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Rethinking macroeconomics: how G5 currency markets have responded to unconventional monetary policy

Neil Lancastle, Faculty of Business and Law, De Montfort University

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Abstract

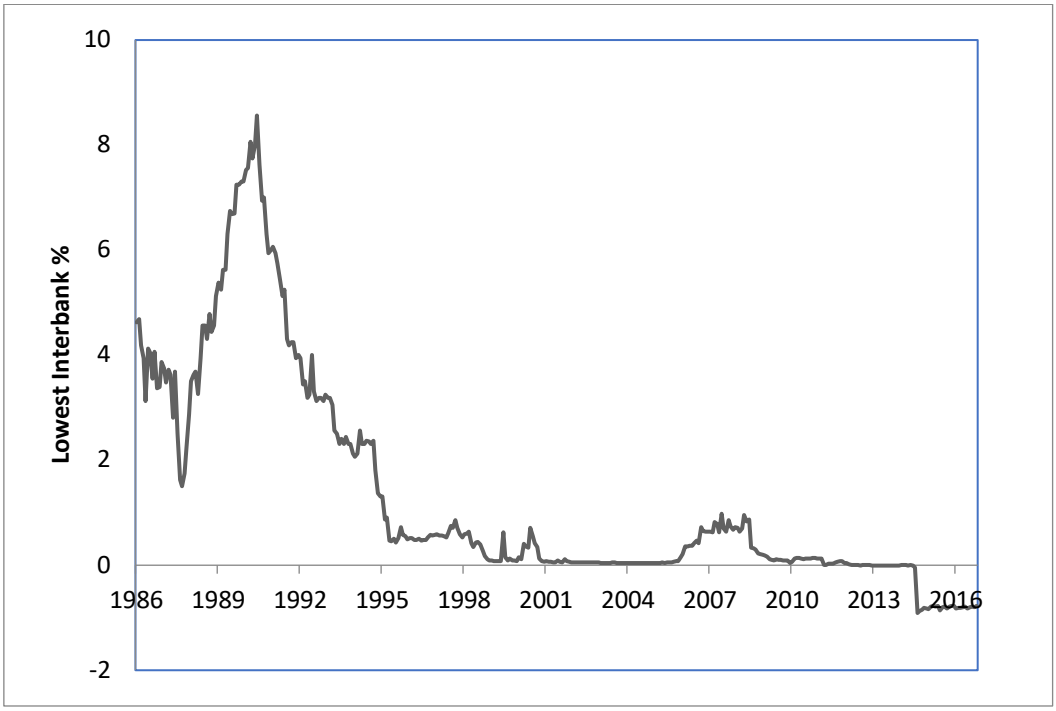
The G5 carry trade, where high interest rate currencies appreciate and low interest rate currencies depreciate, had been a persistent anomaly in financial markets since the collapse of Bretton Woods in 1971. Conventional economics said that the reverse should happen: low interest rates were supposed to stimulate the domestic economy, leading to growth and currency appreciation, rather than fund cross-border positions in search of higher yields. The Global Financial Crisis resulted in a major dislocation of currency markets, after which the G5 carry trade reversed.

This paper is an empirical study of this reversal, and the implications for macroeconomic theory. Using overnight and one-month carry trades as a proxy for market reactions to monetary policy, the period leading up to the Global Financial Crisis and this reversal was increasingly subdued: the so-called 'Great Moderation'. Financial crises show up as outliers in the data: temporary reversals of the carry trade during which periods central banks provide additional liquidity in the form of lower interest rates. These results suggest that, prior to 2008, conventional monetary policy – using high/low interest rates to dampen/boost growth and inflation – was being counteracted by capital flows in the opposite direction, in search of high yields. Only since 2008, with unconventional monetary policy – QE, negative interest rates and a reduction in banks' proprietary trading – have G5 currencies responded as predicted by conventional economics: low/high interest rates G5 currencies have appreciated/depreciated. The results suggest that macroeconomic theories need to be reconsidered, to take account of cross-border capital flows in search of yield, and the effectiveness of unconventional monetary policy.

1. Introduction

Short-term G5 interest rates have been falling consistently since the 1990s. Whilst the Global Financial Crisis had been preceded by a small rise in interbank rates, the lowest one month interbank rate among the G5 economies had fallen below 0.5% in 1996; below 0.1% in 1999; and became negative in 2012 (Figure 1). After the Global Financial Crisis and the collapse of Lehman Brothers, central banks reduced their policy rates further and implemented a range of unconventional monetary policies, including negative rates, QE, and limits on proprietary trading.

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



Low interest rates are supposed to 'stimulate economic growth' (see Lee & Werner, 2018, p26, for a summary) . Similarly, during financial crises, low interest rates are consistent with the Bagehot principle for the central bank to lend 'on every kind of current security, on every sort on which money is ordinarily and usually lent' (Bagehot, 1873, p189). However, low interest rates also fund cross-border positions where investors borrow low interest rate currencies to invest in high interest rate currencies: the 'carry trade'. Until the Global Financial Crisis, the G5 carry trade earned investors around 2% p.a. with relatively low risk (Table 4). This paper investigates how the G5 carry trade changed after the Global Financial Crisis, in response to unconventional monetary policy, using simulated carry trade strategies. Secondly, by investigating differences between overnight and one-month carry trade returns, the paper asks whether market responses can be characterised as an expectation that the central bank will lower rates during crisis: a liquidity put (Mehrling, 2011, p. 18). Lastly, this paper asks what the implications are for conventional macroeconomic theories.

The approach can be applied to a wider range of currencies and durations. As such, it could be a useful tool to monitor the impact of unconventional monetary policies on currency markets.

2. Related Literature

The carry trade is 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). Under conventional macroeconomics, the low interest rate currency is supposed to appreciate and the high interest rate currency was supposed to depreciate, but the empirical results showed the opposite (Froot & Thaler, 1990). Amongst the G5 currencies, this anomaly was sufficiently robust to be 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 had developed strategies to exploit this (FTSE International 2010b; S. Curcuru, Vega, & Hoek, 2010; Melvin & Shand, 2010). More broadly, currency markets exhibit a range of anomalies. Exchange rates are 30-300 times more volatile than interest rates (Gourinchas & Tornell, 2004) and foreign exchange volumes have grown more quickly than GDP, both of which are consistent with period of increased heterogeneity between investors, rather than convergence towards a single and efficient market (Frankel & Froot, 1990; Mark & Wu, 1998).

Fama (1984) suggested that the explanation for the carry trade is 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. However, 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: excess returns are unexpected (Froot & Thaler, 1990; Sarno, Valente, & Leon, 2006). In addition, the carry trade is predominantly a short-run effect, and becomes weaker when long term interest rates are examined (Chinn, 2006; Mehl & Cappiello, 2009; but also see Bekaert & Xing, 2007).

Alternatively, the carry trade is theorised as a reaction to monetary policy, which is responding to changes in output and inflation (Chinn & Meredith, 2004, p410). According to this theory, central banks adjust short term nominal rates in response to changes in inflation, a Taylor rule equation, resulting in short-term predictability (Molodtsova & Papell, 2009). Where there are limits to speculation in foreign exchange markets, small deviations would persist because the excess return is 'not large enough to attract speculative capital' (Sarno, Thornton, & Valente, 2013, p25). However, short-term predictability does not explain why investors continued to earn excess returns until 2008, especially given foreign exchange turnover had continued to increase (BIS, 2016, p7).

Alternatively, in interest rate economics, the long-term interest rate is considered a biased estimate of the future prevailing spot rate, because it includes a liquidity premium for long-term investors. Wilson (1994) summarises the relationship between short term and long term rates according to three phenomena: shift, twist and butterfly. Shift, which explains 80-90% of the variance in interest rate curves, occurs when all of the rates move in parallel; twist, which explains 5-10% of the variance, occurs when short and long rates move in opposite directions; and butterfly, which explains 1-2% of the variance, occurs when intermediate rates move in opposite directions to the short and long term rates. Liquidity preference theory says that this premium exists because investors are risk-averse, and prefer short-term maturities; preferred habitat theory says that investors have different time horizons; and stock-flow economics suggests the premium is simply a mark-up to ensure that banks make a profit after accounting for non-performing loans, deposit interest and expenses (Godley & Lavoie, 2007, p. 401).

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To the author's knowledge, no-one has investigated the impact of the Global Financial Crisis on the G5 carry trade, and whether or not there was a consistent mark-up or liquidity premium for speculating in longer duration markets. The next Sections lay out the research questions, research data, and methodology used to investigate these gaps.

3. Research Questions

i. *How was the G5 carry trade affected by the Global Financial Crisis?*
ii. *Is there evidence that unconventional monetary policy changed the mark-up between overnight and interbank carry trades?*

4. Research Data

In order to simulate the carry trade for the G5 currencies, and test for the impact of monetary policy, overnight and one-month interest rates are used for the most actively traded currency pairs in 2016 (BIS, 2016, p5). Carry trades are simulated by either borrowing or investing at overnight policy rates (Table 1), or at one-month BBALIBOR interbank rates (Table 2). Trades are settled using the prevailing WM/Reuters spot rates (Table 3).

***Table 1:** Overnight Policy Rates*

Currency	Description	Source	Datastream
JPY	Basic discount rate[1]	Bank of Japan	JPDISCR
USD	US Federal Funds target rate[2]	FRB of New York	FRFEDFD
GBP	UK Bank of England base rate[3]	Bank of England	UKPRATE
CHF	Swiss interbank rate[4]	Swiss Economic Institute	SWIBKTN
EUR	Short-term Euro repo rate[5]	Bundesbank	BDPRATE

Table 2: 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

Table 3: Spot Rates

Currency	Description	Source	Datastream

[1] 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.
[2] 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.
[3] 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.
[4] There is no official overnight rate for Switzerland that covers the whole period.
[5] Prior to the launch of the Euro, this was the Bundesbank discount rate.

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

5. Methodology

The decision whether to borrow or invest is taken according to the method employed by the FTSE Forward Rate Bias indices (FTSE International, 2010). Trades are placed in each of the ten currency pairs (CHFUSD, CHFGBP, CHFJPY, CHFEUR, USDGBP, USDJPY, USDEUR, GBPJPY, GBPEUR, JPYEUR) that are formed from the G5 currencies: the low interest rate currency is borrowed to invest in the high interest rate currency. After one month, the trade is settled at the prevailing spot rate.

The carry trade excess return using overnight rates is:

Equation 1: $\alpha_d = ds(m+1) - ID(d)$

Where s = log of the spot exchange rate between the low and high interest rate currency; ID(d) = interest rate differential between high and low overnight rates at the start of the period; α_d *= monthly excess return from overnight rates*

The carry trade excess return using one-month interbank rates is:

Equation 2: $\alpha_m = ds(m+1) - ID(m)$

Where s = log of the spot exchange rate between the low and high interest rate currency; ID(m) = interest rate differential between high and low rate interbank rates; α_m *= monthly excess return from interbank rates*

In both cases, the overnight rate or interbank rate determines the borrowing currency and the investment currency for the next one-month period. To investigate market responses to monetary policy, the difference between these one-month excess returns is calculated. 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 3: $1 + i_m = \prod_{d=1}^{d=30}(1 + i_d) + \pi$

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*

Substituting Equation 3 into Equation 2:

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

Where π^h *and* π^l *are liquidity premia for high and low interest rates respectively*

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

Equation 5: $\alpha_d = ds(m+1) - \beta\left(\prod_{d=1}^{d=30}\left(1 + i_d^h\right) - \prod_{d=1}^{d=30}\left(1 + i_d^l\right)\right)$

From **Equations 4 and 5,** using the same currencies to estimate α_m and α_d, the equation simplifies to:

Equation 6: $\alpha_m - \alpha_d = \pi^l - \pi^h$

From Equation 6, $\alpha_m - \alpha_d$are a proxy for market responses to monetary policy, conventional and unconventional. Following Wilson (1994), if all rates shift in parallel then $\alpha_m - \alpha_d$ would be stable and zero: all part of the yield curve shift in parallel and liquidity premia are constant. If $\pi^l > \pi^h$ $(\alpha_m - \alpha_d > 0)$ and is unstable, this is consistent with markets being dominated by a mark-up or liquidity premium that increases α_m temporarily. Alternatively, if $\pi^h > \pi^l$ $(\alpha_m - \alpha_d < 0)$ and is unstable, this is consistent with a negative mark-up or liquidity call than decreases α_m temporarily.

To investigate the impact of the Global Financial Crisis on the G5 carry trade and liquidity, the Lehman bankruptcy in September 2008 is taken as the event date. According to Melvin and Taylor (2009), the Lehman bankruptcy 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).

6. Results and Analysis

The first research question, how was the G5 carry trade impacted by the Global Financial Crisis, is investigated using descriptive statistics, a before and after t-test, and by visualising the excess returns. Descriptive statistics are shown in Table 4 and Table 5. These include the Information Ratio or annualised Sharpe Ratio (Sharpe, 1994), which is the excess return per unit of risk per year, calculated for each return series. Unpaired t-tests are used to determine if there is a significant difference in excess returns before and after the Global Financial Crisis. These results are shown in Table 6.

Table 4: Excess Returns Before the Global Financial Crisis

Currencies		**Mean[6]**	**Information Ratio**	**Standard Deviation**	**Skew**	**Kurtosis**	**Jarques-Bera**
G5	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	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	αm	2.745% ±2.648%	0.432	22.015	-0.749	2.020	70.589***
	αd	2.021% ±2.313%	0.305	22.948	-0.637	2.025	63.908***
Excluding JPY	αm	2.169% ±2.262%	0.399	18.815	-0.787	2.274	85.459***
	αd	1.975% ±1.908%	0.362	18.916	-0.833	2.479	99.639***
Excluding EUR	αm	2.885% ±2.780%	0.432	23.120	-1.022	3.092	153.46***
	αd	2.510% ±2.346%	0.374	23.262	-1.091	3.680	204.36***
Excluding CHF	αm	2.880% ±2.797%	0.429	23.255	-1.292	4.414	292.14***
	αd	2.643% ±2.343%	0.394	23.236	-1.283	4.488	298.44***

Table 4 shows that, before the Global Financial Crisis, monthly carry trades among G5 currencies were positive and significant at the 5% level except when JPY and USD were excluded. This is consistent with practitioners' belief that JPY and USD were essential to the G5 carry trade, with JPY acting as a funding currency in interbank markets (Breedon, 2001, p151). Using overnight rates, this finding is less significant: carry trades are positive and significant at the 10% level except for the G5 and when GBP is excluded. Information ratios vary from 0.305 to 0.465, which practitioners have described as a 'pure source of alternative beta' (Record PLC, 2009). In summary, the G5 carry trade is significant at the 5% level in interbank markets only, prior to the Global Financial Crisis, provided JPY and USD are included in the currency basket. This suggest that conventional monetary policy resulted in low interest rates funding cross-border positions in search of higher yields, and the high interest rate currency appreciated, the opposite behaviour to that predicted by conventional macroeconomic theory.

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

Table 5: Excess Returns After the Global Financial Crisis

Currencies		Mean	Information Ratio	Standard Deviation	Skew	Kurtosis	Jarques-Bera
G5	αm	-0.942% ±3.370%	-0.190	17.154	-0.641	0.588	8.453*
	αd	-0.290% ±2.283%	-0.072	13.887	-0.354	0.341	2.627
Excluding USD	αm	-1.989% ±3.808%	-0.355	19.387	-0.790	0.100	14.844***
	αd	-0.470% ±2.918%	-0.092	17.752	-0.799	1.363	18.757***
Excluding GBP	αm	-1.123% ±3.365%	-0.277	17.131	-0.554	2.156	24.97***
	αd	-0.055% ±2.387%	0.013	14.522	-0.131	0.819	3.145
Excluding JPY	αm	-0.824% ±3.622%	-0.155	18.441	-0.583	0.767	8.274**
	αd	0.023% ±2.820%	0.005	17.156	0.436	0.878	6.509**
Excluding EUR	αm	-0.698% ±4.564%	-0.104	23.237	-1.078	3.331	66.913***
	αd	-1.506% ±3.429%	-0.250	20.867	-0.976	4.880	117.4***
Excluding CHF	αm	-0.080% ±4.961%	-0.011	25.258	-0.417	0.112	3.000
	αd	0.513% ±3.604%	0.081	21.927	-0.345	0.391	2.678

Table 5 shows that, after the Global Financial Crisis, the G5 carry trade collapses: information ratios are largely negative. This is consistent with the success of unconventional monetary policy - QE, negative interest rates and a reduction in banks' proprietary trading – whereby low interest rates stimulate the domestic economy and the low interest rate currency appreciated. These G5 carry trade losses are negative but not significant at the 5% or 10% level.

Table 6: t-Test Results

Currencies		$\sigma^2_{pre}/\sigma^2_{post}$	T-test (unpaired)
G5	α_m	0.984	Equal variance: p-value = 0.032*
Excluding USD	α_m	0.882	Equal variance: p-value = 0.018*
Excluding GBP	α_m	1.312	Equal variance: p-value = 0.030*
Excluding JPY	α_m	0.929	Equal variance: p-value = 0.089
Excluding EUR	α_m	0.826	Equal variance: p-value = 0.089
Excluding CHF	α_m	0.648**	Unequal variance: p-value = 0.140

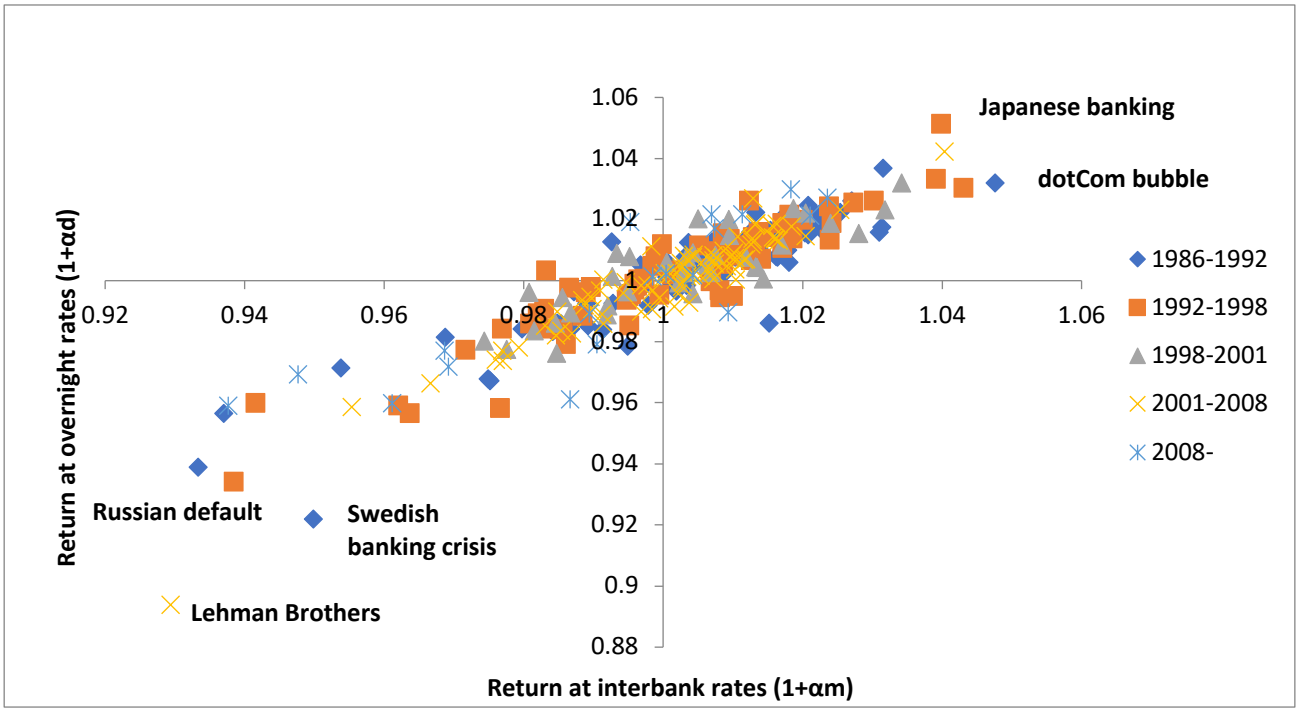
Table 6 investigates whether monthly pre- and post-crisis excess returns are significantly different. At the 5% level, they are significantly different for the G5, as well as for currency combinations that exclude either the USD or GBP. At the 10% level, they are significantly different for the G5 and all currency combinations except when CHF is excluded. Similar to Table 5, these results are consistent with unconventional monetary policy being more effective than conventional. Excluding CHF leads to volatility that is significantly higher, at the 1% level: this is consistent with the CHF being a 'safe haven' currency (Habib & Stracca, 2012, p8) after it was pegged to the EUR, reducing overall volatility. Excluding GBP leads to reduced volatility after the Global Financial Crisis, although this is not significant.

Taken together, these results are consistent with the Global Financial Crisis being a major dislocation in currency markets, as reported by practitioners. Initially, after the Lehman bankruptcy, currency trading activity declined sharply, by about 30 per cent (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 safety.

Figure 2 looks at the outliers, in terms of excess returns. Both positive and negative outliers correspond to financial crises accompanied by central bank intervention. For example, the Swedish Banking crisis had followed a period of steadily reducing interest rates in Switzerland and Japan until, in August 1990, US Dollar interest rates fell sharply. This was a period when, as a consequence of banking competition, US investment banks began to offer cheaper retail and commercial loans and there was the 'de facto repeal of Glass–Steagall' (Wolfgang H. Reinicke, 1995, p. 114). Banking de-regulation continues with a steady reduction of interest rates in the UK, Switzerland and Japan, until the next outlier: the Japanese banking crisis in 1995, when Japanese interbank rates fell below 0.5 per cent. This liquidity put corresponded with positive excess returns, as did the low interest rates that followed the bursting of the dotcom bubble. In contrast, the Russian banking crisis of 1998 led to negative excess returns, despite Japanese interbank rates falling to 0.1 per cent by 1999.

The Lehman Brothers bankruptcy in September 2008 is the most extreme outlier. Having been preceded by a rise in Japanese rates (a 'liquidity call'), the Global Financial Crisis marks a more permanent shift to negative excess returns and a period of unconventional monetary policy (Tables 4, 5 and 6): not only extensive QE, but Switzerland and Europe experimenting with negative policy rates, and the Swiss National Bank pledging to buy "unlimited quantities" of foreign currencies to prevent the Swiss Franc from rising further: the safe haven behaviour seen in Table 6.

Figure 2. Financial Crises as Outliers



In conclusion, these results show a significant reversal of the G5 carry trade after the Global Financial Crisis. Consistent with practitioners' beliefs, CHF acted as a 'safe haven' currency after 2008. Prior to the Global Financial Crisis, the inclusion of JPY as a funding currency, and USD as an investment currency, leads to higher returns (Table 4), in particular the inclusion of JPY (Table 6); and carry trades are more pronounced in interbank markets than in overnight markets

(Table 4). Only with unconventional monetary policy – extensive QE, but Switzerland and Europe experimenting with negative policy rates, and the Swiss National Bank pledging to buy "unlimited quantities" of foreign currency – have G5 currencies responded as predicted by conventional economics: low/high interest rates G5 currencies have appreciated/depreciated.

To investigate the second research question, has unconventional monetary policy changed the mark-åmark-up or liquidity premium is constant and equal across all currencies, then $\alpha_m - \alpha_d$ would be stable and zero: all rates would shift in parallel. If $\pi^l > \pi^h$ $(\alpha_m - \alpha_d > 0)$ and is unstable, this is consistent with markets being dominated by a mark-up or liquidity premium that increases α_m temporarily. Alternatively, if $\pi^h > \pi^l$ $(\alpha_m - \alpha_d < 0)$ and is unstable, this is consistent with a negative mark-up or liquidity call that decreases α_m temporarily.

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

Currencies		Mean	IR	SD	Skewness	Kurtosis	Jarques-Bera
G5	αm- αd	0.009% ±0.552%	0.295	4.090	1.028	12.028	957.26***
Excluding USD	αm- αd	0.018% ± 0.580%	0.130	4.828	1.219	12.842	1907.8***
Excluding GBP	αm- αd	0.724% ±0.804%	0.375	6.680	1.577	10.967	1454.2***
Excluding JPY	αm- αd	0.195% ±0.487%	0.167	4.050	0.810	16.554	3089.2***
Excluding EUR	αm- αd	0.375% ±0.643%	0.243	5.348	0.270	7.370	609.8***
Excluding CHF	αm- αd	0.237% ±0.633%	0.156	5.265	0.601	12.614	1792.8***

From Table 7, before the Global Financial Crisis, the positive sign and skew are consistent with markets being dominated by a mark-up or liquidity premium for holding longer durations. In turn, this is consistent with the expectation that central banks will intervene to provide liquidity during crises: the 'Greenspan put' (Nier & Merrouche, 2010, p7). There is insufficient evidence that $\alpha_m - \alpha_d >$ at the 5% level. However, when GBP is excluded, the null hypothesis can be rejected at the 10% level ($\alpha_m - \alpha_d = 0.724\% \pm 0.673\%$), which is consistent with GBP being central to the co-ordination of mark-ups amongst currency markets participants, given most currency market turnover takes place in the UK (BIS, 2016, p14). After the Global Financial Crisis, $\alpha_m - \alpha_d < 0$ and Information Ratios are negative. This is consistent with market participants no longer expecting a mark-up or additional liquidity in response to crisis: instead, they expect unconventional monetary policy and the low (negative) interest rate currency to appreciate. However, these results are insignificant and the null hypothesis cannot be rejected at the 5% or 10% level (data not shown).

Figure 3 shows how $\alpha_m - \alpha_d$ varies over time. The evidence suggests that mark-ups in response to conventional monetary policy declines in the run up to the Global Financial Crisis, the so-called Great Moderation: interest rate curves are increasingly moving in parallel, known as shift. This is a period where FX turnover is increasing, but this increased activity does not result in the carry trade being arbitraged away: it is still possible to earn excess returns (also see Figure 2). Rather, this is consistent with herding behaviour prior to 2008, until liquidity collapses during the Global Financial Crisis: 'stability is destabilizing' (Wray, 2011, p1).

After the Global Financial Crisis, $\alpha_m - \alpha_d$ becomes less stable: this is consistent with more heterogeneous behaviour by market participants, following limits on proprietary trading. However, the post-crisis null hypothesis that $\alpha_m - \alpha_d < 0$ cannot be rejected: the results are inconclusive that currency markets have systematically altered since 2008. Despite this, they are consistent with a change in market expectations due to unconventional monetary policy – ultra-low short-term rates (Sarno et al., 2006), direct purchases of longer duration assets via

Quantitative Easing (QE) and, in the case of the Swiss National Bank, direct purchases of foreign currency – and the expectation that low interest rates currencies will appreciate. In contrast with the prior literature, there is no support for the G5 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 higher than α_d. However, this might be consequence of the choice of overnight rates and the fact that trades were settled using overnight rates at the start of the period.

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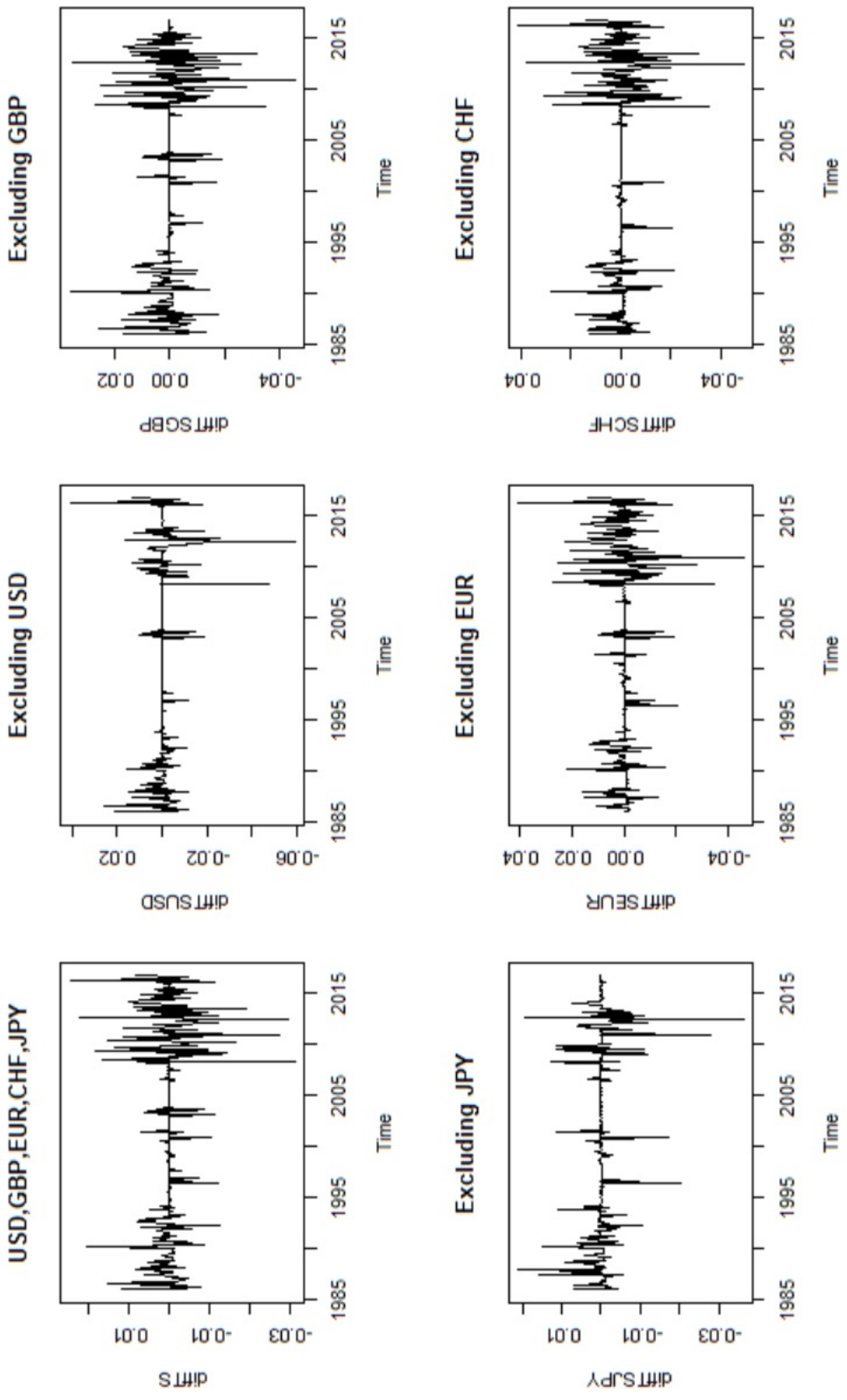

Figure 3: Title needed here?

For market participants, there is a fully hedged carry trade strategy that was profitable before the Global Financial Crisis (excess return 0.724% ±0.804%, Information Ratio 0.375). The strategy involves trading USD, YEN, EUR and CHF only – with the inclusion of GBP, it became unprofitable. The fully hedged strategy is typical of a banks' proprietary trading desk, and mixes maturity transformation with liquidity provision. To provide one-month liquidity, borrow the low interest rate currency in the one-month interbank market and lend the high interest rate currency in the same interbank market: this is a typical carry trade (α_m) and uses the low interest rate currency to provide liquidity in high interest rate currencies. This is hedged in overnight markets by lending the low interest rate currency and borrowing the high-interest rate currency at a shorter duration (α_d). The hedging strategy assumes that central banks will intervene with liquidity in overnight markets during financial crises. Unlike a typical carry trade, this fully hedged strategy has a positive skew – losses are small and frequent, whilst gains are large and infrequent – implying that consistent profits are only possible for insiders who can avoid the bid-ask spread. After the Global Financial Crisis, this fully hedged strategy breaks down.

7. Summary and Conclusion

The intention of this paper was to determine whether unconventional monetary policy, such as QE and ultra-low interest rates, resulted in a change in the way currency markets respond to interest rates. Prior to the Global Financial Crisis, G5 currency markets behaved in the opposite way to that predicted by conventional economics: the G5 carry trade, with JPY as a funding currency and USD as an investment currency, was significant at the 5% level (Table 4). Then, after the Global Financial Crisis, the carry trade reversed: post-crisis excess returns are significantly different at the 5% level for the G5, and even when USD and GDP are excluded (Table 6). Consistent with CHF being a 'safe haven' currency', volatility is higher after the Global Financial Crisi when CHF is excluded, most likely a consequence of CHF being pegged to the EUR. Overall, these results are consistent with the narrative that the Global Financial Crisis represented a major dislocation in G5 currency markets.

Indeed, the extreme outliers in the G5 carry trade are financial crises, with the Lehman bankruptcy as the most significant (Figure 2). Responses to conventional monetary policy are not symmetrical: whilst the Russian bond default and Swedish banking crisis result in a short-term reversal, the Japanese banking crisis and dotcom bubble lead to positive excess returns. However, Figure 3 shows that the period leading up to the Global Financial Crisis was characterised by interest rate curves moving in parallel: the so-called Great Moderation. Then, after 2008 and the Lehman bankruptcy, G5 carry trade returns are consistently negative (Table 5) with increased volatility (Figure 3). These results suggest that unconventional monetary policy – ultra low interest rates and direct purchases of longer duration assets via Quantitative Easing as the 'dealer of last resort' (Mehrling, 2011) and a reduction in banks' proprietary trading – is more effective at getting markets to behave as expected by conventional macroeconomics, whereby low interest rates stimulate the domestic economy.

The findings for liquidity premia are mixed. From Table 7, there is some evidence that, pre-crisis, markets had come to expect central bank to lower interest rates in response to crises, increasing α_m temporarily: this is especially the case when GBP is excluded. These findings are also consistent with herding among market participants: with higher turnover, the carry trade is not arbitraged away, but volatility is reduced. Post-crisis, this market consensus breaks down: volatility increases and unconventional monetary policy results in low interest rate currencies appreciating.

The implication is that macroeconomic theory does not explain how currency markets respond to conventional monetary policy. Low interest rates led to currency depreciation, not appreciation. Whilst there is some evidence for a mark-up or liquidity premium, this is less evident after the Global Financial Crisis. Higher trading volumes do not arbitrage away the excess return; instead, they lead to a reduction in volatility and herding before the next crisis. Only since 2008, with unconventional monetary policies, have low, and negative, interest rates led to currency appreciation. Macroeconomic theory needs to be reconsidered to take account of the effect of cross-border flows in search of yield, and the beneficial effects of unconventional monetary policies such as QE, negative interest rates, and limits to proprietary trading.

These results are sensitive to the interest rates and methodology used, and would warrant further investigation. There are a number of areas for further study. The tests could be repeated with alternative policy rates, weekly rates, 3-month rates, and longer-term rates. Spot rates to USD could be tested, rather than spot rates to GBP. Lastly, more currencies could be included, to investigate the extent to which ultra low G5 interest rates are funding broader carry trade strategies across emerging and developing economies.

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