An Examination Of Uncovered Real Interest Rate Parity In 18 Distinct U.S. Manufacturing Industries

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Abstract

In a departure from the standard literature, we consider micro-level data to draw inferences about the uncovered real interest rate parity in 18 distinct manufacturing industries across 25 countries. The real interest rates are computed based on trade weights at the industry level. We examine the time series properties of real interest differentials by employing a battery of unit root tests. Using industry-specific quarterly observations on deposit and inflation rates, we find robust and statistically significant evidence in support of the uncovered real interest rate parity (UIP) in every industry we consider across all 25 countries.

Introduction

Fluctuations in the foreign exchange market rely on the *interest rate parity* theorem, which relates domestic interest rates and exchange rates. As addressed by previous studies (Frenkel, 1979; Sachs, 1985; Shafer & Loopesko, 1983), if real interest rate parity holds across countries, then information from the real interest differentials will be helpful in explaining real exchange rate movements. In this paper we study the validity of the theory of *uncovered real interest rate parity* (UIP) by examining the properties of real interest differentials when they are computed from the consumer price index and imputed trade weights for 18 distinct U.S. manufacturing industries.

According to Wu and Chen (1998), unit root tests can be applied to evaluate the time series characteristics of real rate of return differentials among industries and/or countries. If real interest rate differentials are stationary, then they should have mean-reverting qualities, for the whole sample or at least over long regimes. In other words, a lack of persistence in fluctuations of these series might be consistent with the implication of real interest rate parity. Thus, an empirical corollary of the theorem of real interest rate parity would entail answering the question: to

what degree do real interest rates co-move across countries? If such co-movement were strong enough — so that by combining different rates across countries all persistence in the residuals vanished — then this would be consistent with interest rate parity. Our objective in this paper is to empirically test whether the uncovered rate parity theorem holds for 18 different industries across 25 countries. We select the 18 industries that, according to Bahmani-Oskooee, Mirzaie, and Miteza (2007), constitute the largest trade industries in the US. We feel finding an answer to this important question would have salient implications for some of the more topical and vibrant debates in international economics — from the effectiveness of monetary policy in trade fluctuations to whether there is evidence of a global business cycle. However, to date, empirical evidence in favor of interest rate parity is mixed at best. Many authors point to indexation and aggregation issues in the indicators that are typically used to test for interest rate parity as possible culprits for such lack of evidence (Cumby & Obstfeld, 1984; Mark, 1985). To deal with possible issues that arise when using aggregate measures, two possible solutions can be broached: one would be to correct, econometrically, the biases in the aggregate indices themselves; and the other would be to disaggregate the rates and investigate the behavior at a micro-level. Given that these biases arise from the aggregation and indexation process, we feel that opting for the second option renders the criticism as a non-starter.

Most of the research on international interest rate parity has involved aggregate measures. For example, Mark (1985) employed CPI-based real interest rate data for six OECD countries to show a general failure to support the real interest rate parity hypothesis. Dutton (1993) measures real interest rates in terms of trade to show evidence of parity. Gagnon and Unferth (1995) combine interest rate data from nine OECD countries. They show that the differentials between the combined "world" interest rate and that of most countries exhibit little serial correlation with the notable exception of the U.S.

There has been a multitude of recent interest in macroeconomic studies that focus on disaggregated data. For example, Boivin and Giannoni (2006) posit that there may be substantial gains from expanding the information set in the estimation of general equilibrium macroeconomic models. They show that using a combination of aggregate and micro-level data may lead to more accurate predictions and even qualitatively different conclusions about key structural relationships. Boivin, Gianonni, and Mihov (2009) include both aggregate and sector-specific data into their model and conclude that disaggregated price data is not as responsive to aggregate macro and monetary shocks and much more responsive to sector-specific

shocks. This important result could only be uncovered by considering disaggregated sector-specific data. Balke (2010) posits that disaggregated data can bring additional explanatory power in identification beyond what is provided by aggregate variables alone. Often, economic theory has implications for sectoral variables as well as for aggregate variables.

Discussions of exchange rate movements have often been based on aggregate trade-weighted exchange rates that use weighting schemes applied to trade-partner exchange rates as functions of all imports and exports of the U.S. economy. These aggregate exchange rate measures are useful at the macro-economic level. However, Goldberg (2004)[1] argues that the focus on national aggregates generally ignores industry-specific distinctions among trading partners. Thus, the movements in specific bilateral exchange rates associated with changes in industry competitive conditions may not be captured appropriately by aggregate trade-weighted indexes. Consequently, Goldberg constructs industry-specific trade weighted indexes to explain differences in corporate profits in the U.S. and finds them to be an improvement over the aggregate measures.

While the above referenced papers highlight a wealth of research in the parity issue by considering aggregate data and, more recently, there has been increasing literature that exalts the value of disaggregated data for macroeconomic models; to our knowledge, there has been little research advanced in the parity issue by considering disaggregated data. This paper contribution is bridging the two lines of research. Thus, we follow Goldberg's methodology in constructing a specific exchange rate index for 18 different industries. Our strategy, involve constructing multiple series of trade-weighted industry-specific real exchange rates and investigate whether the uncovered real interest rate parity holds for 18 industries ranging from the more consumer-oriented, such as furniture and fixtures, to more intermediate and primary levels such as plastics and chemicals. We examine the time series properties of these industry-level measures of trade-weighted real exchange rates. To that end, we employ a battery of unit root tests both in the univariate and multivariate realms. Importantly, we find that for 18 different industries, there is strong and significant evidence in support of the uncovered rate parity among 25 countries.[2]

The rest of this paper is organized as follows. "Interest Rate Parity" provides some motivation and background on the interest rate parity from a theoretical and empirical standpoint. "Trade-Weighted Measures of Exchange Rates and Inflation" expounds on the construction of industry-specific trade weighted measures of the nominal and real interest rates, for a (benchmark) domestic as well as a foreign

country and describes the empirical strategy. "Data" elaborates on some data issues, followed by "Results" and "Conclusion" which summarize our findings.

Interest Rate Parity

The theory of real interest rate parity states that the difference between the domestic and the foreign real interest rates equals the expected depreciation of the domestic real exchange rate. In all cases, the real interest rate parity relationship must be satisfied because it is a restatement of the Fisher equation.

Theoretical Predictions And Empirical Evidence

Interest rate parity is, in essence, an arbitrage condition. Given the rate of return on foreign interest-bearing assets and the domestic interest-bearing assets with identical risk, investors have two options: one is to enter the market and invest in the foreign currency and subsequently at the end of the investment period convert the realized earnings into the domestic currency. The second option is not to enter the market, purchase domestic interest-bearing assets and at the end of the investment period collect returns yielded by the domestic rate. According to standard models of finance, under an interest rate parity environment, no arbitrage opportunities should arise; which implies these two options should yield the same returns.

While the theorem of real interest rate parity is relatively uncontroversial, cross-country empirical evidence is mixed. For example, some studies have shown that trade weights could possibly affect investors' willingness to put their portfolio in a market. Cumby and Obstfeld (1984) and Mark (1985) find that the international interest rate parity relationship does not hold among many countries. They point to measurement bias in the indicators used to calculate inflation and exchange rates as a possible explanation. Chinn and Frenkel (1995) find evidence supportive of real interest rate parity between Japan and Taiwan, the United States and Taiwan, and the United States and Singapore. Wu and Chen (1998) confirm the real interest rate parity across nine advanced economies.[3]

Time Horizons

Choosing an optimal time horizon for the spot exchange, inflation, and deposit interest rates to check the validity of uncovered interest rate parity (UIP) across countries has been a focal point of attention in this literature. Typically, there is little support for UIP from studies that use data with frequencies less than

one year (Baillie & Bollerslev, 2000; Bekaert & Hodrick, 1993, 2001; Mark & Wu, 1998). Conversely, many authors have concluded that UIP holds better at longer horizons[4] (Cumby & Mishkin, 1987; Fujii & Chinn, 2001; Meredith & Chinn, 1998; Mishkin, 1984b; Taylor, 1991). In an interesting contribution, Bekaert, Wei, and Xing (2007) find that the failure of UIP is independent of horizon and, instead, is currency dependent. In this paper we examine whether the UIP holds over quarterly data.[5]

Trade-Weighted Measures of Exchange Rates and Inflation

According to Mishkin (1984a), if the real interest rate parity holds across countries, then the influence of domestic monetary authority on the real interest rate should be diminished or limited to the degree to which domestic policy impacts the world's interest rates. Our aim in this paper is to test whether interest parity holds at the industry level. To that end we select 18 distinct industries based on data availability. We posit that the nominal interest rate for a given industry is not only a function of the aggregate interest rate but, importantly, a function of how intensively are the goods in that particular industry traded around the world. Thus, using contemporaneous trade data from several sources,[6] we construct a trade-weighted, industry-specific, measure of the foreign nominal interest rates as follows:

$$i^*_{jt} = \sum_c \left[\left[\frac{EX^{jc}_t + IM^{jc}_t}{\sum_c (EX^{jc}_t + IM^{jc}_t)} \right] \cdot i^c_t \right], \qquad (1)$$

where i^*_{jt} is an index of the annualized nominal trade-weighted foreign interest rate for industry j[7] at time t. EX^{jc}_t and IM^{jc}_t denote, respectively, the export and import volumes of industry j to country c at time t, and i^c_t is the annual [aggregate] nominal interest rate in country c at time t. Thus, in a two-country (domestic-foreign) model, we theorize that when the domestic country trades with foreign country c in industry j, the annual interest rate in country c at time t (i^c_t) must be weighted by the volume of trade of industry j to country c. This allows us to generate a foreign annual nominal interest rate (i^*_{jt}) that effectively impacts industry j.

Similarly, we build an industry-specific measure of the annualized inflation rate for each industry j as follows

$$\pi^*_{jt} = \sum_c \left[\left[\frac{EX^{jc}_t + IM^{jc}_t}{\sum_c (EX^{jc}_t + IM^{jc}_t)} \right] \cdot \pi^c_t \right], \qquad (2)$$

where π^*_{jt} is an index of the annualized trade-weighted foreign inflation rate for in-

dustry j at time t, and π^c_t is the time t annual inflation rate in country c as given by the consumer price index (one-quarter ahead). We then compute the trade-weighted industry-specific foreign real interest rates (r^*_{jt}) by subtracting π^*_{jt} from i^*_{jt}. Finally, we derive the ex-post real interest differentials ($r_t - r^*_{jt}$)[8] based on trade weights for each specific industry. If the uncovered real interest rate parity holds, then the real interest differentials between the U.S. and its trade-weighted foreign countries in a specific industry should equal the expected real dollar depreciation.

Once our industry-specific rate measures are computed, we investigate whether UIP holds at the industry level for the 25 countries considered by examining the stationarity of $r_t - r^*_{jt}$. If the industry-specific real interest rate differential is stationary, then there should be no long-run impact on the rate differential, given a temporary shock to either the domestic or the foreign rate. In other words, given any nonpermanent shock to a country's rate (whether it comes from domestic demand fluctuations or domestic monetary policy), deviations from parity in the trade-weighted industry-specific real interest may be more or less persistent but *not* permanent. Thus the stationarity of the industry-specific real interest differentials is consistent with the implication of real interest rate parity.

According to the standard model, the uncovered interest rate parity can be specified as

$$E_t s_{t+1} - s_t = i_t - i^*_t, \tag{3}$$

where i_t denotes the nominal interest rates in the home country; i^*_t represents a foreign country's nominal interest rates; s_t represents the spot nominal exchange rates between the home and foreign countries; and E_t is the expectation operator conditional on information available at time t. Equation (3) implies that nominal interest differentials between the home and foreign countries should equal the expected domestic nominal currency depreciation. Empirically, uncovered interest rate parity between countries can be tested in the following form:

$$s_{t+1} - s_t = \alpha + \beta(i_t - i^*_t) + \varepsilon_t, \ \varepsilon_t \sim N(0,\sigma). \tag{4}$$

Under the null hypothesis, if UIP holds, the constant risk premium term, α, should be zero; and β should be one. Thus, under the null, the gap between realized home nominal currency depreciation and the nominal interest differentials are an $I(0)$ process. With a standard application of the Fisher equation, we re-write (4) as

$$q_{t+1} - q_t = (i_t - \pi_t) - (i^*_t - \pi^*_t) + \varepsilon_t, \tag{5}$$

where q_t denotes the domestic country's real exchange rate against its trading partner.

We assume that all industries in the domestic economy face the same nominal interest rates and inflation rates.[9] However, each trading partner of the domestic economy has its distinct export and import shares in a specific manufacturing industry. Real exchange rate fluctuations among industries may lead to biases in the aggregate UIP measure. To address this issue, we use industry-specific trade weights in the computation of the foreign real interest rate as follows

$$\hat{q}_{jt+1} - \hat{q}_{jt} = (i_t - \pi_t) - (i^*_{jt} - \pi^*_{jt}) + \varepsilon_{jt}, \tag{6}$$

where $\hat{q}_t$ is the trade-weighted industry-specific real exchange rate index for a domestic country with its trading partners. Equation (6) can be re-written as

$$\Delta\hat{q}_{jt} = r_t - r^*_{jt} + \varepsilon_{jt}. \tag{7}$$

Once we have both Equations (6) and (7), we posit that if industry-specific disturbances are well-behaved, and the ex-post industry-specific real interest differentials between the home country and its trading partners, $r_t - r^*_{jt}$, are stationary, then so is the realized industry-specific real dollar depreciation, $\Delta\hat{q}_{jt}$.

Data

Data about the nominal interest rates and inflation rates are based on the three-month deposit rates and consumer price index, respectively, from various volumes of the International Financial Statistics (IFS) published by the International Money Fund. According to Dutton (1993), the securities used to compute the interest rate differential across countries may be considered as traded goods, which are free from domestic monetary policy influence. Wu and Chen (1998) used the three-month Euro money-market rate as the nominal interest rate because it is not affected by reserve requirements or exchange controls in their countries. However, due to the lack of data availability, we use the three-month deposit rates which have free market rate properties where banks lend to and borrow freely from each other. Thus, for the United States and its trading partners we use the 3-month deposit rates with annual percentage over quarterly horizon, collected from the IFS database from the

IMF. Countries such as Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, and Spain started to use the Euro as their single currency after 1999, and since then some of them have used the conversion rates and no longer use deposit rates. However, there are missing data for some countries before the introduction of the Euro. To address this, we compare the available deposit rates of these countries to the U.S. federal funds rates, then compute the average gap between each country's deposit rates and the federal funds rates, and we finally set the missing rates to the sum of the federal funds rates and the average gap for each country's deposit rates.

In this model, we consider the U.S. as the domestic country and construct the trade-weighted industry-specific real exchange rates based on the trade share of U.S. main trading partners. In the previous section, we followed Goldberg (2004) to build these measures of industry-specific rates. However, we opt not to use the available trade data for all the trading partners of the United States that Goldberg used. We ultimately drop ten countries from the computation of the new series. Argentina, Brazil, Chile, Columbia, and Mexico, are important trading partners of the United States. However, these counties experienced substantial financial and debt crises in the 1980s and 1990s resulting in extremely high deposit rates and inflation. Furthermore, the institutions of lending and borrowing in some of these Latin American countries, as well as India, Israel, Saudi Arabia, and Venezuela, did not function in a similar manner as those of the United States and Western Europe for much of the sample period we consider. Due to data unavailability, we also drop trade data from Hong Kong. Finally, as evidenced by Table A1 and Table A2, the trade volumes of these ten countries account for a fairly small share of those of the United States relative to the other 25 countries.

Therefore, we construct $\hat{q}_{jt}$ for each manufacturing industry by the trade volume of Australia, Austria, Belgium, Luxembourg, Canada, China, Finland, France, Indonesia, Ireland, Italy, Japan, Korea, Malaysia, Netherlands, Philippines, Portugal, Singapore, South Korea, Spain, Sweden, Switzerland, Thailand, Taiwan, and the United Kingdom. We compute the real interest differentials by using the annualized, ex post industry-specific trade-weighted real exchange and realized inflations rates which span 84 quarters from 1987 to 2008.

Results

Figure 1 displays (annualized) quarterly ex post interest rate differentials for the U.S. and its trading partners in 18 different industries between 1987 and 2008.

Table A1
U.S. Export and Import Destinations by Standard Industrial Classification (SIC)

Standard Industrial Classification	SIC code	China		Japan		European Union		Latin America		Hong Kong		India		Israel		Saudi Arabia		Venezuela	
		1986	1996	1986	1996	1986	1996	1986	1996	1986	1996	1986	1996	1986	1996	1986	1996	1986	1996
Food and Kindred Products	20	0.007	0.021	0.157	0.143	0.349	0.262	0.127	0.136	0.014	0.029	0.005	0.011	0.01	0.006	0.011	0.008	0.010	0.005
Tobacco Manufactures	21	0.001	0.0002	0.102	0.385	0.524	0.399	0.010	0.027	0.153	0.028	0.0004	0.001	0.008	0.015	0.107	0.048	0.0004	0.001
Textile Products	22	0.080	0.041	0.121	0.064	0.26	0.233	0.066	0.164	0.096	0.032	0.032	0.040	0.005	0.011	0.012	0.010	0.007	0.003
Apparel and Related Products	23	0.113	0.190	0.032	0.033	0.118	0.083	0.053	0.207	0.204	0.114	0.024	0.043	0.002	0.01	0.002	0.002	0.001	0.001
Lumber and Wood Products, Except Furniture	24	0.030	0.025	0.164	0.180	0.093	0.091	0.046	0.064	0.005	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Paper and Allied Products	26	0.008	0.031	0.077	0.064	0.197	0.171	0.072	0.114	0.009	0.019	0.002	0.003	0.004	0.004	0.004	0.005	0.009	0.004
Printing and Publishing	27	0.01	0.041	0.100	0.059	0.320	0.246	0.052	0.092	0.039	0.051	0.005	0.004	0.005	0.005	0.002	0.003	0.008	0.002
Petroleum Refining and Related Products	29	0.014	0.003	0.056	0.036	0.233	0.205	0.141	0.168	0.002	0.003	0.022	0.007	0.003	0.005	0.038	0.036	0.203	0.206
Chemicals and Allied Products	28	0.022	0.029	0.144	0.106	0.390	0.343	0.102	0.119	0.013	0.015	0.010	0.008	0.005	0.009	0.008	0.008	0.016	0.009
Rubber and Misc Plastics Products	30	0.008	0.147	0.156	0.110	0.240	0.151	0.103	0.145	0.030	0.012	0.003	0.006	0.010	0.007	0.005	0.003	0.005	0.004
Leather	31	0.033	0.384	0.013	0.016	0.234	0.205	0.133	0.153	0.027	0.023	0.01	0.017	0.001	0.002	0.001	0.001	0.0003	0.001
Stone, Clay, Glass, and Concrete Products	32	0.010	0.089	0.147	0.104	0.355	0.292	0.102	0.138	0.011	0.012	0.003	0.006	0.003	0.004	0.003	0.002	0.013	0.012
Primary Metal Products	33	0.004	0.024	0.146	0.076	0.258	0.233	0.100	0.172	0.003	0.008	0.003	0.005	0.003	0.003	0.002	0.002	0.011	0.016
Fabricated Metal Products, Except Machinery and Transportation Equipment	34	0.009	0.054	0.158	0.107	0.226	0.198	0.071	0.160	0.012	0.010	0.007	0.009	0.010	0.013	0.008	0.010	0.005	0.004
Machinery, Except Electrical	35	0.014	0.031	0.221	0.174	0.354	0.243	0.067	0.094	0.018	0.012	0.006	0.005	0.006	0.006	0.008	0.005	0.013	0.008
Transport Equipment	37	0.005	0.011	0.315	0.191	0.225	0.199	0.044	0.115	0.003	0.005	0.001	0.003	0.005	0.006	0.008	0.016	0.004	0.003
Furniture and Fixtures	25	0.008	0.094	0.042	0.026	0.231	0.122	0.096	0.191	0.012	0.006	0.0004	0.001	0.005	0.005	0.007	0.006	0.0004	0.002
Miscellaneous Manufacturing Commodities	39	0.030	0.241	0.117	0.100	0.262	0.190	0.031	0.058	0.098	0.045	0.050	0.049	0.088	0.089	0.002	0.001	0.002	0.001

Table A2

U.S. Export and Import Destinations by North American Industry Classification System (NAICS)

NAICS	NAICS code	China	Japan	United Kingdom	European Union	Latin America	Hong Kong	India	Israel	Saudi Arabia	Venezuela
		2007	2007	2007	2007	2007	2007	2007	2007	2007	2007
Food Manufacturing	311	0.079	0.069	0.014	0.102	0.211	0.012	0.012	0.005	0.007	0.004
Beverages and Tobacco Products	312	0.004	0.058	0.102	0.466	0.175	0.002	0.001	0.003	0.005	0.001
Textiles and Fabrics and Textile Mill Products	313314	0.325	0.025	0.020	0.100	0.188	0.01	0.083	0.011	0.003	0.001
Apparel and Accessories	315	0.49	0.006	0.006	0.050	0.110	0.039	0.061	0.004	0.0003	0.001
Wood Products	321	0.129	0.011	0.011	0.095	0.138	0.003	0.003	0.001	0.001	0.001
Paper	322	0.095	0.040	0.019	0.137	0.153	0.007	0.005	0.004	0.003	0.002
Printing, Publishing, and Similar Products	323	0.186	0.028	0.092	0.099	0.106	0.023	0.011	0.003	0.002	0.002
Petroleum and Coal Products	324	0.008	0.022	0.071	0.247	0.188	0.0003	0.019	0.006	0.011	0.083
Chemicals	325	0.051	0.058	0.074	0.355	0.117	0.006	0.017	0.015	0.004	0.008
Plastics and Rubber Products	326	0.189	0.061	0.028	0.114	0.188	0.01	0.007	0.009	0.002	0.004
Leather and Allied Product Manufacturing	316	0.657	0.012	0.004	0.109	0.117	0.013	0.011	0.001	0.0004	0.0003
Nonmetallic Mineral Products	327	0.210	0.043	0.024	0.218	0.187	0.005	0.021	0.004	0.002	0.004
Primary Metal Manufacturing	331	0.082	0.048	0.072	0.122	0.190	0.004	0.019	0.003	0.002	0.007
Fabricated Metal Products	332	0.188	0.065	0.039	0.142	0.17	0.005	0.017	0.009	0.005	0.004
Machinery, Except Electrical	333	0.112	0.119	0.045	0.216	0.138	0.006	0.012	0.007	0.014	0.01
Transport Equipment	336	0.037	0.158	0.039	0.182	0.163	0.004	0.015	0.008	0.006	0.004
Furniture and Fixtures	337	0.528	0.006	0.012	0.061	0.072	0.004	0.004	0.002	0.001	0.001
Miscellaneous Manufacturing Commodities	339	0.276	0.049	0.032	0.180	0.082	0.032	0.058	0.11	0.001	0.002

Figure 1
Trade-Weighted Industry-Specific Real Interest Differentials
(The United States is the base country)
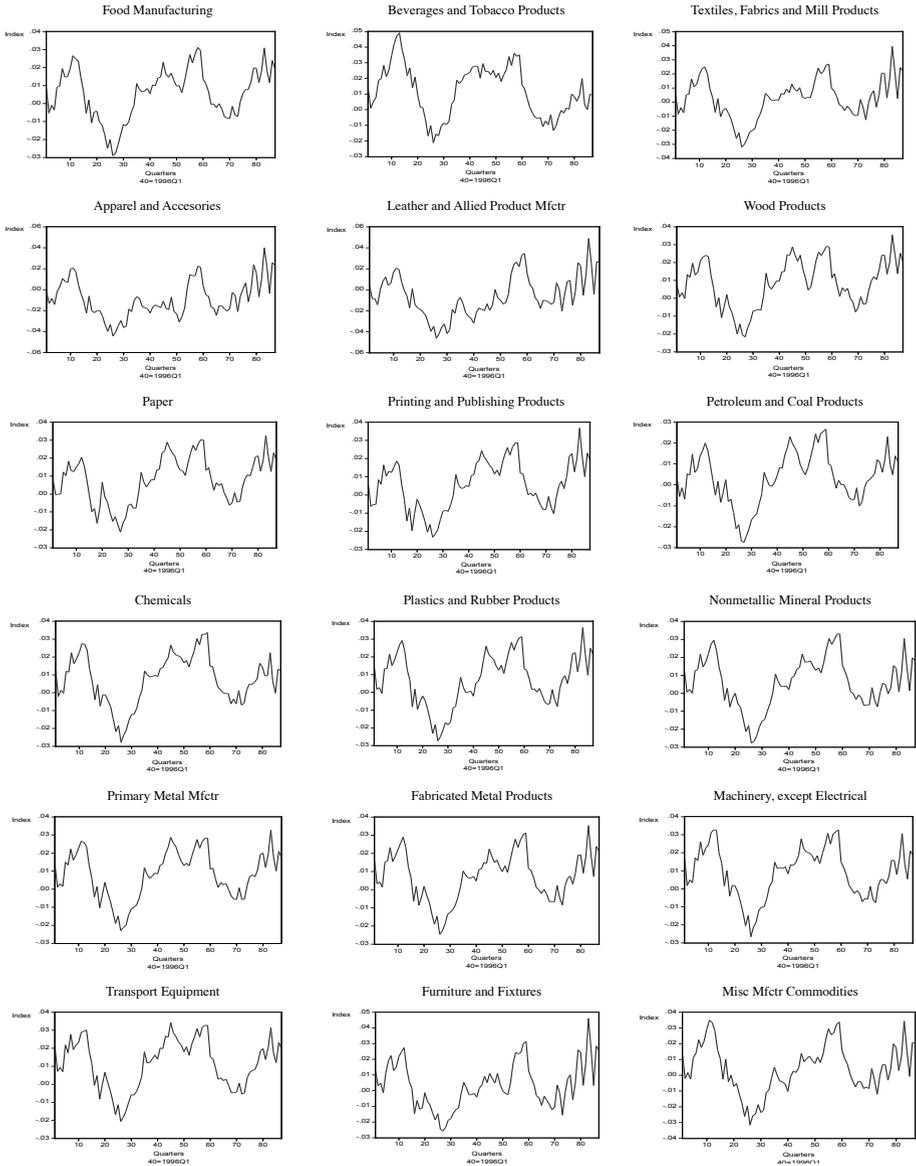
1 The U.S. main trading partners in the member states of European Union include Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, and the United Kingdom.

2 The U.S. main trading partners in the Latin American countries include Argentina, Brazil, Chile, Columbia, and Mexico.

3 As of 2007, the U.S. main trading partners in the member states of the Euro area include Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxembourg, the Netherlands, Portugal, and Spain.

While we find no obvious trends in the real interest differentials for many of the industries considered, these sectoral rates seem to exhibit high persistence in their fluctuations, which may raise doubts about support for UIP in these 18 different U.S. manufacturing industries. We investigate the stationarity of these series with four types of unit root tests. Results for these tests are shown in Table 2 and Table 3.

We, first, test the null of unit root in each industry's real interest-rate differential series with the conventional Augmented Dickey-Fuller (ADF) test (1979). To ensure absence of serial correlation in the residuals, we let the number of lags in the autoregression term be determined by the Schwartz information criterion (SIC). We also allow for seasonal dummies to enter the ADF regression given the mild seasonality we see in some of these series.

Columns (1) through (6) of Table 2 report results of a battery of tests of the stationarity properties of the real interest rate differentials across 18 industries.[10] The first column shows that the standard, the Augmented Dickey Fuller (ADF) test of the null of a unit root is rejected for 15 industries at the 10% significance level.[11] It is well-known that the ADF test may suffer from low power under certain alternatives. To address issues that may arise from residuals that might not be well-behaved, we conduct an extension of the ADF test supported by a generalized least squares regression (ADF-GLS). Elliot, Rothenberg, and Stock (1996) show that this test is more powerful than the conventional ADF test when applied to finite samples with dependent errors. Column (2) in Table 2 shows that the null of a unit root is rejected at the 5% level for every sector.[12] Column (3) reports results for the KPSS (1992) where we investigate the null hypothesis of stationarity in the dependent variable against the alternative of a unit root in these rates. The KPSS test fails to reject the null of stationarity of the rate differentials for every sector. Taken together, results from columns 1-3 suggest that industry-specific interest rate differentials across countries seem to be well-characterized by a stationary, albeit somewhat persistent, process. As we mentioned earlier, some of these unit root tests may suffer from low power under certainly alternatives. Specifically, they may fail to distinguish the persistence characteristics of a unit root process from a stationary process in the presence of important structural breaks. Structural change in interest rates over the sample we consider are a distinct possibility. Thus, we apply the Banerjee, Lumsdaine, and Stock (1992) test of a unit root in the presence of a single structural break (BLS), and the Lee and Strazicich (2003) test of a unit root in presence of multiple structural breaks (LS), in columns (4) and (5) respectively. Both tests show results consistent with those tests that abstracted from the possibility of structural change.

Table 2

Unit Root Test for the Trade-Weighted Industry-Specific Real Interest Differentials (in levels)

NAICS Sector Names	NAICS	(1) ADF $(r - r^*_i)$	(2) ADF-GLS $(r - r^*_i)$	(3) KPSS $(r - r^*_i)$	(4) BLS $(r - r^*_i)$	(5) LS $(r - r^*_i)$	(6) IPS $(r - r^*_i)$
Food Manufacturing	311	-2.865** (n = 0)	-1.995** (n = 0)	0.171 (n = 6)	-2.865* (n = 4)	-3.946** (n = 10)	-1.980*** (n = 0)
Beverages and Tobacco Products	312	-3.567*** (n = 4)	-1.915* (n = 4)	0.147 (n = 6)	-3.567*** (n = 8)	-5.236*** (n = 8)	-3.000*** (n = 4)
Textiles and Fabrics and Textile Mill Products	313/314	-3.196** (n = 4)	-3.149*** (n = 4)	0.197 (n = 6)	-3.196** (n = 4)	-4.345** (n = 5)	-3.200*** (n = 4)
Apparel and Accessories	315	-3.087** (n = 4)	-2.899*** (n = 4)	0.262 (n = 6)	-3.087** (n = 4)	-4.516** (n = 4)	-3.087*** (n = 0)
Wood Products	321	-2.169 (n = 0)	-2.187** (n = 0)	0.208 (n = 6)	-2.538 (n = 5)	-4.047** (n = 4)	-2.169*** (n = 0)
Paper	322	-2.107 (n = 0)	-2.128** (n = 0)	0.256 (n = 6)	-2.323 (n = 1)	-3.924* (n = 10)	-2.107*** (n = 0)
Printing, Publishing and Similar Products	323	-2.611* (n = 0)	-2.208** (n = 0)	0.266 (n = 6)	-2.611* (n = 4)	-3.234 (n = 4)	-2.184*** (n = 0)
Petroleum and Coal Products	324	-2.107 (n = 0)	-2.124** (n = 0)	0.255 (n = 6)	-2.417 (n = 3)	-3.614* (n = 10)	-2.107*** (n = 0)
Chemicals	325	-2.57* (n = 0)	-2.051** (n = 0)	0.171 (n = 6)	-2.782* (n = 4)	-3.379 (n = 10)	-2.103*** (n = 0)

Notes: Columns (1) and (2) present the Augmented Dickey Fuller and Generalized Least Squares extension test of the null of a unit root. Column(3) shows results of Kwiatkowski et al. tests of the null of stationarity. Column (4)shows the Banerjee et al test of the null of a unit root in the presence of a structural break. Column (5) shows the Lee and Strazcich unit root null test in the presence of two structural breaks. Column (6) shows results of a Im et al. panel unit root test. Parentheses contain n which denote optimal lag length selected by each test. An asterisk (***) denotes significance at the 0.01 level, (**) denotes significance at the 0.05 level, and (*) denotes significance at the 0.1 level.

Table 2 cont'd

Unit Root Test for the Trade-Weighted Industry-Specific Real Interest Differentials (in levels)

NAICS Sector Names	NAICS	(1) ADF $(r - r^*_j)$	(2) ADF-GLS $(r - r^*_j)$	(3) KPSS $(r - r^*_j)$	(4) BLS $(r - r^*_j)$	(5) LS $(r - r^*_j)$	(6) IPS $(r - r^*_j)$
Plastics and Rubber Products	326	-2.885* (n = 0)	-2.053** (n = 0)	0.112 (n = 6)	-2.685* (n = 4)	-3.785* (n = 8)	-2.153*** (n = 0)
Leather and Allied Product Manufacturing	316	-2.566* (n = 4)	-2.364** (n = 4)	0.308 (n = 6)	-2.949** (n = 1)	-3.588* (n = 10)	-2.566*** (n = 4)
Nonmetallic Mineral Products	327	-2.587* (n = 0)	-2.177** (n = 0)	0.115 (n = 6)	-2.868* (n = 4)	-3.598* (n = 8)	-2.868*** (n = 4)
Primary Metal Manufacturing	331	-2.692* (n = 0)	-2.05** (n = 0)	0.136 (n = 6)	-2.692* (n = 4)	-3.694* (n = 10)	-2.112*** (n = 0)
Fabricated Metal Products, NESOI	332	-2.746* (n = 0)	-2.187** (n = 0)	0.127 (n = 6)	-2.746* (n = 8)	-3.805* (n = 8)	-2.344*** (n = 0)
Machinery, Except Electrical	333	-3.059** (n = 0)	-2.17** (n = 0)	0.078 (n = 6)	-3.059** (n = 8)	-4.074** (n = 8)	-2.311*** (n = 0)
Transport Equipment	336	-2.852** (n = 0)	-2.002** (n = 0)	0.091 (n = 6)	-2.852* (n = 8)	-3.717* (n = 10)	-2.203*** (n = 0)
Furniture and Fixtures	337	-2.89** (n = 6)	-2.49** (n = 6)	0.183 (n = 6)	-3.157** (n = 5)	-4.002** (n = 5)	-2.570*** (n = 6)
Miscellaneous Manufactured Commodities	339	-3.173** (n = 4)	-2.885*** (n = 4)	0.117 (n = 6)	-3.173** (n = 4)	-4.125** (n = 4)	-3.173*** (n = 4)

Notes: Columns (1) and (2) present the Augmented Dickey Fuller and Generalized Least Squares extension test of the null of a unit root. Column(3) shows results of Kwiatkowski et al. tests of the null of stationarity. Column (4)shows the Banerjee et al test of the null of a unit root in the presence of a structural break. Column (5) shows the Lee and Strazicich unit root null test in the presence of two structural breaks. Column (6) shows results of a Im et al. panel unit root test. Parentheses contain n which denote optimal lag length selected by each test. An asterisk (***) denotes significance at the 0.01 level, (**) denotes significance at the 0.05 level, and (*) denotes significance at the 0.1 level.

We take caution in drawing too much inference from results from any one test on its own but, taken together, a preponderance of the evidence would seem to suggest strong evidence of the stationarity of these 18 industry-specific interest rates. The univariate characteristic of these tests will generally omit cross-country information that a longitudinal-based unit root test might incorporate. To that end, we follow Im, Pesaran and Shin (2003) to apply the IPS panel-based unit root test.

$$\Delta y_{jt} = \alpha_j + \rho_j y_{j,t-1} + \sum_{k=1}^{n_j} \gamma_{jk} \Delta y_{j,t-k} + \varepsilon_{jt}, \quad j = 1,..., N \quad t = 1,...,T, \text{ (8)}$$

for each industry j where the error terms ε_{jt} are with zero means and finite heterogeneous variances, σ^2_j. The IPS evaluation tests if the null hypothesis $H_0 : \rho_j = 0$ for all j against the alternative hypothesis that all series are stationary, $H_1 : \rho_j < 0$, for some j. The $\bar{t}$- statistic constructed from the average ADF t-statistics is in the following form:

$$\bar{Z}_t = \frac{\sqrt{N}[\bar{t}_{NT} - a_{NT}]}{\sqrt{b_{NT}}} \Rightarrow N(0,1) \tag{9}$$

where $\bar{t}_{NT} = \frac{1}{N}\sum_{j=1}^{N} t_{jT}$; $a_{NT} = \frac{1}{N}$; $b_{NT} = \frac{1}{N}$; $E[t_{jt}(n_j)]$ and $Var[t_{jt}(n_j)]$.

In line with previous univariate unit root tests, the IPS test in the form of Equation (8) without a linear time trend is used to evaluate the stationarity of 18 trade-weighted industry-specific real interest differentials. Column (6) in Table 2 presents the IPS test results for the panel of 18 trade-weighted industry-specific real interest differentials. The null of a unit root is rejected at the 1% significance level for every sector.

Evidence from Table 2 seem to be consistent with UIP, when considering the United States as the base country, in 18 different industrial sectors. Taken together, the dynamics in Figure 1 and correlation estimates in Table 3 suggest a strong rate co-movement among these industries which explains how the robust stationarity properties of these variables.

Our results seem to be in direct contradiction to the argument provided by Gagnon and Unferth (1995) who, in failing to reject the null of a unit root, they conclude that the U.S. real interest rate has the largest and most persistent deviations from the estimated world real interest rate. By disaggregating and focusing on industry-specific real interest rate differentials, we find no such evidence of persistence in U.S. industry-specific interest rate deviations from those of 25 other economies under study. The rejection of the null of a unit root in interest rate differentials

Table 3
Correlation Coefficients among the Trade-Weighted Industry-Specific Real Interest Differentials

NAICS	311	312	313/4	315	321	322	323	324	325	326	316	327	331	332	333	336	337	339
311	1.000																	
312	0.816	1.000																
313	0.955	0.704	1.000															
315	0.507	0.100	0.703	1.000														
321	0.611	0.219	0.786	0.948	1.000													
322	0.967	0.811	0.886	0.355	0.469	1.000												
323	0.948	0.774	0.861	0.317	0.444	0.984	1.000											
324	0.967	0.733	0.924	0.461	0.572	0.962	0.975	1.000										
325	0.961	0.777	0.940	0.525	0.631	0.921	0.921	0.945	1.000									
326	0.962	0.893	0.881	0.340	0.474	0.943	0.940	0.933	0.945	1.000								
316	0.979	0.795	0.941	0.486	0.622	0.962	0.953	0.962	0.951	0.955	1.000							
327	0.974	0.857	0.939	0.469	0.606	0.939	0.931	0.940	0.959	0.979	0.979	1.000						
331	0.972	0.859	0.893	0.342	0.468	0.984	0.978	0.961	0.939	0.975	0.977	0.969	1.000					
332	0.981	0.848	0.931	0.438	0.562	0.970	0.958	0.958	0.936	0.968	0.986	0.984	0.987	1.000				
333	0.956	0.927	0.875	0.316	0.450	0.946	0.926	0.913	0.908	0.980	0.955	0.974	0.977	0.980	1.000			
336	0.928	0.905	0.809	0.190	0.325	0.962	0.955	0.912	0.874	0.960	0.931	0.935	0.981	0.962	0.979	1.000		
337	0.913	0.644	0.960	0.707	0.791	0.871	0.852	0.898	0.878	0.832	0.926	0.909	0.868	0.922	0.842	0.795	1.000	
339	0.931	0.774	0.954	0.627	0.758	0.858	0.829	0.871	0.909	0.903	0.951	0.958	0.891	0.934	0.909	0.830	0.932	1.000
	0.90	0.74	0.89	0.50	0.58	0.95	0.93	0.94	0.93	0.95	0.96	0.96	0.95	0.96	0.93	0.87	0.97	0.97

among 25 countries is supportive of relatively close interest rate co-movement at lower frequencies. Thus, importantly, we find that for 18 different industries, there is strong and statistically significant evidence that the uncovered interest rate parity (UIP) holds among 25 countries.

Conclusion

The *interest rate parity* theorem relates domestic interest rates and exchange rates and explains how the difference between the domestic and the foreign real interest rates should equal the expected depreciation of the domestic real exchange rate. Thus, if there is parity in real interest rates among countries, then the impact of domestic monetary policy on the domestic rate will be related to the degree to which policy affects interest rate fluctuations throughout the world. While the theoretical predictions of the interest rate parity are relatively standard and uncontroversial, uncovering this parity in the data has proved difficult. In this paper, we go about un-covering the parity by focusing on disaggregated micro-level data and considering the U.S. as the base country. We investigate the hypothesis of real interest rate parity by employing both univariate and panel-based unit root tests for 18 distinct series of industry-specific trade-weighted real interest differentials across 25 countries. In contrast to the many studies mentioned earlier, we are able to uncover the parity in real interest rates across countries by showing that these micro-level interest rates seem to be stationary in levels. However, most differentials seem to exhibit more persistence than what the theoretical prediction would seem to advance. Accounting for such persistence undoubtedly constitutes an important extension which as yet remains unanswered.

Our results have important policy implications on two avenues: central bank policy and the business sector. Regarding central bank policy, Valcarcel (2011) — on related work — concludes that even if the *Great Moderation* had indeed been a result of better monetary policy, more forward-looking monetary prescriptions would not have had an effect on volatility reductions of the real exchange rate commensurate to that of economic activity. Thus, he argues that policy prescriptions aimed at trade openness, terms of trade, and current accounts should probably take more of a center stage by central banks. Our finding here of micro-level interest rate parity would be informative in that regard. In terms of the business sector, understanding whether interest rate parity holds at the micro level allows firms in these industries to better hedge against exchange rate fluctuations which, according to Valcarcel (2011), have been on the rise since the 1980s.

End Notes

1. This work, however, does not specifically address the interest rate parity issue.

2. In our model, we consider the United States as the benchmark domestic economy. Our results contrasts those of Mark (1985) which lend further support to the idea that failure of aggregate tests of interest rate parity could be due to aggregation issues.

3. Canada, France, Germany, Japan, Italy, the Netherlands, Switzerland, the United States, and the United Kingdom.

4. However, Chaboud and Wright (2005) find evidence in support of UIP when considering exchange rate movements and interest differentials at much higher frequencies.

5. We focus on quarterly frequencies because studies of aggregate measures of the exchange rate have generally failed to support UIP at those frequencies and we want to investigate here whether those results could be an artifact of aggregation issues.

6. The U.S. International Trade Commission, the Feenstra's Trade Database, International Financial Statistics (IFS), the Board of Governors, and Bloomberg L.P., which is based on 24 trading partners in 18 manufacturing industries in the U.S. (refer to data section).

7. J represents any given one of 18 different U.S. manufacturing industries according to USIC code.

8. Where r_t, the real interest rate in the U.S. at time t, represents the domestic rate in our model.

9. It is possible that each manufacturing industry faces different inflation because firms' investment decisions are mainly involved in sales or cost of production. If a firm is concerned more about its sales than production cost, then exports trade share and consumer price index may be used to compute the real interest differential; and import share and producer price index are necessary if the firm considers its production cost more. This study just assumes that the 18 U.S. manufacturing industries face the same CPI-based inflation.

10. Generally, these test results were not sensitive to the (in)exclusion of seasonal dummies.

11. Given that relatively little was known about the time series properties of these industry-specific exchange rates, we test for the differenced series to verify that none of these series could be persistent enough to be characterized by an I(2) process. Indeed, while we show evidence from the ADF test that 15 of the 18 industries we tested can be characterized as level stationary, wood, paper, and petroleum and coal products seem to exhibit an order of integration higher than I(1) according to ADF test. A preponderance of the evidence across all the tests we conducted would seem to suggest that most industry-specific interest rates are level stationary and all are difference-stationary.

12. Except beverages and tobacco products which are rejected at the 10% instead.

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