Journal of International Money and Finance ■■ (2016) ■■–■■

Contents lists available at ScienceDirect

Journal of International Money and Finance

journal homepage: www.elsevier.com/locate/jimf

Purchasing power parity and the behavior of prices and nominal exchange rates across exchange-rate regimes

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ARTICLE INFO

Article history:
Available online

JEL Classification:
F31
F33
F41

Keywords:
Exchange rates
Purchasing power parity
International transmission
Monetary regimes

ABSTRACT

The evidence presented in this paper shows that purchasing power parity as a long-run proposition is indeed a very useful approximation. We see this quite clearly in the panel data for three historical periods examined here – the classical gold standard era from 1870 to 1914, the interwar period from 1921 to 1939, and the period after World War II from 1959 to 1998. 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. Inflation rates adjusted for exchange rate changes in general are highly correlated and bear a one-to-one relation to one another within and across the three periods and the varied monetary regimes that prevailed.

1. Introduction

Let me first of all thank my friend and colleague Iftekhar Hasan for organizing this conference at which I presented this paper and for editing this special issue of *JIMF* – a journal with which I was affiliated for two-thirds of my 50-year career. Let me also thank Kees Koedijk, *JIMF*'s Co-ordinating Editor and a long-time friend for his support. Finally, a heartfelt thanks to all of you who have devoted the time to write papers for this special issue of *JIMF* and to attend the conference.

I begin with some autobiographical remarks that I hope will do justice to this occasion. I will then go on to present the results of research I have conducted on the relations linking price levels and exchange rates during the course of three historical periods: the era of the classical gold standard from 1870 to 1914, the interwar period from 1921 to 1939, and the post-WWII period from 1959 to 1998.

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http://dx.doi.org/10.1016/j.jimonfin.2016.06.015
0261-5606/

The three with the varied monetary regimes provide a series of natural experiments with which to assess the performance of the purchasing-power-parity (PPP) relation as a long-run equilibrium condition. As it turns out, PPP performs very well. Price levels in the varied regimes behave the way theory suggests. Adjusted for exchange rate changes, inflation rates are related one-to-one.

2. Biographical remarks

My career as an economist began at the University of Chicago in autumn 1967. I left Chicago in June 1972 and received my doctorate in summer 1973.

Anyone who wants to get some inkling of what Chicago was like then, should view the video of Gary Becker's interview of Milton Friedman (Friedman and Becker, 2003). Early in the interview the two talk about the distinctive way economics was taught at Chicago, that at Chicago – and unlike many other schools – economic theory was viewed, to use Alfred Marshall's term, as "an engine of analysis." It was something to be applied to real-world problems, not simply an elaborate mathematical construct to be contemplated for its ascetic value. There is also a vignette in the video in which Becker rather whimsically describes his attempt in the first price-theory lecture that he attempted to answer a question that Friedman posed. Friedman's response, as Becker describes it, was "That's no answer. You have just restated the question." Becker said he concluded right away that he had a lot to learn. Becker's experience and his reaction thereto were not unique. Economics was treated as very serious stuff at Chicago. Dilettantism was neither appreciated nor tolerated. Students learned that rather quickly.

Friedman was one of my teachers at Chicago too – not for price theory, which is what he taught for many years before I came to Chicago – but for both monetary economics and the income-expenditure approach to macroeconomics. Friedman was also my thesis advisor. The title of my dissertation was the "Demand for High Powered Money." I published an article derived from it in the *American Economic Review* (Lothian, 1976). At Chicago, I also took courses from two other Nobelists, George J. Stigler and Theodore W. Schultz, both of whom – George in particular – had a considerable impact on me. They taught me how to think like an economist. The other important influences on my intellectual development at Chicago were Larry Sjaastad, Lester Telser, and Al Harberger, and at one-step remove, both Becker and Ronald Coase, yet two more Chicago Nobelists.

I came to Chicago from the Catholic University of America where I had majored in economics. I graduated from CU in spring 1967 *magna cum laude*. I had a number of fine teachers at CU who stimulated my thinking in economics and in a number of other disciplines too – history, philosophy, political science and literature, most notably. My education there stood me in good stead when I got to graduate school.

The other key influence in my life – professional and otherwise – has been my family. My parents were both college graduates in an era when few people attended university. My mother went on to earn a master's degree in English from Columbia University. She was an accomplished Latinist, by all reports an excellent teacher of both Latin and English and well versed in philosophy, theology and intellectual history. My parents taught me to value the life of the mind and much else and, without being overbearing in any way, encouraged me to work hard in my scholastic endeavors. My paternal grandfather and my maternal grandmother, the two grandparents I knew best, and my uncle John, my father's brother, exerted a similar influence.

Last chronologically, but certainly not in any other way, has been my wife Judith and our five grown children. All in various ways have been sources of encouragement. Judy is a scholar in her own right. A nurse and professor, her love of ideas, her penchant for scholarly discourse, and her backing through thick and thin have been important in a host of ways.

My first job after Chicago was at what then was known as First National City Bank and later as Citibank. First National City Bank had a large and truly first-rate economics department in which day-to-day business economics and scholarly pursuits blended together and informed one another. I had the good fortune to work with colleagues there who pursued both facets of economics and did so quite well. You can, as they say, look it up. Peruse issues of the old *Monthly Economic Letter* and read some of the articles. It was head and shoulders above the usual business commentary – understandable to the layman yet scholarly and, viewed in retrospect, very right on very many important issues. Three that readily come to mind are the inflationary role of excessive money-supply growth; the positive

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relation between nominal interest rates and inflation, the Fisher effect; and the illusory nature of the Phillips Curve. These are all old hat now, four decades after the event, but were quite intellectually revolutionary at the time. Ed Nelson a few years ago discovered back issues of the Citibank *Monthly Economic Letter* in the Federal Reserve Board of Governors library. He emailed me to say how impressed he was.

While at Citi, I eventually spent day and a half a week as a research associate of the NBER which then was headquartered in New York. From 1976 to 1983, I worked on a project at the bureau studying the international transmission of inflation with Michael Darby of UCLA; Arthur Gandolfi, a colleague at Citi; Alan Stockman, then also at UCLA; and Anna Jacobson Schwartz. The result was an NBER book of that name (Darby et al., 1983) which became somewhat of a classic and several journal articles (Cassese and Lothian, 1982; Gandolfi and Lothian, 1983).

After Citi I spent two and a half fruitful years at NYU's Stern School as a visiting full professor and then in 1990 came as a full professor at Fordham. In 1997, I was promoted to Distinguished Professor of Finance. In 2002, I founded and became director of the Center for Research in International Finance at Fordham, now named the Frank J. Petrilli Center for Research in International Finance. In 2012, I received the Topetta Family Chair in Global Financial Markets.

Over the past several decades I also have moonlighted occasionally, as a visiting scholar, at the International Monetary Fund (2015) and at Maastricht and Tilburg Universities in the Netherlands and as a visiting lecturer at University College Dublin in Ireland.

For more than two thirds of my career, I was associated with the *Journal of International Money and Finance*. In 1982, Michael Darby, the first editor, and I planned the journal and put together its editorial board. I served on the board for four years. Then in mid-1986, I became editor and Michael Melvin joined me as coeditor and Connie McCarthy as associate editor. Since then *JIMF* has gone on to become the premier journal in its field. I am very proud of that accomplishment.

Let me add something. Much if not most of what I have described was, to use Friedrich Hayek's terminology, "the result of human action, not human design." There was no central plan, so to speak. Along the way, moreover, there was more than one slip twixt cup and lip. That it all has worked out well – or so I believe – has had an element of luck to it but, I believe, also something a good deal more: the grace of God.

Before I turn to the discussion of the empirical results that I report in this paper, I would like to trace out the intellectual process that led me to become interested in and eventually focus my research on the behavior of money, prices and exchange rates.

The simplest answer is "because they were there." When I was in graduate school in the late 1960s and early 1970s and for a decade and a half thereafter, questions about the relationship linking money, prices and exchange rates loomed large. Was the inflation of the time a monetary phenomenon? How did it spread throughout the industrialized world? What role did the exchange-rate system play?

I became increasingly interested in these questions when I joined the Citibank economics department not long after the breakdown of Bretton Woods. What spurred my interest further was the work that I began several years later at the NBER as part of a team investigating the wave of worldwide inflation in the 1970s. The formal focus of that research was on dynamics – on explaining the evolution of the worldwide inflation that was then underway and its transmission among countries. At the time a variant of the monetary approaches to exchange rates and the balance of payments that viewed equilibrium as holding over exceedingly short time periods achieved rather widespread prominence.

I never bought the short-run part of the argument. It was at variance both with my day-to-day observations as a business economist and also with earlier empirical evidence. (See, in particular, Friedman and Schwartz, 1963, pp. 678–79; Gailliot, 1970.) The results of the international transmission project proved consistent with those priors.

Michael Darby and I, in summarizing those results in the concluding chapter of *The International Transmission of Inflation*, described the worldwide inflation process as one of "lagged adjustment to lagged adjustment" (Darby et al., 1983, p. 510). Inflation, our evidence showed, was a monetary phenomenon. Equilibrium in monetary matters, however, was long run and purchasing power parity was a key, but again in the long run.

Two years after that book was published, I published a paper in the *American Economic Review*, "Equilibrium Relationships between Money and Other Economic Variables" (Lothian, 1985) in which

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I examined changes in measures of steady state growth in money supply, price levels, real income, interest rates, and exchange rates in 20 OECD countries between the periods 1956–1973 and 1974–1980. The major conclusions of that exercise were that the neutrality proposition of the quantity theory of money held and so also did PPP. I found only an incomplete Fisher effect, however.

Over the next two years, I published two papers focusing solely on exchange-rate behavior, "Real Dollar Exchange Rates under the Bretton-Woods and Floating-Rate Regimes" in the *Journal of International Money and Finance* and (Lothian, 1986) "The Behavior of Real Exchange Rates" in the *International Journal of Forecasting* (Lothian, 1987) Two major findings came out of this work. The first was that the volatility in major country real and nominal exchanges in the 1970s and early 1980s was principally the result of two major long-lived but largely self-cancelling movements. The second was that these movements appeared to be largely dollar related.

Those two findings – the first in particular – taken together with what I learned in the "*Equilibrium Relationships*" paper provided much of the impetus for my later work on exchange rates. These papers had shown that PPP was not simply a will o' the wisp, but that much more than a decade or two worth of time series data would be needed to investigate its validity in any sort of meaningful way. I therefore turned to long-span historical data and, as a complement to that, cross-country panel data. The relatively new econometric techniques of unit-root and cointegration testing seemed to me to be well suited to this investigation.

Over the next two decades I wrote a series of papers using both types of data, several on my own and a number with coauthors. I published the first of these in *Japan and the World Economy* in 1990 (Lothian, 1990). Examining over a century's worth of annual data for France, Japan, the United Kingdom and the United States, I found a marked tendency for real exchange rates to return to their (measured) equilibrium values. The hypothesis that exchange-rate-adjusted price levels in these countries were cointegrated was generally consistent with the data. Unit-root tests applied to the various real exchange rates much more often than not rejected the hypothesis of non-stationarity in terms of unit roots, or in the case of the yen, non-trend-stationarity. Analysis of earlier periods of floating yen rates, particularly in the later decades of the nineteenth century – pointed to an important link between monetary conditions and real exchange rate variability.

Not long thereafter, Mark Taylor and I began work on real-exchange-rate behavior using two-century-long time series data that we had constructed for France, the United Kingdom and the United States. The result was a series of papers, beginning with an article in the *Journal of Political Economy* in 1996 that has continued to attract substantial scholarly attention (Lothian and Taylor, 1996, 1997, 2000).

In our *Journal of Political Economy* article, Taylor and I found strong evidence of mean-reversion in both franc–sterling and dollar–sterling real exchange rates. Just as important, we showed that the floating-rate period that began in the early 1970s was not any different from the standpoint of long-run behavior than the 180-year period that preceded it. The simple, stationary autoregressive models that we estimated on pre-float data easily outperformed nonstationary real exchange rate models in dynamic forecasting exercises during the period of the float. These equations, moreover, explained 60 to 80 percent of the in-sample variation in real exchange rates.

Taylor and I followed up on this research a number of years later with a paper that investigated several other features of real exchange-rate behavior – the influence of productivity growth, nonlinearities in adjustment and shifts in volatility between nominal exchange rate regimes (Lothian and Taylor, 2008).

As a complement to the time-series studies, I used cross-country data for the floating-rate period to examine the PPP relation in two additional papers (Lothian and Simaan, 1998; Lothian and Taylor, 1997). The upshot of both was that PPP held but that it took time to do so – three or more years for changes in exchange rates and differentials in inflation rates to show substantial convergence. Lags of this length were remarkably consistent with those that I found in my paper in *Japan and the World Economy* and that Taylor and I found in our paper in the *Journal of Political Economy*.

Two additional papers shed further light on real-exchange-rate behavior. In the first, Cornelia McCarthy and I used data for Ireland and three other countries – Germany, the United Kingdom and the United States – to examine the stability of real exchange rates both over time and across regimes (Lothian and McCarthy, 2002). We focused on Ireland because of the diversity of its exchange-rate arrangements

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– currency union with Britain, followed by a close link to the other EU countries under the Exchange Rate Mechanism and then membership in the Euro. We found substantial evidence in favor of PPP and that the regime, other than Ireland's currency union with the UK, did not matter.

In the second, Martin Evans and I studied the time-series properties of the real exchange rates of Germany, Italy, Japan and the UK relative to the US dollar (Evans and Lothian, 1993). The question of interest was whether in fact real exchange rates evolved solely as a result of permanent shocks and thus followed random walks, as a number of researchers had claimed. Contra the random walk hypothesis, we found statistically significant temporary components for at least part of the period for all four exchange rates. We concluded that the random-walk characterization of real exchange rates under the float is a useful first-pass statistical characterization but is unreliable for discriminating among alternative theoretical models.

3. Price levels and exchange rates

The issue that I address now is the long-term behavior of price levels and nominal exchange rates and the roles played by money-supply behavior and by the monetary regime. The data I use in this investigation are multi-country panels for three widely separated time periods. I focus on three related questions. Does international price behavior differ in the ways that theory suggests under different monetary regimes and if so how specifically? Is the regime itself a crucial variable and if so in which ways? Do inflation rates adjusted for changes in nominal exchange rates converge, or put another way, does purchasing power parity hold over the long run?

The first body of data that I use is for the period 1870–1914, the era of the classical gold standard in many but not all countries. The second is for the interwar period from 1921 to 1939. The third and last is for the Bretton Woods and post-Bretton Woods era of floating exchange rates. What all three have in common are differences over both time and space in underlying monetary regimes and in monetary behavior more generally. In this regard, they provide a nice set of natural experiments.

To set the stage, I first outline a bare-bones two-country theoretical model that is consistent with both the historical development of monetary theory and more modern analysis. I then go on to present my empirical results.

In all three periods, price levels in the various countries behave the way theory suggests. Longer term changes in price levels adjusted for exchange-rate changes, moreover, bear a positive and in most instances one-to-one relation to one another. The one partial exception is the interwar years, but that appears to be due to the interferences with trade and capital movements that became endemic in the later part of that period.

The results also speak to the related question of the applicability of purchasing power parity under different exchange-rate regimes. A typical objection to studies of purchasing power parity that use long-term time series data is one of aggregation bias. These data suggest that this is a non-issue as it pertains to the *long-term* performance of PPP.

3.1. Theoretical considerations

To see the potential differences in economic behavior under different exchange-rate regimes and the role played by the purchasing-power-parity condition, consider the following simple long-run, two-country equilibrium model.[1] One country, the "domestic economy," is a small country whose trade and financial markets are completely open; the other, the "foreign country," is a large country with a 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:

[1] The model is consistent with Friedman and Schwartz (1963), Lucas (1982), Darby and Lothian (1989) and Lucas and Nicolini (2015).

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

and

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

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 foreign currency of a unit of the domestic currency.

In the fixed-exchange-rate case, s is constant and the domestic price level will take whatever value is consistent with p', the foreign-country price level. Money supplies in the two countries will adjust to differences in the quantities of real money balances demanded.

In the floating-exchange-rate case, in contrast to the situation under fixed exchange rates, monetary policies in the two countries will be independent and under control of the respective central banks. Their price levels are determined by (1a) and (1b). If the behavior of money supplies differs, so too will the behavior of 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.[2] 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.

4. Empirical evidence

The classical gold standard era, when viewed in retrospect, was in most ways a time 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 interwar period, 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 post-WWII era, which like its predecessor, began on a high note with the 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." That in turn was followed by another period of relative stability – the "Great Moderation" as it came to be known. 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 purchasing power parity worked.

In the empirical work that follows, I present evidence on the links between price behavior and the monetary regime. I then go on to investigate that behavior further in the context of the purchasing-power-parity relation. I do this using an alternate form of the PPP relation in which the exchange-rate adjusted US inflation rate is the dependent variable and the foreign inflation rate is the independent

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

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variable. The observations in each instance are subperiod averages of the yearly data. The equation took the following form:

$$DP_t' + DS_{it} = \alpha + \beta\, DP_{it} + e_{it}, \tag{3}$$

where $DP_t' + DS_{it}$ is the sum of the average change in the logarithm of the US price level and the average change in the logarithm of the ith foreign currency per US dollar exchange rate in period t, DP_{it} is the average change in the logarithm of the ith foreign price level in period t, and e_{it} is the error term assumed normal and independently distributed and mean zero.

4.1. The gold standard era, 1870–1913

I have collected annual data for 25 countries for the years 1870 to 1913 for price levels and for exchange rates relative to the U.S. dollar.[3] By 1875, the majority of these countries were on the gold standard, with the United 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, 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 world stock of monetary gold in those years was relatively stable. It grew by an average rate of only 1.35 percent per annum from 1869 to 1889 – down considerably from the 4.52 percent per annum pace registered over the previous two decades – but then accelerated substantially to an average rate of 3.39 percent per annum between 1889 and 1909.[4] 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 until 1897. The world stock of silver, in contrast, was rising and the monetary demand declining as countries on bimetallic standards like France switched to gold.[5]

We see the resultant differences in price behavior in the top half of Fig. 1 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 the 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 Fig. 1, 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, I believe, is that most geared their domestic monetary policies to exchange-rate stability vis-à-vis the gold countries. The stock of money in the five European paper-currency countries for which I could obtain data (Austria-Hungary, Greece, Italy, Portugal and Spain) grew at an average annual rate of 1.02 percent per annum between 1885 and 1896 and then accelerated to 3.89 percent per annum between 1897

[3] The price data are mainly for consumer prices. 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 the data was Catão and Solomou (2005).

[4] The gold data are taken from table 14.1 in Rockoff (1984).

[5] There are no figures on the monetary stock of silver, but figures on silver production show steady increases in the rates of production averaging 45 percent from one decade to the next over the sixty-year period beginning in 1860 and ending in 1910. Figures on gold production, in contrast, more or less mirror the behavior of the monetary stock of gold, showing slight decreases in production in the first three decadal comparisons followed by very substantial increases thereafter. The source of both sets of production data is Warren and Pearson (1933), table 26, page 145.

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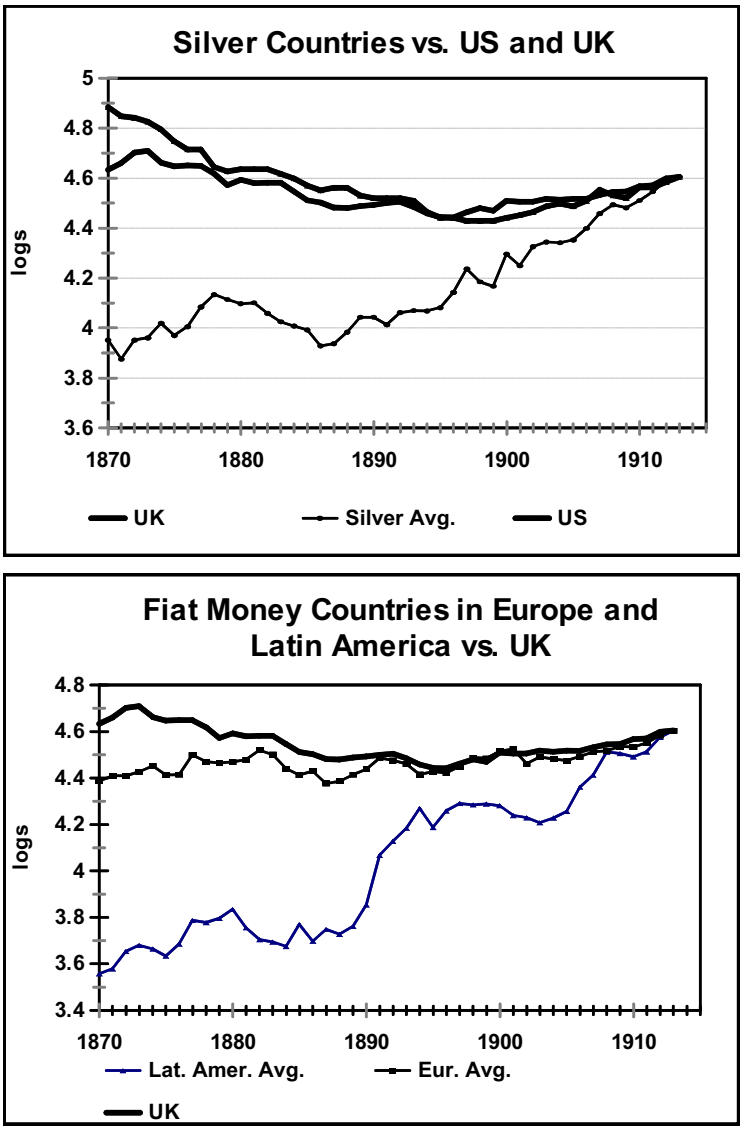

Fig. 1. Consumer price behavior under different monetary regimes, 1870–1913.

and 1913. In the three paper-currency countries in Latin America, money grew by 6.06 percent per annum and 4.83 percent per annum in the two periods respectively.

The difference in the first two instances and the similarity in the third are illustrated further in Table 1, 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 a dummy-variable regression reported in Table 2. 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 Fig. 1, the dummy variables for the Latin American

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Table 1
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 percent 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 percent 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 2
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		0.857

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 jointly are zero. Figures beneath the coefficients are conventional t statistics.

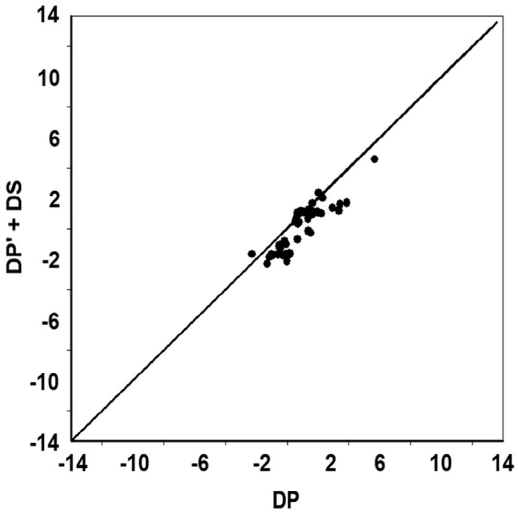

Fig. 2. Exchange rate change vs. inflation differentials, period averages: 1871–96 and 1897–1913.

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.

Shown in Fig. 2 is a scatter plot of averages for 1871–96 and 1897–1913 of exchange-rate adjusted US inflation vs. foreign inflation. Drawn in as a frame of reference is a 45 degree line through the origin. Consistent with theory, we see a close to one-to-one positive relationship between the two

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variables. The regression results reported at the top of Table 4 confirm these visual impressions. The estimated slope coefficient in the regression is .92. The R^2 is .78. In the countries in which exchange rates floated, exchange rates evidently moved to reflect the differences in price behavior and in the countries in which exchange rates were fixed, as they were in the gold countries, inflation rates evidently converged.

4.2. 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) had 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 transmission of monetary shocks to the rest of the gold-standard world.

As the Depression worsened, the international monetary system came under increasing pressure. In September 1931, the United Kingdom abandoned the gold standard, devaluing the pound relative to the dollar and other gold-based currencies. More and more countries quickly followed. Other countries like Germany and many of its Central and Eastern European neighbors adopted exchange controls. Their currencies remained nominally the same but effectively were devalued and traded as such in black markets (Eichengreen, 2008). Then in 1933, the United States too abandoned gold. The result was a new system of managed floating exchange rates, but one accompanied by capital controls and interferences of various sorts in international trade. The international financial integration that characterized the classical gold standard era and much of the period preceding it went by the boards.

Friedman and Schwartz (1982, pp. 290–2) show this quite clearly in their study of US and UK monetary trends. Using an estimate of the purchasing-power-parity dollar–pound exchange rate in 1970 and the GNP deflators for the two countries, they derive an annual series for the period 1870 to 1980 for the real exchange rate. The series averages are not very different in the two subperiods. There thus appears to be mean reversion, as Friedman and Schwartz point out (though not in those terms) and as subsequent research confirms (Lothian and Taylor, 1996). There is, however, a marked break in volatility pre- and post-1931. The range of fluctuations about the averages close to triples from the first subperiod to the second, rising from plus or minus 10 percent up to 1931 to plus 33 percent to minus 25 percent thereafter. Friedman and Schwartz point explicitly to the numerous devaluations that took place under the managed exchange-rate regime as a major culprit.

Commenting on the difference between the two subperiods, Friedman and Schwartz write:

> Since 1931 there have been tremendous improvements in communications and in transportation. The jet aircraft now spans the ocean in a few hours. Satellite transmission and television and radio communications link countries instantaneously and at relatively low cost. The cliché is it has become one world. In the economic world, the reality is clearly the reverse. The law of one price was far closer to being satisfied before 1931 than after. The technological improvements, which might have been expected to unify the world, have been more than offset by governmental intervention, which has fragmented the world into separate, isolated markets. Chart 6.5 [plotting the ratio of the actual to the PPP exchange rate] demonstrates vividly how powerful and effective government intervention has been in rendering the law of one price far less applicable after 1931 than it was before.

Jackson and Lothian (1993) use the cross-country dispersion of *ex post* real interest rates across a group of major developed countries over the period 1871 to 1990 as a measure of integration. They reach very much the same conclusions for the period covered by Friedman and Schwartz, but go on

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to present evidence of a return to greater integration in the 1980s. Lothian (2002) and Obstfeld and Taylor (2004), using a variety of measures of integration, extend Jackson and Lothian's results.

The data for the interwar period that I analyze here are for a panel of 26 countries for the years 1921 to 1939. Omitted are observations for episodes of hyperinflation.[6] First, let me turn to the behavior of price levels in the early 1930s and then to the relation between inflation rates and changes in exchange rates. If my account of the transmission mechanism during the Depression is correct, 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 which left gold in 1931, changed monetary standards. In the latter two instances, these differences in price behavior should also be paralleled by movements in exchange rates.

Plotted in the top panel of Fig. 3 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 other is rather stark – 25 to 30 percent 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 bottom panel of Fig. 3 is the average log price level of the sterling bloc, the 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 Fig. 1, therefore, the monetary standard clearly matters.[7] 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 3 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.

Fig. 4 presents a scatter plot of the exchange-rate adjusted US inflation rate vs. the foreign inflation rate like that reported above for the classical gold standard era. In the chart, I plot averages of these data for the periods 1921–1929 and 1930–39. Like the comparable chart for the gold-standard era, there is a clear positive relation between the two variables. Nevertheless, it is much less precisely determined than in the gold-standard period. The difference is apparent both when we compare Fig. 4 with Fig. 2 visually and when we compare the corresponding regression results for the two periods in Table 4.

The slope coefficient of .90 for the interwar data is close to and not significantly different from unity as it was in the regression for the gold-standard era. The standard error of the regression, however, is much higher (3.25 versus 0.71) and the R^2 lower (.51 versus .78). The glass is, so to speak, both half full and half empty. Given the interferences with trade and capital movements and the shifts to managed exchange rates that became common in the wake of the Great Depression, measured exchange rates during this period very likely were only highly imperfect proxies for their equilibrium values. The looser relation – the half empty part of the glass – is, therefore, far from totally surprising. What is perhaps somewhat surprising is how well the theory does in the face of what amounts to a stress test.

[6] 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 database maintained by Global Financial Data (2007). League of Nations publications (1926–1939/40) and Officer (2015) What Was the Exchange Rate Then? were the sources of the data for China.

[7] 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.

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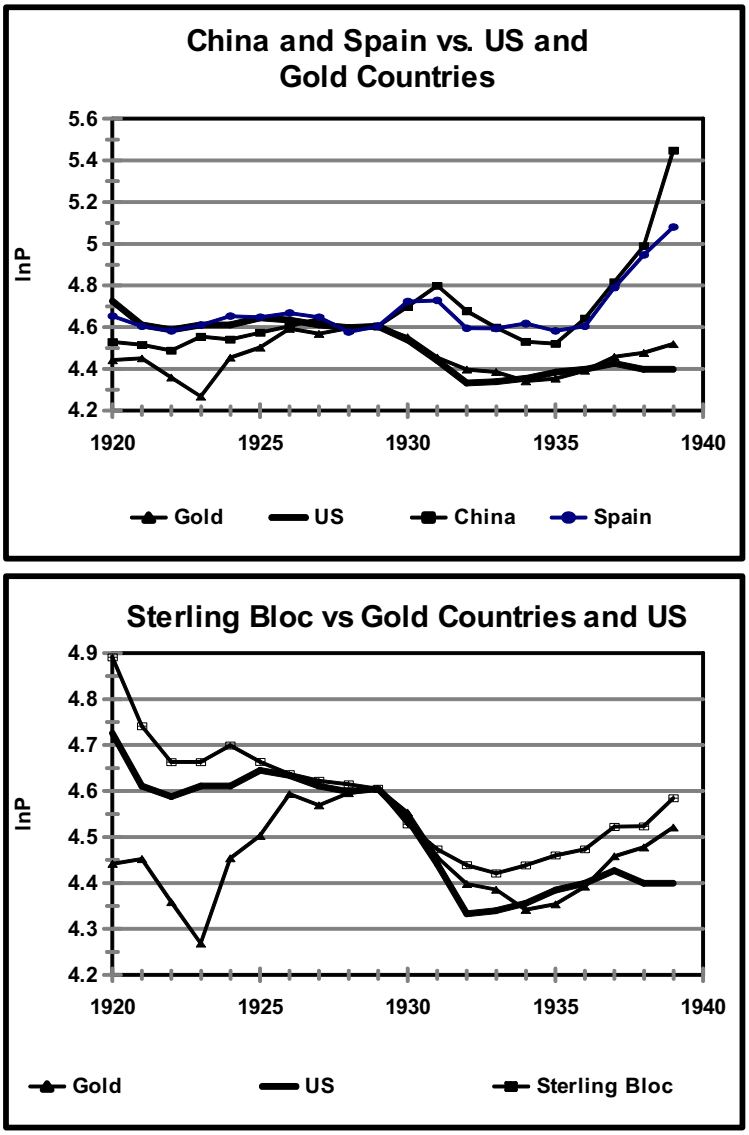

Fig. 3. Consumer price behavior under different monetary regimes, 1921–1939.

4.3. 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." 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. Until the mid-1960s, U.S. inflation was low. Then, as U.S. monetary policy became more expansive and

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Table 3
Average rates of inflation under different monetary regimes Pooled data for 26 countries, 1921–1939.

	US	Gold	Stg. Bloc	Misc. 7	All
All figures in percent per annum					
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

Note: Figures in the table are logarithmic changes expressed in percent 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.

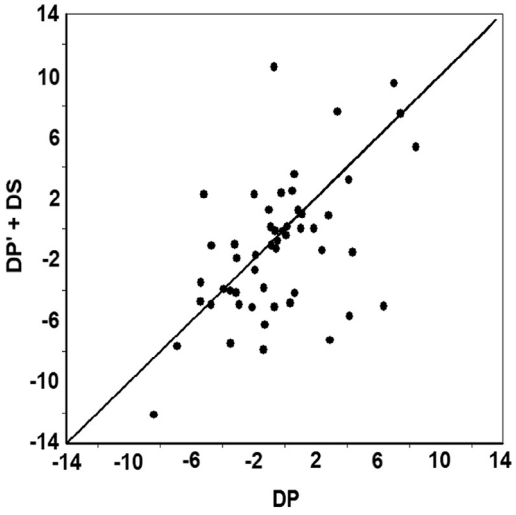

Fig. 4. Exchange rate change vs. inflation differentials, period averages: 1921–29 and 1930–1939.

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. In the early 1980s the pendulum 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 series 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 5 provides summary statistics for inflation in the 20 OECD countries over this period that are consistent with this description.[8] Shown in the top line of the table for the 20 countries combined are the average rates of CPI inflation for the periods 1959–71, 1972–83 and 1984–98. Shown in the lower half are the corresponding cross-country standard deviations. We see increases from the first to the second subperiod in the average rate of inflation

[8] The table is adapted from Lothian and McCarthy (2009). Data are annual observations for the following countries: 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.

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Table 4
Exchange-rate adjusted US inflation vs. foreign inflation: Regression results for the three periods.

Period	α	β	R^2/SEE
1870–1913			
Coefficient	–0.673	0.915	0.780
Std. error	0.113	0.068	0.708
t	–5.945	13.449	
t β = 1		–1.252	
1921–1939			
Coefficient	–0.009	0.904	0.512
Std. error	0.005	0.127	3.251
t	–2.003	7.098	
t β = 1		–0.754	
1959–1998			
Coefficient	–0.010	1.063	0.890
Std. error	0.003	0.050	1.395
t	–2.843	21.064	
t β = 1		1.244	

Note: Regressions took the form $DP_t' + DS_{it} = \alpha + \beta\, DP_{it} + e_{it}$, where $DP_t' + DS_{it}$ is the sum of the average the logarithmic changes in the US price level and the average ith foreign currency per US dollar exchange rate in period t, DP_{it} is the average the logarithmic changes in the ith foreign price level rate in period t, and e_{it} is the error term.

Table 5
Summary statistics for rates of inflation, 20 OECD countries 1960–1998.

	1960–70	1971–82	1983–98
All figures in percent per annum			
Means	3.76	9.70	3.94
Standard deviations	1.73	3.82	2.45

Note: Figures in the table are based on logarithmic changes converted to percent per annum. 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.

and in the dispersion of the inflation rates of the individual countries about that average of 5.9 and 2.1 percentage points respectively followed by decreases of 5.7 and 1.4 percentage points from the second to the third subperiod. As Lothian and McCarthy (2009) show, the upward shifts in the average rate of inflation from 1959–1971 to 1972–1983 mirror the similar shifts in excess money growth that took place in these countries. The same is true on the downside, with the decreases in inflation from 1972–1983 to 1984–1998 again mirroring the decreases in excess money growth.

The increase from the first to second period in the cross-country dispersion of inflation rates is what one would expect given the change in the exchange-rate regime from pegged to floating rates that occurred in these years and given the different policy goals that prevailed in the various countries in the 1970s and early 1980s. The subsequent decrease in dispersion is explicable in terms of the widespread shift toward ant-inflation monetary policy that took place as the 1980s wore on.

Reported at the bottom of Table 4 are the results of the regression of average rates of exchange-rate adjusted US inflation against foreign inflation for the full 1959 to 1998 period. As in the two earlier episodes, there is an almost one-to-one positive relation between the two variables – a slope coefficient of 1.06 versus .90 and .92 in the interwar and gold regressions respectively. The R^2 in the regression of .89 is high. The standard error of the regression of 1.40 percent is much lower than in the regression for the interwar years of 3.25 percent, but double that in the regression for the gold-standard era of .71 percent.

Table 6 presents the results of regressions to test the stability of the relation across the three periods. The t tests for the dummy variables to allow differences in intercepts and slopes individually are all

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Table 6
Exchange-rate adjusted US inflation vs. foreign inflation: Regression results for the post-WWII subperiods.

Period	α	β	R^2/SEE
1959–1971			
Coefficient	–0.009	1.061	0.539
Std. error	0.009	0.238	1.002
t	–0.985	4.460	
t $\beta = 1$		0.256	
1972–1983			
Coefficient	0.378	0.956	0.800
Std. error	1.192	0.116	1.878
t	0.317	8.246	
t $\beta = 1$		–0.383	
1984–1998			
Coefficient	–0.820	0.924	0.700
Std. error	0.604	0.147	1.119
t	–1.356	6.302	
t $\beta = 1$		–0.518	

Note: Regressions took the form $DP_t' + DS_{it} = \alpha + \beta\, DP_{it} + e_{it}$, where $DP_t' + DS_{it}$ is the sum of the average the logarithmic changes in the US price level and the average ith foreign currency per US dollar exchange rate in period t, DP_{it} is the average logarithmic change in the ith foreign price level in period t, and e_{it} is the error term.

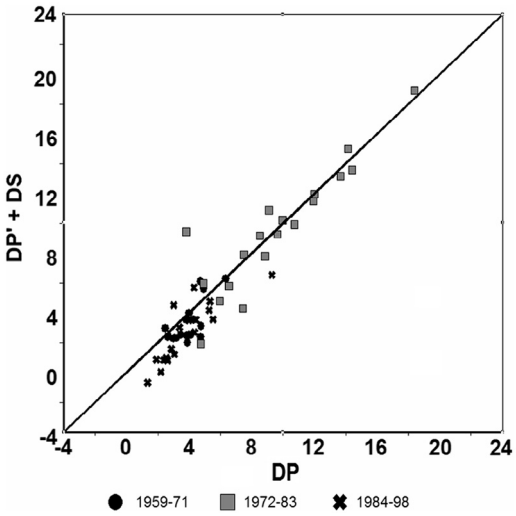

Fig. 5. Exchange rate change vs. inflation differentials, period averages: 1959–71, 1972–83, 1984–98.

low and not statistically significant at conventional levels. The F test for all four variables as a group is similarly low and statistically insignificant.

Fig. 5 presents a scatter plot of the post-WWII data broken down by subperiods. The circles, squares and x's represent the observations for the first, second and third subperiods, respectively. What we see here too is a very nearly homogeneous relationship over time. This is borne out further by the results of the regressions for the subperiods reported in Table 6 and the test results reported in Table 7. The three slope coefficients fall in the narrow range of .92 to 1.06; their average is .98. The stability of the relation across the three periods in Table 7 cannot be rejected at anything close to conventional levels of significance. These results are of considerable interest given the stories of aggregation bias

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Table 7
Exchange-rate adjusted US inflation vs. foreign inflation: Regressions to test for stability across the post-WWII subperiods.

	Constant	*DP*	*D72*	*D84*	*DPxD72*	*DPxD84*	R^2/*SEE*
Coefficient	–0.010	1.063					0.890
Std. error	0.003	0.050					1.395
t	–2.843	21.064					
t $\beta = 1$		1.244					
Coefficient	–0.009	1.061	0.013	0.001	–0.105	–0.137	0.899
Std. error	0.013	0.329	0.016	0.015	0.340	0.376	1.389
t	–0.711	3.221	0.829	0.073	–0.310	–0.364	
t $\beta = 1$		0.185					
F (4,55)	1.124						

Note: DP is the average logarithmic change in the ith foreign price level, *D72* is a dummy variable for the 1972–83 subperiod and *D84* is a dummy variable for the 1984–98 subperiod.

Table 8
Exchange-rate adjusted US inflation vs. foreign inflation Regressions to test for stability across the three sample periods.

	Constant	*DP*	*D21*	*D59*	*DPxD31*	*DPxD59*	R^2/*SEE*
Coefficient	–0.008	1.008					0.807
Std. error	0.002	0.039					2.031
t	–4.176	25.677					
t $\beta = 1$		0.198					
Coefficient	–0.007	0.915	–0.003	–0.003	–0.011	0.148	0.810
Std. error	0.003	0.196	0.004	0.006	0.211	0.209	2.039
t	–2.066	4.674	–0.583	–0.504	–0.051	0.707	
t $\beta = 1$		–0.435					
F(4,154)	0.697						

Note: DP is the average logarithmic change in the foreign price level, *D21* is a dummy variable for the 1921–39 period and *D59* is a dummy variable for the 1959–98 period.

due to combing data for fixed- and floating-rate regimes and the breakdown of PPP during the recent floating-rate regime that have abounded in the literature.

Table 8 speaks to the related question of stability across the three broader historical periods. Shown there are the results of a pooled regression using the data for the gold-standard, interwar and post-WWII periods combined and of tests of stability across the three periods like those reported in Table 7 for the post-WWII subperiods. The t tests for the dummy variables to allow differences in intercepts and slopes individually again are low and not statistically significant. The same thing is the case for the F test for all of the variables taken together.

5. 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 the behavior of nominal exchange rates under floating rates and the behavior of price levels among countries under fixed rates. We see this in the panel data for the three episodes that I have examined: the classical gold-standard period, the interwar period and the varied monetary regimes of the post-WWII era.

Acknowledgements

I want to thank John Devereux, Gerald P. Dwyer, Iftekhar Hasan, Rachel Pownall, Christian Wolff and participants at the 11th International Conference on Macroeconomic Analysis and International

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Finance at the University of Crete, and at seminars at the Graduate Center, CUNY, University College Cork, the University of Piraeus, Maastricht University and the University of Rome Tor Vergata and at the Conference at Fordham held in my honor for comments on this paper and its earlier incarnation. I would also like to thank Caitlin Leary and Elizabeth J. Lothian for help in data collection, Owen Daly for editorial assistance and Luis Catão for generously providing me with his data for the gold-standard era.

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