Evidence on Financial Globalization and Crises: Interest Rate Parity

by

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The Interest Rate Parity (IRP) relationship is one of the most relied upon indicators of financial globalization. IRP plays such a key role in global macroeconomic models that it is taken as a benchmark for perfect capital mobility between markets. In this paper, we review the theoretical basis and historical origins of the interest rate parity relationship. Empirical evidence supporting IRP became so wide-spread that by the start of the 21st century, economists and financial professionals essentially took IRP for granted. However, with the start of the global financial crisis in summer 2007 deviations from IRP increased significantly. Empirical evidence suggests that deviations can be linked to greater credit and counterparty risk among bank dealers, and a reduction in risk capital, as well as wider bid-ask spreads in currency markets. In the aftermath of the global financial crisis, deviations from covered interest parity have increased considerably relative to a decade ago. Calibrating whether these deviations are efficient market violations, or simply a reflection of greater costs and risks, is a new challenge for financial economists.

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1. Introduction and Overview

The Interest Rate Parity (IRP) relationship is one of the most relied upon indicators of financial globalization. When the parity relationship holds, covered yields are identical on assets that are similar in all important respects (e.g. maturity, default risk, exposure to capital controls, and liquidity) except for their currency of denomination. The parity relationship plays such a key role in global macroeconomic models that IRP is taken as a benchmark for perfect capital mobility between markets. Like other parity conditions in international finance, IRP has historical origins that go back centuries to David Hume, David Ricardo and possibly earlier. In the twentieth century, the theory of interest rate parity was formalized by John Maynard Keynes (1923). Empirical studies in the later half of the twentieth century documented the extent to which various factors such as asynchronous data, non-comparability in asset risks, transaction costs, and taxes accounted for deviations from parity. With the development of offshore capital markets in the 1960s, researchers found a market setting where the data largely supported IRP up to a tolerance that depended on foreign exchange and money market transaction costs. For the next 50 years, further research on higher frequency data, assets with longer maturities, and alternative pairs of currencies provided further support to the IRP relationship. However, in financial markets where mobility is impeded, deviations from IRP can be large and volatile. Common examples include countries that restrict currency convertibility. A more vivid example is the recent global financial crisis that commencing in the summer of 2007 allowed substantial deviations from IRP among the world's major convertible currencies.

In the remainder of this chapter, we review the theoretical basis and historical origins of the interest rate parity relationship. In section 3, we introduce the idea of 'limits to arbitrage' and other factors often associated with parity deviations. We present empirical evidence on parity in section 4. More recent evidence of deviations during the 2007-09 financial crisis, and possible explanations, are discussed in section 5. The final section offers conclusions and cautionary notes on the interpretation of deviations from IRP.

2. Origins and Theory of Interest Rate Parity

Arbitrage is a central concept in financial economics. References to arbitrage and its impact on prices can be found in the works of early political economists such as Ricardo (1811), Cournot (1838) and Walras (1870).[1] It was John Maynard Keynes, however, writing in the *Tract on Monetary Reform* (1923) who popularized the expression interest rate parity. Keynes described (in words) the mathematical notion of parity between the forward premium and interest differential, and also offered a list of reasons why parity might be violated, as it often was in many markets during Keynes' life.

To develop the parity relation, consider a world with two currencies, the USD ($) and the GBP (£), one-period interest rates in the two currencies given by i($,1) and i(£,1) and spot and one-period forward rates in $/£ defined by S_t and $F_{t,1}$ respectively. The forward contract binds the buyer to deliver $F_{t,1}$ units of USD in one period, in exchange for £1. On the other hand, an agent could borrow $S_t/(1+i(£,1))$ units of USD today at a

[1] For example, in Walras (1874, Lesson 34, para. 314) "Whenever this state of general equilibrium is disturbed, it will be restored by arbitrage operations in bills of exchange exactly like arbitrage operations in commodities. … Bills of exchange are *par excellence* the most suitable commodities for arbitrage operations."

cost of i($,1), exchange the USD for GBP in the spot market, and invest those GBP at the rate i(£,1) for one-period, which would also result in net proceeds of £1 one period hence. Both alternatives: (1) buying one GBP at a cost $F_{t,1}$ and (2) borrowing USD today at a cost i($,1), converting the USD to GBP in the spot market, and investing those GBP at the rate i(£,1) result in the same cash flows in period one. As a result, ignoring the impact of transaction costs, taxes, and uncertainty, the two alternatives must have the same price or cost. This equality of prices is summarized in equation 1.

$$F_{t,1} = S_t \frac{1 + i(\$,1)}{1 + i(£,1)} \tag{1}$$

Equation (1) demonstrates that in equilibrium, the forward rate is set equal to the spot rate augmented by the ratio of yields between the two currencies. The equation also implies that the forward rate is a redundant instrument. The cash flows of a forward contract can be fully replicated by a spot contract combined with borrowing and lending in the two currencies. This fact helps to explain why forward contracts are typically not observed in less developed or emerging financial markets where borrowing and lending is limited, and why deviations from parity could appear when either borrowing or lending is impeded.

It is a simple matter, but still useful, to rearrange the terms in equation (1) to inspect the following relationships.

$$1 + i(\$,1) = [1 + i(£,1)] \frac{F_{t,1}}{S_t} \qquad\qquad 1 + i(£,1) = [1 + i(\$,1)] \frac{S_t}{F_{t,1}} \qquad (2), (3)$$

Equation (2) reveals that investing in USD is equivalent to first converting USD to GBP in the spot market, then investing GBP at the market interest rate, and covering the currency exposure by selling principal and expected interest earnings in GBP at the forward rate $F_{t,1}$. Equation (3) demonstrates the analogous concept, that the yield on a GBP position is equivalent to the yield on a USD position teamed with a forward contract to cover against exchange risk. Equations (2) and (3) help clarify that in equilibrium, markets should reach a parity (i.e. Interest Rate Parity) between interest rates in foreign and domestic currencies. Because the replicating transaction involves covering foreign currency exposure, interest rate parity is sometimes referred to as the Covered Interest Parity (CIP) relationship.

Equations (2) and (3) also suggest that if borrowing in one market, say USD, is impeded, then agents can compensate by borrowing in GBP and simultaneously entering into offsetting spot and forward currency contracts. Or if investing in GBP seems subject to unusual costs or risks, agents can create a synthetic GBP position by investing in a USD security and simultaneously entering into offsetting spot and forward currency contracts. Creating synthetic positions is straightforward, but as we discuss in Section 5, they can create considerable value when financial markets are constrained or under stress. Precisely at these times, investors may willingly choose a synthetic that yields less, or borrowers may choose a synthetic that costs more in order to overcome a market dislocation.

By taking equation (1) and subtracting one from both the left and right-hand-side terms, we have

$$\frac{F_{t,1} - S_t}{S_t} = \frac{i(\$,1) - i(£,1)}{1 + i(£,1)} \qquad (4)$$

which shows that the percentage forward premium is (approximately) equal to the interest differential. In equilibrium, a currency with the high interest rate should trade a forward discount to reflect the fact that a lower return is available in the second currency.[2] Readers should be careful to distinguish equation (4) from the Uncovered Interest Parity (UIP) relationship which states that the interest differential should equal the expected rate of depreciation in the USD (home currency), or

$$\frac{i(\$,1) - i(£,1)}{1 + i(£,1)} = \frac{E(S_{t+1}) - S_t}{S_t} \qquad (5)$$

Covered interest parity (equation 4) suggests a pure arbitrage in which prices of all four variables can be observed simultaneously, while UIP relies on the expected future spot rate which cannot be observed directly at time *t*, or compared to the actual future spot rate until time *t+1*.

The IRP equilibrium condition described in equations (1) – (4) is facilitated by arbitrage. In equation (1), if $F_{t,1}$ were less than the synthetic price given by $S_t \frac{1 + i(\$,1)}{1 + i(£,1)}$, arbitragers would buy the forward contract and sell the synthetic, helping to restore a balance. "Selling the synthetic" GBP forward would entail borrowing GBP, buying USD in the spot market, and investing in USD for one period. In equation (2), if USD interest rates exceeded GBP rates on a covered basis, arbitragers would borrow in GBP, hedge themselves with spot and forward contracts, and lend the synthetic USD at a higher rate. At the margin, arbitrage purchases tend to raise prices (of currency and money market instruments), sales tend to lower prices (of currency and money market instruments), and thus tend reduce any measured deviations from parity. However, arbitrage transactions entail both costs (in currency markets and money markets) and risks (of default on investment positions or forward contracts, or possible controls on capital movements).

[2] For example, given S = 1.50 \$/£, i(\$) = 4% and i(£) = 8%, we expect F = 1.444 \$/£. The GBP has the higher interest rate and it is at a discount (i.e. cheaper) in the forward market.

These costs and risks serve to limit the amount of arbitrage and retard the speed or even preclude an ultimate convergence of rates toward parity.

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3. Limits to Arbitrage and Factors Associated with Parity Deviations

While the mathematics of IRP are straightforward, it has long been recognized that there are many reasons why the forward premium and interest differential would not satisfy a simple mathematical relationship. Keynes (1923) provided a list of cautionary reasons why arbitrage might be insufficient to produce IRP. He emphasized that arbitragers can be subject to credit risks if a counterparty were to default on a forward contract or on a investment position in one currency (that is used to offset a short position in another currency). When the legs of an arbitrage are conducted in different countries, another risk is opened through possible capital controls and sovereign risks. As Keynes (1923, pp. 126-7) argued, arbitragers might weigh the "small turns" they could earn out of interest differentials against the possibility of large losses through a credit event, and find that these "may deter conservative banks from doing the business on a substantial scale at any reasonable rate at all." In much the same vein, Keynes suggested that these risks could curtail the amount of funds committed to arbitrage. As he expressed it, "the floating capital normally available, and ready to move from centre to centre for the purpose of taking advantage of moderate arbitrage profits between spot and forward exchange, is by no means unlimited in amount, and is not always adequate to the market's requirements."[3]

During Keynes' lifetime and up until the development of offshore capital markets, deviations from CIP were frequent, and typically attributed to these usual suspects. In the

[3] Keynes (1923, pp. 128-9).

first foreign exchange market monograph prepared by the Federal Reserve Bank of New York, Holmes (1959) adopted Keynes' assertion that deviations from CIP would need to reach 0.50% per annum to make it worthwhile for arbitragers to move funds from one market to another. Holmes reaffirmed that during the Bretton-Woods period, arbitrage flows could be limited by exchange controls in place, but flows could also be deterred by possible future controls, sovereign risks, bank credit risk, as well as the limited stock of bank capital available. Holmes (1959, pp. 51-2) discussed several examples including the Suez Canal crisis of October 1956 and the Sterling Exchange Crisis of August 1957 that opened up sizeable CIP deviations (of 2-3 percent or more) favoring flows to the USD and out of GBP. These deviations calculated using U.S. and U.K. Treasury Bill rates lasted for several weeks or more, to be eventually trimmed when domestic policy responded to the imbalance or the crisis subsided.

4. Empirical Evidence on Interest Rate Parity from the Last 50 Years

Empirical studies of covered interest parity have focused on a short list of possible explanations – transaction costs, risk of default or non-performance in foreign exchange contracts, sovereign risks and capital controls, taxes, and non-synchronous or poor-quality data – most of which were alluded to by Keynes. In their survey of studies from the 1950s and 1960s, Officer and Willett (1970) highlighted the importance of limits to arbitrage and transaction costs in allowing deviations from CIP, which they concluded "need not imply either disequilibrium or market imperfection." However, accurate measures of transaction costs and market imperfection were still an unsettled matter.

a. Early Empirical Studies

Branson (1969) is one of the earliest studies to investigate how tightly market data satisfied CIP. Using weekly data over a six-year period, 1959-64, Branson measured the arbitrage incentive between US and UK Treasury bills. Market discussions in the *Federal Reserve Bulletin* labeled certain periods as "speculative." Once those periods were eliminated, Branson estimated that the average deviation was about 0.18%, which he took as a reasonable figure, lower than 0.50% offered by Keynes and higher than a 0.06% estimate offered by Einzig (1961) both based on their market experience. Calculations using US and Canadian Treasury Bills over a shorter period produced a similar 0.18% estimate of the minimum inventive needed to induce covered arbitrage between these countries.

About the same time, Aliber (1973) offered the idea that arbitrage between traditional Treasury Bills exposed the arbitrageur to differential political risks and risks of capital controls. If one considered arbitrage between offshore instruments (e.g. $ and £ deposits issued by the same Zurich bank), then political risks would be identical and not separately impede arbitrage. Based on weekly data for the January 1968 – June 1970 period, Aliber showed that CIP deviations were far smaller, and more tightly distributed around zero, using offshore instruments compared to Treasury Bills.[4] Furthermore deviations in the offshore market were symmetrical about zero, whereas deviations using Treasury Bills were skewed right and occasionally very large (ranging from 2% to over 8.0%). This led Aliber to conclude that CIP using Treasury Bills captured a non-random element which he labeled political risk.

[4] Aliber (1970) reported that 81% of the deviations were within 0.5% using offshore instruments, while only 28% were within that interval using Treasury Bills.

In a pair of papers, Frenkel and Levich (1975, 1977) proposed a new technique for measuring the efficiency of international capital market in eliminating arbitrage profit opportunities. Rather than make an interpretation based on a regression of the forward premium against an interest differential, or calculation of the mean deviation, FL argued that each data point should be treated as a separate event and a new opportunity for the market to engage in arbitrage and establish parity. Thus how well CIP worked could be summarized by the percentage of data points captured within a "neutral band" given by an independent estimate of transaction costs. Using estimates of foreign exchange transaction costs (based on triangular currency arbitrage) and money market transaction costs (based on spreads), FL (1975) showed that after taking transaction costs into account, there were few, if any, deviations from CIP remaining in 1962-67, a tranquil pegged rate period. In that sense, CIP held exceedingly well among currency pairs in the offshore market.

In a follow-up paper, FL (1977) extended their sample to include 1968-69, a more turbulent pegged rate period, and 1973-75, a managed floating rate period immediately after the demise of Bretton Woods. Once again considering arbitrage between the $ and £ (as well as the Canadian dollar), FL concluded that transactions costs had risen during both the turbulent peg and managed floating periods, but CIP still held in the sense that in offshore markets, very few observations indicated the availability of an arbitrage profit after taking transaction costs in account.

b. Refinements to the Traditional Model and Improved Data

Over the next 10-15 years, various authors contributed additional refinements to the basic textbook story of interest rate parity. Some authors focused on the size of the neutral band (believing that previous studies had overstated the margin needed to induce arbitrage), others considered omitted factors (such as taxes), and still others investigated how empirical estimates of transaction costs and the quality and periodicity of data impacted the results.

Deardorff (1979) hypothesized that “round trip” arbitrage – that is, starting with one USD and measuring whether 4 transactions, either clockwise or counter-clockwise as in Exhibit 1 left the arbitrageur with more or less than one USD – was really an overly demanding measure. In practice, a manager holding USD today but needing GBP in one period had two stylistic choices. The manager could (1) enter into a forward purchase of GBP today and retain his USD earning interest until delivery date on the forward, or (2) buy GBP on the spot market today and invest the proceeds at the market interest rate for one period. Deardorff argued that even the smallest discrepancy would induce the manager to pick the lowest purchase price, and help restore parity. Deardorff showed that the interest rate parity “box” in Exhibit 1 held many similar comparisons, which he dubbed “one-way arbitrage.” Deardorff claimed that the incentives to engage in one-way arbitrage were so prevalent, that these would take hold first, result in far smaller deviations from IRP, and in all likelihood preclude the possibility of round-trip arbitrage based on market prices.

Levi (1977) observed that the traditional IRP formulation ignored taxes and that as a practical matter it was after-tax (rather than pre-tax) gains and losses that drove arbitrage. If taxes applied similarly on gains and losses in currency markets as well as on interest paid or earned on money market instruments, then the traditional expression of IRP (our equation 4, for example) would be unaffected. However, if currency market transactions were subject to capital gains tax (τ_k), and interest income were subject to ordinary income tax (τ_y), and the tax rates were unequal, then the interest rate parity line would no longer be a 45° line as implied by equation (4). In particular, in the likely case that $\tau_k < \tau_y$, the IRP line would flatten.

For example, assume τ_k = 25% and τ_y 50% meaning that arbitrageurs kept three-quarters of the gain on a forward-spot transaction, but only one-half of the net interest earned from the interest differential. The ratio $(1-\tau_y) / (1-\tau_k)$ = 0.50/0.75 = 0.67 suggests that the after-tax IRP line has a slope of 0.67 compared the pre-tax IRP line which has a slope of 1.0. In addition, Levi noted that it was possible for residents of one country to face the tax rates just described while residents of another country could face no taxes or equal taxes on capital gains and interest charges. It that case, covered interest arbitrage could entail a measure of tax arbitrage as well.[5]

While Levi's treatment of taxes raises challenges to the traditional model, market prices are ultimately determined by the marginal actor, who in forex markets is likely to be a hedge fund or bank operating offshore in a low-tax or no-tax setting. In this case, while the traditional IRP line would still reflect market equilibrium, any agents subject to differential capital gains and ordinary income tax rates could see these points as a profit opportunity.

[5] Still other complications are introduced when short-term transactions are subject to ordinary income tax rates while long-term transaction are given capital gains tax treatment.

Adler and Dumas (1979) argued that the traditional formulation of IRP assumed that forward contracts were risk-free when in fact these contracts, as well as bank money market instruments, were subject to default. Adler and Dumas went on to suggest that the risk in forward contracts and covered interest arbitrage transactions should not be treated in isolation, but rather in the context of the larger portfolio of stocks and bonds open to investors. Despite this, the authors acknowledged that in practice and during "normal" times, an interbank market restricted to very high quality names might operate independently to eliminate arbitrage opportunities.

Adding to the discussion of political risk as a source of deviations from IRP, Dooley and Isard (1980) highlighted the distinction between known capital controls in place, and the prospect of future capital controls. The former, because they are known, represent only a cost or barrier to arbitrage, while the latter are unknown and represent a risk that could inhibit arbitrage. During the 1970-73 period of controls in Germany, the authors concluded that as much as 1-2 percent per annum of observed deviations from IRP could be attributed to the political risk of future controls.

Other authors focused more on the quality and type of data used in empirical studies of IRP. Clinton (1988) noted that interbank dealers typically trade in FX swaps (representing a simultaneous purchase and sale of foreign exchange) that benefit from a single small bid-ask spread rather than deal separately in spot and forward contracts which each carry their own spread. With this modification, Clinton showed that the width of the neutral bank in IRP was smaller than in previous studies. Despite this, Clinton's empirical evidence still supported the conclusion that markets were efficiently eliminating nearly all arbitrage opportunities.[6]

Taylor (1989) offered the first empirical study using high-frequency data that was carefully time-synchronized. Taylor's data covered three days (November 11, 12, and 13) in 1985 taking observations every 10 minutes from 9:00 am until 4:50 pm for a total of 144 data points per day. Observations on all IRP variables were recorded to have a tolerance of one minute with each other. Taylor's metric was similar to the Frenkel-Levich (1975, 1977) studies, that is simply counting the number of profit opportunities available through arbitrage for different currency pairs (US dollar-German mark, and US dollar-UK sterling) and different maturities (1, 3, 6, and 12 months). With four maturities, six borrowing-lending currency combinations, and 144 data points the complete sample totaled 3,456 observations. Taylor confirmed that the foreign exchange market was highly efficient in the sense that there were virtually no opportunities for round-trip arbitrage, and only few and scattered possibilities for one-way arbitrage.

c. Further Applications and Empirical Evidence on IRP

As empirical evidence favoring covered interest parity mounted, researchers moved on to consider further implications of IRP as well as various financing and investment strategies based on equation (4) and also to subject the theory to more stringent tests based on higher frequency data.

[6] McCormick (1979) also raised the possibility that published, printed data sources available in the 1970s might not be adequately time-synchronized and could overstate interbank trading costs. Even so, McCormick (1979, p. 416) concluded that using higher quality Reuters exchange market data led to the same result that virtually all discrepancies from CIP in the offshore market could be explained by transaction costs.

In the lead up to the floating exchange rate period, stylistic models in international finance often considered real interest rate equalization as a criterion for international capital mobility. In somewhat the same vein, Feldstein and Horioka (1980) reasoned that if capital were perfectly mobile internationally, then countries should be able to borrow enough abroad to fund domestic investment whenever there was a shortfall in domestic savings or government crowding out. Finding that national investment and savings rates were highly correlated led Feldstein and Horioka to conclude that capital was not highly mobile, a conclusion that seemed at odds with the surge in international financial activity. Against this backdrop, Frankel and MacArthur (1988) examined data for 24 countries, including many smaller industrialized countries and emerging markets. Frankel and MacArthur measured the size of covered interest differentials, which they took as measures of the barriers to international capital mobility. Overall, the authors concluded that "the covered interest differential is a better measure of capital mobility – in the sense of financial market integration across national boundaries – not only than savings-investment correlations, but also than real interest differentials."[7] Covered interest parity remains the benchmark for detecting departures from perfect capital mobility.

As financial markets in other countries developed, and in particular as the currency swap market developed, market practitioners implicitly relied on covered interest arbitrage to synthetically create new securities and develop opportunistic strategies toward borrowing and investing. For example, where companies were constrained to obtain funding through illiquid, and relatively costly, bank loans, many firms elected to borrow using liquid, low cost USD commercial paper and swap the proceeds into their domestic currency using spot and forward contracts. This is a direct

[7] Frankel and MacArthur (1988, p. 1111)

application of equation (3) and equivalent to creating a synthetic domestic currency commercial paper contract. In another application of equation (3), Koh and Levich (1994) demonstrated that highly liquid USD interest rate futures contracts could be combined with currency futures contracts to create synthetic foreign currency interest rate futures. These examples illustrate the use of synthetics to overcome a particular market failure – either the lack of a domestic commercial paper market or a domestic interest rate futures market.

On the other hand, equation (2) suggests that if borrowers could spot unusually low funding rates abroad (or if investors could spot unusually high yields), then combining the foreign currency security with a currency swap could translate and preserve these gains into the agent's home USD currency. In separate studies, McBrady and Schill (2007) examine a large sample of sovereign government and agency issuers and McBrady, Mortal and Schill (2010) examine a similarly large sample of international corporate bond offerings. The authors find that the currency choices for both sets of issuers follow an opportunistic pattern. In an example of one-way arbitrage, bond issues appear timed to take advantage of deviations from long-term covered interest parity, even when the yield difference is as small as 4 to 14 basis points. The analysis leads McBrady, Mortal and Schill (2010, p. 695) to conjecture that "that opportunistic issuance by corporations may be a primary mechanism for driving covered interest yields toward parity."

Finally, just prior to the recent global financial crisis, Akram, Rime and Sarno (2008, 2009) produced a pair of studies based on tick-by-tick data over a seven-month period (February 13 – September 30, 2004), 3 exchange rates (USD/EUR, USD/GBP, and JPY/USD) and 4 maturities (1, 3, 6, and 12 months). Counting bid and ask quotations, the number of sample observations exceeds 45 million. At this level of microscopic examination, the authors develop several important findings. First, deviations from covered interest parity are present in the data; they are short lived (from 30 seconds to 4 minutes in some cases) but they are economically significant. Opportunities for one-way arbitrage (both so-called owner's arbitrage and borrower's arbitrage) appear more numerous (perhaps 10-50% of the observations) and these may also be economically significant (in the range of 2-6 pips). These profit opportunities are quickly dissipated, more so when market activity is high, but less so when volatility increases. Overall, the market seems fairly efficient while still opening a window for algorithmic traders to search out very small profits in the dispersed forex market landscape.

5. Empirical Evidence on Interest Rate Parity During the Global Financial Crisis

The global financial crisis of 2007-09 thrust most financial markets into a period of stress and disruption of certain trading metrics. In some respects, foreign exchange markets continued to operate smoothly. For example, spot currency trading volume in London and New York actually rose in October 2008 compared to October 2007. And because of the CLS Bank launched in 2002, banks could confidently trade forex with other banks and many corporate counterparties without fear of a total loss resulting from settlement risk given default by a counterparty.[8] In other respects, however, the foreign

[8] In a forex trade involving USD 1,500,000 exchanged for GBP 1,000,000 the CLS Bank collects both legs of the transaction before sending the funds on to the appropriate counterparty, thus eliminating settlement risk. However, not all forex trades are intermediated by the CLS Bank. Indeed, the German KFW Bank delivered EUR 300 million to Lehman Brothers on September 15, 2008 and lost the entire amount as the

exchange market experienced disruptions similar to that in other markets. Melvin and Taylor (2009) document that comparing the post-Lehman crisis period of Sept-Oct. 2008 with the pre-crisis period of Sept-Oct. 2007, bid-ask spreads in spot and 3-month swap transactions in the major currency pairs increased by a factor of 4-5 times, or more. Spreads for longer maturities, less active currency pairs and larger size deals experienced even greater increases.

Deviations from covered interest parity provide their own barometer of conditions in the foreign exchange market. Exhibit 2 shows 3-month CIP deviations for the EUR-USD daily from January 1, 2000 until September 30, 2010. The period through July 2007 appears tranquil with essentially all deviations bounded within 25 basis points of parity and upwards of 95% of all deviations bounded with 10 basis points of parity. This period strongly conveys the notion of a highly liquid market with virtually perfect capital mobility between short-term EUR and USD instruments.

Whiffs of the impending crisis appear in the summer of 2007 when two hedge funds operated by Bear Stearns suspended redemptions and BNP-Paribas announced that they were unable to value three hedge funds. By the fall of 2007, one of the top mortgage banks in the United Kingdom, Northern Rock, sought support from the Bank of England. By February 2008, Northern Rock was nationalized, and by March 2008, Bear Stearns collapsed and was sold to JP Morgan Chase. In the initial phase of this pre-Lehman crisis period, deviations from CIP jumped to roughly 40 basis points, then recovered, and after the Bear Stearns collapse returned to the 40-50 basis point range through the summer of 2008.

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bankrupt Lehman could not deliver their USD leg of the transaction. See Levich (2009) for a discussion of the role of the CLS Bank in forex clearing and settlement.

Once Lehman Brothers failed on September 15, 2008, deviations from CIP in the most active currency pair in the most active financial market in the world spiked to over 200 basis points and for the most part remained above 100 basis points for the next three months. Even though CIP deviations subsided to the 25-50 basis point range by spring 2009, and have continued in this range for the remainder of the sample, it is clear that this is a far higher range compared to the tranquil period of near perfect capital mobility in the first few years of the millennium.[9]

Several authors have studied what factors led to the sharp increase in CIP deviations at the start of the crisis, and the rapid decline in CIP deviations in the spring of 2009. According to Baba and Packer (2009) and corroborated by Coffey et al. (2009), the combination of funding shortages in the US financial markets as well as a heightened sense of counterparty risk even among large banks active in the foreign exchange market led to a deterioration in liquidity and observed deviations from covered interest parity in the USD-EUR pair.[10] Both of these studies find that prior to the Lehman Brothers bankruptcy, capital constraints and liquidity risk proxies explain much of the observed deviations from CIP. After the Lehman collapse, Coffey et al. (2009 September) find that counterparty risk and credit risk proxies become significant variables explaining CIP deviations. Genberg et al. (2009) analyze CIP deviations for the USD-EUR and five other currency pairs. Their results suggest that CIP deviations were smaller for Hong Kong,

[9] Graphs of several other exchange shown in the Appendix reveal a similar pattern of small CIP deviations during the tranquil period up until the summer of 2007, followed by a period of increasing turbulence and larger CIP deviations, and then a large spike in deviations after the Lehman Brothers bankruptcy. In most cases, CIP deviations are now generally larger than at the start of the millennium.

[10] Griffoli and Ranaldo (2011) analyze CIP deviations using high frequency data on 5 currency pairs including the EUR-CHF, a non-dollar pair. The authors conclude that most CIP deviations can be explained by funding liquidity constraints in USD, and only a small part due to the risk of default by the forward counterparty. Hence, based on this dataset, the possibility of risk was not a major factor in limiting arbitrage and opening up CIP deviations.

Japan and Singapore (versus the USD) consistent with lower implied bank default risks in those countries.

During the crisis period, banks outside the United State had particular difficulty accessing USD facilities. To meet their various USD funding obligations, these banks turned to the synthetic approach suggested by equation (2). By borrowing in the their home currencies (EUR, GBP, or others), perhaps through access to the home central bank, and then executing an FX swap, banks could synthetically create a USD position, but only at a premium to a direct position in USD.[11] The synthetic approach helps to understand one policy response to this aspect of the global financial crisis.

In the spring of 2009, the U.S. Federal Reserve along with other central banks opened up substantial official swap facilities. With these official swaps, the supply of USD offshore increased and non-U.S. banks could access USD through their home central bank rather than through their traditional U.S. commercial bank counterparties (who were subject to heightened default risk). Coffey et al. (2009, September) show that the successive rounds of official swap facility lines opened in the spring 2009 played a significant role in bringing down CIP deviations, and in that sense, helping to restore greater international capital mobility. In a related study by Baba and Shim (2010), the authors show that the Bank of Korea's use of U.S. Federal Reserve swap lines had a significant impact on reducing dislocations in the Korean won/US dollar market, while using the Bank's own foreign reserve had no significant impact. Despite these policy initiatives, Exhibit 2 suggests that deviations from covered interest parity are

[11] Baba and Packer (2009) note that the situation is analytically similar to that of Japanese banks in the 1990s that faced a "Japan Premium" (i.e. higher borrowing costs in the offshore USD market) because of the declining credit quality of Japanese bank loan portfolios. Japanese banks could attempt to circumvent the premium by borrowing in JPY and entering into an FX swap to synthetically create a USD position. For more on the Japan Premium, see Peek and Rosengren (2001).

experiencing a new normal, with deviations in the range of 25-50 basis points for the EUR-USD pair rather than in the range of 10-25 basis points which had been observed a decade previously.

6. Conclusions and Cautionary Notes on Parity Deviations

As McBrady et al. (2010, p. 695) so well expressed it, “Interest rate parity is a bedrock assumption of international finance.” Over the first half of the twentieth century, comparisons of short-term Treasury-bill rates on a covered basis often showed sizeable departures from parity. For the most part, economists attributed much of these deviations to the costs and risks of executing arbitrage transactions. With the gradual opening up of international capital markets, and especially offshore markets in the 1960s and 1970s, measured departures from CIP shrunk substantially. Economists have come to define the covered interest parity condition as a measure of international capital mobility. By the start of the 21st century, economists essentially took covered interest parity for granted at least among the G10 countries and probably much more widely. Sovereigns and private companies were active in international market, searching for minor deviations from CIP and seizing upon them to issue (or buy) foreign bonds, execute a currency swap, and lock in a small, but nearly risk-free gain.

In the aftermath of the global financial crisis, currency bid-ask spreads have widened, counterparty risks seem greater and more uncertain, and in many cases risk capital is more scarce and expensive. In this setting, deviations from covered interest parity have widened considerably relative to a decade ago. The challenge for researchers as well as practitioners is to accurately measure and price the costs of strategies based on deviations from CIP. All observed deviations from CIP are not necessarily efficient market violations. Deviations from CIP can reflect the implicit additional cost and risk of trying to utilize the lower cost, or higher yielding currency on a covered basis. Measuring those costs, and recalibrating the efficiency and mobility of international capital markets is a new challenge for financial economists.

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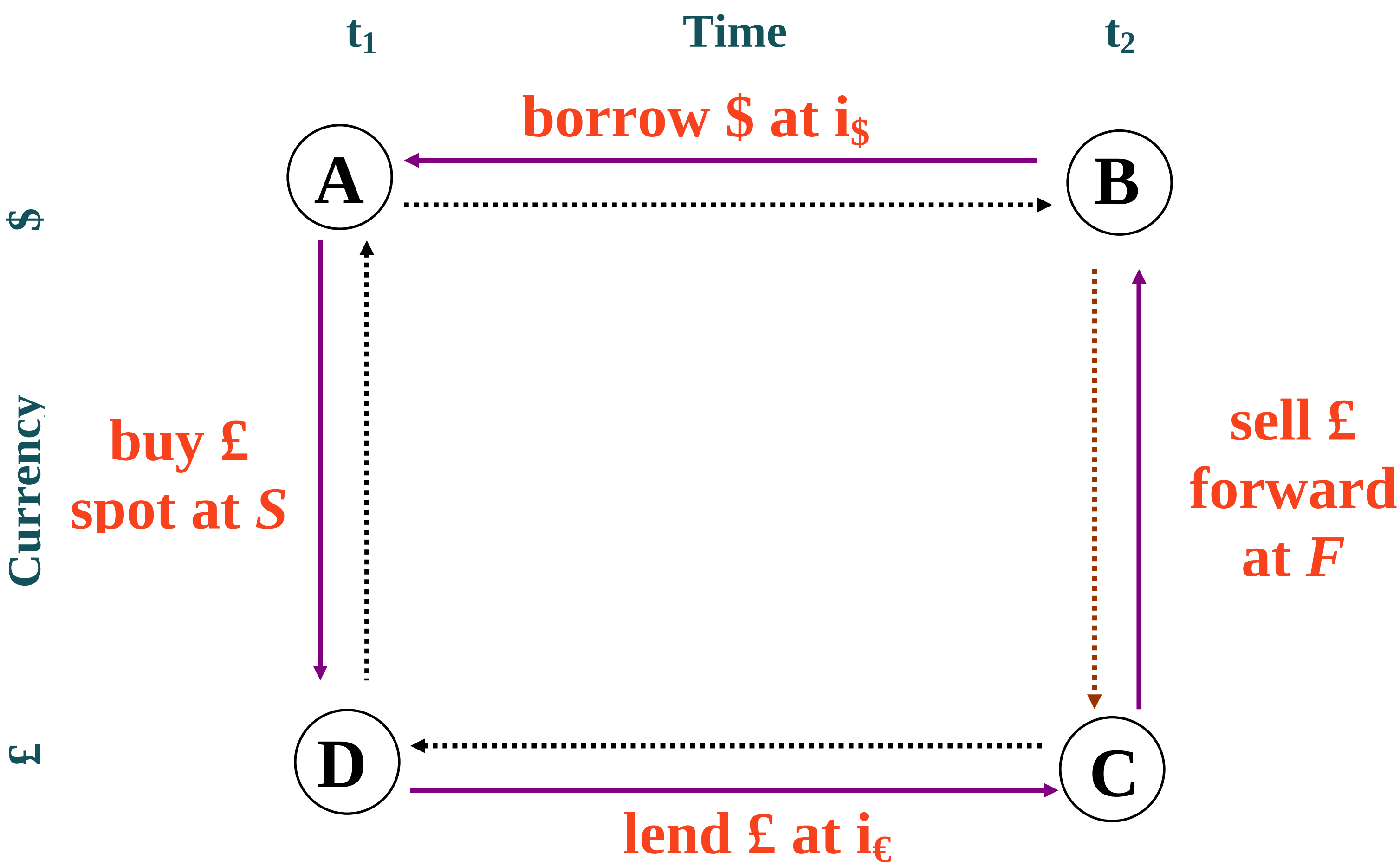
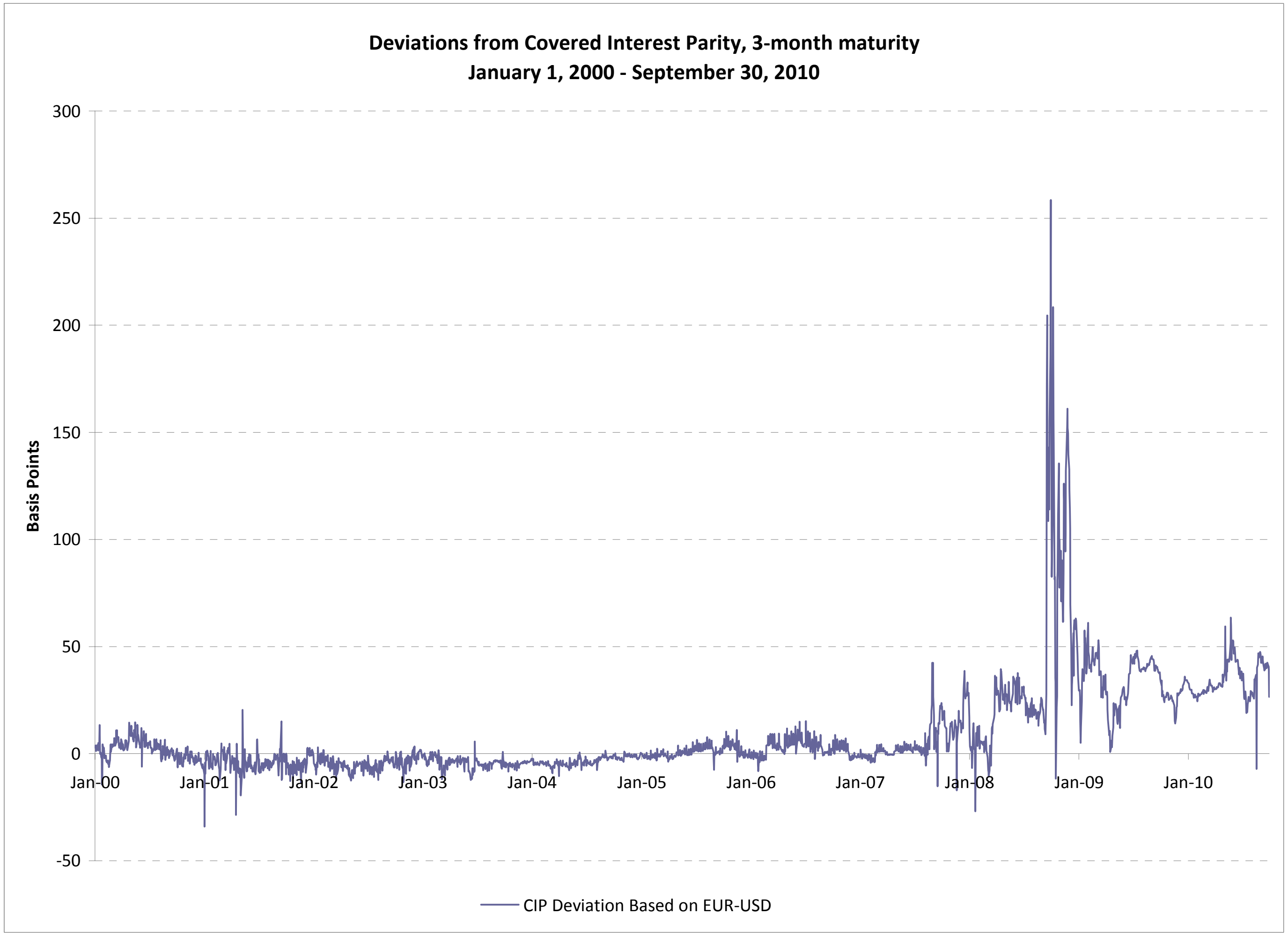
Exhibit 1. Round-Trip Arbitrage Flows in Covered Interest Parity

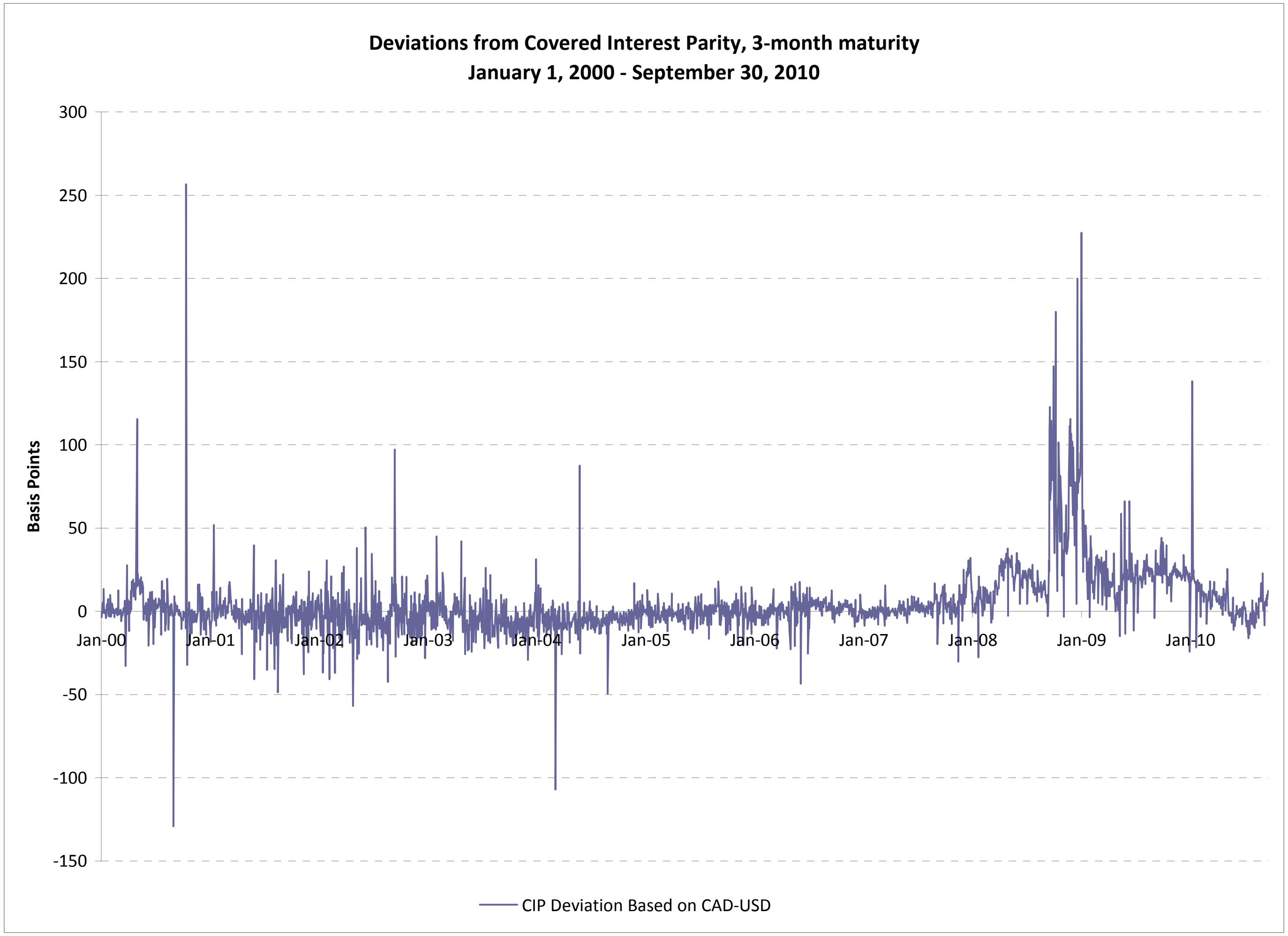


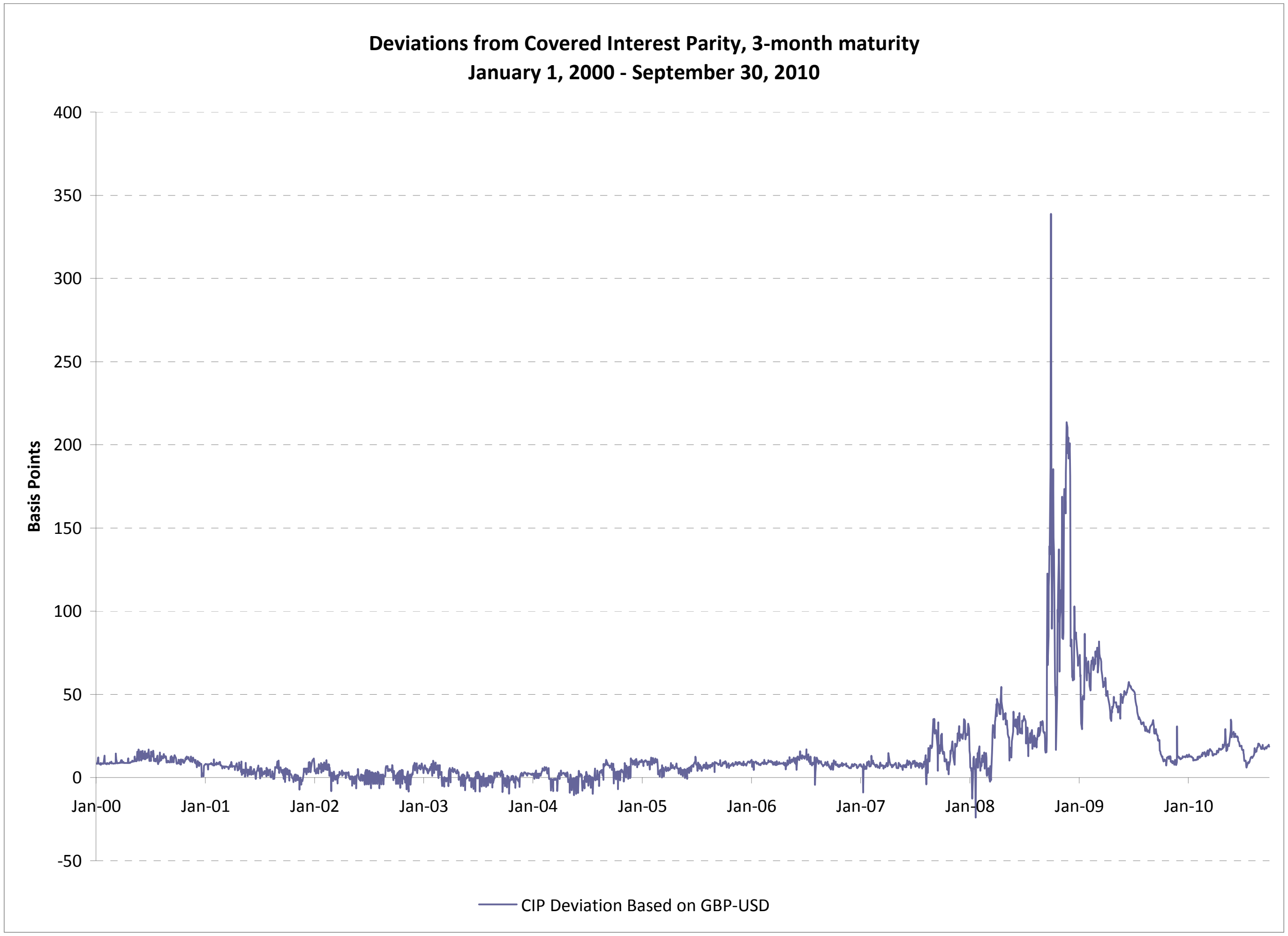
Note: Labels (buy, sell, borrow, lend) refer to the counter-clockwise transactions.

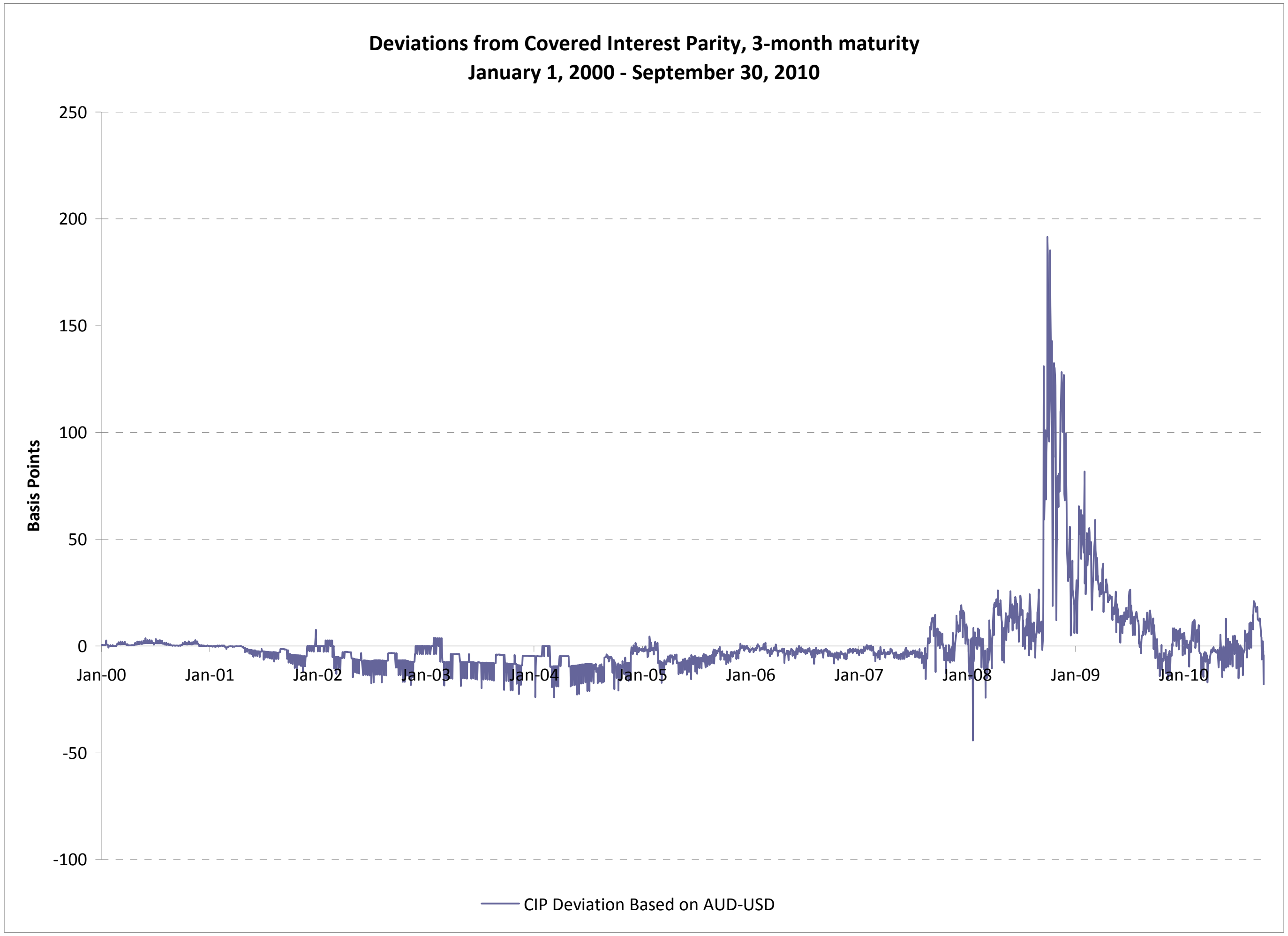
Exhibit 2. Deviations from Covered Interest Parity in the EUR-USD, 3-Month Maturity. Daily data January 1, 2000 – September 30, 2010. Source: Bloomberg.

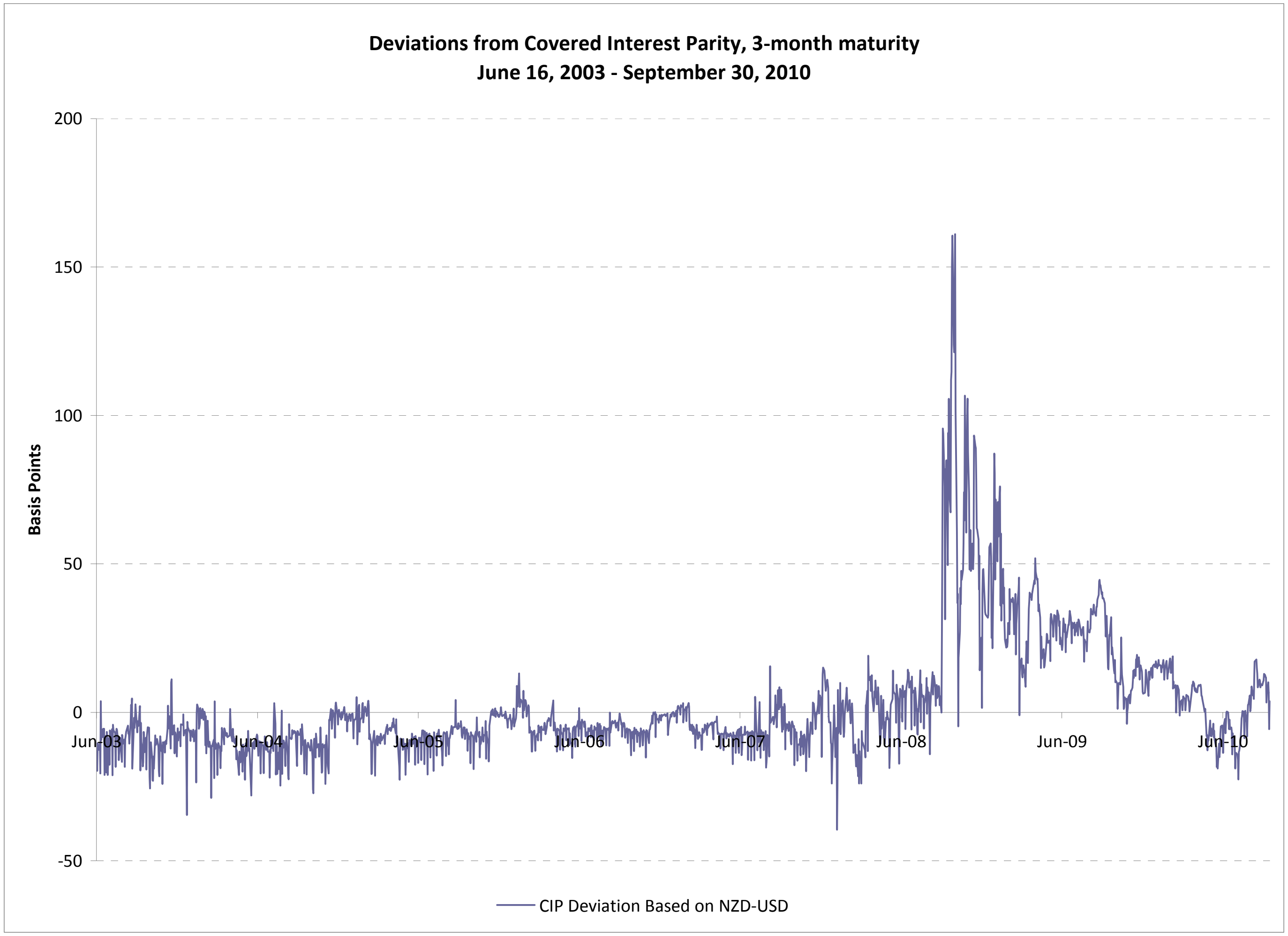


Appendix. Deviations from Covered Interest Parity, Selected Currency Pairs, 3-Month Maturity. Daily data January 1, 2000 – September 30, 2010. Source: Bloomberg.




Deviations from Covered Interest Parity, 3-month maturity
January 1, 2000 - September 30, 2010
Basis Points
400
350
300
250
200
150
100
50
0
-50
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
CIP Deviation Based on GBP-USD


Deviations from Covered Interest Parity, 3-month maturity
January 1, 2000 - September 30, 2010
250
200
150
100
50
0
-50
-100
Basis Points
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10
CIP Deviation Based on AUD-USD



Deviations from Covered Interest Parity, 3-month maturity
June 16, 2003 - September 30, 2010
Basis Points
200
150
100
50
0
-50
Jun-03
Jun-04
Jun-05
Jun-06
Jun-07
Jun-08
Jun-09
Jun-10
CIP Deviation Based on NZD-USD