Co-movements in international dollar price levels

Gary Shelley and Frederick Wallace

Universidad de Quintana Roo

July 2007

Co-Movements in International Dollar Price Levels

by:

Gary L. Shelley*
Department of Economics & Finance
East Tennessee State University
Johnson City, TN 37614

and

Frederick H. Wallace
Departamento de Ciencias Económico-Administrativas
Universidad de Quintana Roo
Chetumal, Quintana Roo
Mexico

July 9, 2007

***Corresponding Author, (423) 439-5139, Shelley@etsu.edu.** **We thank Alan Taylor for providing the data.**

Co-Movements in International Dollar Price Levels

Abstract:

This paper studies the relation between movements in the U.S. price level and the dollar price levels of nineteen other countries. Using the band pass filter developed by Christiano and Fitzgerald (2003), we examine correlations between dollar prices when decomposed into their high, medium, and low frequency cycles. The low frequency cycle in the U.S. price series is highly correlated with low frequency cycles in dollar price levels of the majority of countries in our sample. The high correlation between low frequency cycles persists over a variety of historical sub-periods, including the eras of fixed and flexible nominal exchange rates. This result, suggesting the existence of a common long-run price cycle, is consistent with long-run purchasing power parity. In contrast, both high and medium frequency cycles are more highly correlated prior to the Great Depression. This result is consistent with studies finding greater stability of real exchange rates during the era of the gold standard. Also, it appears that the increased volatility of U.S. real exchange rates after the 1973 move to flexible exchange rates was largely due to declines in the co-movement of short-run dollar price cycles.

Keywords: Purchasing power parity, real exchange rate volatility, band-pass filter.

JEL Categories: F41, E31

1. Introduction

This study examines the relation between movements in the U.S. price level and dollar denominated price levels in nineteen other countries.[1] Co-movements, or lack thereof, in dollar price levels have implications for two types of studies involving real exchange rates. The first set of studies tests the theory of purchasing power parity (PPP).[2] Simply stated, if long run PPP holds then the real exchange rate, the difference between price levels measured using a common currency, is stationary around a constant mean.[3] Rejection of a unit root in a real exchange rate thus is supportive of PPP. Although the empirical evidence is mixed, the proposition that arbitrage will tend to eliminate deviations from PPP over the long run is appealing to most economists.

We do not employ formal statistical tests of PPP such as unit root or cointegration tests. Rather, we measure the correlations between movements in cyclical components of dollar price levels across countries. The advantage to our approach is that the band-pass filter allows us to examine correlations between the low frequency (long-run) cyclical components of dollar prices. If PPP is a valid long-run phenomenon, then persistent, low-frequency movements in the U.S. price level should be matched by low frequency movements in foreign dollar prices.[4] We also can examine whether PPP is likely to hold over shorter horizons by examining the cross-country correlations of higher frequency price cycles.

The ability to estimate low frequency cycles in dollar price levels is especially advantageous if PPP holds strictly as a long-run phenomenon. To illustrate this point, consider a

---

[1] Price levels and real exchange rates referred to in this paper are logged.
[2] See Sarno and Taylor (2002) and Taylor (2002) for surveys.
[3] The real exchange rate may be stationary with a mean differing from zero due to transportation costs and other trade frictions.
[4] Because we compare movements in dollar price levels, our results are relevant for studies of relative rather than absolute purchasing power parity.

hypothetical case in which country specific events drive short term movements in dollar price levels, but PPP holds in the long-run. The correlation between U.S. and foreign high frequency price cycles then is likely to be low, while the correlation between low frequency cycles will be highly positive. In this case, the long run relation between dollar prices should be more apparent in data with high frequency cycles removed.[5] The long-run relation could be especially difficult to uncover in unfiltered data if short run, high frequency movements account for a large proportion of the overall variation in dollar price series. Looking ahead, we find that this hypothetical example accurately characterizes the relation between U.S. dollar prices and a large proportion of the foreign dollar price levels included in our study.

Results of this study also are relevant for the body of literature examining differences in the short-term volatility of real exchange rates across nominal exchange rate regimes and historical periods. High volatility of real exchange rates is a concern to policymakers for a variety of reasons, including effects on the domestic capital stock (Neumann, 2005), distortions in consumption allocations (Devereux and Engel, 2007)), and reductions in trade volume (Arize, 1998 and Arize, Osang, and Slottje, 2006). Strong, positive correlations between dollar price levels are consistent with stable real exchange rates. Low correlations suggest real exchange rate volatility. In many cases, our results show that cross-country correlations of both high and medium frequency movements in dollar price levels decreased near the beginning of the Great

[5] Band-pass filters have been used in several studies to better examine long-run relationships. Valdovinos (2003) finds a stronger negative relation between filtered inflation and real growth than with unfiltered data. Lee and Ni (1997) find that more persistent, medium-term changes in government spending have greater real output effects than do short term changes. Robertson (2004) finds a strong positive relation between the 3-5 year cycles in relative prices and relative wages in Mexico, but finds little or no relation between higher frequency movements in those series.

Depression. This suggests that real exchange rates were more stable prior to the onset of the Great Depression and the collapse of the gold standard.[6]

Finally, many studies have found that the volatility of U.S. real exchange rates increased with the move from fixed to flexible nominal exchange rates.[7] For the period of flexible exchange rates, we find strong positive correlations between the medium as well as the low frequency components of many dollar denominated price levels; however, high frequency movements usually are uncorrelated.[8] This suggests that the high volatility of U.S. real exchange rates in this era likely is due to a lack of co-movement in short term price cycles rather than any long-run, persistent divergence from PPP.

2. Co-Movement of Unfiltered Dollar Prices

Taylor's (2002) data set includes logged annual price levels and dollar exchange rates for the U.S. and nineteen other countries.[9] There are at least one-hundred years of observations for each country, allowing us to estimate the low frequency components of the dollar price series.[10] Dollar denominated price levels are calculated as:

$$d_t^f = e_t^f + p_t^f \, . \tag{1}$$

[6] Studies addressing the possibility that breakdowns in the gold standard lead to greater real exchange rate volatility include Kool and Koedijk (1997), and Chernyshoff, Jacks, and Taylor (2005).
[7] Examples include Mussa (1986), Lothian (1998), and Norrbin and Pipatchaipoom (2007).
[8] We define the flexible exchange rate period as post 1973, the time after the collapse of the Bretton-Woods agreement. However, it should be noted that some countries in the sample, Mexico for example, maintained fixed/managed exchange rates well into the 1990s.
[9] The countries are Argentina, Australia, Belgium, Brazil, Canada, Denmark, Finland, France, Germany, Italy, Japan, Mexico, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the UK. More details about the data can be found in Taylor.
[10] The importance of using long-span data is demonstrated by Diebold, Husted, and Rush (1991), who find that rejection of PPP may be reversed if data sets with longer time spans are used.

For each year t in foreign country f, d_t^f is the log dollar denominated price level, e_t^f is the logged nominal exchange rate (dollars per unit of foreign currency), and p_t^f is the logged foreign price level.

Percentage changes (log differences) are used to measure movements in the unfiltered series. We first examine the correlations between the unfiltered growth rates of the U.S. price level and the dollar price level of each foreign country over the full data sample. Results are presented in Table 1. The average correlation over the nineteen countries is .327. Given the close geographic proximity, strong cultural ties, and high volume of trade, it is unsurprising that the highest correlation is with Canada at a value of .703. However, there are no other correlations greater than .50. Fifteen of the eighteen other correlations are between .203 (Portugal) and .495 (the U.K.), indicating a weak, positive relation between changes in dollar prices in these countries and U.S. price movements. The correlations for three countries, Germany, Brazil, and Mexico, are less than .20. Somewhat surprisingly, given its geographic location, the correlation for Mexico is lowest of the nineteen countries, with a value of -0.029. With the exception of Canada, the unfiltered data provide little evidence that dollar prices in other countries move closely with those in the U.S.

Several studies suggest that the variability of real exchange rates has changed over time. An increase in variance of real exchange rates implies a reduction in co-movement of common-currency prices. A variety of potential breakpoints have been identified in the literature. Chernyshoff, Jacks, and Taylor (2005) argue that real exchange rates became more variable after WWI because the interwar (1918-1940) gold standard did not work as well as the pre-WWI classical gold standard. Kool and Koedijk (1997) show that the interwar period was unstable with respect to nominal exchange rate regimes, as the period included a brief experiment with floating exchange rates (1922-1925), a return to the gold standard (1925-1931), and finally the depression era abandonment of the gold standard in favor of managed exchange rates.

To investigate the possibility that the relation between common currency prices changed after WWI, correlations are calculated between movements in U.S. and foreign dollar price levels with data through 1914 and then for a 1919-1996 sub-period. These correlations, displayed in Table 2, provide scant evidence to suggest that dollar price series moved more closely together prior to WWI. The average correlation for all countries in our data set is lower prior to WWI (.179) than it is afterward (.291). Correlations are slightly higher prior to WWI than they are in the full sample for Belgium, Finland, Germany, Italy, Portugal, and the U.K.; but only the U.K. has a correlation exceeding .35 for the pre-WWI era.

Grilli and Kaminsky (1991) find a change in the time series properties of the real exchange rate between the U.S. dollar and the British pound after World War II.[11] We investigate the possibility of a structural break at WWII by comparing the correlations of the changes in the logged dollar denominated price levels for the sub-period through 1938 and the post-WWII sub-period of 1948-1996. Results are presented in Table 3. The pre-WWII average correlation of .348 is higher than the post-WWII average correlation of .248. Although the difference in average correlations is not large, pre-war correlations exceed .50 for six countries. Of these six; Canada, Italy, the Netherlands, Sweden, Switzerland, and the U.K.; only Canada had a correlation exceeding .50 in the full sample. Correlations for four additional countries (Denmark, Finland, France, and Norway) exceed .40 for the pre-WWII period. Dollar denominated price level changes appear to have moved somewhat more closely together prior to

[11] They find that the real exchange rate is a random walk if tests are applied to data beginning with the post-WWII adoption of the Bretton-Woods system through 1986. However, they are able to reject the presence of a unit root in the real exchange rate when pre-WWII data are included.

WWII than afterward. However, there is little evidence of a strong relation between movements in dollar price levels of the U.S. and countries other than Canada in the pre-WWII era. Canada remains the only country with a correlation exceeding .60 in either sub-period.

Mussa (1986) and Lothian (1998) argue that the variance of real exchange rates is much higher under floating nominal exchange rate regimes than fixed nominal exchange rates. If so, movements in common currency prices should not be as highly correlated in the era of flexible exchange rates. Correlations between dollar price movements are calculated for the fixed exchange rate era (through 1973) and for the flexible exchange rate period (1974 through 1996).[12] These correlations are shown in Table 4. The average correlation differs only slightly for the two periods, with values of .321 and .248 respectively. Just three countries (Canada, Switzerland, and the U.K.) have correlations exceeding .50 in the pre-1973 sample. There is little evidence that dollar price levels moved more closely together under fixed exchange rates than under the current system of flexible exchange rates.

Finally, we examine correlations between movements in unfiltered price series prior to and following the onset of the Great Depression. The breakdown in international trade and abandonment of the gold standard by many countries during the early years of the depression may have changed the relation between international dollar price movements. To assess the likelihood of this explanation, we examine correlations for two sub-periods, start-1929 and 1930-1996. Results are in Table 5. The difference between average correlations, .438 versus .247, is the largest for any breakpoint considered. The correlation of changes in a foreign dollar price level with changes in the U.S. price level exceeds .40 only for Canada in the years 1930-1996, but exceeds .40 for 13 countries in the pre-depression era. Furthermore, correlations for eleven

[12] There was a brief period of flexible exchange rates following WWI (see Kool and Koedijk), but this includes only a small number of annual observations in the pre-1973 sample. Also, see footnote 4.

countries exceed .50 for the pre-depression period, with four of these (Canada, Sweden, Switzerland, and the U.K.) exceeding .70. When using unfiltered data, the pre-Depression period displays the strongest co-movement of price levels, thus the conditions most conducive to both exchange rate stability and PPP.

3. Co-Movement of Filtered Dollar Prices in the Full Sample

The band-pass filter (CF filter) developed by Christiano and Fitzgerald (2003) presents an alternative method for studying long-run economic relationships.[13] The CF filter allows a time series to be decomposed into cyclical components falling into a variety of frequency bands. For example, suppose that one wishes to examine the classical "business" cycles of 2-8 year frequency in a time series. There exists an orthogonal decomposition:

$$x_t = y_t + \tilde{x}_t \ . \tag{2}$$

The y_t component is the series of interest and has power only in the business cycle frequencies while the $\tilde{x}_t$ component has no power in these frequencies. Christiano and Fitzgerald show that an estimate, $\hat{y}_t$, of the y_t component can be obtained in the frequency domain by minimizing the conditional expected mean squared error:

$$Min : E[(y_t - \hat{y}_t)^2 \mid \{x_t\}] \ . \tag{3}$$

In our application, the $\{\hat{y}_t\}$ series is the "filtered" dollar price series.

The CF filter offers several advantages over other commonly used filters. The BK filter, introduced by Baxter and King (1999), is a competing band-pass filter. However, Christiano and Fitzgerald find that their filter dominates the BK filter in terms of their optimality criterion, particularly when estimating cycles in the lower frequency bands. Everts (2006) also finds that

[13] See Christiano and Fitzgerald paper for technical details regarding derivation of the filter.

the CF filter produces more accurate estimates of low frequency cycles than does the BK filter. In addition, unlike the BK filter, the CF filter estimates cycles for the full data sample. The HP filter, of Hodrick and Prescott (1997), is not appropriate for our study because it is strictly a high-pass filter, intended to remove low frequency components of time series leaving only the higher frequency, short-run cyclical component.

We use the CF band-pass filter to decompose each dollar price level series into high, medium, and low frequency cycles. The high frequency (short run) cycle in a series has a frequency of 2-8 years which corresponds to the usual definition of the business cycle. The medium frequency (medium run) cycle and the low frequency (long run) cycle in a series are defined as having frequencies of 8-20 years and 20-40 years, respectively. The short, medium, and long run cycles in the U.S. price series are presented in Figures 1-3. Full sample correlations for the short, medium, and long run frequency co-movements in U.S. and foreign dollar price level changes are in Table 6.

For the full sample, dollar price changes do not move closely together over either the short run or the medium run. The average correlation of short term movements for the nineteen countries is only .064. The only short run correlation larger than .30 is Canada at .576. Correlations of the medium frequency cycles provide only slightly more evidence of co-movement between the dollar price levels. The average correlation over the medium run cycle is .297. Five of nineteen countries have correlations greater than .50 for medium term movements, but only two of these exceed .70.

The correlations for long run movements in the dollar price series, however, provide a much different picture. The average correlation between long run movements in the price series is .737 for all countries. Correlations for fifteen of the nineteen countries exceed .70, and nine correlations exceed .90. The nine countries are Italy (.976), France (.965), the Netherlands (.94.7%), the U.K. (.929), Finland (.921), Belgium (.918), Canada (.911), Japan (.906), and Norway (.903). The large number of high correlations suggests that there is a common long-run cycle in many dollar-denominated price series. As shown for the United States in Figure 3, this cycle captures the rapid growth in prices following WWI and WWII, as well as the inflation of the 1970's. It also clearly shows the deflation occurring during the Great Depression and the decline in inflation associated with the period of the 1950's.

The existence of a common long run dollar price cycle for many countries suggests that PPP is a reasonable long-run proposition. In contrast, the generally low correlations at the 2-8 year frequency suggest that short run price level movements are likely due to country specific causes.[14] It appears that the low correlations between unfiltered price movements reported in the previous section are due, in many cases, to country-specific short term (and to a lesser extent medium term) movements in dollar prices that obscure a common long run cycle.

The only countries with long run correlations less than .70 are Mexico (.37), Germany (.318), Argentina (.317), and Brazil (-.218). There are several potential explanations for the deviation of these countries from the long run price cycle of the United States. Argentina, Brazil, and Mexico are developing Latin American countries that have experienced periods of high inflation and nominal exchange rate controls.[15] Alba and Papell (2007) find that PPP with the U.S. is less likely to hold for countries with lower growth rates than the U.S. and for countries that have experienced high inflation.[16] Germany, too, had a notable period of

[14] An alternative explanation is that common aggregate shocks affect the countries but differing degrees of price stickiness imply low short run correlations.
[15] The long run dollar price levels of the three Latin American countries are not highly correlated with each other.
[16] In addition, Hausman, Panizza, and Rigobon (2006) find that real exchange rate volatility for developing countries is approximately three times that of developed countries. Gonzaga and Terra (1997) find high real exchange rate volatility for Brazil, which they attribute to high inflation volatility.

hyperinflation and is the only country in the sample to experience defeat in both world wars thus may not share the post-war price experiences that are important for the long term cycles of most of the other countries.

4. Co-Movement of Filtered Dollar Prices in the Sub-Samples

As discussed in section 2 above, several dates have been suggested for a possible change in the volatility of real exchange rates. Our results with unfiltered data indicate a breakpoint corresponding to the beginning of the Great Depression. We now return to this issue by studying the correlations of the band-pass filtered cycles in differenced U.S. and foreign dollar price series for the sub-periods defined earlier. In addition, we examine whether the evidence of a common long-run dollar price cycle, found in the previous section, is robust across sub-periods.

4a. The World Wars

We first examine correlations within the pre WWI and post WWI sub-samples. These correlations at short, medium, and long run frequencies are presented in Table 7. Average correlations of long run cycles are virtually identical for the two periods (.774 versus .747). Only six countries have markedly different correlations of long-term cycles in the two sub-periods. Argentina, Brazil, and Mexico have higher pre-WWI correlations at the low frequency. In contrast the post-WWI correlations are notably higher for the Netherlands, Spain, and Germany.

The average correlation of medium term cycles is higher for the pre-WWI period (.436) than for the post-war period (.225). Ten countries have medium price cycles that have correlations with the U.S. exceeding .70 prior to WWI. The five countries with the highest correlations are Finland (.939), Canada (.878), Norway (.864), the U.K. (.862), and Sweden (.862). Correlations of medium term cycles exceed .50 only for Canada and Finland in the post-war period. It appears that the degree of co-movement between medium cycles in dollar price levels was higher prior to WWI than afterward.

The average correlation of short term cycles before WWI is .172 and .06 in the post-WWI era. Correlations for Sweden, Finland, the U.K., and Canada exceed .50 in the pre-WWI period, while this is true only for Canada in the post-WWI period. Thus there is little evidence of stronger co-movement in short term cycles prior to WWI. Interestingly, the largest correlation in absolute terms in either sub-period is -.738 for Mexico prior to WWI. Our conjecture is that specie flows from Mexico to the U.S. during and immediately preceding the Mexican Revolution caused price level movements in opposite directions while specie movements in the other direction occurred after the hostilities ended in Mexico.[17]

Correlations for samples divided at WWII are presented in Table 8. Although the average correlation of long-term cycles is higher for the pre-war (.84) than the post-war (.654) periods, most of the difference is accounted for by Argentina, Brazil, Switzerland, and Mexico. There is little difference in the average correlation of medium frequencies for the pre-war (.343) and post-war (.297) eras. Although eight medium term correlations exceed .50 for the pre-WWII era, the size of these correlations tends to be smaller than for the pre-WWI era. Average correlation of short-term frequencies is small for both sub-periods (.168 and -.076 respectively), with only the correlation for pre-war Canada exceeding .50.

4b. Fixed versus Flexible Nominal Exchange Rates

[17] The revolution lasted from 1910-1917 although some armed conflict continued long after.

Table 9 lists the correlations for periods of fixed and flexible exchange rate regimes. There is little difference in average correlation across the two regimes at any cyclical frequency. For most countries the correlation between long term cycles remains highly positive for both periods. However for Japan and Switzerland the correlation with the U.S. long-term cycle noticeably declines in the flexible exchange era. In the case of Japan, the correlation declines from .92 to .483, and for Switzerland, the correlation decreases from .776 to .256. Except for these two cases the strong, positive co-movement of U.S. long-run dollar price movements and those of most other countries was not altered by the switch to flexible exchange rates.

The average correlations of medium cycles for the fixed and flexible exchange rate eras are .292 and .377 respectively. Despite the small difference in overall averages for the two sub-periods, for six countries (France, Germany, Italy, Spain, Brazil, and Portugal) the correlation increases noticeably during the period of flexible exchange rates. The average for these six countries increases from .091 in the fixed exchange era to .622 in the flexible exchange rate era. Four countries (Finland, Canada, Denmark, and Sweden) have correlations exceeding .50 in both exchange rate eras. These results for long and medium run cycles contrast with a common finding of studies using unfiltered data, namely greater volatility of real exchange rates (less co-movement of dollar price levels) in the flexible exchange rate era. Therefore, if, indeed, real exchange rate volatility did increase with the introduction of floating rates then the short term movements in the individual price series must account for the rise in volatility. To this issue we now turn.

The average correlation with U.S. short-run price cycles decreases slightly with the adoption of flexible exchange rates, although the averages are low for both periods (.09 with fixed exchange rates and -.136 with flexible exchange rates). However, the small change in average conceals some dramatic changes in individual short term correlations. For the U.S. and Canada, the correlation falls from .651 prior to 1974 to -.24 afterwards. The U.S.-Germany correlation declines from .032 to -.674, while the correlations with Spain and Sweden decline by more than .5 and change from positive to negative. Interestingly, short term price level changes between the U.S. and thirteen other countries are negatively correlated during the flexible rate period, while seven cases exhibit negative correlations during the fixed exchange rate era. These reductions in co-movement of short run price cycles are consistent with greater real exchange rate variability upon the change to flexible nominal exchange rates.

4c. The Great Depression

Finally, we examine the possibility that the co-movement of price levels was altered by the Great Depression. Correlations are shown in Table 10. Average correlation over long run cycles is .835 for the sample ending in 1929 and .718 for the sample beginning in 1930. As before, this small difference is due to markedly higher correlations in the earlier period between the U.S. and just a few countries (Argentina, Brazil, Switzerland, and Mexico). Changes in the correlations are much smaller for other countries in the study. In most instances, the strong, positive relation in dollar price level changes over long-run cycles appears robust to the sub-period examined.

Average correlation at medium term frequencies is .415 for the sub-period through 1929 and .165 for 1930-1996. Ten correlations for individual countries in the pre-1930 era exceed .60 over the medium run, with seven exceeding .70: Canada (.909), Sweden (.869), the U.K. (.829), Finland (.807), the Netherlands (.792), Denmark (.768), and Switzerland (.761). The only two correlations with U.S. medium term cycles more than .50 in the post-1929 sample are for Canada and Finland, and neither of these exceeds .60. The pre-depression period thus provides the strongest evidence of co-movement of medium term dollar price cycles. Mexico is again noteworthy in having dollar price level change movements that are highly negatively correlated with those of the U.S., especially for the period since 1930.

The average correlation with short run U.S. price cycles is .295 before the depression and -.147 after the onset of the depression. Short run correlations for Canada (.771), Sweden (.699), Switzerland (.631), the U.K. (.624), Spain (.621), Japan (.553), and the Netherlands (.512) exceed .50 in the pre-depression era while none exceed .50 in the post-1929 era. This is the strongest set of correlations with U.S. short-run cycles for any period examined. Not only does it appear that short-term movements in dollar prices moved more closely together prior to the onset of the Great Depression; but there is little evidence in the post-depression period of any short run, positive correlation between price level changes in the U.S. and those of any other country. Indeed, some of the differences in the correlations across the two sub-periods are startling. The correlation of dollar price level changes in Sweden and the U.S. is .699 before the Depression and -.283 afterwards, a decrease of nearly .9. The values for the U.S. and Germany diminished from basically zero (.032) to -.674, a decline in excess of .7

5. Conclusions

Correlations between unfiltered movements in U.S. and foreign dollar price levels tend to be small thus providing little evidence that PPP holds between the U.S. and any country in our dataset other than Canada. However, when dollar price series are subjected to the band-pass filter, there is strong evidence of co-movement in long-run price cycles. In addition, the strong, positive correlation between long-run cycles tends to be robust to the sample period examined.

These results from filtered data suggest that there is a common long-run cycle in the dollar price levels of the U.S. and most other countries in the study; therefore, purchasing power parity appears likely to hold over the long run.

The lack of co-movement of unfiltered dollar prices implies that real exchange rates will be volatile. When using unfiltered data for a variety of sub-periods identified in other studies, we find the greatest evidence of change in the co-movement of price levels for the pre and post depression sub-periods. However, most of the correlations of unfiltered dollar prices, regardless of sub-period, are less than .5. When correlations are calculated using band-pass filtered data for different sub-periods, the strongest evidence of price level co-movement at both the short and medium frequencies is in the pre-depression era. Overall, these results imply greater real exchange rate stability prior to the Great Depression.

Long run price cycles tend to remain highly correlated after the move to flexible exchange rates. In addition, medium run cycles in dollar price levels are more highly correlated in the flexible exchange rate era. Thus it appears that increases in real exchange rate volatility associated by other studies with the introduction of floating nominal exchange rates is due to country specific short-run price movements rather than more persistent deviations from PPP.

Overall the results consistently reveal scant evidence of positive correlations of dollar denominated price level changes in the U.S. and other countries across the business cycle frequency but much stronger correlations at the low frequency. The findings suggest that PPP generally holds for the U.S. and most other countries over the long run but that the decreased co-movement of short term price levels (i.e. increased real exchange rate volatility) may conceal the relationship in empirical work with unfiltered data. Not surprisingly Canada generally displays the most consistently large, positive co-movement with the U.S. price level. In contrast there is virtually no positive co-movement between U.S. and Mexican dollar price levels except for long-run cycles prior to World War II.

References

Alba, J., and Papell, D., 2007, Purchasing power parity and country characteristics: evidence from panel data tests, *Journal of Development Economics*, 83, 240-251.

Arize, A, 1998, The long-run relationship between import flows and real exchange rate volatility: the experience of eight European economies, *International Review of Economics and Finance*, 7(4), 417-435.

Arize, A., Osang, T., and Slottje, D., 2007, forthcoming, Exchange rate volatility in Latin America and its impact on foreign trade, *International Review of Economics and Finance*

Baxter, M., and King, R., 1999, Measuring business cycles: approximate band-pass filters for economic time series, *Review of Economics and Statistics*, 81, 575-593.

Chernyshoff, N., Jacks, D., and Taylor, A., 2005, Stuck on gold: real exchange rate volatility and the rise and fall of the gold standard, NBER working paper #11795.

Christiano, J., and Fitzgerald, T., (2003), The Band Pass Filter, *International Economic Review* 44(2), 435-465.

Devereux, M., and Engel, C., 2007, forthcoming, Expenditure switching versus real exchange rate stabilization: competing objectives for exchange rate policy, *Journal of Monetary Economics*

Diebold, F.X., Husted, S. and Rush, M., 1991, Real exchange rates under the gold standard, *Journal of Political Economy* 99(6), 1252-1271.

Gonzaga, G., and Terra, M., 1997, Equilibrium real exchange rate, volatility, and stabilization, *Journal of Development Economics*, 54, 77-100.

Grilli, V., and Kaminsky, G., 1991, Nominal exchange rate regimes and the real exchange rate, *Journal of Monetary Economics* 27, 191-212.

Everts, M., 2006, Band-pass filters, unpublished working paper, Munich Personal RePEc Archive, paper #2049.

Hausmann, R., Panizza, U., and Rigobon, R., 2006, The long-run volatility puzzle of the real exchange rate, *Journal of International Money and Finance*, 25, 93-124.

Hodrick, R., and Prescott, E., 1997, Postwar business cycles: an empirical investigation, *Journal of Money, Credit, and Banking*, 29, 1-16.

Kool, C.J.M., and Koedijk, K.G., 1997, Real exchange rates between the wars, *Journal of International Money and Finance* 16(2), 211-232.

Lee, K., and Ni, S., 1997, An empirical analysis of the output effects of temporary and persistent government purchases, *Journal of Macroeconomics,* 19(4), 717-730.

Lothian, J., 1998, Some stylized facts of floating exchange rates, *Journal of International Money and Finance*, 17, 29-39.

Mussa, M., 1986, Nominal exchange rate regimes and the behavior of real exchange rates: evidence and implications, in: Karl Brunner and Allan Meltzer, eds., Real business cycles, real exchange rates, and actual policies, Carnegie-Rochester Conference Series on Public Policy (North-Holland, Amsterdam).

Neumann, M., 1995, Real effects of exchange rate volatility, *Journal of International Money and Finance,* 14(3), 417-426.

Norrbin, S., and Pipatchaipoom, O., 2007, Is the real dollar rate highly volatile?, *Economics Bulletin,* 6(2), 1-15.

Robertson, R., 2004, Relative prices and wage inequality: evidence from Mexico, *Journal of International Economics,* 64, 387-409.

Sarno, L. and Taylor M.P., 2002. The Economics of Exchange Rates. Cambridge University Press, Cambridge.

Taylor, A., 2002, A century of purchasing power parity, *Review of Economics and Statistics* 84(1), 139-150.

Valdovinos, C., 2003, Inflation and economic growth in the long run, *Economics Letters*, 80 (2), 167-173.

Wallace, F. and Shelley, G., 2006, An alternative test of purchasing power parity, *Economics Letters* 92, 177-183.

Table 1

Correlation with U.S. Price Level
Log-Differenced Data
Full Sample

Country	Correlation
Argentina	0.239
Australia	0.382
Belgium	0.255
Brazil	0.113
Canada	0.703
Denmark	0.399
Finland	0.39
France	0.416
Germany	0.055
Italy	0.363
Japan	0.24
Mexico	-0.029
Netherlands	0.396
Norway	0.404
Portugal	0.203
Spain	0.394
Sweden	0.43
Switzerland	0.374
UK	0.492
Average	0.327315789

Table 2
Correlation with U.S. Price Level
Log-Differenced Data
Pre-WWI and Post-WWI Samples

	Start - 1914	1919 - End
Argentina	-0.038	0.228
Australia	0.026	0.387
Belgium	0.179	0.004
Brazil	-0.134	0.103
Canada	0.29	0.728
Denmark	0.163	0.457
Finland	0.222	0.179
France	0.09	0.405
Germany	0.267	-0.048
Italy	0.342	0.302
Japan	-0.252	0.239
Mexico	0.102	0.119
Netherlands	0.228	0.425
Norway	0.372	0.375
Portugal	0.294	0.092
Spain	0.141	0.348
Sweden	0.337	0.386
Switzerland	0.197	0.366
UK	0.566	0.429
Average	0.178526316	0.290736842

Table 3
Correlation with U.S. Price Level
Log-Differenced Data
Pre-WWII and Post-WWII Samples

	Start - 1938	1948 - End
Argentina	0.099	0.233
Australia	0.334	0.275
Belgium	0.288	0.319
Brazil	-0.008	-0.022
Canada	0.716	0.557
Denmark	0.485	0.195
Finland	0.473	0.203
France	0.439	0.315
Germany	0.164	0.178
Italy	0.582	0.542
Japan	0.172	0.202
Mexico	-0.246	0.049
Netherlands	0.52	0.129
Norway	0.438	0.208
Portugal	0.183	0.423
Spain	0.327	0.262
Sweden	0.533	0.29
Switzerland	0.579	0.05
UK	0.542	0.312
Average	0.348421053	0.248421053

Table 4
Correlation with U.S. Price Level
Log-Differenced Data
Fixed and Flexible Exchange Rate Regime Samples

	Start - 1973	1974 - End
Argentina	0.108	-0.003
Australia	0.322	0.281
Belgium	0.282	0.326
Brazil	-0.039	-0.448
Canada	0.691	0.516
Denmark	0.387	0.484
Finland	0.441	0.339
France	0.474	0.411
Germany	0.096	0.273
Italy	0.37	0.473
Japan	0.31	0.43
Mexico	-0.198	-0.406
Netherlands	0.474	0.326
Norway	0.404	0.271
Portugal	0.128	0.317
Spain	0.362	0.383
Sweden	0.43	0.287
Switzerland	0.541	0.132
UK	0.521	0.325
Average	0.321263158	0.248263158

Table 5
Correlation with U.S. Price Level
Log-Differenced Data
Pre-Depression and Post-1929 Samples

	Start-1929	1930-end
Argentina	0.128	0.232
Australia	0.547	0.2
Belgium	0.261	0.371
Brazil	0.03	0.079
Canada	0.75	0.604
Denmark	0.504	0.256
Finland	0.566	0.199
France	0.475	0.346
Germany	0.149	0.339
Italy	0.629	0.246
Japan	0.481	0.237
Mexico	-0.262	0.087
Netherlands	0.586	0.269
Norway	0.552	0.104
Portugal	0.174	0.349
Spain	0.552	0.216
Sweden	0.766	0.099
Switzerland	0.707	0.206
UK	0.725	0.245
Average	0.437894737	0.246526316

Table 6
Correlation with U.S. Price Level
Band-Pass Filtered Data
Full Sample

	20-40 Year Cycle	8-20 Year Cycle	2-8 Year Cycle
Argentina	0.317	-0.061	-0.038
Australia	0.768	0.211	0.114
Belgium	0.918	0.33	-0.076
Brazil	-0.218	0.15	-0.104
Canada	0.911	0.772	0.576
Denmark	0.843	0.594	0.131
Finland	0.921	0.717	-0.049
France	0.965	0.23	0.162
Germany	0.318	-0.238	0.021
Italy	0.976	0.377	-0.228
Japan	0.906	0.099	0.204
Mexico	0.37	-0.518	-0.365
Netherlands	0.947	0.451	0.168
Norway	0.903	0.445	0.122
Portugal	0.735	0.127	-0.348
Spain	0.89	0.391	0.189
Sweden	0.853	0.564	0.242
Switzerland	0.746	0.417	0.285
UK	0.929	0.579	0.208
Average	0.736736842	0.296684211	0.063894737

Table 7
Correlation with U.S. Price Level
Band-Pass Filtered Data
Pre-WWI and Post-WWI Samples

	20-40 Year Start - 1914	20-40 Year 1919 - End	8-20 Year Start - 1914	8-20 Year 1919 - End	2-8 Year Start - 1914	2-8 Year 1919 - End
Argentina	0.76	0.274	0.198	-0.121	0.329	-0.074
Australia	0.314	0.825	0.464	0.089	0.042	0.145
Belgium	0.783	0.966	0.738	0.271	0.022	-0.148
Brazil	0.976	-0.325	-0.664	0.25	0.105	-0.113
Canada	0.911	0.952	0.878	0.722	0.575	0.547
Denmark	0.89	0.846	0.797	0.52	-0.056	0.263
Finland	0.817	0.955	0.939	0.599	0.65	-0.211
France	0.896	0.974	0.454	0.186	-0.207	0.249
Germany	0.353	0.389	0.283	-0.417	-0.47	0.099
Italy	0.966	0.979	0.453	0.403	-0.059	-0.24
Japan	0.858	0.928	-0.745	0.244	0.243	0.188
Mexico	0.636	0.322	-0.4	-0.572	-0.738	-0.254
Netherlands	0.648	0.986	0.797	0.39	0.319	0.156
Norway	0.886	0.91	0.864	0.186	0.33	0.134
Portugal	0.708	0.806	0.405	-0.069	-0.012	-0.359
Spain	0.535	0.92	0.786	0.381	0.396	0.143
Sweden	0.958	0.841	0.862	0.435	0.719	0.17
Switzerland	0.997	0.689	0.744	0.36	0.442	0.285
UK	0.826	0.95	,862	0.425	0.644	0.157
Average	0.77463158	0.74668421	0.43627778	0.22536842	0.17231579	0.05984211

Table 8
Correlation with U.S. Price Level
Band-Pass Filtered Data
Pre-WWII and Post-WWII Samples

	20-40 Year Start - 1938	20-40 Year 1948 - End	8-20 Year Start - 1938	8-20 Year 1948 - End	2-8 Year Start - 1938	2-8 Year 1948 - End
Argentina	0.836	0.122	0.124	-0.189	0.253	-0.139
Australia	0.764	0.823	0.468	-0.305	0.244	-0.047
Belgium	0.912	0.98	0.345	0.383	-0.127	0.155
Brazil	0.506	-0.619	-0.109	0.422	-0.173	-0.11
Canada	0.881	0.943	0.854	0.708	0.702	-0.116
Denmark	0.866	0.881	0.732	0.271	0.235	-0.058
Finland	0.909	0.979	0.752	0.597	0.034	-0.138
France	0.975	0.953	0.108	0.65	0.205	0.156
Germany	0.335	-0.008	-0.302	0.486	0.08	-0.308
Italy	0.984	0.957	0.491	0.572	0.009	0.127
Japan	0.925	0.912	-0.098	0.26	0.172	0.268
Mexico	0.764	0.164	-0.453	-0.89	-0.405	-0.229
Netherlands	0.916	0.984	0.567	0.427	0.377	-0.013
Norway	0.936	0.859	0.56	0.076	0.326	-0.201
Portugal	0.744	0.678	0.072	0.574	-0.382	-0.467
Spain	0.9	0.913	0.339	0.688	0.411	-0.229
Sweden	0.943	0.747	0.75	0.378	0.48	-0.175
Switzerland	0.963	0.192	0.589	0.215	0.362	0.143
UK	0.91	0.973	0.735	0.312	0.398	-0.055
Average	0.840473684	0.65436842	0.34336842	0.29657895	0.16847368	-0.07557895

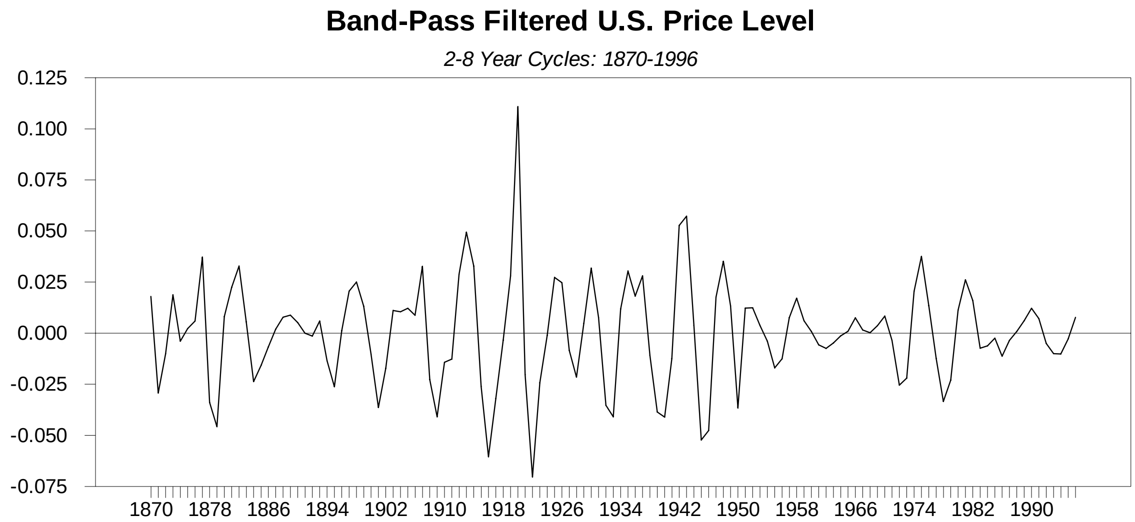
Table 9
Correlation with U.S. Price Level
Band-Pass Filtered Data
Fixed and Flexible Exchange Rate Regime Samples

	20-40 Year Start - 1973	20-40 Year 1974 - End	8-20 Year Start - 1973	8-20 Year 1974 - End	2-8 Year Start - 1973	2-8 Year 1974 - End
Argentina	0.426	0.432	0.059	-0.235	-0.012	-0.127
Australia	0.776	0.917	0.281	-0.495	0.152	-0.106
Belgium	0.917	0.975	0.321	0.384	-0.092	0.105
Brazil	-0.196	-0.464	-0.1	0.585	-0.17	-0.125
Canada	0.915	0.993	0.785	0.784	0.651	-0.24
Denmark	0.842	0.983	0.618	0.556	0.13	0.158
Finland	0.925	0.95	0.722	0.73	-0.023	-0.279
France	0.965	0.972	0.173	0.541	0.191	-0.04
Germany	0.346	-0.153	-0.28	0.626	0.032	-0.674
Italy	0.978	0.991	0.344	0.668	-0.241	-0.084
Japan	0.92	0.483	0.098	0.131	0.212	0.079
Mexico	0.472	0.493	-0.454	-0.949	-0.397	-0.196
Netherlands	0.945	0.97	0.491	0.544	0.193	0.119
Norway	0.912	0.886	0.446	0.441	0.164	-0.224
Portugal	0.735	0.858	0.078	0.619	-0.319	-0.584
Spain	0.906	0.982	0.328	0.695	0.269	-0.264
Sweden	0.881	0.935	0.569	0.652	0.328	-0.209
Switzerland	0.776	0.256	0.454	0.428	0.366	0.098
UK	0.936	0.93	0.615	0.45	0.279	0.01
Average	0.75668421	0.70468421	0.292	0.37657895	0.09015789	-0.13594737

Table 10
Correlation with U.S. Price Level
Band-Pass Filtered Data
Pre-Depression and Post-1929 Samples

	20-40 Year Start - 1929	20-40 Year 1930 - End	8-20 Year Start - 1929	8-20 Year 1930 - End	2-8 Year Start - 1929	2-8 Year 1930 - End
Argentina	0.85	0.232	0.252	-0.189	0.226	-0.099
Australia	0.668	0.825	0.603	-0.392	0.43	-0.162
Belgium	0.892	0.976	0.377	0.191	-0.123	0.024
Brazil	0.766	-0.457	-0.232	0.35	-0.07	-0.14
Canada	0.828	0.952	0.909	0.576	0.771	0.197
Denmark	0.836	0.844	0.768	0.211	0.221	0.029
Finland	0.892	0.963	0.807	0.504	0.189	-0.243
France	0.957	0.968	0.074	0.466	0.397	-0.126
Germany	0.407	0.267	-0.387	0.239	0.09	-0.299
Italy	0.976	0.976	0.612	0.443	0.2	-0.489
Japan	0.903	0.935	-0.149	0.276	0.553	0.109
Mexico	0.737	0.277	-0.454	-0.729	-0.418	-0.29
Netherlands	0.877	0.983	0.792	0.246	0.512	-0.107
Norway	0.923	0.894	0.647	-0.05	0.48	-0.414
Portugal	0.732	0.767	0.072	0.357	-0.43	-0.231
Spain	0.842	0.911	0.74	0.304	0.621	-0.22
Sweden	0.936	0.81	0.869	0.111	0.699	-0.283
Switzerland	0.97	0.553	0.761	0.15	0.631	0.076
UK	0.879	0.959	0.829	0.073	0.624	-0.127
Average	0.835315789	0.71763158	0.41526316	0.16510526	0.29489474	-0.14710526

Figure 1



Band-Pass Filtered U.S. Price Level
2-8 Year Cycles: 1870-1996
0.125
0.100
0.075
0.050
0.025
0.000
-0.025
-0.050
-0.075
1870
1878
1886
1894
1902
1910
1918
1926
1934
1942
1950
1958
1966
1974
1982
1990

Figure 2

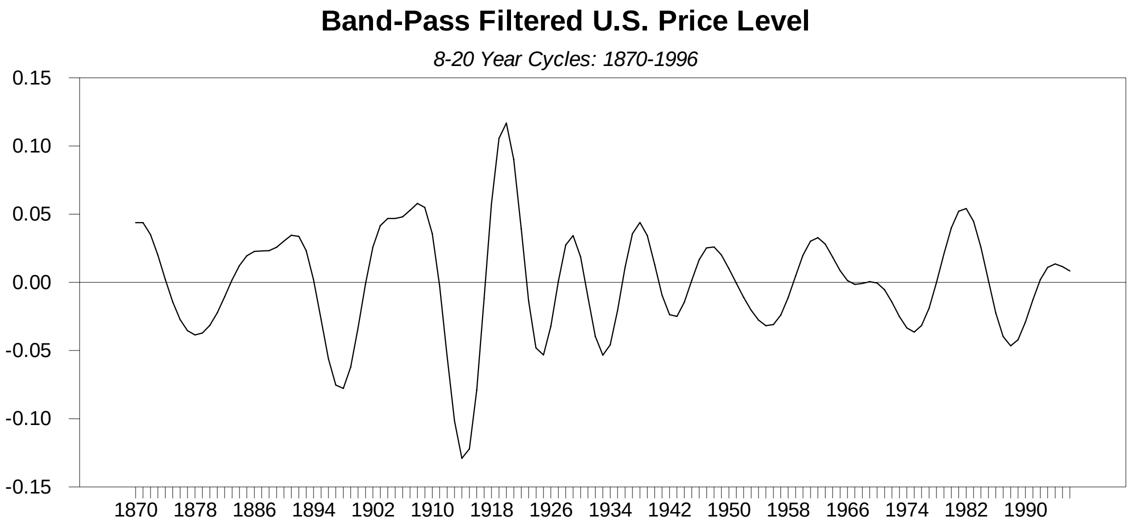
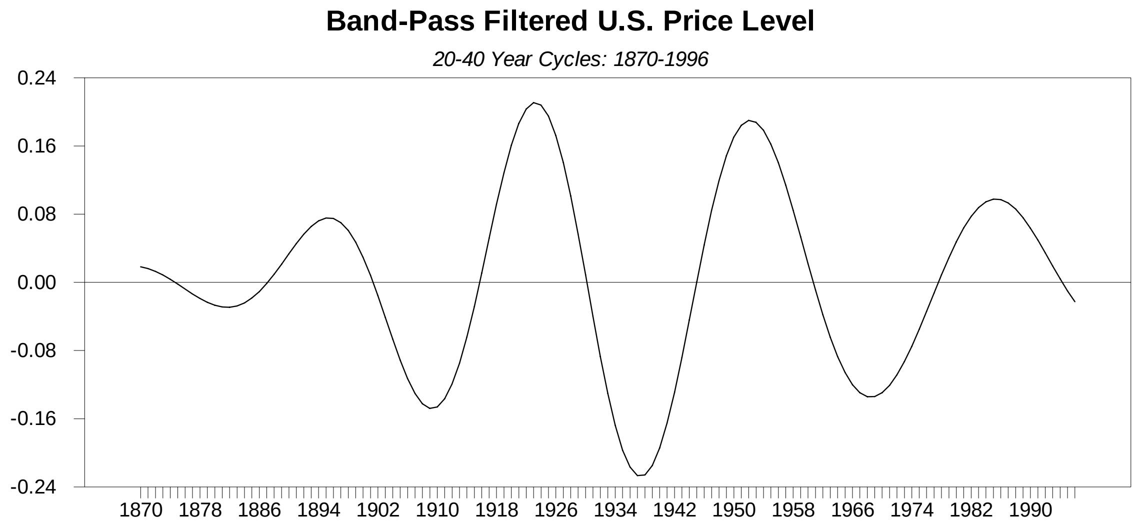

Band-Pass Filtered U.S. Price Level
8-20 Year Cycles: 1870-1996
0.15
0.10
0.05
0.00
-0.05
-0.10
-0.15
1870 1878 1886 1894 1902 1910 1918 1926 1934 1942 1950 1958 1966 1974 1982 1990

Figure 3


Band-Pass Filtered U.S. Price Level
20-40 Year Cycles: 1870-1996
0.24
0.16
0.08
0.00
-0.08
-0.16
-0.24
1870 1878 1886 1894 1902 1910 1918 1926 1934 1942 1950 1958 1966 1974 1982 1990