Spain – had fiat currencies for most or all of the period.

Money supply behavior in both the silver countries and the Latin American paper-currency countries differed substantially from that in the gold countries, particularly in the period up until 1897. The stock of gold in those years was relatively stable. Coupled with increases in the demand for gold as more and more countries joined the gold standard and given increases in the demand for real cash balances due to growth in real income and in the United States, to increased financial sophistication, this led to slow continuous declines in the price levels in the gold countries. The world stock of silver, in contrast, was rising and the monetary demand declining as countries on bimetallic standards like France switched to gold.

We see the resultant differences in price behavior in the top half of Figure 3 where I have plotted the log CPIs of the United Kingdom, as representative of gold-standard countries, and the United States along with the average of the log CPIs of the silver countries. In the chart, we also see a progressive narrowing of the divergence between the U.S. and U.K. price levels as one would expect as the United States' resumption of gold became closer.

We see a similar divergence in price behavior for the Latin American fiat-currency countries vis-à-vis the UK in the bottom half of Figure 3, but only very minor divergence in the case of the European fiat-currency countries. The reason why there is no difference for the European countries is that most geared their domestic monetary policies to exchange-rate stability vis-à-vis the gold countries.

The difference in the first two instances and the similarity in the third are illustrated further in Table 2, which lists subperiod means and standard deviations for various groups of countries. These differences in behavior across monetary standards are highlighted further in the results of theregression reported in Table 3. Included in the regression were dummy variables for European paper-money countries, for Latin American paper-money countries, and for silver countries along with a dummy variable for the second period to allow for differences in monetary behavior between the two periods.

Consistent with the picture in Figure 3, the dummy variables for the Latin American paper-money countries and for the silver countries were both statistically significant and in line with the differences in price behavior observed in the charts.

Exchange rates in general reflected these differences in price behavior. We see this both in the plot of exchange rate changes against inflation differentials in Figure 4 and the regression results reported in the uppermost part of Table 4. As in the case of the long historical series, I again ran the regressions both ways, in the first instance with the exchange-rate change as the dependent variable and in the second with the inflation differential as the dependent variable. These regressions have a high R^2 and estimated slope coefficients that in both instances are fairly close to unity – .79 and .93, respectively. The first is significantly different from unity, while the second is not. Given the likelihood of much greater measurement errors in inflation rates than in exchange-rate changes, the second regression is quite probably the more reliable of the two.

V. B. The Interwar Years

In the late 1920s, the United States and the countries of Europe appeared be returning to the status quo ante of the pre-1914 era. The first strong inkling that this was not to be the case was the stock market crash in the United States in October 1929 and the recession that began shortly thereafter. From then on the situation worsened, gradually at first and then by what appeared to be an ever-accelerating pace. What caused the progressive worsening and turned an already severe business contraction into the Great Depression, in the Friedman-and-Schwartz account (1963, chapter 7) was the virtually unprecedented contraction in the stock of money in the United States. What facilitated its spread – again according to Friedman and Schwartz and as Irving Fisher (1934) argued at the time – was the gold standard. As the U.S. money supply fell in the successive waves of banking panic, gold flowed in from abroad. The result was a decline in foreign money supplies and resultant monetary shocks in the rest of the gold-standard world.

If this account of the transmission mechanism is correct, and PPP worked passably well, then we ought to see highly similar price-level behavior in the countries on gold and dissimilar behavior in countries on different monetary standards or that, like the United Kingdom in 1931, left gold. In the latter two instances, these differences in price behavior should also be paralleled by movements in exchange rates.

Clearly, however, money was not neutral in this episode in its effects in the United States. U.S. real income fell by an unprecedented amount and unemployment soared. Those declines in business activity and spending by themselves could be expected to lead to a cyclical decline in real income abroad. This episode, therefore, does not provide the tidy comparisons of equilibrium positions envisioned in the theoretical discussions of PPP. If anything, it provides a stress test for the theory.

The data that I use for the interwar period here are annual data for consumer prices and foreign vs. U.S. dollar exchange rates for 26 countries over the years 1912-1939, with data for episodes of hyperinflation omitted. [11]

The charts presented in the two panels of Figure 5 and the summary statistics in Table 5 provide the first bits of evidence on how well the theory held during this episode. Plotted in the top panel of Figure 5 are the average log price level of the gold countries and the log price levels of the United States, China, which was on a silver standard, and Spain, which had a floating exchange rate. The contrast here between price behavior in the gold countries and the United States on the one hand and in China and Spain on the author is rather stark – 25 to 30 per cent declines between 1929 and 1934 in the U.S. and the other gold countries' price levels and little or no net change in the Chinese and Spanish price levels. Plotted in the top panel of Figure 5 are is the average log price level of the sterling bloc against the

[11] The countries, listed by exchange-rate group, are as follows: Belgium, Czechoslovakia, France, Germany, Italy, the Netherlands, Poland, and Switzerland, the gold countries; Australia, Denmark, Egypt, Finland, India, New Zealand, Norway, South Africa, Sweden, and the United Kingdom, the sterling bloc, whose ties with gold were severed when the United Kingdom left gold in 1931; Argentina, Austria, Canada, China, Japan, Mexico, Spain, the miscellaneous group, and the United States. The source of most of the data was the data base maintained by Global Financial Data. League of Nations publications and What Was The Exchange Rate Then? from EH.Net were the sources of the data for China.

average log price level of the gold countries and the log price level of the United States. From 1925, when the United Kingdom returned to gold, until 1931, when the United Kingdom left gold all three series move roughly in sync. Then in 1931 price levels of the sterling bloc began to diverge from those of the gold countries and the United States. As we saw in the first chart in Figure 5, therefore, the monetary standard clearly matters.[12] Transmission of monetary disturbances takes place across countries on the same monetary standard and is largely absent for countries on different standards.

The summary statistics in Table 5 add to this evidence. We see similar price behavior in the gold countries and the United States in the 1930-34 quinquennium, and dissimilarities for both vis-à-vis the sterling bloc and the miscellaneous group of countries. In 1935-39, when interferences in the foreign exchange market became common the cross-country disparity in price behavior increased. The other noticeable feature of Table 5 is the much greater variability of prices in this period than in the gold standard era.

The middle panel of Table 4 reports the results of regressions like those reported earlier in which the exchange-rate change and the inflation differential alternate as dependent and independent variables. The data here are in the form of averages for the periods 1921-1929 and 1930-39. These results, like those for the gold standard period, show a fairly strong positive relation between the two variables but one that is much less precisely determined. We see this both in the much higher standard errors of these regressions and in the much greater difference between the two estimated slope coefficients – the first, .90, and hence close to the theoretical value of unity, but the second only .58.

Given the interferences with international trade and the functioning of the foreign-exchange markets that became common in the wake of the Great Depression, measured exchange rates during ths period very likely were only highly imperfect proxies for their equilibrium values. I am, therefore, inclined to give much greater weight to the first estimate.

[12] See Fisher (1934) and Choudhri and Kochin (1980) and the discussion in Friedman and Schwartz (1963, chapter 7) for further evidence on the difference in behavior across monetary standards in this episode.

The plot of the two variables in Figure 6 tells a similar story – a clear positive relation, much greater variation in both inflation differentials and exchange-rate changes and much more dispersion about the 45-degree line drawn through the origin than in the gold-standard period.

V. C. The Post-WWII Period

John Taylor (2002), in reviewing the history of the post-WWII era, described it as "the Great Inflation flanked by two periods of relative price stability. The description is quite apt.

In the years up until 1971, the Bretton Woods System of pegged exchange rates exerted a powerful force on inflation behavior in the countries making up that system. Under the Bretton Woods regime, cross-country inflation differences were non-zero but generally quite small. In the absence of revaluation or devaluation, inflation rates and monetary policies could not wander too far from inflation in the United States, the reserve-currency country. And up until the mid-1960s, U.S. inflation was low. Then, as U.S. monetary policy became more expansive and inflation rose, pressure mounted. Finally, in 1971 Bretton Woods broke down and the industrialized world moved to a system of floating exchange rates. Inflation on average rose and remained high until the early 1980s. At the same time cross-country differences emerged as some countries like Germany and Switzerland pursued low-inflation monetary policies, while others like Italy and the United Kingdom went to the other extreme. Since the early 1980's the pendulum has shifted again as one central bank after another has put monetary policy on a much less inflationary track.

The result of these changes in regime is a set of natural experiments with which to assess the effects of the monetary-policy differences on the behavior of inflation rates in the countries in question and on the behavior of their exchange rates.

Table 6 provides summary statistics for twenty OECD countries over this period that are

consistent with this description.[13] Shown in the upper half of the table for the 20 countries combined for the periods 1960-71, 1972-82 and 1983-98 are average rates of CPI inflation, average rates of change of nominal foreign vs. U.S. dollar exchange rates and average rates of growth of the excess supply of money proxied by the ratio of broadly defined money to real GDP. Shown in the lower half are corresponding cross-country standard deviations.

The first thing to notice is the clear parallel between the average rates of excess money growth and inflation – increases from the first to the second period and then decreases from the second to the third and of roughly the same magnitude. Average rates of nominal exchange-rate growth show a similar temporal pattern. The period-to-period changes are, however, considerably less than those for either inflation or excess money. The cross-country standard deviations of all three variables also rise and then decline across the three periods. The decline in the cross-country standard deviation of nominal exchange-rate growth from the second to the third period is, however, much smaller than the other two declines.

Figure 7 shows a plot of the period-average rates of nominal-exchange-rate growth against inflation differentials. The circles, triangles, and squares represent the observations for the first, second and third periods, respectively. At the bottom of Table 5 are the corresponding regression results.

Again as in the other two episodes there is a clear positive relation between the two variables. With the exception of one or two outliers most of the points are scattered near the 45-degree line. There is, moreover, no noticeable difference in behavior across the three periods.

I tested the restriction that the slopes and intercepts were the same across the three periods and could not reject the hypothesis at anything close to conventional levels.[14] I regard this result of considerable interest given the standard stories of aggregation bias due to combing data for fixed- and floating-rate regimes and the breakdown of PPP during the recent floating-rate regime.

[13] The table is adapted from Lothian and McCarthy (2006). Data are annual observations for the following countries: The Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States. The source of most of these data was the *International Financial Statistics* on CD ROM.

[14] The F ratio to test differences in slopes and intercepts jointly was 2.62; the F ratio to test differences in intercepts alone was 3.51. Neither was significant at anything close to conventional levels.

The R^2 in the regressions is high and the standard errors considerably lower than in the regressions for the interwar era but somewhat higher than those for gold. The estimated slope coefficients in the two regressions are .97 and .84, respectively, the first neither significantly nor substantially different from unity, the latter significantly though not substantially different from unity. If the measurement errors in exchange rate changes and inflation differentials were equal, then a simple average of the first and the reciprocal of the second, 1.08 (.97 + 1.19) would provide the best estimate of the effect of the inflation differential on the exchange-rate change.

VI. Conclusions

Purchasing power parity is not simply another application of the law of one price. It is instead a proposition about the equilibrium behavior of price levels and exchange rates (and their rates of change) that is best understood as one key element in a broader monetary equilibrium model. It thus pertains to the long run. The evidence I have presented here shows that as a long-run proposition PPP is indeed a very useful approximation. This is so both with regard to exchange rate behavior and the behavior of price levels among countries. We see this in long-term historical data and in the panel data for the three episodes – the classical gold-standard period, the interwar period and the varied monetary regimes of the post-WWII era – that I have examined. Low frequency movements of exchange rates and relative price levels are highly correlated and more often than not bear a close to one-to-one relation to one another. Price-level behavior across countries differs in the way that PPP suggests under different monetary arrangements and is highly similar when those monetary arrangements are similar. These results thus add to our knowledge of monetary equilibrium conditions, complementing those of Lothian (1985), Dwyer and Hafer(1988) and Rolnick and Weber (1997).

References

Catão, Luis A. V. and Solomos N. Solomou, "Effective Exchange Rates and the Classical Gold Standard Adjustment" *American Economic Review*, Vol. 95 September 2005, 1259-1275.

Campbell, Rachel, Kees Koedijk, James R. Lothian and Ronald Mahieu, "Irving Fisher, Expectational Errors, and the UIP Puzzle," unpublished working paper, Fordham and Erasmus Universities, 2007.

Choudhri, Ehsan U. and Levis A. Kochin The Exchange Rate and the International Transmission of Business Cycle Disturbances: Some Evidence from the Great Depression, *Journal of Money, Credit and Banking*, Vol. 12, No. 4, Part 1. (Nov., 1980), pp. 565-574.

Darby, Michael R., James R. Lothian and Arthur E. Gandolfi, Alan C. Stockman and Anna J. Schwartz. *The International Transmission of Inflation*. Chicago: University of Chicago Press for the National Bureau of Economic Research, 1983.

Darby, Michael R. and James R. Lothian, "International Transmission Afloat," in Michael Bordo, ed., *Money, History and International Finance: Essays in Honor of Anna J. Schwartz*. Chicago: University of Chicago Press for the National Bureau of Economic Research, 1989, 203-244.

Dimand, Robert W. "Irving Fisher on the International Transmission of Booms and Depressions through Monetary Standards, *Journal of Money, Credit and Banking*, February 2003, 35, 49-90.

Dwyer, Gerald P., Jr. and R.W. Hafer, Is Money Irrelevant? Federal Reserve Bank of St. Louis Review, May/June 1988, 3-17.

Edison, H.J., J.E. Gagnon and W.R. Melick 'Understanding the empirical literature on purchasing power parity: The post-Bretton Woods era,' *Journal of International Money and Finance*, February 1997, 16: 1-17

Fisher, Irving. *The Rate of Interest*. New York Macmillan, 1907.

Fisher, Irving. *The Purchasing Power of Money: Its Determination and Relation to Credit, Interest and Crises*. New York: Macmillan, 1918.

Fisher, Irving. *Are Booms and Depressions Transmitted Internationally Through Monetary Standards*? New Haven, 1934. [a second printing from Sect. 2. Rapp. XXII session de l'Institut international de statistique, London, 1934.]

Friedman, Milton and Anna J. Schwartz. *A Monetary History of the United States, 1867-1960.* Princeton: Princeton University Press, 1963,

Global Financial Data, (http://www.globalfinancialdata.com/index.php3).

Grice-Hutchinson, Marjorie. *The School of Salamanca: Readings in Spanish Monetary Theory, 1544-1605*. Oxford: Clarendon Press, 1952.

Grice-Hutchinson, Marjorie. *Early Economic Thought in Spain, 1177-1740*, London: Allen and Unwin, 1978.

Grice-Hutchinson, Marjorie. *Economic Thought in Spain: Selected Essays* (edited and with an introduction by Laurence S. Moss and Christopher K. Ryan). Brookfield, Vt: Edward Elgar, 1993.

Humphrey, Thomas M. "John Wheatley's Theory of International Monetary Adjustment." Federal Reserve Bank of Richmond, *Economic Quarterly*, Summer 1994 Vol. 80 No. 3

Huffman, Wallace E. and James R. Lothian, "The Gold Standard and the Transmission of Business Cycles, 1833 to 1932," in Michael Bordo and Anna J. Schwartz, eds, *A Retrospective on the Classical Gold Standard*. Chicago: University of Chicago Press for the National Bureau of Economic Research, 1984.

International Monetary Fund, *International Financial Statistics*, CD ROM version

Johnson, Harry G. "The Case for Flexible Exchange Rates, 1969." Federal Reserve Bank of St. Louis *Review*, June 1969, 51: 12-.22.

League of Nations. *Monthly Bulletin of Statistics*, various issues.

Lothian, James R. "Equilibrium Relationships between Money and Other Economic Variables," *American Economic Review*, September 1985, 75: 828-835.

Lothian, James R. "A Century Plus of Japanese Exchange-Rate Behavior," *Japan and the World Economy*, February/March 1990, 2: 47-70.

Lothian, James R. "A History of Yen Exchange Rates" in William T. Ziemba, Warren Bailey and Yasushi Hamao, eds, *Japanese Financial Market Research*, Amsterdam: Elsevier, 1991.

Lothian, James R. and Cornelia McCarthy. "Real Exchange-Rate Behaviour under Fixed and Floating Exchange Rate Regimes," *The Manchester School*, March 2002, 70: 229-245.

Lothian, James R. and Cornelia McCarthy. "The Behavior of Money and Other Economic Variables: Two Natural Experiments" Unpublished paper, Fordham University, 2006.

Lothian, James R. and Mark P. Taylor, "The Recent Float from the Perspective of the Past Two Centuries," *Journal of Political Economy*, June 1996, 104: 488-509.

Lothian, James R. and Mark P. Taylor, "Real Exchange Rates over the Last Two Centuries: How Important Is the Harrod-Balassa-Samuelson Effect?" Unpublished paper Fordham and Warwick Universities, August 2006.

Lucas, Robert E. Jr. Interest Rates and Currency Prices in a Two-country World, *Journal of Monetary Economics*, November 1982, 10: 335-359.

Mussa, Michael. "Nominal Exchange Rate Regimes and the Behavior of Real Exchange Rates: Evidence and Implications," *Carnegie-Rochester Conference Series on Public Policy*, Autumn 1986, 25: 117-214.

Officer, Lawrence H., *Purchasing Power Parity and Exchange Rates: Theory, Evidence and Relevance* . Greenwich, Conn. : JAI Press, 1982.

Officer, Lawrence H., "What Was The Exchange Rate Then?" http://eh.net/hmit/exchangerates/.

Rogoff, Kenneth, "The Purchasing Power Parity Puzzle," *Journal of Economic Literature*, June 1996, 34: 647-668.

Rolnick, Arthur J. and Warren E. Weber, Money, Inflation, and Output under Fiat and Commodity Standards, *Journal of Political Economy*, December 1997, 105: 1308-1321

Sarno, Lucio and Mark P. Taylor, "Purchasing Power Parity and the Real Exchange Rate," *IMF Staff Papers*, Issue No. 1, 49: 2002, 65-106.

Taylor, Alan, "A Century of Purchasing Power Parity," *Review of Economics and Statistics*, February 2002, 4**:** 39-150.

Taylor, Alan and Taylor, Mark P., "The Purchasing Power Parity Debate," *Journal of Economic Perspectives*, Fall 2004, 18: 135-138.

Wheatley, John, *A Report on the Reports of the Bank Committees*. Shrewsbury: Printed by W. Eddowes, 1819.

Wheatley, John, *An Essay on the Theory of Money and Principles of Commerce*. London, Printed for T. Cadell and W. Davies, by W. Bulmer and Co., 1807-22.

Wheatley, John, *Remarks on Currency and Commerce*. London: Cadell and Davies, 1803.

Table 1. Exchange-Rate Changes vs. Inflation Differentials, Regression Results for France, Japan and the U.S. vs. the U.K., 1791-2005 and Subperiods

	Intercept	(P/Puk)	S	R/SEE
France	0.462	0.836		0.891
	1.269	12.145		1.544
		(-2.375)		
	-0.310		1.066	0.891
	-.734		12.145	1.742
			(0.747)	
US	-0.173	0.576		0.536
	-.690	4.808		1.162
		(-3.538)		
	0.029		0.931	0.536
	0.003		4.808	1.477
			(-0.359)	
Japan	-0.084	0.969		0.972
	-.147	20.319		2.076
		-0.650		
	0.171		1.003	0.972
	0.293		20.319	2.112
			(0.057)	
All	0.090	0.930		0.940
	,406	29.167		1.623
		(-2.202)		
	-0.016		1.011	0.940
	-0.070		29.167	1.692
			(0.326)	

Note: Figures directly beneath the coefficient estimates are conventional t statistics; figures in parentheses are t statistics to test the hypothesis that the coefficient is unity.

Table 2. Rates of Inflation under Different Monetary Regimes, Pooled Data for 28 Countries 1870-1913

	Period	Silver	Paper		Core	Other	All
			Lat. Amer.	Europe			
			all figures in per cent per annum				
Means	**1870-1896**	1.47	2.71	0.00	-0.61	-0.71	0.09
	1897-1913	2.13	1.96	1.07	1.06	1.56	1.51
Std. Dev.	**1870-1896**	0.16	0.99	0.67	0.79	0.63	1.32
	1897-1913	1.28	3.51	0.81	0.24	0.68	1.24

Note: Figures in the table are logarithmic changes expressed in per cent per annum terms. The following countries were included in the sample:(silver) China, India, Japan, Mexico; (Latin America paper currencies) Argentina, Brazil, Chile; (European paper currencies) Austria-Hungary Greece, Italy, Portugal, Spain, Russia; (core) France, Germany, the United Kingdom and the United States and (other) Australia, Belgium, Canada, Denmark, Egypt, Finland, the Netherlands, New Zealand, Norway, Sweden, and Turkey.

Table 3. Inflation Regressions, Pooled Data for 28 Countries for the Subperiods 1870-1896 and 1897-1913

Intercept	DEUR	DLAT	DSILV	D2	F(50,2)	R^2/ SEE
-0.502	-0.001	0.035	0.020	0.019	32.751	0.680
-2.540	-0.291	7.605	3.700	7.848	0.030	0.857

Note: DEUR is a dummy variable for the European paper-currency countries, DLAT is a dummy variable for the Latin-American paper-currency countries, DSILV is a dummy variable for the silver-standard countries and D2 is a dummy variable for the second (1897-1913) subperiod. The F Ratio is for the test of null hypothesis that the coefficients of DLAT and DSILV are both zero. Figures beneath the coefficient estimates are t values.

Table 4. Exchange-Rate Changes vs. Inflation Differentials Regression Results for Three Periods

Sample Period	Dependent Variable	Intercept	Independent Variable		R^2/ SEE
			dlnS	$dln(P/P_{US})$	
1870-1913	dlnS	-0.485		0.789	0.730
		-3.947		11.751	0.720
				(-3.150)	
	$dln(P/P_{US})$	0.743	0.926		0.730
		6.686	11.751		0.780
			(-0.939)		
1921-1939	dlnS	-0.760		0.900	0.523
		-1.566		7.260	3.248
				(-0.808)	
	$dln(P/P_{US})$	1.041	0.582		0.523
		2.808	7.260		2.611
			(-5.223)		
1958-1998	dlnS	-0.815	0.968		0.810
		-4.794	15.297		1.101
			(-0.510)		
	$dln(P/P_{US})$	0.945	0.837		0.810
		6.820	15.297		1.024
			(-2.986)		

Note: Figures directly beneath the coefficient estimates are conventional t statistics; figures in parentheses are t statistics to test the hypothesis that the coefficient is unity. The countries included in the three samples are as listed in Tables 2, 4 and 6, respectively.

Table 5. Rates of Inflation under Different Monetary Regimes, Pooled Data for 26 Countries 1921-1939

		US	Gold	Stg. Bloc	Misc. 7	All
Means			*all figures in per cent per annum*			
DlnP	**1921-24**	-2.86	-2.83	-4.80	-3.86	-3.96
	1925-29	-0.12	3.02	-1.88	-0.19	0.15
	1930-34	-4.99	-5.27	-3.33	-2.56	-3.79
	1935-39	0.88	3.59	2.93	7.56	4.30
DlnS	**1921-24**		-5.65	-0.51	-0.41	-1.88
	1925-29		3.11	-2.05	0.06	0.19
	1930-34		-9.88	0.99	3.38	-1.82
	1935-39		6.38	0.68	6.67	4.18
Std. Dev.						
DlnP	**1921-24**		9.89	3.93	3.80	5.66
	1925-29		4.78	2.73	2.69	3.96
	1930-34		2.34	2.41	1.78	2.40
	1935-39		3.85	1.15	5.56	4.39
DlnS	**1921-24**		10.52	7.04	4.17	7.54
	1925-29		5.75	4.24	3.34	4.81
	1930-34		1.21	2.52	4.89	6.71
	1935-39		7.36	3.72	7.02	6.45

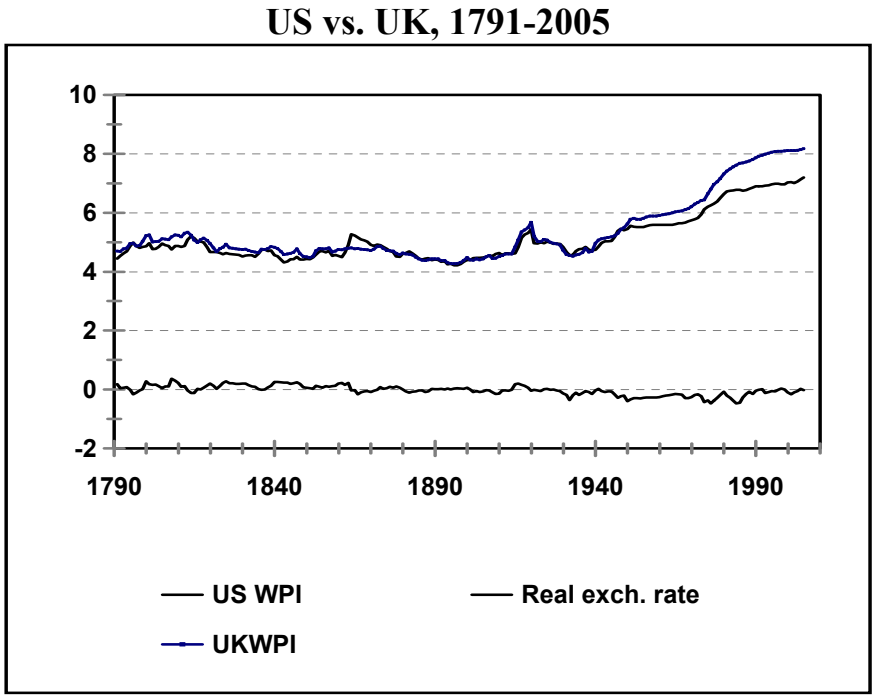
Note: Figures in the table are logarithmic changes expressed in per cent per annum terms. The following countries were included in the sample: (gold) Belgium, Czechoslovakia, France, Germany, Italy, the Netherlands, Poland, Switzerland; (sterling Bloc) Australia, Denmark, Egypt, Finland, India, New Zealand, Norway, South Africa, Sweden, U.K.; (miscellaneous) Argentina, Austria, Canada, China, Japan, Mexico, Spain.

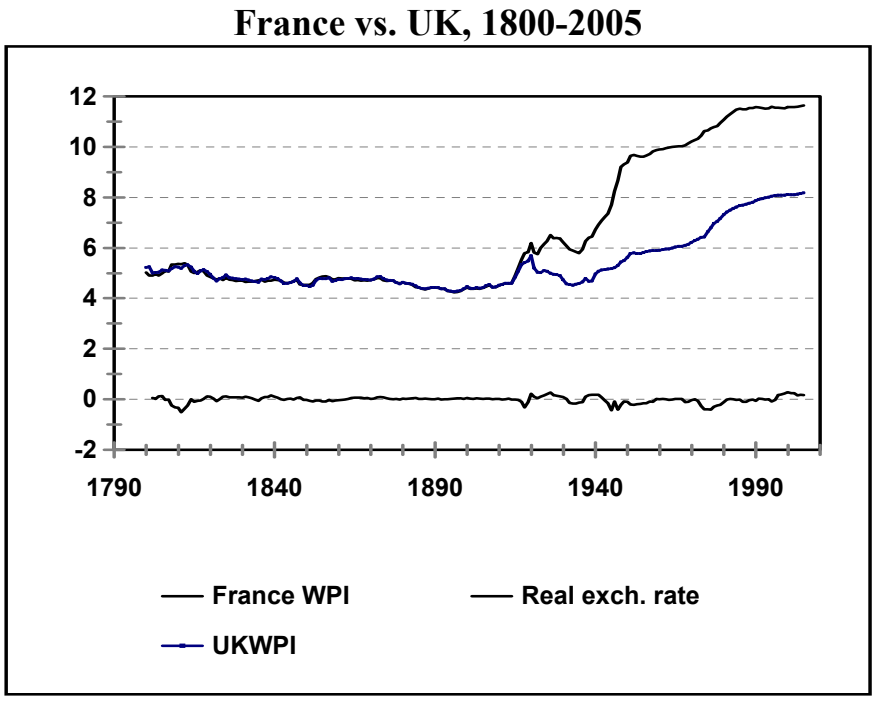
Table 6. Summary Statistics for Rates of Change of Prices, Excess Money and Nominal Foreign vs. U.S. Dollar Exchange Rates, Pooled Data for 20 OECD Countries 1960-1998

	1960-70	1971-82	1983-98
Means			
dlnP	3.76	9.70	3.94
dln(M2/y)	5.00	10.33	4.91
dlnS	0.59	0.84	0.15
Std. Dev.			
dlnP	1.73	3.82	2.45
dln(M2/y)	4.93	5.64	4.78
dlnS	1.92	6.26	5.90

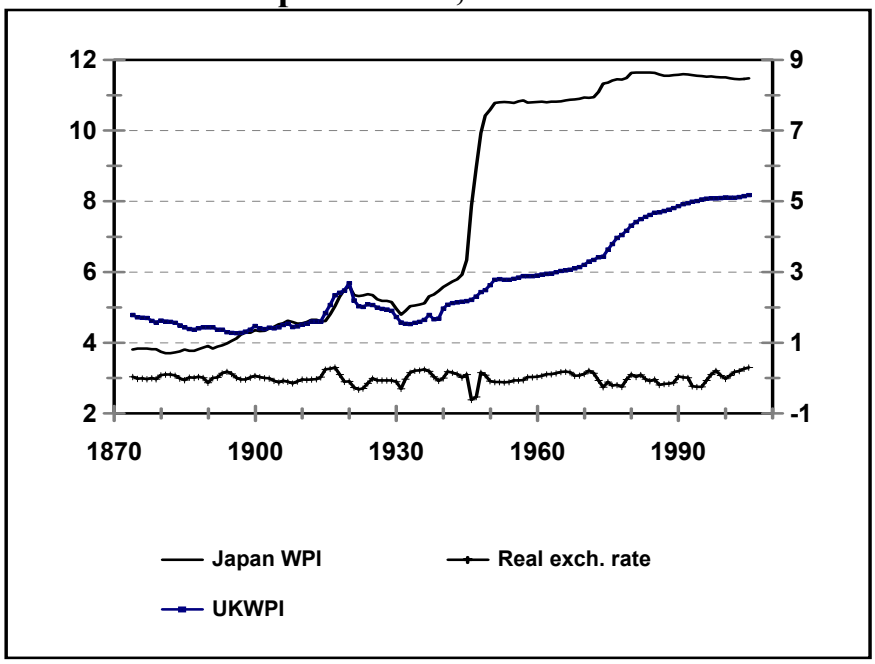
Note: Figures in the table are based on logarithmic changes converted to per cent per annum. The symbol (M2/y) denotes the ratio of M2, defined as IFS "money" plus "quasi-money" to real GDP, used as a proxy for the excess supply of money. The means and standard deviation are both cross-country measures. The following countries were included in the sample: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States.

Figure 1. Log Price Levels and Real Exchange Rates, France, Japan and the US vs. the UK





Japan vs. UK, 1874-2005



Note: The Japanese vs. U.K. log real exchange rate series is in the form of deviations from a linear trend.

Figure 2. Exchange Rate Change vs. Inflation Differentials, France, Japan and the US vs. the UK, 10-Year Averages, 1791-2005

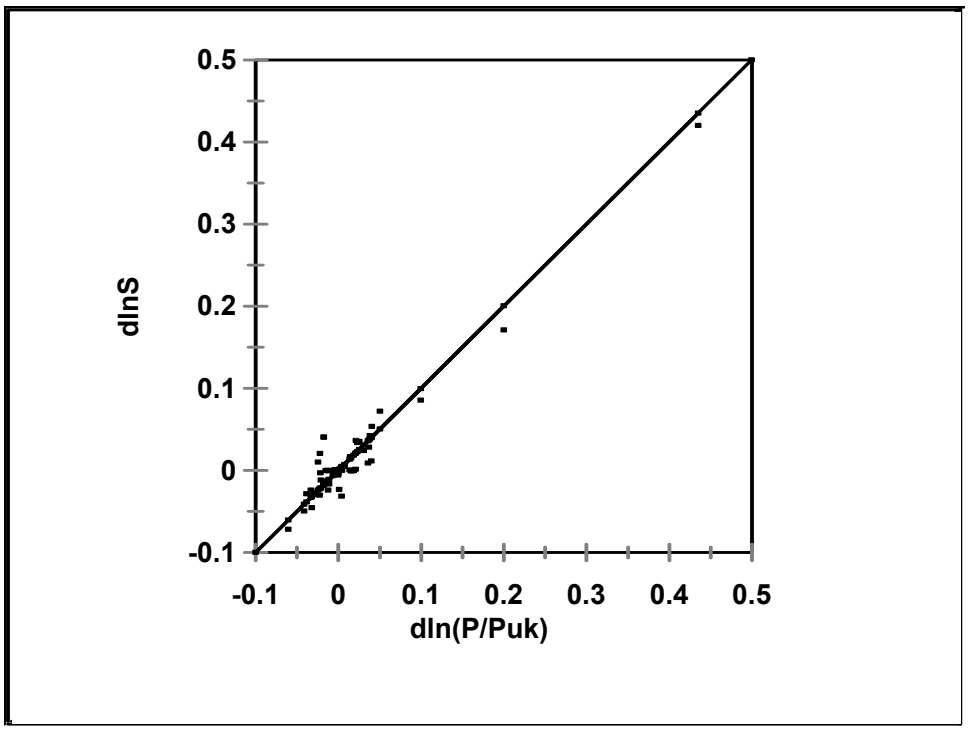
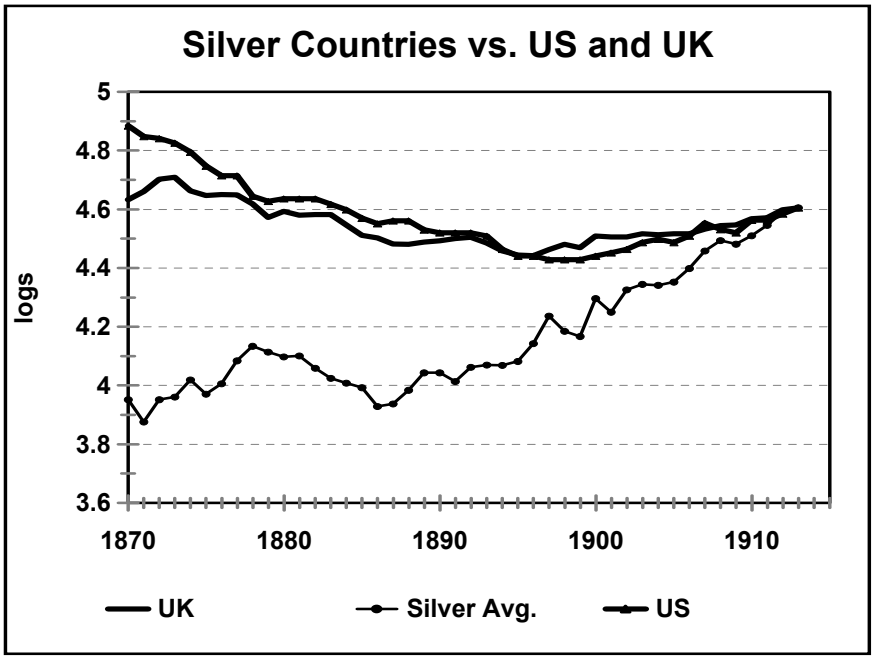


Figure 3. Consumer Price Behavior under Different Monetary Regimes, 1870-1913 .



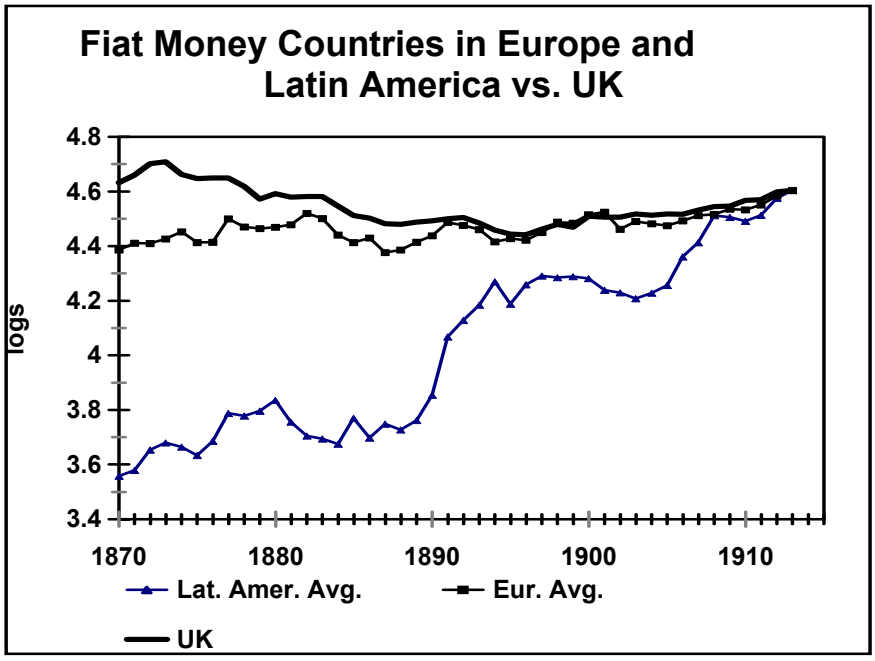


Figure 4. Exchange Rate Change vs. Inflation Differentials, Period Averages: 1871-96 and 1897-1913

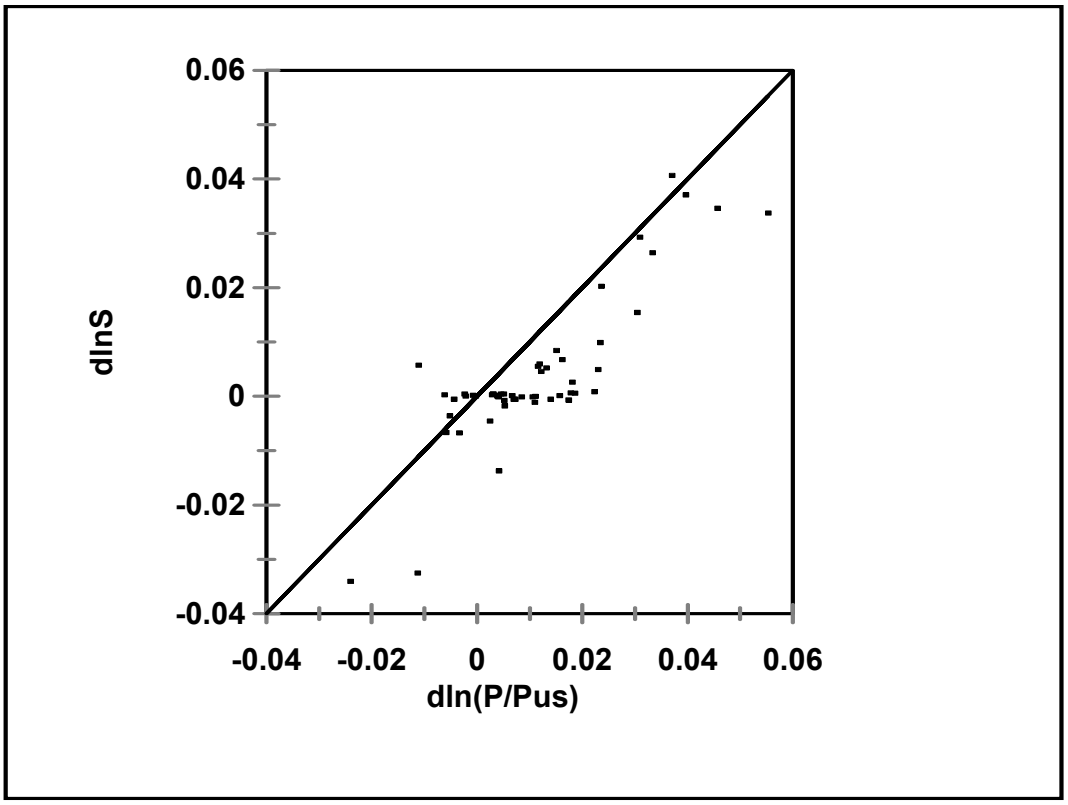
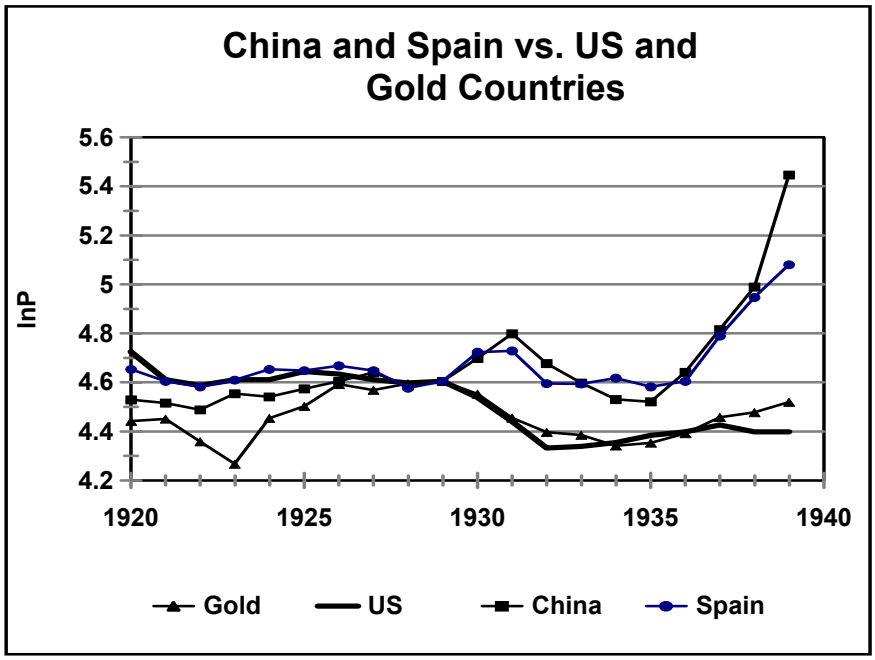


Figure 5. Consumer Price Behavior under Different Monetary Regimes, 1921-1939



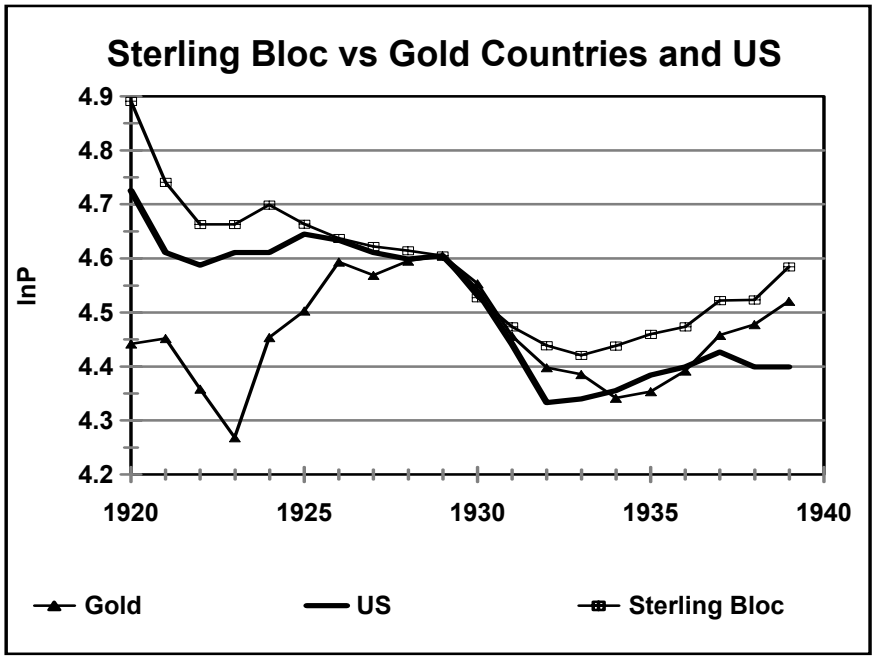


Figure 6. Exchange Rate Change vs. Inflation Differentials, Period Averages: 1921-29 and 1930-1939

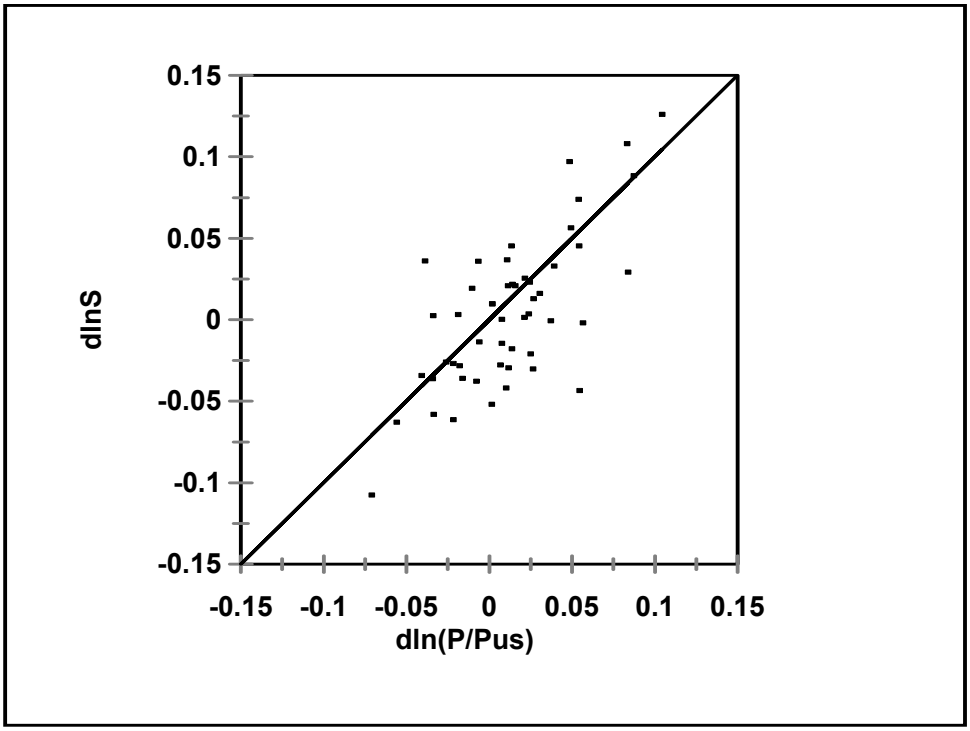


Figure 7. Exchange Rate Change vs. Inflation Differentials, Period Averages: 1960-70, 1971-82, 1983-98