Carry trade in developing and developed countries: A Granger causality analysis with the Toda-Yamamoto approach

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Abstract

This paper explores empirically the relationship among speculative financial futures (carry trade), nominal exchange rates, and interest rates differentials in developing and developed countries, during the periods of quantitative easing, tapering and quantitative tightening based on the changes of policy interest rates in the United States (US). The public data supplied by the US Commodity Futures Trading Commission Large Trader Reporting Data is taken as a proxy for foreign exchange carry trade. With a time-series model for each country, we estimate the Granger causality using Vector Autoregressive (VAR) models as proposed by Toda and Yamamoto (1995). We investigate three developing countries (Brazil, Mexico, and Russia) and seven developed countries (Australia, Canada, Euro area countries, Japan, New Zealand, Switzerland, and the United Kingdom). Our findings give support to a better understanding of the relationship between foreign exchange activity and monetary policy.

JEL Classification: C32; C58; E44; F31; G15
Keywords: Carry trade; Foreign exchange market; Interest rate differentials; Toda–Yamamoto causality

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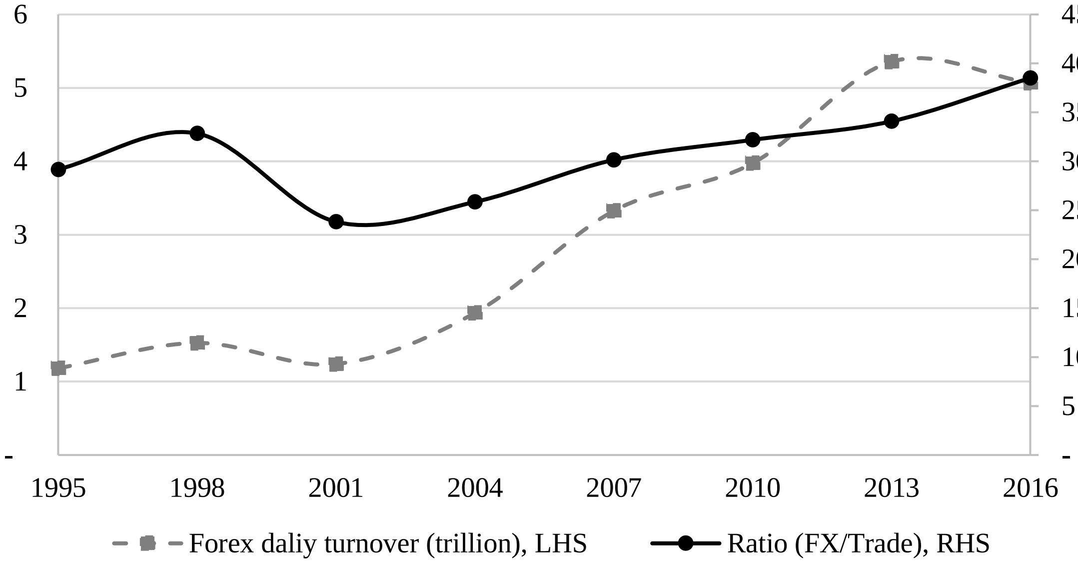
1. Introduction

Due to the increased interconnectedness of global financial markets at the end of the 20th century and beginning of the 21st century, interest rate differentials among countries have fostered speculative capital flows seeking higher yields. Central bankers worldwide set their base interest rate accordingly with their mission. Every country has its singularity and characteristics, which demands a unique set of monetary policies. In this sense, some countries are obliged to set high interest rates (usually, developing and underdeveloped countries), while others present low interest rates (notably, developed countries). Speculators profit from this type of structure to seek financial gains, contradicting what is expected by the uncovered interest rate parity (UIP), one of the fundamental theories of international finance.

Moreover, currency speculation is not a new phenomenon, showing its first institutional developments in the Middle Ages (Accominotti, 2016). Foreign exchange markets (Forex) have augmented their size significantly in recent decades. Financialization of the world economy has led the daily turnover in Forex markets to surpass by 40 times the daily amount of trade in US dollars, as shown in Graph 1. In 1995, the ratio FX-to-Trade was 29, i.e., the amount traded in foreign exchange markets exceed the amount of trade in 29 times. From 2001 until 2016, which accounts for the latest data, there is an uptrend from 24 to 39 on this ratio, respectively.

Graph 1: Forex daily turnover, in trillion US$, and the ratio between Forex daily turnover and daily trade (ratio FX/Trade), 1995-2016



Source: Bank for International Settlements (BIS) for the daily forex turnover. International Monetary Fund (IMF) for trade, using the sum of exports and imports of goods and services in current US$. Own calculations for the ratio.
Notes: Forex data is the mean daily turnover for April. Monthly data (April) for trade was divided by 20 (business days) to transform it into a daily mean.

One significant financial operation of the Forex market involves carry trade. By targeting "international interest differentials," carry traders (investors applying the carry trade investment strategy) "shift their asset holdings from low interest-rate currencies to higher-return currencies" (Greenville, 2010). Carry traders search for investments with higher yields or rate of return, which are traded by an initially carried investment position. This initial investment must necessarily present a lower interest rate than the other investment.

Likewise, the real danger of carry trade comes with derivatives. Through a derivative, investments are leveraged, charging only a small margin at the beginning of the investment. Gains and losses magnitudes are potentialized using these types of contracts. Therefore, "carry trade is a risk-trading practice *par excellence*" (Gabor, 2015). The risk of these financial transactions relies not only on the interest rate spread but also on the exchange rate movements.

In this paper, I use the public data supplied by the US Commodity Futures Trading Commission (CFTC) Large Trader Reporting Data, which is commonly cited by market participants as an indicator of trends in carry trade activities. This data on speculative financial futures by non-financial entities may be taken as a proxy for foreign exchange (FX) carry trade (Galati et al., 2007; Curcuru et al., 2010). Nevertheless, one caveat is that the weekly FX positioning data represents only a small fraction of carry trade operations (BIS, 2015). As pointed by Rossi (2012), the ideal would be high-frequency data (hourly or daily). Nonetheless, considering short-run dynamics, weekly data can also be considered as high-frequency.

By exploring the relationship of carry trade and related financial variables, this paper fills a gap in the literature on carry trade. On the one hand, there is a vast literature on portfolios optimization. In this sense, carry trade is a profitable financial operation, disregarding the impacts on the real economy. On the other hand, there are authors criticizing carry trade and its consequences. Nonetheless, this branch of literature lacks empirical analyses.

2. Methodology and data

By following the model estimated by Nishigaki (2007), this article focuses on the relationship among carry trade (CT), nominal exchange rates (ER), interest rates differentials (IRD), investor's sentiment (VIX), local stock market prices (SM), and US stock market prices (SMUS).

2.1 Methodology

I summarize the model in the following VAR system, as it is similarly proposed by Amiri and Ventelou (2012):

$$ER_t = \lambda_1 + \sum_{i=0}^{k} \alpha_{11i} ER_{t-i} + \sum_{j=k+1}^{p} \alpha_{12j} ER_{t-j} + \sum_{i=0}^{k} \beta_{11i} NP_{t-i} + \sum_{j=k+1}^{p} \beta_{12j} NP_{t-j} + \sum_{i=0}^{k} \gamma_{11i} IRD_{t-i} + \sum_{j=k+1}^{p} \gamma_{12j} IRD_{t-j} + \sum_{i=0}^{k} \delta_{11i} VIX_{t-i} + \sum_{j=k+1}^{p} \delta_{12j} VIX_{t-j} + \sum_{i=0}^{k} \phi_{11i} SM_{t-i} + \sum_{j=k+1}^{p} \phi_{12j} SM_{t-j} + \sum_{i=0}^{k} \psi_{11i} SMUS_{t-i} + \sum_{j=k+1}^{p} \psi_{12j} SMUS_{t-j} + \varepsilon_{1t} \quad (1)$$

$$NP_t = \lambda_2 + \sum_{i=0}^{k} \beta_{21i} NP_{t-i} + \sum_{j=k+1}^{p} \beta_{22j} NP_{t-j} + \sum_{i=0}^{k} \alpha_{21i} ER_{t-i} + \sum_{j=k+1}^{p} \alpha_{22j} ER_{t-j} + \sum_{i=0}^{k} \gamma_{21i} IRD_{t-i} + \sum_{j=k+1}^{p} \gamma_{22j} IRD_{t-j} + \sum_{i=0}^{k} \delta_{21i} VIX_{t-i} + \sum_{j=k+1}^{p} \delta_{22j} VIX_{t-j} + \sum_{i=0}^{k} \phi_{21i} SM_{t-i} + \sum_{j=k+1}^{p} \phi_{22j} SM_{t-j} + \sum_{i=0}^{k} \psi_{21i} SMUS_{t-i} + \sum_{j=k+1}^{p} \psi_{22j} SMUS_{t-j} + \varepsilon_{2t} \quad (2)$$

(3)

$$IRD_t = \lambda_3 + \sum_{i=0}^{k} \gamma_{31i} IRD_{t-i} + \sum_{j=k+1}^{p} \gamma_{32j} IRD_{t-j} + \sum_{i=0}^{k} \alpha_{31i} ER_{t-i} + \sum_{j=k+1}^{p} \alpha_{32j} ER_{t-j} + \sum_{i=0}^{k} \beta_{31i} NP_{t-i} + \sum_{j=k+1}^{p} \beta_{32j} NP_{t-j} + \sum_{i=0}^{k} \delta_{31i} VIX_{t-i} + \sum_{j=k+1}^{p} \delta_{32j} VIX_{t-j} + \sum_{i=0}^{k} \phi_{31i} SM_{t-i} + \sum_{j=k+1}^{p} \phi_{32j} SM_{t-j} + \sum_{i=0}^{k} \psi_{31i} SMUS_{t-i} + \sum_{j=k+1}^{p} \psi_{32j} SMUS_{t-j} + \varepsilon_{3t}$$

$$VIX_t = \lambda_4 + \sum_{i=0}^{k} \delta_{41i} VIX_{t-i} + \sum_{j=k+1}^{p} \delta_{42j} VIX_{t-j} + \sum_{i=0}^{k} \alpha_{41i} ER_{t-i} + \sum_{j=k+1}^{p} \alpha_{42j} ER_{t-j} + \sum_{i=0}^{k} \beta_{41i} NP_{t-i} + \sum_{j=k+1}^{p} \beta_{42j} NP_{t-j} + \sum_{i=0}^{k} \gamma_{41i} IRD_{t-i} + \sum_{j=k+1}^{p} \gamma_{42j} IRD_{t-j} + \sum_{i=0}^{k} \phi_{41i} SM_{t-i} + \sum_{j=k+1}^{p} \phi_{42j} SM_{t-j} + \sum_{i=0}^{k} \psi_{41i} SMUS_{t-i} + \sum_{j=k+1}^{p} \psi_{42j} SMUS_{t-j} + \varepsilon_{4t} \quad (4)$$

$$SM_t = \lambda_5 + \sum_{i=0}^{k} \phi_{51i} SM_{t-i} + \sum_{j=k+1}^{p} \phi_{52j} SM_{t-j} + \sum_{i=0}^{k} \alpha_{51i} ER_{t-i} + \sum_{j=k+1}^{p} \alpha_{52j} ER_{t-j} + \sum_{i=0}^{k} \beta_{51i} NP_{t-i} + \sum_{j=k+1}^{p} \beta_{52j} NP_{t-j} + \sum_{i=0}^{k} \gamma_{51i} IRD_{t-i} + \sum_{j=k+1}^{p} \gamma_{52j} IRD_{t-j} + \sum_{i=0}^{k} \delta_{51i} VIX_{t-i} + \sum_{j=k+1}^{p} \delta_{52j} VIX_{t-j} + \sum_{i=0}^{k} \psi_{51i} SMUS_{t-i} + \sum_{j=k+1}^{p} \psi_{52j} SMUS_{t-j} + \varepsilon_{5t} \quad (5)$$

$$SMUS_t = \lambda_6 + \sum_{i=0}^{k} \psi_{61i} SMUS_{t-i} + \sum_{j=k+1}^{p} \psi_{62j} SMUS_{t-j} + \sum_{i=0}^{k} \alpha_{61i} ER_{t-i} + \sum_{j=k+1}^{p} \alpha_{62j} ER_{t-j} + \sum_{i=0}^{k} \beta_{61i} NP_{t-i} + \sum_{j=k+1}^{p} \beta_{62j} NP_{t-j} + \sum_{i=0}^{k} \gamma_{61i} IRD_{t-i} + \sum_{j=k+1}^{p} \gamma_{62j} IRD_{t-j} + \sum_{i=0}^{k} \delta_{61i} VIX_{t-i} + \sum_{j=k+1}^{p} \delta_{62j} VIX_{t-j} + \sum_{i=0}^{k} \phi_{61i} SM_{t-i} + \sum_{j=k+1}^{p} \phi_{62j} SM_{t-j} + \varepsilon_{6t} \quad (6)$$

The null hypothesis of the Granger causality test is that the dependent variable *does* not Granger cause the independent variable (excluded variable). To find evidence that the other variables Granger cause CT, conditions in Table 3 must hold, as it is shown in equation (2). Table 4 shows the conditions for the Granger causality in the direction of other variables to CT, following equations (1), (3), (4), (5), and (6).

Table 1. Conditions for Granger causality from the other variables to CT

Direction	**ER→CT**	**IRD→CT**	**VIX→CT**	**SM→CT**	**SMUS→CT**
Condition	$\alpha_{21i} \neq 0\forall_i$	$\gamma_{21i} \neq 0\forall_i$	$\delta_{21i} \neq 0\forall_i$	$\phi_{21i} \neq 0\forall_i$	$\psi_{21i} \neq 0\forall_i$

Table 2. Conditions for Granger causality from CT to the other variables

Direction	**CT→ER**	**CT→IRD**	**CT→VIX**	**CT→SM**	**CT→SMUS**
Condition	$\beta_{11i} \neq 0\forall_i$	$\beta_{31i} \neq 0\forall_i$	$\beta_{41i} \neq 0\forall_i$	$\beta_{51i} \neq 0\forall_i$	$\beta_{61i} \neq 0\forall_i$

The ordering does not matter in this paper. The results from the Granger causality tests do not change if the variables are ordered differently.

2.2 Data

In Table 3, we find all variables used in our analyses. For carry trade (CT), the weekly data of non-commercial traders provided by the U.S. Commodity Futures Trading Commission's (CFTC) Commitments of Traders Report (COTR) is used as a proxy. Usually, trades in the currency markets are over-the-counter (OTC), which difficult the modeling of carry trade (Gubler, 2014). Not only the data represents a small fraction of carry trade using these currencies, but some traders may also be using these contracts for other purposes (Curcuru et al., 2010). Each futures contract has information that is not publicly available, leaving space to this misinterpretation. Nonetheless, this is the best public data available.

The number of contracts is in local currency units (LCU). Definitions of the other variables are displayed in Table 3. Overall, I follow the same group of variables proposed by Nishigaki (2007). Nonetheless, the specific variables for funding currencies are the main difference: ERF, CTF, and IRDF. Moreover, the day that the CFTC releases the carry trade data is the reference date for the other variables, whose values are daily.

Table 3. Description of variables

Variable	Definition	Source
ER	Nominal exchange rates, USD/LCU	BIS
ERF	Nominal exchange rates, LCU/USD	BIS*
CT	Ratio of long positions over short positions (Long/Short)	CFTC*
CTF	Ratio of short positions over long positions (Short/Long)	CFTC*
IRD	Difference between the country's policy interest rate and the policy interest rate in the United States	BIS*
IRDF	Difference between the policy interest rate in the United States and policy country's interest rate and	BIS*
VIX	- CBOE DJIA Volatility Index (for AUD, CAD, JPY, MXN, NZD, RBL, CHF, and GBP) - CBOE Brazil ETF Volatility Index (for BRL) - CBOE EuroCurrency ETF Volatility Index (for EUR)	FRED
SM	- S&P/ASX 200, ^AXJO (AUD) - IBOVESPA, ^BVSP (BRL) - S&P/TSX, ^GSPTSE (CAD) - EURONEXT 100, ^N100 (EUR) - NIKKEI 225, ^N225 (JPY) - S&P/BMV IPC, ^MXX (MXN) - S&P/NZX 50, ^NZ50 (NZD) - MOEX Russia, IMOEX.ME (RBL) - Swiss Market Index, ^SSMI (CHF) - FTSE 100, ^FTSE (GBP)	Yahoo Finance
SMUS	S&P 500, ^GSPC (United States)	Yahoo Finance

*: Author's calculation with data from the source.

Two primary samples were established, following the movements of the US monetary policy: monetary easing (ME) and monetary tightening (MT). Additionally, MT may be divided into two subsamples: MTT (monetary tightening, target currency) and MTF (monetary tightening, funding currency). Table 4 shows the number of observations for each country and sample.

Table 4. Number of observations for each country and sample

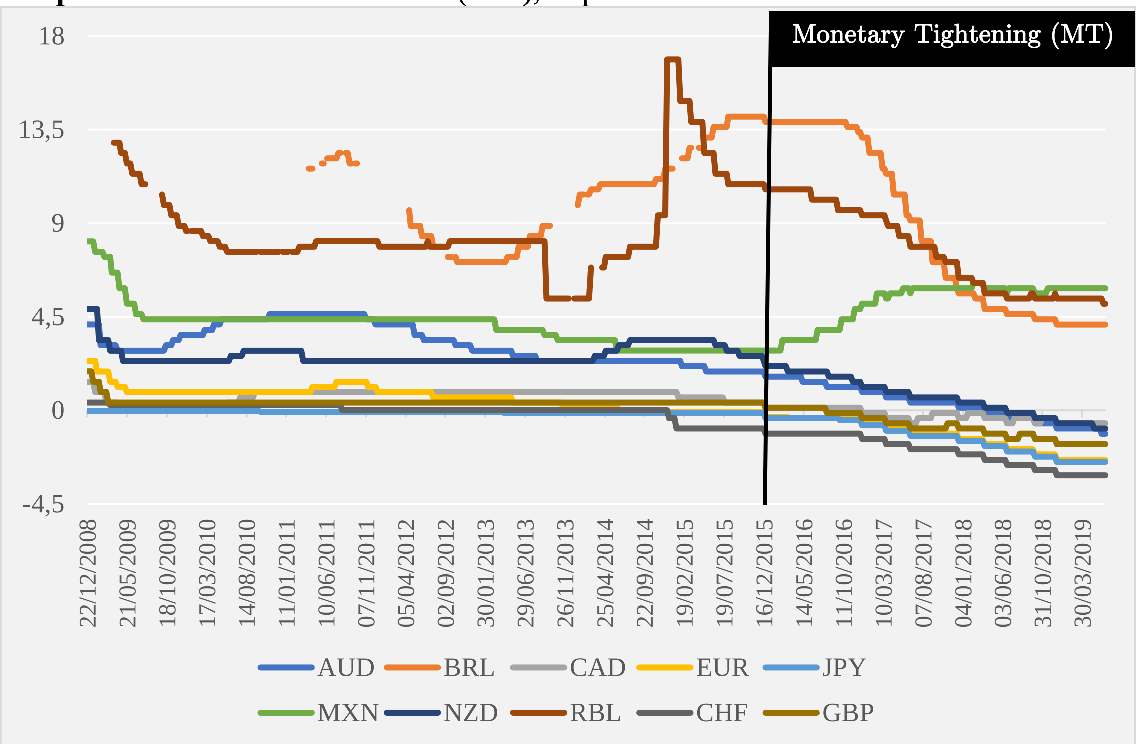
Country	Period	Sample			
		ME	MT	MTT	MTF
Australia (AUD)	12/30/2008 - 06/25/2019	364	184	118	66
Brazil (BRL)*	04/12/2011 - 06/25/2019	189	184		
Canada (CAD)	12/30/2008 - 06/25/2019	364			
Euro area countries (EUR)	12/30/2008 - 06/25/2019	364	184		
Japan (JPY)	12/30/2008 - 06/25/2019	364	184		
Mexico (MXN)	12/30/2008 - 06/25/2019	364	184		
New Zealand (NZD)	12/30/2008 - 06/25/2019	364			54
Russia (RBL)*	03/31/2009 - 06/25/2019	202	184		
Switzerland (CHF)	12/30/2008 - 06/25/2019	364	184		
United Kingdom (GBP)	12/30/2008 - 06/25/2019	364	184		

Notes: Samples with no observations (blank) are excluded from estimations. They are not stable (eigenvalues larger than one).

* Weeks with no data were excluded.

In terms of classification between target and funding currencies, I consider the signal of IRD. If IRD is larger than zero, it is a target currency; if IRD is negative, funding currency. Three currencies are considered target currencies in both samples (ME and MT): BRL, MXN, and RBL (see Graph 2). Not surprisingly, these are the only developing countries in this study. As for funding currencies, only JPY and CHF are classified as such for the entire analyzed period. In the MT sample, the US becomes a potential target for carry trade, funded by the developed countries' currencies.

Graph 2: Interest rate differentials (IRD), in per cent



Source: Author's own elaboration with data from the Bank for International Settlements (BIS).

3. Estimation results[1]

3.1 Preliminary procedures

The integration order of the variables is the element needed to apply the Toda and Yamamoto (1995) technique (Table 5 shows the results). In this sense, I apply the unit roots tests with one structural break with unknown breakpoints developed by Clemente, Montañés and Reyes (1998). I chose the AO (Additive Outlier) model, which first estimates equation (9) to remove the deterministic part of the variable:

$$y_t = \mu + d_1 DU_{1t} + \tilde{y}_t \tag{9}$$

Then, the test searches for the minimal t-ratio for the unit-root hypothesis ($\rho = 1$) in the following model:

$$\tilde{y}_t = \sum_{i=0}^{k} \omega_{1i} DTB_{1t-i} + \rho \tilde{y}_{t-1} \sum_{i=0}^{k} c_i \Delta \tilde{y}_{t-1} + e_t. \tag{10}$$

Table 5. Variables stationary, I(0), for each country and sample

Country	**Sample**			
	ME	**MT**	**MTT**	**MTF**
Australia (AUD)	CT, VIX	ER	VIX	VIX
Brazil (BRL)	SM	All I(1)		
Canada (CAD)	CT, VIX			
Euro area countries (EUR)	ER, IRD, VIX	CTF, VIX, SM		
Japan (JPY)	VIX	ERF		
Mexico (MXN)	ER, IRD, VIX	ER, IRD, SM		
New Zealand (NZD)	VIX			All I(1)
Russia (RBL)	VIX	All I(1)		
Switzerland (CHF)	CTF, VIX, SM	ERF		
United Kingdom (GBP)	ER, CT, IRD, VIX	SM		

As mentioned by Amiri and Ventelou (2012), the Toda and Yamamoto (1995) approach avoids possible misspecification of the models in the presence of non-stationary variables. After knowing the integration order (d), we need to select the maximum lag length of the VAR model (p). To ensure the usual asymptotic chi-square null distribution of the Wald tests, we added lagged exogenous variables. The number of lags of these variables is specified by d plus p. By doing this, we are proceeding with a modified Wald test (MWald test). Therefore, as put by Toda and Yamamoto (1995), "it is clearly desirable to have a testing procedure which is robust to the integration and cointegration properties of the process so as to avoid the possible pretest biases."

In order to choose p, we first generated tests for the optimal lag length. Two tests statistics (likelihood-ratio - LR, and Akaike's final prediction error - FPE) and three information criteria (Akaike - AIC, Hannan and Quinn - HQIC), and Schwarz's Bayesian - SBIC were considered. Following these results, we proceeded with the Lagrange-multiplier (LM) test for residual autocorrelation. If the optimal lag length order did not present the autocorrelation problem, we carried the stability test (eigenvalue stability

[1] Supplement statistical material can be supplied upon request.

condition). If the optimal lag length order failed the autocorrelation test, we chose the lag order with the highest p-value in this test. The procedure continued with the stability test at the end. More than being present in the tests of optimal lag length order, the lag order *p* must not have autocorrelated residuals and succeed in the stability test (no eigenvalue larger than one).

Additionally, I included an exogenous dummy variable for the tapering period (TAPER) on the ME sample. TAPER starts on May 2013, with Ben Bernanke mentioning for the first time the possibility of tapering (Chari et al., 2017). It ends with the first hike in the US policy interest rate on the 15th December 2015. This dummy is critical to account for the period wherein the quantitative easing monetary policies started to unwind.

3.2 Empirical results

Table 6 shows the results for the ME period. Jointly, all variables are preceding carry trade in Australia, Canada, and the United Kingdom. For the euro, IRD precedes movements in carry trade. In the case of NZD, VIX Granger causes CT. On the other side, CT is also impacting other variables. CT is anticipating movements in the exchange rate for EUR and RBL. For the latter, a top exporter country in the world, carry trade may be negatively affecting the real economy. Other results indicate that carry trade is Granger causing IRD (Australia), VIX (New Zealand), and SM (Euro area countries). Additionally, the lack of evidence for developing may be derived from the high profitability of carry trade during the ME period. In this sense, speculators profited from high interest rate differentials and exchange rate appreciation, without fearing losses.

For funding currencies during the ME period, we can see the results in Table 7. There is evidence for bi-directional Granger causality between ERF and CT (Japan), and IRDF and CT (Switzerland). Furthermore, ERF is also preceding CT in Switzerland, and VIX is anticipating CT in Japan. In a combined impact, all variables are preceding carry trade in both Japan and Switzerland. Last but not least, carry trade show strong evidence of Granger causation of local stock prices. Speculative investors use funding currencies as leverage to buy other assets (Nishigaki, 2007). With the upsurge (reduction) in short positions in the futures market, an appreciation (depreciation) of exchange rates in LCU/USD is expected. Therefore, for funding currencies, a higher (lower) value of local currency in comparison to the US dollar may increase (decrease) investors' interest in local stock markets.

During the monetary tightening period, as Table 8 demonstrates, all are Granger cause carry trade for Australia (in both MT and MTT periods), Mexico, and Russia. For Australia (sample MTT) and Mexico, movements on exchange rates and US stock prices anticipate carry trade. In the case of Mexico, IRD precedes carry trade during this period. Furthermore, the central bank of Mexico also conducted a monetary tightening during this period, which maintained high interest rate differentials with the US. VIX also Granger causes CT for Mexico and Russia.

On the other hand, only Brazil presents evidence of carry trade anticipating other variables. For the Brazilian economy, carry trade precedes movements in IRD and local stock markets. With monetary easing by the Brazilian central bank during this period, IRD has decreased substantially. Therefore, speculative capital may be unwinding ahead of changes in the Brazilian policy interest rate. Likewise, stock prices in Brazil are affected by capital flight.

For funding currencies, Table 9 shows the results for the MT period. There are three typical results for all countries. Firstly, exchange rates Granger cause carry trade. As Gubler (2014) pointed out for the CHF as a funding currency, nominal exchange rate fluctuations are a good predictor of carry trade with the USD as a target currency. Secondly, SM anticipates CTF. With the possibility to use leverage with carry trade, international speculative investors borrow in the funding currency and invest in local stock markets (Nishigaki, 2007). Thirdly, all variables are jointly preceding carry trade.

Moreover, individually, Switzerland presents both interest rate differentials and US stock prices as predictors of carry trade. For the Swiss economy, IRDF and SMUS Granger cause CTF. With the IRDF peaking at this period, carry trade provides excellent opportunities to borrow in Swiss francs and invest with leverage in the US stock market. Lastly, as for the Japanese economy, VIX presents evidence as predictor of CTF.

Additionally, as Table 9 shows, carry trade also predicts the other variables for funding currencies. For Australia and New Zealand, there is reasonable evidence for carry trade as a predictor of ERF and IRDF. CTF also anticipates IRDF for Switzerland. The safe-haven characteristics of the Swiss franc are supported by the bidirectional causality of IRDF and CT. As pointed out by Vallet (2016), Switzerland has an advantage of "interest rates bonus." In the case of VIX and SMUS, carry trade Granger causes both for the Swiss franc and the sterling. Likewise, there is evidence of Granger causality from CTF to SM for Australia and the Euro area countries.

Although using different datasets and methodologies, my results are similar to Mogford and Pain (2006), Klitgaard and Weir (2004), Nishigaki (2007), Gubler (2014), and Mulligan and Steenkamp (2018).

Table 6. Granger causality tests for target currencies, sample ME

Direction	Other variables to CT						CT to other variables				
	ER→CT	IRD→CT	VIX→CT	SM→CT	SMUS→CT	All→CT	CT→ER	CT→IRD	CT→VIX	CT→SM	CT→SMUS
Australia	0.3245	0.4767	0.0328**	0.0310**	0.1062	0.0043***	0.3806	0.0729*	0.6237	0.4043	0.6656
Brazil	0.9678	0.5212	0.8110	0.6034	0.7242	0.9949	0.9940	0.9361	0.9999	0.9077	0.8123
Canada	0.3447	0.7075	0.1650	0.0076***	0.0050***	0.0205**	0.2999	0.1978	0.9263	0.8574	0.6788
Euro area	0.3406	0.0012***	0.2962	0.7107	0.9213	0.1023	0.0126**	0.7287	0.2982	0.0446**	0.6520
Mexico	0.1474	0.6767	0.6542	0.6818	0.7407	0.2861	0.9479	0.8474	0.8830	0.8650	0.9924
New Zealand	0.1506	0.6667	0.0826*	0.9870	0.1495	0.3453	0.4985	0.9913	0.0564*	0.8886	0.1879
Russia	0.9352	0.9443	0.3811	0.8640	0.4893	0.7899	0.0116**	0.8288	0.4597	0.7483	0.1460
United Kingdom	0.0218**	0.3504	0.3645	0.9246	0.6996	0.0798*	0.2395	0.7315	0.4462	0.4114	0.3486

Notes: p-values followed by the usual symbols for the statistical significance levels: *** for 1%, ** for 5% and * for 10%.

Table 7. Granger causality tests for funding currencies, sample ME

Direction	Other variables to CTF						CTF to other variables				
	ERF→CT	IRDF→CTF	VIX→CTF	SM→CTF	SMUS→CTF	All→CTF	CTF→ERF	CTF→IRDF	CTF→VIX	CTF→SM	CTF→SMUS
Japan	0.0002***	0.6270	0.0274**	0.7202	0.4327	0.0002***	0.0551*	0.9900	0.6245	0.0230**	0.1839
Switzerland	0.0000***	0.0280**	0.6151	0.1333	0.3470	0.0000***	0.2017	0.0709*	0.2528	0.0025***	0.3376

Notes: p-values followed by the usual symbols for the statistical significance levels: *** for 1%, ** for 5% and * for 10%.

Table 8. Granger causality tests for target currencies, sample MT (for Australia, also sample MTT)

Direction	Other variables to CT						CT to other variables				
	ER→CT	IRD→CT	VIX→CT	SM→CT	SMUS→CT	All→CT	CT→ER	CT→IRD	CT→VIX	CT→SM	CT→SMUS
Australia	0.0114**	0.2901	0.1818	0.6587	0.3213	0.0463**	0.3603	0.3260	0.2235	0.4792	0.8877
Australia-MTT	0.0091***	0.4878	0.1248	0.9435	0.0512*	0.0142**	0.5916	0.3538	0.7526	0.7291	0.7128
Brazil	0.3125	0.1123	0.9667	0.3270	0.7127	0.2997	0.4895	0.0280**	0.1027	0.0509*	0.9656
Mexico	0.0023***	0.0051***	0.0166**	0.1339	0.0985*	0.0060***	0.5820	0.3417	0.9620	0.9773	0.7866
Russia	0.4196	0.2808	0.0001***	0.3249	0.3288	0.0002***	0.5245	0.6907	0.9232	0.6814	0.7940

Notes: p-values followed by the usual symbols for the statistical significance levels: *** for 1%, ** for 5% and * for 10%.

Table 9. Granger causality tests for funding currencies, sample MT (for Australia and New Zealand, sample MTF)

Direction	Other variables to CTF						CTF to other variables				
	ERF→CT	**IRDF→CTF**	**VIX→CTF**	**SM→CTF**	**SMUS→CTF**	**All→CTF**	**CTF→ERF**	**CTF→IRDF**	**CTF→VIX**	**CTF→SM**	**CTF→SMUS**
Australia	0.0122***	0.2364	0.6744	0.0291**	0.2287	0.0091***	0.0527*	0.0703*	0.3951	0.0875*	0.6866
Euro	0.0015***	0.3513	0.7302	0.0006***	0.1093	0.0000***	0.1166	0.1772	0.5683	0.0679*	0.1122
Japan	0.0186**	0.9038	0.0321**	0.0044***	0.1031	0.0005***	0.8247	0.2627	0.6663	0.4706	0.4007
New Zealand	0.0124**	0.4622	0.1925	0.0610*	0.7240	0.0209**	0.0576*	0.0444**	0.9294	0.6022	0.8227
Switzerland	0.0083***	0.0163**	0.1942	0.0713*	0.0049***	0.0013***	0.8255	0.0550*	0.0084***	0.1323	0.0004***
United Kingdom	0.0001***	0.9670	0.4155	0.0346**	0.9589	0.0054***	0.1763	0.7568	0.0491**	0.4284	0.0697*

Notes: p-values followed by the usual symbols for the statistical significance levels: *** for 1%, ** for 5% and * for 10%.

4. Conclusions

This paper adds new empirical results to the carry trade literature by exploring different data sets, comprised of different currencies (funding and targeting currencies) and samples (quantitative easing and tightening). By using the Toda-Yamamoto approach, Granger causality tests present robust evidence of the relations between carry trade and related financial variables.

With data from de future markets in the United States, which is one of the largest in the world, my results indicate different behavior of carry traders in different pairs of currency and monetary policies. During the period of monetary easing by the Federal Reserve, the group of target currencies pairing with the US dollar is much bigger than in the period of monetary tightening. In the latter, only developing country currencies remain with higher policy interest rates than the US.

With the inclusion of other assets, represented by the stock prices in the local market and in the US, carry trade can be better understood. In this sense, not only the exchange rate, interest rate differentials, and investor's sentiment matter. Furthermore, results show evidence on how carry trade may affect the real economy.

Finally, far from being definitive, the results are suggestive in the linkages of carry trade in the cases of funding and target currencies during the periods of monetary easing and tightening. For future research, strong causation and timing require structural vector autoregressive (SVAR) models.

7. References

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