Title

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Publication Date
2002-06-20

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June 20, 2002

*The authors thank Werner Antweiler for providing the foreign exchange rate data and Kent Daniel, Ken French and Xiaoyan Zhang for providing the Fama-French factor returns data and Marshall Blume, Andrew Karolyi, seminar participants at the Stockholm School of Economics and at the brown-bag lunch seminar series at Wharton for useful comments on an earlier draft of the paper. All remaining errors are ours.

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Extracting Inflation from Stock Returns to test Purchasing Power Parity

Abstract

We provide a novel method for extracting estimates of *realized* pure price inflation from stock returns. The key is recognizing that pure price inflation should affect nominal returns of all traded assets by exactly the same amount. The popular Fama-French three-factor model is employed to purge stock returns of real economic factors. We uncover evidence that purchasing power parity holds quite well using the extracted inflation measures.

Extracting Inflation from Stock Returns to test Purchasing Power Parity

Purchasing power parity (PPP) is the simple proposition that prices in different countries should be equal if they are converted to the same currency. The absolute version of PPP is based on the law of one price, which maintains that arbitrage should tend to equilibrate prices of the same good at different locations. If the composition of the basket of goods used for constructing price indices is identical across countries, PPP trivially follows from the law of one price.

However, frictions to goods arbitrage such as transportation costs and other impediments to trade (the extreme being non-tradable goods such as land), inhibits cross-country price equalization. Even with such frictions, the relative version of PPP, which maintains that the *change* in price levels across countries should be the same after adjusting for the change in the exchange rate, may still hold if *relative* price changes across countries are identical. For instance, a pure money shock will change nominal prices of all goods, services and assets but relative prices will remain constant and the relative version of PPP will hold.

Although simple, the PPP hypothesis has defied empirical confirmation for decades. There seems to be little agreement about why it fails so spectacularly when taken to data.[1] The PPP puzzle in its most basic form can be described as follows. If PPP holds, then changes in the exchange rate must equal the concurrent inflation differential between two countries. Empirically, changes in exchange rates are extremely volatile, with a yearly standard deviation typically on the order of 12-13% for developed countries, while inflation

[1]Rather than provide a long list of relevant references here, we point the reader to an excellent survey by Rogoff, 1996.

differentials have yearly standard deviations less than 1% (see Rogoff, 1998). Moreover, although PPP says that exchange rate changes should equal inflation differentials, they are usually only weakly correlated (Rogoff, 1996).

Previous empirical studies testing PPP used prices of financial assets on one side of the equation (i.e., the prices of foreign currencies) and official inflation data on the other side of the equation (i.e., CPI or PPI or WPI). We wondered if the PPP puzzle would be affected if inflation data were estimated from prices of financial assets such as stock prices. We attempt to settle that question in this paper. Our method exploits the fact that pure price inflation should affect nominal returns of all traded assets by exactly the same amount.

Of course, asset returns are influenced by factors other than pure price inflation. To extract pure price inflation from returns they must be purged of other influences. This requires an asset pricing model. We adopt the popular Fama-French three-factor model to describe the return generating process. Purging stock returns of real economic factors essentially amounts to finding the return on a zero-beta portfolio, i.e., a portfolio that is insensitive to real factors while responding to pure inflation. Alternatively, one could have used the nominal return on a traded risk-free asset to estimate pure price inflation. Unfortunately, there are no obvious proxies for traded risk-free assets.

Notice that yields on securities such as treasury bills measure *expected* returns on a default-free asset and are influenced by *expected* inflation. To study PPP, we require estimates of *realized* returns on a risk-free asset, which will be affected by realized pure price inflation.

I. Theoretical Framework and Empirical Methodology

A. Extracting (Unexpected) Inflation from Stock Returns

We assume that the real stock returns in an economy follow a three-factor model:

$$r_{it} - r_{ft} = \sum_{k=1}^{3} \beta_{ik} f_{kt} + \epsilon_{it}, \tag{1}$$

where r_{it} is the real return for asset i at time t, r_{ft} is the real risk free rate, the $f_{kt}, k = 1, 2, 3$ represent real factors that describe the return generating process for securities in the economy, ϵ_{it} is a spherical disturbance and the β's ar fixed sensitivity coefficients. Following Fama and French (1995), the three factors can be approximated by[2]

1. returns on the market index in excess of the risk-free rate, $r_{Mt} - r_{ft}$,
2. returns on the zero-investment SMB portfolio, $r_{St} - r_{Bt}$, where r_{St} (r_{Bt})is the return on a small (big) cap portfolio, and
3. returns on the zero-investment HML portfolio, $r_{Ht} - r_{Lt}$, where r_{Ht} (r_{Lt}) is the return on a high (low) book/market portfolio

so that

$$r_{Mt} - r_{ft} = f_{1t} + u_{1t},$$

$$r_{St} - r_{Bt} = f_{2t} + u_{2t},$$

[2]These factors are created using domestic stocks only. One might argue that with integrated world capital markets, return generating factors might include some world factors as well. But if world factors were included, we would have to convert returns denominated in foreign currencies into domestic units. We want to avoid having exchange rates appear in both the dependent and independent variables in our PPP tests. To the extent that the asset pricing model is mis-specified because relevant world factors are excluded, the results will be biased against finding the PPP relation. Furthermore, Griffin (2002) finds that domestic factor models explain much more of the time-series variation in returns and generally have lower pricing errors than the world factor model.

$$r_{Ht} - r_{Lt} = f_{3t} + u_{3t},$$

where u's represent the unknown measurement errors in estimating the true return generating factors in the economy.

Let r denote real variables and R nominal variables, then

$$R = r + \pi$$

if π measures the pure price inflation. In positing that stock returns respond to pure price inflation in this simple way, we are not ignoring the possibility that inflation, particularly unexpected inflation, can have real affects in the economy and thus could influence real stock returns. Our assumption is that such real effects on stock returns are spanned by the three Fama-French factors.

The three factor model (1) can then be rewritten as:

$$\begin{aligned} R_{it} - R_{ft} \quad = \quad & \beta_{i1} \left[R_{Mt} - R_{ft} \right] + \beta_{i2} \left[R_{St} - R_{Bt} \right] + \beta_{i3} \left[R_{Ht} - R_{Lt} \right] \\ & -\beta_{i1} u_{1t} - \beta_{i2} u_{2t} - \beta_{i3} u_{3t} + \epsilon_{it}. \end{aligned} \tag{2}$$

Even though the realized nominal returns on all stocks and portfolios of equity securities are observable, we do not, in fact, observe the *realized* risk-free rate R_{ft}.[3] We can, however, observe the TBill rate, which measures the *expected* nominal risk-free rate. Thus,

$$R_{ft} = \mathrm{E}_{t-1}[R_{ft}] + u_{R_{ft}} = \mathrm{E}_{t-1}[r_{ft} + \pi_t] + u_{R_{ft}} = TBill_{t-1} + u_{R_{ft}},$$

[3] One way to think about the realized nominal return on a risk-free security is that it is the return on a default-free security whose ex post return is indexed by realized inflation. One should not, however, use the realized returns of securities such as the Treasury Inflation Protected Securities (TIPS) as a measure of R_{ft} because these returns are linked to official inflation data such as the changes in the CPI.

where $u_{R_{ft}}$ represents the unexpected portion of the ex-post nominal risk-free return caused by unexpected rate of inflation and the unexpected real risk-free return. It is worth pointing out that the realized real return on a TBill, measured as the difference between the contractual return on these default-free securities and the realized inflation, $Tbill_{t-1} - \pi_t$, is *not* necessarily equal to the real *risk-free* return because unanticipated inflation could make Treasury Bills risky in real terms.

Substituting in (2) above and rewriting,

$$R_{it} - TBill_{t-1} = \beta_{i1}\left[R_{Mt} - TBill_{t-1}\right] + \beta_{i2}\left[R_{St} - R_{Bt}\right] + \beta_{i3}\left[R_{Ht} - R_{Lt}\right] + \eta_{it}, \qquad (3)$$

where

$$\eta_{it} \equiv (1 - \beta_{i1})u_{R_{ft}} - \beta_{i1}u_{1t} - \beta_{i2}u_{2t} - \beta_{i3}u_{3t} + \epsilon_{it} \qquad (4)$$

and where the u's and ϵ are i.i.d. normal, cross-sectionally independent, serially-uncorrelated over time and are assumed to be homoscedastic.

Equation (3) is the basis for our empirical analysis. The construct required for testing PPP is $u_{R_{ft}}$. To extract it from nominal stock returns, we implement a Fama-MacBeth cross-sectional regression based on (3). To mitigate estimation errors in the betas, we employ industrial portfolios for both domestic and foreign stocks. The first step is a time-series regression in which the nominal industrial portfolio returns in excess of the treasury bill rate are regressed on the excess market portfolio returns and the two Fama-French factor returns. This step produces the estimate of the beta's and the residual η_{it}. Notice that the regressors are not orthogonal to the residual term because of the presence of measurement error terms u's in both the regressors and the residuals. This will make the estimates of beta coefficients biased. The direction of the bias, however, cannot be ascertained very easily in a multiple regression.

The second step is a cross-sectional regression, without an intercept term, based on equation (4), which is carried out at each time t. In this step, the residual from the time-series regression for each portfolio i, η_i, is the dependent variable, and $\left(1 - \hat{\beta}_{i1}\right)$ and $-\hat{\beta}_{ik}$ $(k = 1, 3)$ are the explanatory variables. The parameter estimate associated with $\left(1 - \hat{\beta}_{i1}\right)$ is then an estimate of $u_{R_{ft}}$ for each t. By suppressing the intercept, this regression is not degenerate even though $\left(1 - \hat{\beta}_{i1}\right)$ and $\hat{\beta}_{i1}$ are perfectly related.

We then construct the series $TBill_{t-1} + \hat{u}_{R_{ft}} = \hat{R}_{ft} = \hat{r}_{ft} + \hat{\pi}_t$ for both foreign and domestic countries. The difference in the two series provides an estimate of the ex post inflation differential plus the difference between the ex post real risk-free rates which we assume is random (Adler and Lehman, 1983), and iid.

B. Testing PPP

The final step is the test of the PPP hypothesis. The relative PPP hypothesis implies that

$$\Delta s_t = \pi_t^* - \pi_t \tag{5}$$

where s_t denote the logarithm of the nominal exchange rate defined as the price of domestic currency in units of foreign currency (e.g., yen per dollar) and π_t^* and π_t denote the change in log price indices and thus are the inflation rates in foreign and domestic countries respectively.

We test the relative PPP hypothesis by regressing the estimated inflation differential on the change in the nominal exchange rate, i.e.,

$$R_{ft}^* - R_{ft} = a + b\Delta s_t + \epsilon_t \tag{6}$$

which is equivalent to

$$\pi_t^* - \pi_t = a + b\Delta s_t + \epsilon_t'$$

where

$$\epsilon_t' \equiv \epsilon_t + (r_{ft} - r_{ft}^*).$$

We test the null hypothesis: $H_0 : a = 0$ and $b = 1$. Notice that because our method extracts an estimate of inflation with some noise, the inflation differential is the dependent variable in our regression.

Some readers may be wondering if our test of the PPP in (6) essentially amounts to testing the Uncovered Interest Rate Parity relation which states that the *expected* change in the exchange rates must equal the difference in nominal default-free interest rates. In our notation, this is equivalent to testing the following relation:

$$TBill_{t-1}^* - TBill_{t-1} = \mathrm{E}_{t-1}\left[R_{ft}^* - R_{ft}\right] = \mathrm{E}_{t-1}\Delta s_t.$$

The Uncovered Interest Rate Parity relation is usually tested by regressing the *realized* changes in the exchange rates on the nominal default-free interest rate differential (measured by the difference in TBill rates) which are determined ex-ante and thus incorporate only the *expected* inflation differential. Notice, however, that our test of the PPP in (6) regresses that the *realized* changes in the nominal risk-free rates, which incorporate *realized* inflation differential, on the *realized* changes in the exchange rates.

C. Some Simulation Evidence

If the true beta coefficients were regressors in the second-stage cross-sectional regressions, the estimate of $u_{R_{ft}}$ would be unbiased. But there are two potential problems. First, estimates of betas from the time series regressions could be biased. Second, even if the beta estimates were unbiased, they are estimated with some noise,which induces an errors-in-variables problem in the second stage cross-sectional regressions. We now provide simulation evidence about the extent of these potential difficulties.

Simulation procedure:

First notice that

$$r_{Mt} - r_{ft} = R_{Mt} - R_{ft}$$

is not observable because we don't observe the realized risk-free rate R_{ft} but instead we observe the expected risk-free rate represented by the TBill rate. If we let f'_{1t} denote the observable market excess return $R_{Mt} - Tbill_{t-1}$, then it is easy to see that

$$\begin{aligned} f'_{1t} &= R_{Mt} - TBill_{t-1} \\ &= R_{Mt} - R_{ft} + (R_{ft} - TBill_{t-1}) \\ &= r_{Mt} - r_{ft} + u_{R_{ft}} \\ &= f_{1t} + u_{1t} + u_{R_{ft}}, \end{aligned}$$

where $u_{R_{ft}}$ represents the unexpected movement in the nominal risk-free rate. We let f'_{1t} denote the proxy for the first factor f_{1t} in the return generating model (1). The proxies for the second and third factors respectively are the returns on the SMB and the HML portfolios which are observable, i.e.,

$$r_{St} - r_{Bt} \equiv f'_{2t} = f_{2t} + u_{2t},$$

$$r_{Ht} - r_{Lt} \equiv f'_{3t} = f_{3t} + u_{3t}.$$

Our goal in the simulation exercise is to create factors f_{kt}, and *independent* errors u_{kt} and $u_{R_{ft}}$ in such a manner that the means and variances of the factor proxies match those observed in data.

We create the three factors f_{1t}, f_{2t}, f_{3t} and the noise terms associated with each of these factors u_{1t}, u_{2t}, u_{3t} and the noise in the risk-free rate $u_{R_{ft}}$ in such a way that the volatility of the independent noise terms is a fraction $\{10\%, 30\%, 50\%, 70\%, 90\%\}$ of the volatility of the proxies for the three factors. Notice that some combinations of volatility of u_{1t} and $u_{R_{ft}}$ will not be feasible since the noise of the two noise terms cannot exceed 100% of the volatility of f_{1t}. The factors are then created as follows:

$$f_{1t} = \bar{f}'_{1t} + \sqrt{1 - \rho^2 - \omega^2}\left[f'_{1t} - \bar{f}'_{1t}\right],$$

$$f_{kt} = \bar{f}'_{kt} + \sqrt{1 - \rho^2}\left[f'_{kt} - \bar{f}'_{kt}\right], \quad k = 2, 3$$

where

$$\bar{f}'_{kt} = \frac{1}{T}\sum_{t=1}^{T} f'_{kt}, \quad k = 1, 2, 3,$$

ρ represents the volatility (standard deviation) of u_{kt} as a fraction of the volatility of f_{kt} and ω represents the volatility of $u_{R_{ft}}$ as a fraction of the volatility of f_{1t}. This ensures that the mean of the factor f_{kt} equals the mean of the observed proxy for that factor f'_{kt}, and that the volatility of $f_{1t} + u_{1t} + u_{R_{ft}}$ and $f_{kt} + u_{kt}, k = 2, 3$ matches the mean and (approximately) the volatility of the observed proxies for the three factors.

We create a series for the *realized* nominal risk-free rate in the economy as follows:

$$R_{ft} = TBill_{t-1} + u_{R_{ft}}.$$

We then simulate the realized nominal returns on 30 U.S. and 33 Japanese industry portfolios using the following return generating process:

$$R_{it} - R_{ft} = \alpha + \sum_{k=1}^{3} \beta_{ik} f_{kt} + \epsilon_{it},$$

where α and β_{ik} are estimates obtained by running the realized U.S. and Japanese market excess return on the thirty U.S. and 33 Japanese industry portfolios on the realized three Fama-French factor proxies and the volatility of ϵ_{it} is set to be the same as that of the estimate of volatility of the residual from these Fama-French industry regressions.

Once the data are generated we extract an estimate of $u_{R_{ft}}$ and regress this estimate on the original $u_{R_{ft}}$ to see how well the method is able to extract the true value.

The above procedure is repeated 10 times for each combination of the volatility specification, and the average slope coefficient estimate, its standard error, and the R^2 are reported in Table I.

Notice that our empirical method is indeed quite effective in extracting unbiased estimates of $u_{R_{ft}}$ from stock returns when ρ and ω are low; the slope coefficients are close to 1 with small standard errors. The adjusted R^2s are not always high indicating that $u_{R_{ft}}$, although unbiased, is extracted with considerable noise. Notice also, that for any given ρ, the effectiveness first improves and then deteriorates as ω increases. Our method produces poor estimates only when both ρ and ω are high.

We next simulate the exchange rate series so that by construction the PPP holds perfectly in the sense that:

$$R^*_{ft} - R_{ft} = \Delta s_t,$$

where the superscript * denotes the variable for the foreign country. We then check the PPP relation with the extracted series by running the following regression:

$$\hat{R}^*_{ft} - \hat{R}_{ft} = a + b\Delta s_t + \epsilon_t.$$

These results re reported in Table II. As before the slope coefficients are close to 1 with small standard errors and R^2s are higher when ρ is small and ω is neither too low nor too high. As might have been anticipated, the PPP test performs poorly when both ρ and ω are very high. Again notice that the adjusted R^2s are not always high even though the slope coefficients are close to 1 with small standard errors. The constant terms are never significantly different from zero.

II. The Data

All the U.S. industrial returns, the T-bill rate, and the three Fama-French factors are from Kenneth French's web-site[4] with the sample ranging from July 1926 to December 2000. The UK, German, and Japanese industrial returns are from Datastream. For the UK and Germany, total returns including dividends are available while only capital gains returns are available for Japan. The market returns for the UK, Japan, and Germany are constructed using the total (including dividend) market returns from Datastream, and the SMB and HML factor returns are kindly provided by Xiaoyan Zhang. The Tbill rate for the UK is also from Datastream, the Tbill rate for Germany is from Bloomberg, and the Tbill rate for Japan is from Kent Daniel and Datastream. The sample period for the UK is from January 1986 to December 1999, for Japan it is from May 1983 to December 1999, and for Germany

[4]http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/

it is from January 1988 to December 1999.

The foreign exchange rate is defined as the foreign currency (Yen, British £ or German DM) per US dollar and the change in the foreign exchange rate is calculated from the end of month to the end of month using the daily foreign exchange rate kindly provided by Pacific Foreign Exchange Rate Service.[5] (The foreign exchange rate changes were also calculated from the beginning of the month to the beginning of the month, and the empirical results were virtually unchanged.)

Table III provides sample mean and volatility of the Fama-French three factors for the U.S., the UK, Germany and Japan.

III. Empirical Results

Time-series regressions of the industry portfolio returns are reported in Tables IV-VII. The adjusted R^2 varies materially among industries, from as low as 17% to as high as 88%. Our simulation results indicate that efficiency in extracting unanticipated inflation increases with R^2. Instead of using industry returns, one could conceivably use returns on portfolios designed to minimize unexplained time series variation and thereby improve our results. To the extent that industry returns are not necessarily optimal, our procedure here is biased against finding a confirmation of the PPP hypothesis.

Next, a cross-sectional regression is carried out by regressing the unexplained industrial excess returns (residuals) at each point of time on the estimates of the betas from the time series regressions. The estimates for $u^*_{R_{ft}}$ and $u_{R_{ft}}$ are stored for each t. We find that both series exhibit extraordinarily high sample volatility, which is probably due to the estimation

[5] The foreign exchange rate is from http://pacific.commerce.ubc.ca/xr/.

error in the betas from the time series regression.

Before carrying out the PPP regression, we first test for unit roots in the foreign exchange rate changes and the unexpected inflation estimates. Both the Augmented Dickey-Fuller and the Phillips-Perron tests reject the null of unit roots under various specifications.

Tables VIII-X report the PPP regression results. Three different sets of regressions were carried out; at the monthly frequency (Table VIII), using non-overlapping bi-monthly observations (Table IX) and using non-overlapping quarterly observations (Table X). In order to adjust for the impact of heteroscedasticity and serial correlation, the Newey-West adjusted standard errors are reported in the Tables VIII-X. In order to check how fast foreign exchange rates adjust to accommodate the unexpected inflation differentials, we also add lags and leads of Δs into the regression.

At the monthly frequency, the coefficients for the contemporaneous exchange rate changes are significantly different from zero but not significantly different from one for the Japanese Yen - US \$ and the German DM and US \$ pair. Surprisingly, the one-period lead $\Delta s(+1)$ is found to be of roughly the same magnitude as the current adjustment and is significantly different from zero. At the bi-monthly and quarterly frequencies, the results are broadly consistent with the PPP hypothesis for all three pairs of currencies. The intercepts in all regressions are not significantly different from zero. The adjusted R^2s, though not high, are not very different from our simulation results especially for the German DM - US \$ pair.

We do not report the results for three other cross currency pairs. The coefficient estimates are similar to those found in the results reported for currency pairs involving US \$ but they are not statistically significant. It is worth mentioning here that the efficacy of these PPP tests depends critically on how well the Fama-French three factor model describes the stock returns. It seems to fit the U.S. data quite well and has been subjected to intensive study; other countries, however, have not been scrutinized as thoroughly.

Controlling for Momentum Factor

Some scholars have argued that the three factor model of Fama and French does not adequately capture the time series variation in stock returns and in fact a fourth real factor, Momentum, explains a significant portion of stock returns.[6] We obtained the data for the fourth Momentum factor for the U.S. from Kenneth French's web-site and repeated our analysis. For brevity, we are not reporting the time-series regressions of the industrial portfolio returns.

Tables XI-XIII report the PPP regression results. The results support the PPP hypothesis even more strongly. In particular, the slope coefficients are closer to one and have smaller standard errors, and the R^2s are higher for the Yen - US \$, and the UK £- US \$ pairs for all frequencies. The results remain virtually unchanged for the German DM - US \$ pair for which the original results in Tables VIII-X were already quite strong.

Could this be evidence of a missing world factor?

We did not include a world factor in the asset pricing model (for the reasons given in footnote 2). This means that the factor generating model could possibly be mis-specified in the sense that the residuals η_{it} from the time-series regressions in (3) or our estimates of $u_{R_{ft}}$ contain a missing world factor. The same world factor, expressed in units of foreign currencies, could also be contained in the corresponding estimates of $u_{R^*_{ft}}$. This suggests the

[6]Carhart (1997) uses a 4-factor model to evaluate mutual fund performance and argues that the 4-factor model noticeably reduces the average pricing errors relative to both the CAPM and the 3-factor model.

possibility that our PPP tests might merely be detecting a much weaker phenomenon; viz., the law of one price holds for the world factor. To check on this possibility, we performed the following procedure.

The Morgan Stanley Composite Index (MSCI)[7] is a proxy for a world factor. We regressed the residuals from the time series industry returns and our estimates of $u_{R_{ft}}$ on MSCI returns. The results (not reported here for brevity) reveal that neither the residuals from time series regressions nor the estimates of $u_{R_{ft}}$ for any country are related to the MSCI returns.

Relation between extracted inflation measures and official inflation estimates

One might wonder, what relation, if any, exists between our extracted pure price inflation estimates and inflation estimates constructed from macroeconomic data. A direct comparison is difficult for two reasons. One, our pure price inflation estimates are estimated with considerable noise. Two, inflation measures using CPI or PPI data would include not only pure price inflation but also effects of relative price changes.

Nevertheless, in Table XIV, we report results from regressions of our estimates of total inflation and unanticipated inflation on estimates of total inflation and unanticipated inflation respectively from the CPI and PPI data for the U.S. The results, in general, indicate a positive and significant relation between our measures and official measures. However, at monthly intervals our extracted measures are not only more volatile but also appear to be multiples of official inflation. The slope coefficients range from roughly three to eight. This might be induced by the sluggish revisions in official price indices, a supposition supported by the decline in the slope coefficients as the data interval is lengthened to quarterly, semian-

[7]The data was downloaded from the MSCI web-site http://www.msci.com/

nual and annual. (The power of the results naturally decreases as interval lengthens from a month to a year because the number of non-overlapping observations decreases considerably.)

IV. Concluding Remarks

Our paper makes two contributions. First, we provide a novel method for extracting estimates of *realized* pure price inflation, which involves extracting estimates of unexpected inflation, from stock returns by exploiting the fact that pure price inflation should affect nominal returns of all traded assets by exactly the same amount.

Second, we provide compelling evidence indicating that the purchasing power parity hypothesis holds quite well when we use the extracted inflation measures from stock prices. This is in sharp contrast to the poor performance of the PPP hypothesis documented in the extensive literature surveyed in Rogoff (1996) where the inflation estimates are obtained from macroeconomic series such as the CPI.

The strong confirmation of the PPP hypothesis using our estimates suggests an intriguing possibility that perhaps the "true" price level in the economy is much more volatile than what has been historically measured using macroeconomic price level series that have been suspected to be too sluggish in responding to monetary shocks (Dornbusch, 1976). Since nominal prices of assets are not "sticky" and free to adjust, not only would they adjust to current monetary shocks, but, as was argued by Mussa (1982), also to shocks that causes *expectations* of future price levels to change. Mussa's analysis suggests that "information that changes these expectations can have a profound effect...., even if the current observed change that embodies this information is seemingly not very large." If we can plausibly argue that price level volatility is much higher than suspected then this may also obviate the need for reliance on some form of exchange rate “overshooting”, as in the seminal paper by Dornbusch (1976), to explain exchange rate volatility, particularly given the fact that implications of his overshooting model do not seem to be supported by empirical evidence (Rogoff, 2002).

Table I
Simulation Results of the Effectiveness of Extracting $u_{R_{ft}}$ from Stock Returns

This table reports the simulation results of the effectiveness of extracting the unexpected risk-free rate $u_{R_{ft}}$ for different combinations of ρ and ω where ρ represents the volatility of u_{kt} as a fraction of the volatility of f_{kt} and ω represents the volatility of $u_{R_{ft}}$ as a fraction of the volatility of f_{1t}. The extracted $\hat{u}_{R_{ft}}$ is regressed on the simulated input $u_{R_{ft}}$. The procedure is simulated ten times, and the average slope coefficient estimate, its standard error and the adjusted R^2 are reported.

		U.S.					Japan				
ω	ρ:	10%	30%	50%	70%	90%	10%	30%	50%	70%	90%
10%	Slope	0.97	0.96	0.72	1.05	0.92	0.95	1.15	0.94	0.88	0.96
	S.E.	(0.12)	(0.34)	(0.56)	(0.67)	(0.46)	(0.09)	(0.29)	(0.45)	(0.60)	(0.46)
	$\bar{R}^2$	0.27	0.05	0.01	0.02	0.03	0.38	0.09	0.03	0.02	0.03
30%	Slope	0.98	1.01	0.97	0.70	0.89	0.99	0.99	1.01	0.78	0.88
	S.E.	(0.05)	(0.14)	(0.21)	(0.24)	(0.16)	(0.04)	(0.11)	(0.17)	(0.22)	(0.15)
	$\bar{R}^2$	0.66	0.24	0.11	0.05	0.16	0.76	0.33	0.17	0.07	0.17
50%	Slope	0.95	0.97	0.88	0.68	n.a.	0.97	0.98	0.96	0.72	n.a.
	S.E.	(0.06)	(0.12)	(0.17)	(0.19)	n.a.	(0.05)	(0.09)	(0.14)	(0.16)	n.a.
	$\bar{R}^2$	0.58	0.28	0.14	0.07	n.a.	0.65	0.42	0.22	0.10	n.a.
70%	Slope	1.00	0.85	0.56	0.48	n.a.	1.00	0.92	0.73	0.61	n.a.
	S.E.	(0.09)	(0.14)	(0.18)	(0.16)	n.a.	(0.08)	(0.11)	(0.16)	(0.15)	n.a.
	$\bar{R}^2$	0.40	0.17	0.06	0.06	n.a.	0.48	0.29	0.11	0.09	n.a.
90%	Slope	0.92	0.30	n.a.	n.a.	n.a.	0.93	0.43	n.a.	n.a.	n.a.
	S.E.	(0.19)	(0.20)	n.a.	n.a.	n.a.	(0.16)	(0.18)	n.a.	n.a.	n.a.
	$\bar{R}^2$	0.12	0.01	n.a.	n.a.	n.a.	0.16	0.03	n.a.	n.a.	n.a.

Table II
Simulation Results of the PPP Regression

This table reports the PPP regression results using simulated data for different combinations of ρ and ω where ρ represents the volatility of u_{kt} as a fraction of the volatility of f_{kt} and ω represents the volatility of $u_{R_{ft}}$ as a fraction of the volatility of f_{1t}. The regressors are the constant and the simulated change in foreign exchange rate, which is constructed as

$$\Delta s_t = R^*_{ft} - R_{ft},$$

where R^*_{ft} and R^*_{ft} are constructed from the actual simulated input on $u_{R^*_{ft}}$ and $u_{R_{ft}}$. The dependent variable is the inflation differential constructed from extracted $u_{R^*_{ft}}$ and $u_{R_{ft}}$:

$$\Delta \pi_t = \hat{R}^*_{ft} - \hat{R}_{ft}.$$

ω	ρ:	10%	30%	50%	70%	90%
10%	Constant	0.00	-0.03	-0.02	-0.03	-0.05
	S.E.	(0.08)	(0.21)	(0.35)	(0.46)	(0.32)
	Slope	0.94	0.98	0.80	0.82	0.71
	S.E.	(0.10)	(0.30)	(0.47)	(0.61)	(0.44)
	$\bar{R}^2$	0.33	0.06	0.02	0.01	0.02
30%	Constant	0.01	0.06	-0.04	-0.03	-0.03
	S.E.	(0.09)	(0.24)	(0.39)	(0.47)	(0.32)
	Slope	0.98	0.99	0.94	0.73	0.89
	S.E.	(0.04)	(0.11)	(0.18)	(0.22)	(0.15)
	$\bar{R}^2$	0.73	0.31	0.14	0.06	0.18
50%	Constant	0.09	-0.16	0.02	-0.05	n.a.
	S.E.	(0.18)	(0.35)	(0.52)	(0.61)	n.a.
	Slope	0.96	1.02	1.01	0.70	n.a.
	S.E.	(0.05)	(0.10)	(0.15)	(0.17)	n.a.
	$\bar{R}^2$	0.67	0.38	0.21	0.09	n.a.
70%	Constant	-0.05	-0.06	-0.17	-0.16	n.a.
	S.E.	(0.35)	(0.56)	(0.83)	(0.76)	n.a.
	Slope	0.97	0.90	0.70	0.56	n.a.
	S.E.	(0.07)	(0.12)	(0.17)	(0.15)	n.a.
	$\bar{R}^2$	0.52	0.26	0.09	0.07	n.a.
90%	Constant	0.09	-0.02	n.a.	n.a.	n.a.
	S.E.	(0.90)	(1.16)	n.a.	n.a.	n.a.
	Slope	0.90	0.45	n.a.	n.a.	n.a.
	S.E.	(0.15)	(0.19)	n.a.	n.a.	n.a.
	$\bar{R}^2$	0.18	0.03	n.a.	n.a.	n.a.

Table III
Summary Statistics

This table reports sample mean and sample volatility for the three Fama-French factor returns for the U.S., UK, Germany and Japan. The sample mean and volatility for the change in the foreign exchange rate are also reported. The sample period for the U.S. and Japan is from May 1983 to December 1999, for UK is from January 1986 to December 1999, and for Germany is from January 1988 to December 1999. The numbers are percent per month.

Variable	Mean	Standard Deviation
US Market	1.36	4.24
US SMB	-0.20	2.67
US HML	0.15	2.72
US Tbill	0.48	0.16
UK Market	1.39	4.83
UK SMB	0.05	4.11
UK HML	0.26	2.55
UK Tbill	0.71	0.26
UK £- US $	-0.07	3.14
German Market	1.34	5.15
German SMB	-0.44	4.41
German HML	0.28	3.26
German Tbill	0.44	0.17
German DM - US $	0.15	3.10
Japan Market	0.75	5.92
Japan SMB	0.03	3.34
Japan HML	0.13	3.07
Japan Tbill	0.30	0.21
Japanese Yen - US $	-0.42	3.52

Table IV

Time Series Regressions of Excess Industrial Returns on the Fama-French Three Factors (U.S.)

This table reports the regression results of excess industrial portfolio returns on the Fama-French three factors for the U.S. with sample period from January 1986 to December 1999. The Newey-West adjusted standard errors are reported in parentheses to the right of the coefficient estimates.

Industry	Constant		$R_m - Tbill$		R_{SMB}		R_{HML}		Adj. R^2
Food	-0.017	(0.27)	0.967	(0.06)	-0.444	(0.12)	0.044	(0.17)	0.633
Beer	0.103	(0.27)	0.798	(0.08)	-0.360	(0.11)	-0.268	(0.16)	0.500
Smoke	0.176	(0.54)	0.926	(0.11)	-0.195	(0.23)	0.154	(0.33)	0.271
Games	0.099	(0.31)	1.174	(0.07)	0.336	(0.17)	-0.103	(0.22)	0.699
Books	-0.216	(0.19)	1.088	(0.06)	0.087	(0.07)	0.196	(0.12)	0.757
Household	0.198	(0.14)	1.018	(0.04)	-0.389	(0.06)	-0.144	(0.07)	0.851
Apparel	-0.872	(0.33)	1.180	(0.08)	0.462	(0.12)	0.232	(0.22)	0.648
Health	0.247	(0.24)	0.902	(0.06)	-0.404	(0.09)	-0.456	(0.18)	0.710
Chems	-0.164	(0.20)	1.129	(0.06)	0.051	(0.07)	0.424	(0.17)	0.685
Textiles	-0.582	(0.36)	1.116	(0.08)	0.854	(0.12)	0.681	(0.18)	0.615
Cnstr	-0.324	(0.20)	1.192	(0.04)	0.245	(0.07)	0.307	(0.09)	0.825
Steel	-0.355	(0.30)	1.149	(0.07)	0.533	(0.11)	0.407	(0.15)	0.610
FabPr	-0.291	(0.25)	1.163	(0.04)	0.626	(0.08)	0.286	(0.10)	0.776
ElcEq	0.195	(0.34)	1.076	(0.06)	0.538	(0.12)	-0.501	(0.25)	0.761
Autos	-0.296	(0.26)	1.262	(0.05)	0.216	(0.08)	0.716	(0.13)	0.708
Carry	-0.300	(0.28)	1.147	(0.09)	0.081	(0.10)	0.339	(0.17)	0.640
Mines	-0.355	(0.43)	0.795	(0.11)	0.790	(0.16)	0.371	(0.19)	0.308
Coal	-0.712	(0.36)	0.974	(0.08)	0.634	(0.16)	0.559	(0.20)	0.455
Oil	-0.035	(0.28)	0.854	(0.07)	0.051	(0.13)	0.540	(0.12)	0.447
Util	-0.165	(0.22)	0.611	(0.06)	-0.284	(0.11)	0.580	(0.14)	0.462
Telcm	0.437	(0.29)	0.928	(0.07)	-0.156	(0.09)	-0.022	(0.13)	0.627
Servs	0.638	(0.18)	1.004	(0.05)	0.262	(0.10)	-0.882	(0.13)	0.848
BusEq	0.266	(0.31)	0.985	(0.07)	0.305	(0.14)	-0.565	(0.19)	0.696
Paper	-0.273	(0.18)	1.088	(0.06)	0.105	(0.09)	0.267	(0.16)	0.682
Trans	-0.507	(0.24)	1.162	(0.06)	0.325	(0.10)	0.496	(0.10)	0.702
Wholesale	-0.317	(0.17)	1.025	(0.05)	0.426	(0.06)	0.016	(0.11)	0.870
Retail	0.200	(0.23)	1.085	(0.07)	0.163	(0.08)	-0.168	(0.10)	0.746
Meals	-0.302	(0.24)	1.079	(0.06)	0.284	(0.12)	0.091	(0.14)	0.735
Finance	-0.232	(0.14)	1.159	(0.05)	-0.160	(0.07)	0.474	(0.07)	0.881
Other	-0.775	(0.32)	1.199	(0.06)	0.258	(0.09)	0.265	(0.21)	0.696

Table V

Time Series Regressions of Excess Industrial Returns on the Fama-French Three Factors (U.K.)

This table reports the regression results of excess industrial portfolio returns on the Fama-French three factors for the U.K. with sample period from January 1986 to December 1999. The Newey-West adjusted standard errors are reported in parentheses to the right of the coefficient estimates.

Industry	Constant		$R_m - Tbill$		R_{SMB}		R_{HML}		Adj. R^2
Mining	0.166	(0.42)	1.183	(0.12)	0.212	(0.20)	0.187	(0.27)	0.426
OilGas	0.229	(0.28)	0.878	(0.09)	-0.028	(0.08)	0.507	(0.18)	0.518
Chemcals	-0.316	(0.32)	1.060	(0.06)	0.111	(0.09)	-0.168	(0.18)	0.631
Cnstr	-0.749	(0.28)	1.270	(0.06)	0.141	(0.08)	0.543	(0.13)	0.718
ForestryPaper	-0.024	(0.54)	1.171	(0.13)	0.392	(0.19)	0.073	(0.30)	0.303
Steel	-0.008	(0.45)	1.300	(0.10)	0.308	(0.15)	0.507	(0.21)	0.402
AerospaceDefense	-0.377	(0.38)	1.117	(0.10)	0.164	(0.16)	-0.046	(0.22)	0.526
Divs. Industrials	-0.610	(0.27)	1.076	(0.05)	0.050	(0.06)	-0.042	(0.15)	0.660
ElcEq	0.240	(0.35)	1.091	(0.13)	0.449	(0.24)	-0.497	(0.27)	0.529
EngMachinery	-0.346	(0.28)	1.223	(0.07)	0.291	(0.09)	-0.005	(0.17)	0.691
Autos	0.084	(0.38)	1.256	(0.09)	0.142	(0.11)	-0.106	(0.19)	0.568
Textiles	-1.260	(0.41)	1.202	(0.09)	0.284	(0.14)	0.222	(0.22)	0.640
Beverages	-0.128	(0.25)	0.928	(0.07)	-0.226	(0.11)	-0.242	(0.14)	0.685
Food	-0.183	(0.23)	0.810	(0.07)	-0.047	(0.11)	-0.092	(0.17)	0.651
Health	-0.294	(0.21)	0.943	(0.05)	0.183	(0.06)	-0.348	(0.16)	0.670
Pack	-0.347	(0.34)	1.128	(0.07)	0.178	(0.12)	-0.070	(0.17)	0.558
Prsnl.Care	-0.323	(0.36)	0.826	(0.08)	-0.203	(0.10)	0.014	(0.19)	0.389
PharmBiotech	0.782	(0.30)	0.840	(0.08)	-0.097	(0.09)	-0.901	(0.17)	0.573
Tobacco	0.346	(0.47)	0.776	(0.16)	-0.308	(0.17)	0.214	(0.25)	0.326
Dist.	-0.409	(0.28)	1.182	(0.06)	0.307	(0.08)	0.015	(0.11)	0.693
GenRetail	-0.516	(0.24)	0.904	(0.05)	-0.174	(0.08)	0.209	(0.14)	0.664
Ent.Hotels	-0.312	(0.28)	1.178	(0.08)	0.075	(0.08)	0.316	(0.11)	0.743
Media	0.064	(0.22)	1.272	(0.06)	0.371	(0.10)	-0.184	(0.10)	0.758
ResPub	-0.144	(0.26)	0.819	(0.08)	-0.154	(0.06)	0.269	(0.11)	0.620
Support	-0.096	(0.20)	1.085	(0.05)	0.375	(0.07)	-0.138	(0.08)	0.725
Transport	-0.261	(0.25)	1.023	(0.05)	0.058	(0.07)	0.200	(0.15)	0.732
FoodDrugRetailers	-0.225	(0.33)	0.684	(0.06)	-0.126	(0.09)	0.186	(0.18)	0.385
Telecom	0.605	(0.38)	0.856	(0.09)	-0.134	(0.11)	-0.200	(0.17)	0.498
Banks	0.440	(0.25)	1.117	(0.08)	-0.346	(0.08)	0.436	(0.19)	0.720
Insurance	-0.387	(0.25)	1.073	(0.07)	-0.166	(0.08)	0.181	(0.11)	0.679
LifeAssurance	0.479	(0.28)	0.925	(0.06)	-0.122	(0.07)	0.067	(0.14)	0.557
InvFirm	-0.100	(0.15)	1.066	(0.05)	0.165	(0.06)	0.031	(0.07)	0.870
RealEstate	-0.761	(0.23)	1.003	(0.08)	0.109	(0.07)	0.943	(0.13)	0.718
OtherFin	-0.054	(0.25)	1.298	(0.07)	0.297	(0.07)	0.106	(0.18)	0.748
IT Hardware	1.367	(1.14)	1.412	(0.27)	0.845	(0.49)	-0.904	(0.82)	0.253
Software	0.649	(0.47)	1.136	(0.11)	0.857	(0.22)	-0.461	(0.24)	0.505

Table VI

Time Series Regressions of Excess Industrial Returns on the Fama-French Three Factors (Germany)

This table reports the regression results of excess industrial portfolio returns on the Fama-French three factors for Germany with sample period from January 1988 to December 1999. The Newey-West adjusted standard errors are reported in parentheses to the right of the coefficient estimates.

Industry	Constant		$R_m - Tbill$		R_{SMB}		R_{HML}		Adj. R^2
Autos	-0.343	(0.34)	1.118	(0.09)	-0.287	(0.14)	0.179	(0.19)	0.736
Banks	-0.220	(0.23)	0.911	(0.07)	-0.255	(0.08)	0.378	(0.12)	0.782
Chemcals	-0.058	(0.25)	0.825	(0.08)	-0.239	(0.09)	0.308	(0.10)	0.698
Media	1.126	(0.67)	0.853	(0.14)	0.454	(0.16)	-0.656	(0.26)	0.229
BSC Resources	0.082	(0.27)	1.120	(0.08)	0.463	(0.09)	0.223	(0.12)	0.663
FoodBevrge	-0.205	(0.17)	0.851	(0.06)	0.612	(0.07)	-0.034	(0.07)	0.618
Technology	-0.010	(0.31)	1.081	(0.07)	-0.090	(0.09)	0.018	(0.11)	0.698
Insurance	0.075	(0.29)	1.010	(0.08)	-0.167	(0.11)	-0.234	(0.17)	0.712
TRSPT&LGISTC	-0.048	(0.43)	1.190	(0.13)	0.280	(0.17)	0.305	(0.13)	0.463
Machinery	-0.554	(0.25)	1.244	(0.06)	0.481	(0.08)	0.215	(0.09)	0.753
Industrial	1.252	(0.43)	1.071	(0.11)	-0.010	(0.11)	-0.251	(0.24)	0.584
Construction	-0.483	(0.39)	1.475	(0.10)	1.003	(0.17)	0.036	(0.11)	0.586
PharmHlth	0.440	(0.26)	0.878	(0.06)	0.274	(0.11)	-0.261	(0.12)	0.555
Retail	-0.376	(0.37)	1.247	(0.13)	0.593	(0.10)	-0.185	(0.14)	0.546
Software	2.578	(0.83)	1.434	(0.15)	0.467	(0.22)	-0.087	(0.25)	0.308
Telecom	0.284	(0.67)	0.738	(0.13)	0.076	(0.18)	-0.397	(0.27)	0.170
Utilities	0.063	(0.23)	0.689	(0.07)	-0.009	(0.09)	0.222	(0.08)	0.594
Financial SRV	0.552	(0.33)	0.935	(0.13)	0.518	(0.14)	-0.123	(0.12)	0.408
Consumer Cyclical	-0.541	(0.40)	1.188	(0.08)	0.604	(0.11)	0.082	(0.14)	0.545

Table VII

Time Series Regressions of Excess Industrial Returns on the Fama-French Three Factors (Japan)

This table reports the regression results of excess industrial portfolio returns on the Fama-French three factors for Japan with sample period from January 1988 to December 1999. The Newey-West adjusted standard errors are reported in parentheses to the right of the coefficient estimates.

Industry	Constant		$R_m - Tbill$		R_{SMB}		R_{HML}		Adj. R^2
AirTransport	0.194	(0.57)	0.909	(0.11)	0.151	(0.12)	-0.049	(0.26)	0.348
Banks	0.315	(0.62)	0.964	(0.09)	-0.133	(0.11)	0.117	(0.15)	0.388
Chemical	0.010	(0.18)	1.076	(0.04)	0.164	(0.06)	-0.097	(0.09)	0.853
Communication	0.998	(0.63)	1.158	(0.10)	-0.105	(0.10)	-0.658	(0.19)	0.481
Construction	-0.504	(0.35)	1.065	(0.08)	0.241	(0.11)	0.344	(0.23)	0.605
ElcEq	0.007	(0.33)	0.950	(0.07)	-0.171	(0.09)	0.047	(0.34)	0.555
Utilities	-0.040	(0.35)	0.913	(0.09)	-0.539	(0.11)	0.698	(0.37)	0.467
Fisheries	-0.526	(0.30)	0.999	(0.07)	0.497	(0.10)	0.193	(0.17)	0.628
Foods	-0.008	(0.27)	0.894	(0.05)	0.218	(0.07)	-0.011	(0.10)	0.728
GlassCeramics	-0.039	(0.23)	1.057	(0.05)	0.105	(0.05)	-0.179	(0.09)	0.797
Insurance	0.337	(0.43)	1.107	(0.09)	-0.392	(0.10)	0.219	(0.19)	0.559
Steel	-0.382	(0.50)	1.131	(0.06)	-0.085	(0.11)	0.271	(0.17)	0.581
LandTransport	0.306	(0.35)	1.017	(0.08)	-0.013	(0.09)	0.179	(0.35)	0.522
Machinery	-0.202	(0.19)	1.071	(0.04)	0.358	(0.06)	-0.011	(0.11)	0.859
MarineTransport	-0.566	(0.50)	1.293	(0.09)	0.314	(0.14)	0.164	(0.26)	0.584
MetalProducts	-0.278	(0.24)	0.947	(0.06)	0.582	(0.08)	0.312	(0.12)	0.711
Mining	-0.241	(0.44)	1.093	(0.06)	0.605	(0.08)	-0.381	(0.13)	0.573
Non-ferrous Mets	-0.021	(0.22)	1.169	(0.05)	0.080	(0.06)	-0.185	(0.12)	0.774
OilCoal	-0.409	(0.41)	1.021	(0.09)	0.200	(0.11)	-0.009	(0.13)	0.533
OtherFinancials	-0.131	(0.40)	1.037	(0.06)	0.208	(0.10)	0.153	(0.12)	0.635
OtherProducts	0.251	(0.28)	0.832	(0.05)	0.140	(0.10)	0.016	(0.16)	0.649
Pharmaceutical	0.282	(0.32)	0.800	(0.06)	0.003	(0.07)	-0.136	(0.12)	0.531
PrecisionInstr.	0.174	(0.36)	0.922	(0.08)	0.107	(0.08)	-0.247	(0.30)	0.558
Paper	-0.287	(0.30)	0.824	(0.10)	0.235	(0.09)	0.171	(0.12)	0.524
RealEstate	0.081	(0.33)	1.267	(0.13)	-0.307	(0.16)	0.355	(0.36)	0.536
Retail	0.039	(0.24)	0.908	(0.05)	0.224	(0.07)	0.249	(0.10)	0.702
Rubber	0.437	(0.30)	1.033	(0.05)	0.133	(0.11)	0.068	(0.12)	0.675
Securities	-0.002	(0.52)	1.506	(0.17)	-0.391	(0.15)	0.347	(0.20)	0.621
Service	0.174	(0.34)	0.922	(0.06)	0.361	(0.09)	0.167	(0.13)	0.679
Textiles	-0.289	(0.22)	0.999	(0.04)	0.236	(0.08)	0.071	(0.13)	0.769
Transport Equip.	0.200	(0.21)	0.910	(0.04)	-0.302	(0.08)	0.183	(0.16)	0.716
Warehouse	-0.206	(0.31)	1.113	(0.08)	0.326	(0.11)	0.425	(0.27)	0.625
Wholesale	-0.359	(0.22)	1.079	(0.05)	0.095	(0.07)	0.133	(0.10)	0.830

Table VIII
PPP Regressions using Monthly Observations

This table presents PPP regressions using the unexpected inflation differential estimates. First, a time-series regression is carried out to estimate betas and residuals for each industry portfolio. Second, a cross-sectional regression is carried out to estimate the unexpected nominal risk-free rate by regressing the residuals on beta estimates at each point of time. Third, the PPP regression is carried out, in which the dependent variable is defined as the difference between the estimates of nominal risk-free rates in Japan, UK or Germany and that in the United States. The regressor is the change in the foreign exchange rate measured as yen or British pounds or Deutschemarks per U.S. dollar. Newey-West adjusted standard errors are reported in parentheses.

Currency Pair	Constant	Δs	$\Delta s(+1)$	Adj. R^2
Japanese Yen-US $	0.036	0.522		0.026
	(0.639)	(0.250)*		
	0.290	0.498	0.590	0.061
	(0.635)	(0.245)*	(0.216)*	
UK £- US $	0.019	0.283		0.004
	(0.732)	(0.189)		
	0.054	0.254	0.272	0.007
	(0.732)	(0.181)	(0.167)	
German DM- US $	-0.091	0.648		0.048
	(0.667)	(0.227)*		
	-0.018	0.575	0.615	0.092
	(0.635)	(0.207)*	(0.240)*	

*: significantly different from zero at 5%.
**: significantly different from zero at 10%.

Table IX
PPP Regressions using Bi-Monthly Observations

This table presents PPP regressions using the unexpected inflation differential estimates. First, a time-series regression is carried out to estimate betas and residuals for each industry portfolio. Second, a cross-sectional regression is carried out to estimate the unexpected nominal risk-free rate by regressing the residuals on beta estimates at each point of time. Third, the PPP regression is carried out, in which the dependent variable is defined as the difference between the estimates of nominal risk-free rates in Japan, UK or Germany and that in the United States. The regressor is the change in the foreign exchange rate measured as yen or British pounds or Deutschemarks per U.S. dollar. Newey-West adjusted standard errors are reported in parentheses.

Currency Pair	Constant	Δs	$\Delta s(+1)$	Adj. R^2
Japanese Yen-US $	0.276	0.763		0.063
	(1.021)	(0.337)*		
	0.474	0.752	0.052	0.053
	(1.025)	(0.339)*	(0.256)	
UK £- US $	0.090	0.679		0.058
	(1.435)	(0.150)*		
	0.250	0.694	0.091	0.051
	(1.454)	(0.149)*	(0.220)	
German DM- US $	-0.302	1.056		0.164
	(1.209)	(0.276)*		
	-0.317	1.009	0.473	0.188
	(1.193)	(0.257)*	(0.223)*	

*: significantly different from zero at 5%.
**: significantly different from zero at 10%.

Table X

PPP Regressions using Quarterly Observations

This table presents PPP regressions using the unexpected inflation differential estimates. First, a time-series regression is carried out to estimate betas and residuals for each industry portfolio. Second, a cross-sectional regression is carried out to estimate the unexpected nominal risk-free rate by regressing the residuals on beta estimates at each point of time. Third, the PPP regression is carried out, in which the dependent variable is defined as the difference between the estimates of nominal risk-free rates in Japan, UK or Germany and that in the United States. The regressor is the change in the foreign exchange rate measured as yen or British pounds or Deutschemarks per U.S. dollar. Newey-West adjusted standard errors are reported in parentheses.

Currency Pair	Constant	Δs	$\Delta s(+1)$	Adj. R^2
Japanese Yen-US $	0.756	0.841		0.101
	(1.587)	(0.380)*		
	0.252	0.856	-0.466	0.117
	(2.177)	(0.361)*	(0.331)	
UK £- US $	0.126	0.634		0.023
	(2.250)	(0.348)**		
	0.299	0.646	-0.162	0.009
	(2.246)	(0.347)**	(0.363)	
German DM- US $	-0.562	1.303		0.235
	(1.951)	(0.342)*		
	-0.992	1.258	0.428	0.234
	(1.881)	(0.332)*	(0.296)	

*: significantly different from zero at 5%.

**: significantly different from zero at 10%.

Table XI
PPP Regressions with Momentum as an Additional Factor
for the U.S. (Monthly Observations)

This table presents PPP regressions using the unexpected inflation differential estimates. First, a time-series regression is carried out to estimate betas and residuals for each industry portfolio. For the U.S. time series regression, momentum factor is included in addition to the Fama-French three factors. Second, a cross-sectional regression is carried out to estimate the unexpected nominal risk-free rate by regressing the residuals on beta estimates at each point of time. Third, the PPP regression is carried out, in which the dependent variable is defined as the difference between the estimates of nominal risk-free rates in Japan, UK or Germany and that in the United States. The regressor is the change in the foreign exchange rate measured as yen or British pounds or Deutschemarks per U.S. dollar. Newey-West adjusted standard errors are reported in parentheses.

Currency Pair	Constant	Δs	$\Delta s(+1)$	Adj. R^2
Japanese Yen-US $	0.059	0.577		0.031
	(0.678)	(0.259)*		
	0.292	0.549	0.636	0.069
	(0.674)	(0.252)*	(0.231)*	
UK £- US $	0.022	0.326		0.007
	(0.746)	(0.195)**		
	-0.005	0.304	0.278	0.011
	(0.745)	(0.184)**	(0.165)**	
German DM- US $	-0.091	0.650		0.048
	(0.672)	(0.227)*		
	-0.023	0.578	0.610	0.091
	(0.641)	(0.207)*	(0.242)*	

*: significantly different from zero at 5%.
**: significantly different from zero at 10%.

Table XII

PPP Regressions with Momentum as an Additional Factor for the U.S. (Bi-Monthly Observations)

This table presents PPP regressions using the unexpected inflation differential estimates. First, a time-series regression is carried out to estimate betas and residuals for each industry portfolio. For the U.S. time series regression, momentum factor is included in addition to the Fama-French three factors. Second, a cross-sectional regression is carried out to estimate the unexpected nominal risk-free rate by regressing the residuals on beta estimates at each point of time. Third, the PPP regression is carried out, in which the dependent variable is defined as the difference between the estimates of nominal risk-free rates in Japan, UK or Germany and that in the United States. The regressor is the change in the foreign exchange rate measured as yen or British pounds or Deutschemarks per U.S. dollar. Newey-West adjusted standard errors are reported in parentheses.

Currency Pair	Constant	Δs	$\Delta s(+1)$	Adj. R^2
Japanese Yen-US $	0.364	0.867		0.074
	(1.146)	(0.355)*		
	0.537	0.852	0.138	0.066
	(1.146)	(0.360)*	(0.269)	
UK £- US $	0.099	0.744		0.067
	(1.461)	(0.146)*		
	0.115	0.750	0.124	0.058
	(1.495)	(0.144)*	(0.206)	
German DM- US $	-0.302	1.055		0.163
	(1.223)	(0.277)*		
	-0.330	1.005	0.471	0.186
	(1.206)	(0.258)*	(0.227)*	

*: significantly different from zero at 5%.

**: significantly different from zero at 10%.

Table XIII
PPP Regressions with Momentum as an Additional Factor for the U.S. (Quarterly Observations)

This table presents PPP regressions using the unexpected inflation differential estimates. First, a time-series regression is carried out to estimate betas and residuals for each industry portfolio. For the U.S. time series regression, momentum factor is included in addition to the Fama-French three factors. Second, a cross-sectional regression is carried out to estimate the unexpected nominal risk-free rate by regressing the residuals on beta estimates at each point of time. Third, the PPP regression is carried out, in which the dependent variable is defined as the difference between the estimates of nominal risk-free rates in Japan, UK or Germany and that in the United States. The regressor is the change in the foreign exchange rate measured as yen or British pounds or Deutschemarks per U.S. dollar. Newey-West adjusted standard errors are reported in parentheses.

Currency Pair	Constant	Δs	$\Delta s(+1)$	Adj. R^2
Japanese Yen-US $	0.755	0.953		0.119
	(1.820)	(0.393)*		
	0.133	0.989	-0.496	0.140
	(1.715)	(0.366)*	(0.321)	
UK £- US $	0.151	0.758		0.036
	(2.303)	(0.347)*		
	0.006	0.748	-0.209	0.020
	(2.343)	(0.355)*	(0.395)	
German DM- US $	-0.561	1.301		0.231
	(1.981)	(0.345)*		
	-1.017	1.252	0.424	0.230
	(1.905)	(0.334)*	(0.300)	

*: significantly different from zero at 5%.
**: significantly different from zero at 10%.

Table XIV

Regression of Extracted Inflation on Official Inflation Measures (U.S.)

This table presents the results of regressing the extracted total and unexpected inflation on the official inflation measures. The extracted unexpected inflation is $\hat{u}_{R_{ft}}$ and the extracted total inflation is $\hat{R}_{ft} = TBill_{t-1} + \hat{u}_{R_{ft}}$. We use both CPI and PPI inflation rates as the official total inflation measures. The official unexpected inflation measure is simply the CPI or PPI inflation rate minus the Tbill rate. The monthly, the non-overlapping quarterly, semi-annual and annual frequencies of the data are used in the regressions. Newey-West adjusted standard errors (S.E.) are reported in parentheses.

Price Index	Dependent Variable	Frequency	Constant	S.E.	Official Infl. Rate	S.E.	Adj. $\bar{R}^2$
PPI	$\hat{R}_{ft}$	monthly	0.035	(0.445)	3.087	(0.756)*	0.059
		quarterly	-0.143	(1.057)	3.713	(0.833)*	0.137
		semiannual	0.781	(1.972)	2.357	(1.472)	0.040
		annual	3.873	(3.963)	0.888	(0.904)	-0.060
CPI	$\hat{R}_{ft}$	monthly	-1.638	(0.625)*	8.061	(1.804)*	0.063
		quarterly	-4.808	(2.201)*	7.926	(2.796)*	0.075
		semiannual	-5.980	(4.568)	5.573	(2.534)*	0.024
		annual	-7.694	(6.828)	4.193	(2.004)*	0.007
PPI	$\hat{u}_{R_{ft}}$	monthly	0.824	(0.523)	2.674	(0.780)*	0.044
		quarterly	2.846	(1.590)	3.080	(0.908)*	0.093
		semiannual	2.369	(3.905)	1.282	(1.433)	-0.013
		annual	-2.330	(6.645)	-0.630	(0.912)	-0.070
CPI	$\hat{u}_{R_{ft}}$	monthly	0.992	(0.652)	5.464	(2.031)*	0.027
		quarterly	1.896	(2.563)	3.483	(3.422)	0.002
		semiannual	-1.509	(5.261)	-1.386	(4.093)	-0.034
		annual	-11.368	(7.926)	-5.220	(2.790)	0.058

*: significantly different from zero at 5%.

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