AN EMPIRICAL INVESTIGATION INTO THE REVERSAL OF THE CARRY TRADE

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ABSTRACT

The carry trade, where profits can be made in currency markets using price information alone, has been a persistent anomaly in financial markets since the collapse of Bretton Woods. The paper investigates the reversal of the carry trade since the Global Financial Crisis, aims to contribute towards a better understanding of currency markets, and to understand how the carry trade reacts to changes in the short-term policy rate. The results suggest that the carry trade is not a risk-premium, but is driven by momentum. The reversal of the carry trade, and changes in reaction to short-term policy rates, are consistent with a change in the effectiveness of monetary policy since the Global Financial Crisis, where central banks intervene directly to provide domestic liquidity: a liquidity put.

JEL Codes: E58, F31

Keywords: Global financial crisis; carry trade; liquidity

JEL Codes: E44, E58, F31, G14

Keywords: Exchange rate economics; liquidity; central banking

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1. INTRODUCTION

The short-term funding rate in developed economies has fallen dramatically since the 1990s (**Figure 1**): the lowest available one month interbank rate fell below 0.5% in 1996; below 0.1% in 1999; and negative in 2012. The Global Financial Crisis had been preceded by a small rise in interbank rates, with the lowest interbank rate above 0.5% at the end of 2006. However, after the Global Financial Crisis and the collapse of Lehman Brothers, central banks reduced their policy rates and Swiss interbank rates turned negative when the Swiss National Bank pegged CHF to the EUR.

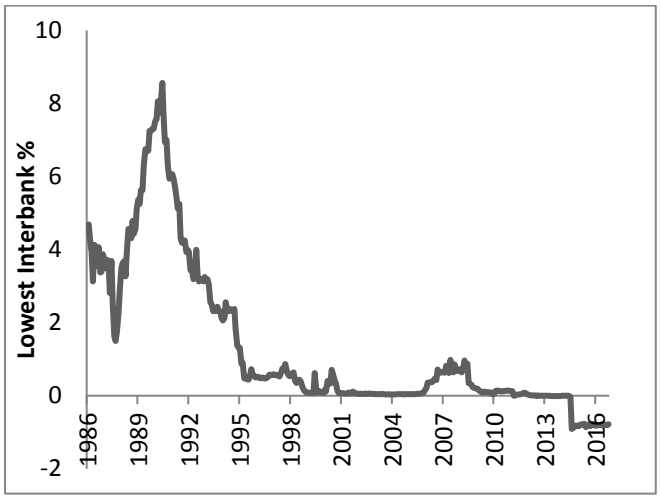


Figure 1. Lowest interbank rate among the G5 economies since July 1986

Near zero funding rates are designed to stimulate domestic investment and recovery. However, they also fund a wide range of carry trade strategies, where investors borrow in low interest rate currencies and invest in high interest rate currencies. Until the Global Financial Crisis, this carry trade earned investors around 2% p.a. with relatively low risk (**Table 4**). This paper investigates how the carry trade has changed since the Global Financial Crisis, using simulated carry trade strategies. The proposed method offers a technique to estimate how each currency contributes to international liquidity, and to determine whether policy rates have supported the carry trade under the Bagehot principle to lend freely on good collateral: a liquidity put (Mehrling, 2011, p. 18).

The proposed method can be extended to include a wider range of currencies, including developing economies, and to investigate liquidity across different parts of the yield curve. As such, it could be a useful tool in the understanding how changes in policy rates impact currency markets.

2. Related Literature

The carry trade has been a persistent anomaly in exchange rate economics. According to the literature on market efficiency it should not be possible to forecast 'returns with variables like dividend yields and interest rates' (Fama, 1991, p. 1576). The low interest rate currency is supposed to appreciate and the high interest rate currency is supposed to depreciate, but the empirical results showed the opposite (Froot & Thaler, 1990). The anomaly has been sufficiently robust that it was described as a 'pure source of alternative beta... (with)... a long-term return over 30 years that is comparable to that of global equities and superior to that of global bonds' (Record PLC, 2009). FTSE, Deutsche Bank, Barclays and others have developed strategies to earn speculative profits from the anomaly (FTSE International 2010b; S. Curcuru, Vega, & Hoek, 2010; Melvin & Shand, 2010).

Currency markets have several anomalies. Exchange rates are 30-300 times more volatile than interest rates (Gourinchas & Tornell, 2004). Foreign exchange volumes have grown more quickly than GDP, which various scholars have theorised is consistent with greater heterogeneity between investors, rather than a convergence towards an efficient market (Frankel & Froot, 1990; Mark & Wu, 1998). Fama (1984) suggested that the missing explanation was a risk premium on high interest rate currencies: if investors perceive a high interest rate currency to be risky they go short, which leads to currency depreciation and for the high interest rate currency to appreciate in the future. Survey data suggests that investors' ex ante expectations are that excess returns cannot be earned (Cavaglia, Verschoor, & Wolff, 1994; Frankel & Chinn, 1993; Frankel & Froot, 1987). Rather, the carry trade is an ex post phenomenon, which suggests that excess returns are unexpected (Froot & Thaler, 1990; Sarno, Valente, & Leon, 2006). In addition, the carry trade is predominantly a short-term effect: there is mixed evidence that the carry trade is weaker when long term interest rates are examined (Chinn, 2006; Mehl & Cappiello, 2009; but also see Bekaert & Xing, 2007). Lastly, the idea of a central bank reaction function has been proposed (Chinn & Meredith, 2004).

Sarno and Valente (2006) suggest that the carry trade can be explained by momentum, where market participants regularly jump on a bandwagon, altering their choice of fundamentals which they use to predict short term interest rates. Another recent approach incorporated a Taylor rule equation, whereby the short term interest rate is a response to the long term rate, the output gap and the difference between actual and target inflation rates: this model predicted changes in the spot rate (Molodtsova & Papell, 2009) and supported the idea that market participants are herding.

In interest rate economics, Wilson (1994) describes the relationship between short term policy rates, and longer-term rates according to three phenomena shift, twist and butterfly: shift explains 80-90% of the variance in interest rate curves and occurs when all of the rates move in parallel; twist explains 5-10% of the variance when short and long rates move in opposite directions; and butterfly explains 1-2% of the variance when the intermediate rate moves in opposite directions to the short and long term rates. In interest rate economics, the long-term interest rate is not an unbiased estimate of the future prevailing spot rate: there is a liquidity premium for long-term investors.

There are three theories that explain this liquidity premium. Liquidity preference theory says that investors are risk-averse, and tend to prefer short term maturities. Preferred habitat theory says that investors have different time horizons. Stock-flow consistent economics says that the difference between the short term and long term rate is simply a mark-up applied by banks to ensure they make a profit after accounting for non-performing loans, deposit interest and expenses (Godley & Lavoie, 2007, p. 401).

In summary, the literature suggests that the carry trade is more pronounced when short-term rates are used (Chinn, 2006; Mehl & Cappiello, 2009; but also see Bekaert & Xing, 2007). In interest rate economics, according to the shift effect, 80-90% of the variance in interest rate curves arises because short-term and long-term interest rates move in parallel (Wilson, 1994).

3. Research Questions

i. *How has the carry trade been affected by the Global Financial Crisis?*

ii. *How does the carry trade respond to changes in the short-term policy rate?*

4. Research Data

Simulated carry trades are calculated using spot rates and interest rates. Three sets of interest rates are used: overnight, BBALIBOR one-month interbank, and BBALIBOR one-year interbank. BBALIBOR rates are the price at which private banks lend to each other.

Table 1: Spot Rates

Currency	Description	Source	Datastream
JPY	Japanese Yen to Sterling spot	WM/Reuters	JAPAYEN
USD	US Dollar to Sterling spot	WM/Reuters	USDOLLR
GBP	Sterling to US Dollar spot	WM/Reuters	UKDOLLR
CHF	Swiss Franc to Sterling spot	WM/Reuters	SWISSFR
EUR	Euro to Sterling spot	WM/Reuters	EURSTER

Table 2: Overnight Rates

Currency	Description	Source	Datastream
JPY	Basic discount rate[3]	Bank of Japan	JPDISCR
USD	US Federal Funds target rate[4]	FRB of New York	FRFEDFD
GBP	UK Bank of England base rate[5]	Bank of England	UKPRATE
CHF	Swiss interbank rate[6]	Swiss Economic Institute	SWIBKTN
EUR	Short-term Euro repo rate[7]	Bundesbank	BDPRATE

[3] The Bank of Japan conducts open market operations at the basic discount rate, such as rediscounting bills or extending loans to financial institutions. It is also the Bank of Japan's policy interest rate.

[4] In the United States, the main refinancing rate is the federal funds effective rate, at which depository institutions lend balances at the Federal Reserve to other depository institutions overnight. The daily rate is a weighted average of rates on trades through New York brokers.

[5] The Bank of England's official policy rate. From 1972 - 1981 this was replaced by a minimum lending rate which was set in a weekly tender; from 1981 – 1986 the bank began to publish a different dealing rate for loans of different duration (typically one to fourteen days); and after 2006 the bank also published an official bank rate which is paid on reserves.

[6] There is no official overnight rate for Switzerland that covers the whole period.

[7] Prior to the launch of the Euro, this was the Bundesbank discount rate.

Table 3: Interbank Rates

	Currency	Description	Source	Datastream
One-month	JPY	Japanese interbank one month	BBA	BBJPY1M
	USD	US interbank one month	BBA	BBUSDIM
	GBP	UK interbank one month	BBA	BBGBP1M
	CHF	Swiss interbank one month	BBA	BBCHF1M
	EUR	Europe interbank one month	BBA	BBEURIM
12-month	JPY	IBA JPY LIBOR 12 month	BBA	BBJPY12
	USD	IBA USD LIBOR 12 month	BBA	BBUSD12
	GBP	IBA GBP LIBOR 12 month	BBA	BBGBP12
	CHF	IBA CHF LIBOR 12 month	BBA	BBCHF12
	EUR	IBA EUR LIBOR 12 month	BBA	BBDEM12

5. METHODOLOGY

To estimate whether the carry trade was affected by the Global Financial Crisis, trades were placed in each of the ten currency pairs (CHFUSD, CHFGBP, CHFJPY, CHFEUR, USDGBP, USDJPY, USDEUR, GBPJPY, GBPEUR, JPYEUR) that can be formed from the five most highly traded currencies. These calculations were then repeated for each combination of four currencies. Using either one-year, one-month or overnight rates: the low interest rate currency was borrowed to invest in the high interest rate currency. After one month, the trade was settled at the prevailing spot rate. The Lehman bankruptcy in September 2008 is taken as the date of the Global Financial Crisis. According to Melvin and Taylor (2009), this event was marked by incredible levels of currency market volatility, with much higher spreads: between Sterling and US Dollars there was a 5500 per cent increase in spread volatility as the 'pound sold off dramatically in the fall of 2008' (Melvin & Taylor, 2009, p. 13). A two-sample t-test was carried out on the excess returns pre- and post-Global Financial Crisis, where the one-month excess return is:

Equation 1: $\alpha_m = ds(m+1) - \beta ID(m)$

Where s = log of the spot exchange rate between the low and high interest rate currency; ID = interest rate differential between high and low interest rate currency; α_m = monthly excess return; β= Fama's β coefficient

In addition, the Information Ratio or annualised Sharpe Ratio (Sharpe, 1994), which is the excess return per unit of risk per year, was calculated for each return series. **Figure 1**, **Tables 4 and 5** show the excess returns, Information Ratios and their descriptive statistics. **Table 6** summaries the results of the two-sample t-tests.

To determine whether or not there is a central bank reaction function, the difference between the carry trade using overnight (policy) rates, and the carry trade using one-month interbank rates, was investigated. Liquidity preference theory says that a longer-term interest rate is equivalent to rolling over at the short-term rate, plus a constant liquidity premium:

Equation 2: $1 + i_m = \prod_{d=1}^{d=30}(1 + i_d) + \pi$

Where i_m is the monthly interest rate (interbank), i_d is the overnight central bank rate, and π is a constant liquidity premium for one-month

From **Equations 1 and 2**:

Equation 3: $\alpha_m = ds(m+1) - \beta\left(\prod_{d=1}^{d=30}(1+i_d^h) - \prod_{d=1}^{d=30}(1+i_d^l)\right) - (\pi^h - \pi^l)$

Where β, π^h and π^l are unknown

With overnight interest rates, the excess return after one month is:

Equation 4: $\alpha_d = ds(m+1) - \beta\left(\prod_{d=1}^{d=30}(1+i_d^h) - \prod_{d=1}^{d=30}(1+i_d^l)\right)$

From **Equations 3 and 4**, using the same currencies to estimate α_m and α_d, $\beta_m = \beta_d$ and the equation simplifies to:

Equation 5: $\alpha_m - \alpha_d = \pi^l - \pi^h$

Therefore, the impact on liquidity of the Global Financial Crisis, and of changes to the short-term policy rate, can be estimated using **Equation 5:** twist and butterfly effects will show as deviations from zero. These results are shown in **Table 7** and **Figure 2**.

6. Results and Discussion

Table 4 shows that, prior to the Global Financial Crisis, all of the carry trade strategies have positive excess returns. The lowest mean excess return is 1.935% ±2.275% when the Japanese Yen was excluded: this is consistent with the narrative that Japanese Yen was the most popular funding currency (Hattori & Shin, 2009); the highest mean excess return is 2.885% ±2.780% when the Euro is excluded. The main result, using five currencies, rejects α_m= 0 at the 95% confidence level but does not reject α_d= 0 and α_y= 0 at the 90% confidence level. The Information Ratio is positive in all cases, ranging from 0.305 to 0.465. The negative skew is consistent with the narrative that the carry trade goes 'up by the stairs and [comes] down in the elevator' (Plantin & Shin, 2011, p. 5):

Table 4: Excess Returns Before the Global Financial Crisis

Currencies		Mean[8]	Information Ratio	Standard Deviation	Skew	Kurtosis	Jarques-Bera
USD, GBP, EUR, CHF, JPY	αy	2.305% ±2.435%	0.394	20.246	-1.158	3.498	196.56***
	αm	2.644% ±2.381%	0.463	19.805	-1.218	6.865	233.06***
	αd	2.296% ±2.422%	0.395	20.137	-1.269	7.378	285.94***
Excluding USD	αy	2.358% ±2.631%	0.373	21.879	-1.372	5.223	388.63***
	αm	2.526% ±2.598%	0.405	21.575	-1.444	5.600	443.29***
	αd	2.341% ±2.190%	0.373	21.725	-1.439	5.650	448.98**
Excluding GBP	αy	2.246% ±2.738%	0.342	22.770	-0.733	1.628	53.626***
	αm	2.745% ±2.648%	0.432	22.015	-0.749	2.020	70.589***
	Ad	2.021% ±2.313%	0.305	22.948	-0.637	2.025	63.908***
Excluding JPY	Ay	1.935% ±2.275%	0.354	18.914	-0.726	2.142	74.78***
	αm	2.169% ±2.262%	0.399	18.815	-0.787	2.274	85.459***
	Ad	1.975% ±1.908%	0.362	18.916	-0.833	2.479	99.639***
Excluding EUR	Ay	2.465% ±2.806%	0.366	23.328	-1.026	3.000	147.47***
	αm	2.885% ±2.780%	0.432	23.120	-1.022	3.092	153.46***
	Ad	2.510% ±2.346%	0.374	23.262	-1.091	3.680	204.36***
Excluding CHF	Ay	2.520% ±2.842%	0.369	23.635	-1.241	4.052	252.15***
	αm	2.880% ±2.797%	0.429	23.255	-1.292	4.414	292.14***

[8] Annualised as monthly return x 12, showing a 95% confidence level for αm and 90% confidence interval for αy and αd

	Ad	2.643% ±2.343%	0.394	23.236	-1.283	4.488	298.44***

Table 5 shows a reversal in the carry trade since the Global Financial Crisis. Excess losses vary from -1.989% ±3.808% if the US Dollar is excluded, to 0.513% ±3.604% if the Swiss Franc is excluded. Information Ratios are largely negative, from -0.277 to 0.081:

Table 5: Excess Returns After the Global Financial Crisis

Currencies		**Mean**	**Information Ratio**	**Standard Deviation**	**Skew**	**Kurtosis**	**Jarques-Bera**
USD, GBP, EUR, CHF, JPY	Ay						
	αm	-0.942% ±3.370%	-0.190	17.154	-0.641	0.588	8.453*
	Ad	-0.290% ±2.283%	-0.072	13.887	-0.354	0.341	2.627
Excluding USD	Ay						
	αm	-1.989% ±3.808%	-0.355	19.387	-0.790	0.100	14.844***
	Ad	-0.470% ±2.918%	-0.092	17.752	-0.799	1.363	18.757***
Excluding GBP	Ay						
	αm	-1.123% ±3.365%	-0.277	17.131	-0.554	2.156	24.97***
	Ad	-0.055% ±2.387%	0.013	14.522	-0.131	0.819	3.145
Excluding JPY	Ay						
	αm	-0.824% ±3.622%	-0.155	18.441	-0.583	0.767	8.274**
	Ad	0.023% ±2.820%	0.005	17.156	0.436	0.878	6.509**
Excluding EUR	Ay						
	αm	-0.698% ±4.564%	-0.104	23.237	-1.078	3.331	66.913***
	Ad	-1.506% ±3.429%	-0.250	20.867	-0.976	4.880	117.4***
Excluding CHF	Ay						
	αm	-0.080% ±4.961%	-0.011	25.258	-0.417	0.112	3.000
	Ad	0.513% ±3.604%	0.081	21.927	-0.345	0.391	2.678

These figures are consistent with the narrative that the Global Financial Crisis represented a major dislocation in currency markets. Initially, there were reports that currency trading activity declined sharply, by about 30 per cent, after the Lehman bankruptcy (Becker & Clifton, 2007, p. 38). The Global Financial Crisis is described as follows: 'it is not easy for scholars to appreciate fully the magnitude of the dislocations that have occurred in the FX market… fears were met on August 16, 2007: on this date, a major unwinding of the carry trade occurred and many currency market investors suffered huge losses' (Melvin & Taylor, 2009, p. 2). Melvin and Taylor identified three stages during the Global Financial Crisis: an initial deleveraging as risk appetites fell and investors sought to reduce risk, followed by a second stage where forced sales by prime brokers led to increased risk aversion among investors, and lastly a flight to quality as investors bought Treasury Bills and cash.

Figure 1 shows that other financial crises appear as outliers. The first crisis follows a period of low interest rates in Switzerland and Japan until, in August 1990, US Dollar interest rates began to fall sharply. This fall coincides with the introduction of banking competition in the US, where investment banks offer retail and commercial loans and there is competitive pressure to reduce the mark-up on longer-term loans: the 'de facto repeal of Glass–Steagall' (Wolfgang H. Reinicke, 1995, p. 114). Following the Swedish banking crisis of 1992, another outlier, the Great Moderation begins with a period of lower interest rates in the UK, Switzerland and Japan, and a further decline in interest rate differentials. The next major outlier is the Japanese banking crisis in 1995, with Japanese interbank rates falling below 0.5 per cent. After the Russian banking crisis of 1998, Japanese interbank rates fall further to 0.1 per cent by 1999. From March 2006, Japanese rates begin to rise, reaching around one per cent in August 2007 prior to the Lehman Brother bankruptcy in September 2008. Since the Global Financial Crisis, both Switzerland and Europe have experimented

with negative policy rates, and the Swiss National Bank has pledged to buy "unlimited quantities" of foreign currencies and prevent the Swiss Franc from rising further.

Figure 1. Financial Crises as Outliers

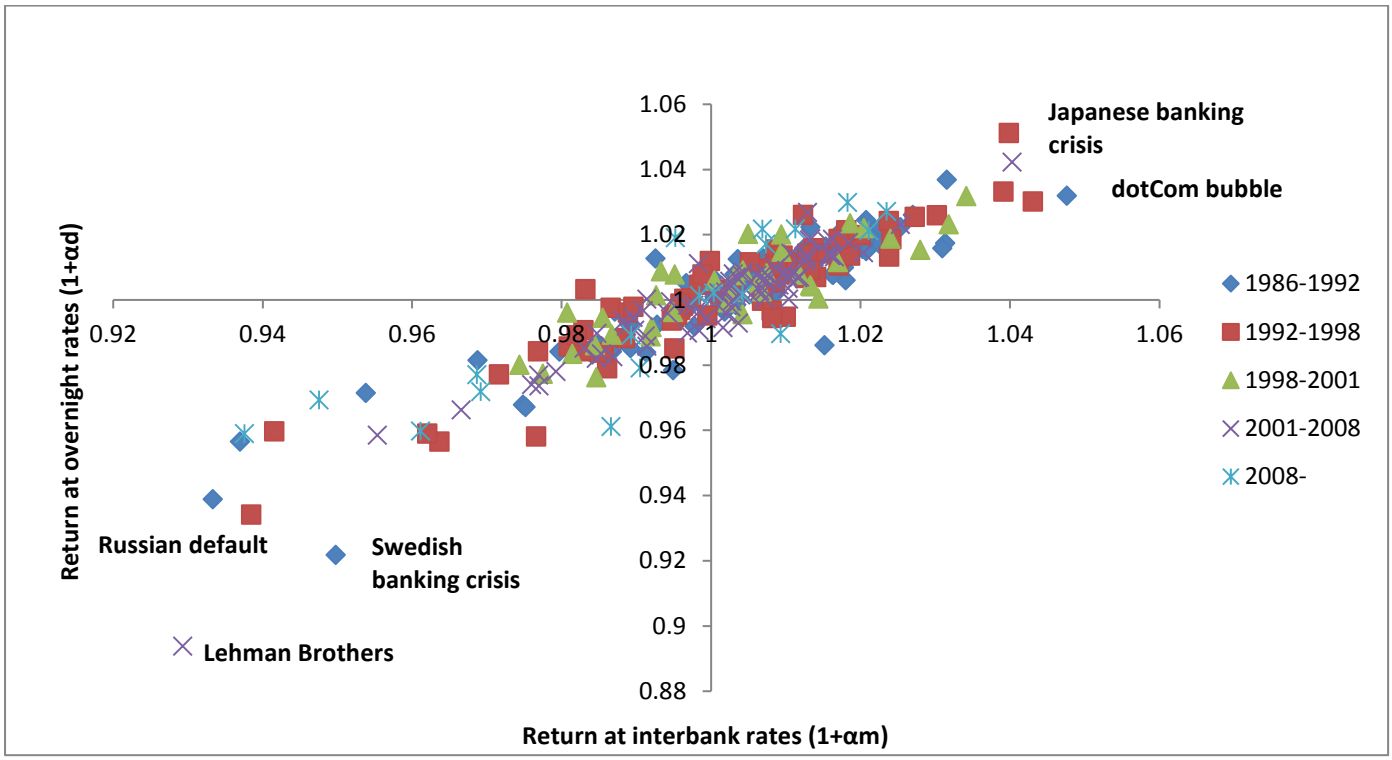


Table 3 shows the results of two sample t-tests comparing α_m and α_d before and after the Global Financial Crisis. When the Swiss Franc is excluded, there is insufficient evidence to reject the null hypothesis that $\alpha_m$and α_d are significantly different at the 10% level. When Japanese Yen is excluded, there is sufficient evidence to reject the null hypothesis that $\alpha_m$and α_d are significantly different at the 10% level, but not at the 5% level. In all cases where the Swiss Franc and Japanese Yen are included, there is sufficient evidence that α_m and α_d are different in the pre- and post-Global Financial Crisis periods at the 10% level, with the exception of α_d where Sterling is excluded. α_m is significantly different at the 5% level in three simulations: for all currencies, excluding the US Dollar, and excluding Sterling (p-values = 0.032, 0.018 and 0.030 respectively). α_d is significantly different at the 5% level where the Euro is excluded (p-values = 0.043):

Table 6: T-Tests

Currencies		$\sigma^2_{pre}/\sigma^2_{post}$	T-test (unpaired)
USD, GBP, EUR, CHF, JPY	α_m	0.984	Equal variance: p-value = 0.032*
	α_d	1.289	Equal variance: p-value = 0.056
Excluding USD	α_m	0.882	Equal variance: p-value = 0.018*

	α_d	1.013	Equal variance: p-value = 0.076
Excluding GBP	α_m	1.312	Equal variance: p-value = 0.030*
	α_d	1.650*	Unequal variance: p-value = 0.135
Excluding JPY	α_m	0.929	Equal variance: p-value = 0.089
	α_d	0.987	Equal variance: p-value = 0.172
Excluding EUR	α_m	0.826	Equal variance: p-value = 0.089
	α_d	0.932	Equal variance: p-value = 0.043*
Excluding CHF	α_m	0.648**	Unequal variance: p-value = 0.140
	α_d	0.811	Equal variance: p-value = 0.187

These results are consistent with momentum in foreign exchange markets. The period prior to the Global Financial Crisis, low interest rate economies depreciate and high interest rate economies appreciate: this runs contrary to the literature on market efficiency. During financial crises, this effect reverses for short periods (**Figure 1**), with a persistent reversal since the GFC in response to ultra-low rates from central banks (Sarno et al., 2006), as well as direct purchases of assets via Quantitative Easing (QE). In contrast with the literature, there is no support for the carry trade being more pronounced when very short term rates are used (Chinn, 2006; Mehl & Cappiello, 2009; but also see Bekaert & Xing, 2007): **Table 7** shows the opposite, with α_m excess returns consistently higher than α_y and α_d:

Table 7: Differences between α_y, α_m and α_d Before the Global Financial Crisis

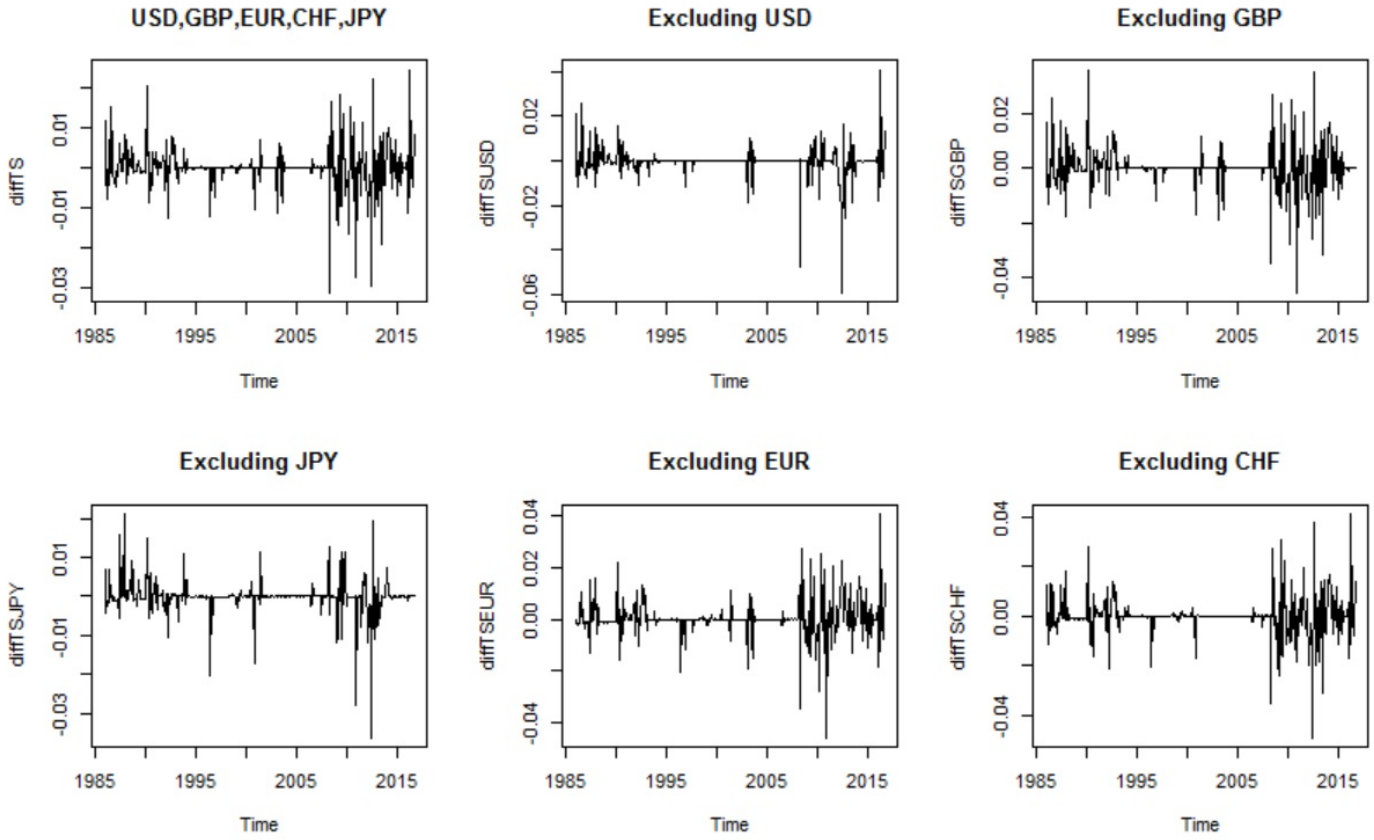
Currencies		Mean	IR	SD	Skewness	Kurtosis	Jarques-Bera
USD, GBP, EUR, CHF, JPY	αm- αd	0.009% ±0.552%	0.295	4.090	1.028	12.028	957.26***
	αy- αd	0.349% ±0.492%	0.007	4.590	1.141	11.560	1550.3***
Excluding USD	αm- αd	0.018% ± 0.580%	0.130	4.828	1.219	12.842	1907.8***
	αy- αd	0.017% ±0.565%	0.013	4.697	0.844	13.459	2054.6***
Excluding GBP	αm- αd	0.724% ±0.804%	0.375	6.680	1.577	10.967	1454.2***
	αy- αd	0.225% ±0.889%	0.105	7.395	1.974	17.132	3451.7***
Excluding JPY	αm- αd	0.195% ±0.487%	0.167	4.050	0.810	16.554	3089.2***
	αy- αd	-0.040% ±0.590%	-0.028	4.898	0.309	8.701	849.65***
Excluding EUR	αm- αd	0.375% ±0.643%	0.243	5.348	0.270	7.370	609.8***
	αy- αd	-0.045% ±0.713%	-0.027	5.928	0.662	11.036	1379.5***
Excluding CHF	αm- αd	0.237% ±0.633%	0.156	5.265	0.601	12.614	1792.8***
	αy- αd	-0.123% ±0.643%	-0.079	5.351	-0.127	8.891	883.52***

Regarding the evidence for a central bank reaction function and liquidity premia, there is insufficient evidence to reject the null hypothesis that that $\pi^l - \pi^h = 0$. In most cases for $\alpha_m - \alpha_d$, there is also insufficient evidence to reject the null hypothesis. When Sterling is excluded, the null hypothesis that $\pi^l - \pi^h = 0$ cannot be rejected at the 5% level ($\pi^l - \pi^h = 0.724\% \pm 0.804\%$), but it can be rejected at the 10% level ($\pi^l - \pi^h = 0.724\% \pm 0.673\%$). The Information Ratio for $\pi^l - \pi^h$ when Sterling is excluded in 0.375. Unlike the carry trade, however, these excess returns show a strong positive skew: going up in the escalator and coming down by the stairs. This central bank reaction function reverses after the Global Financial Crisis: $\pi^l - \pi^h$ is

negative, as before the null hypothesis that $\pi^l - \pi^h$ is zero cannot be rejected, and Information Ratios are negative (data not shown).

The positive skew and Information Ratio imply that speculators could earn fully hedged excess returns prior to the Global Financial Crisis by speculating across the yield curve. For example: borrow the low interest rate currency, and lend the high interest rate currency, at a longer duration: this is a typical carry trade. Then, hedge this by lending the low interest rate currency at a shorter duration, and borrow the high-interest rate currency at a shorter duration. This result is consistent with banks earning a mark up from maturity transformation (Godley & Lavoie, 2007, p. 401), but with different strategies depending on their expectations for interest rates. The fully hedged position can be rearranged as: lend the low interest rate currency at a shorter duration, and borrow the low interest rate currency at a longer duration, in the expectation that low rates will rise; and borrow the high-interest rate currency at a shorter duration, and lend at a shorter duration, in the expectation that high interest rates will fall. This suggests that the carry trade prior to the Global Financial Crisis can be explained as a market failure where low rates simulate overseas investment, with speculators expecting mean reversion. However, the stimulative effect of low interest rates on overseas investment disappears after the Global Financial Crisis: instead, low interest rates and QE stimulate domestic investment. **Figure 2** shows the tendency for $\pi^l - \pi^h$ to revert towards zero declines after the Global Financial Crisis:

Figure 2



The findings before the Global Financial Crisis are consistent with Wilson (1994): most of the relationship between short-term and medium-term interest rates is explained by shift: all parts of the yield curve move together and deviations from zero (which represents shift and butterfly) are rare. The findings are consistent with a more effective response of currency markets to the central bank (Chinn & Meredith, 2004) since the Global Financial Crisis, with greater volatility and greater deviations from constant (zero) liquidity.

7. Summary and Conclusions

There is clear evidence that the carry trade between Sterling, US Dollar, Euro, Swiss Franc and Japanese Yen reversed after the Global Financial Crisis (**Table 6**). The most extreme outlier in the period 1986 to October 2008 was the Lehman bankruptcy (**Figure 1**), with a strong reversal in the carry trade. This finding is consistent with a behavioural explanation for the carry trade: prior to the Global Financial Crisis there was momentum and positive excess returns ($\alpha > 0$), followed by reversal ($\alpha < 0$) after the Global Financial Crisis.

When Sterling is excluded, there is evidence that $\pi^l - \pi^h > 0$ at the 10% significance level, but not at the 5% significance level. This implies a liquidity put in low interest rate currencies, rather than a risk premium for high interest rate currencies. However, the results are sensitive to the currencies included, the duration of the interest rates used, and the source of exchange rates (in this case, exchanges rates are to and from Sterling). The results suggest that the carry trade is consistent with banks earning a mark-up from maturity transformation, and varying their hedging strategies in the expectation that interest rates are mean-reverting: that low rates will rise, and high rates will fall. The finding is consistent with preferred habitat theory, where banks

switch from overnight to one-month funding depending on their expectations about the future path of policy rates. Whilst this mark up increases the potential returns, there is inconclusive evidence for a persistent liquidity premium ($\pi^l - \pi^h > 0$).

The evidence for persistent momentum prior to the GFC are consistent with low interest rates fuelling cross-border speculation: expansionary monetary policy was rendered less effective. Since the GFC, expansionary monetary policy, including QE, has led to a reversal and an increase in the exchange rate for low interest rate economies.

There are a number of shortcomings with this paper that need to be addressed. The theoretical framework could be developed more fully; the results could be extended to include more currencies, 3-month rates, and long-term rates; the excess return using overnight rates could be calculated using daily interest rates, rather than monthly interest rates; spot exchange rates to USD could be used; alternative policy rates could be tested, such as an alternative to the Bundesbank prior to the launch of the Euro. However, the methodology has the potential to offer new insights into the effectiveness of monetary policy.

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