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The developed market currency tango: Carry trade and hedging during 2014 – 2019

VECM and DCC approach

By

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Abstract: In this study carry trade activity in AUD, CAD, EUR and YEN vis the USD between 2014 – 2019 was analysed. The first approach employs a VECM, analyse evidence of carry trade recorded in the exchange rate pairs Futures, Forwards and Spot. Results show evidence of carry with the USD being the target currency, while the others being the funding currency. However, the AUD shows specific traits of carry trade in a reverse manner, since the AUD was yielding higher interest rates than USD. The second part of the analysis investigates evidence of hedging with the help of DCC, where the returns of the currency futures and S&P 500 are used, where S&P 500 represents the USD stock market. The results show evidence of YEN being used as a hedge vis the S&P 500, while the USD shows evidence of hedging vis the AUD and CAD. The EUR case shows evidence of neither directions

Keywords: Carry trade, hedging, currency market, GARCH DCC, VECM

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Intro

The days of Bretton-woods system are way gone, the current system the Non-system is a mix of free and managed floating exchange rate like the USD, the Chinese renminbi and swiss Franc before its de-pegging 2015. Hard pegs were more common until the beginning of 21^{st} century. The floating exchange rate has raised the acronym, the fear of the floating due unexpected predictability of floating exchange rate, e.g. the Mexican peso crisis and Black Wednesday in the U.K. All crisis begun with speculative attacks against the currencies of the economies, due to the market belief of expected depreciation of the currency's vis e.g. the USD. The currency crisis ignited a flight to quality of capital, due to, e.g. loss of confidence of the economic outlook.

The expectations ground itself on the interest rate differential between the exchange rates pairs, e.g. GBP/USD. However, it was also grounded in the view of the macroeconomic fundamentals in the country's contra the fundamentals in, e.g. U.S.A the difference of fundamental macroeconomic outlook between the economies.

Interest rate differential has been the key driving force behind exchange rate movements since the introduction of the Non-system, hence this has paved way for the market focus on currency carry trade positions. Carry trade usually defines a leverage cross-currency position designed to take advantage of the interest rate differential. The strategy involves borrowing in the low-yielding currency, e.g. issuing a bond then buying an asset in the higher-yielding currency, e.g. a bond. The profit comes out of the interest differential of the position, and the position is profitable as long as the currency pairs stay at the same level or the higher-yielding currency appreciates. However, unexpected events may erode profit.

Thus, the position is grounded on the belief that the higher-yielding currency will either appreciate or not depreciate at all vis the lower-yielding currency, this is the Covered Interest rate Parity condition (CIP)[1]. Where the reverse, i.e. an expectation of lower-yielding appreciating vis the higher-yielding is the Uncovered Interest rate Parity (UIP).

Traditionally, carry trade are used by large financial institutions, e.g. hedge funds, banks, and commodity trading advisor. However, this can be done by daily Alex and Ann (retail traders), by simple buying foreign stocks in a higher-yielding country than theirs through any platform. Thus,

[1] More on this will pop-up through the paper, section 2.1.2 presents the details

they may realise gains from the trade and additionally gains from the interest rate differential, i.e. the exchange rates movements. Hence, interest rate differential, i.e. carry trade influences everyday choices for financial institutions, business with foreign operations and every day Alex and Ann. The mentioned actors or specifically the professional FX traders try to realise gains by implementing different strategy approaches, some choose just to follow the trend, i.e. the trend strategy, while others base their decision on fundamentals such a macroeconomic outlook, i.e. the fundamental-based strategy. The approach of this paper is to highlight when these approaches observed in the carry trade activity, thus, providing a guide for which approach any traders professional and non-professional should place weight on when trading currencies.

Furthermore, to navigate in the jungle of interest rates, one has to understand the key drivers behind the interest rates and expected interest rate changes, e.g. central banks policies. Thus, this paper ought to investigate the carry trade activity between the developed market currencies, the AUD, CAD, EUR and the YEN vis the USD. With the two first mentioned being commodity-linked economies and the two latter being safe-haven linked currencies.

Volatility in the stock markets tends to be accompanied by currency volatility, evidently by the currency crisis of the ’90s, since investors, traders, Alex and Ann buys stocks and need to obtain currencies to settle trade while some other party is selling stocks needs to receive currency to exchange. Thus, consequently, an increase in currency volatility can be explained by increasing stock market volatility and vice versa. Hence it of interest to investigate the time-varying correlation between them, which this study is ought to do in the second part of the analysis. Hence, this paper differently to other papers, since this paper is not ought to analyse the portfolio returns of the carry trade, but rather the behaviour of carry trade positions and their return relation, i.e. flight to quality/ hedging characteristics when stock market volatility increases.

Specifically, whether if carry trades are utilising the interest rate differential or do they behave differently, subsequently whether the currency pairs reveals hedging characteristics between them and the U.S stock market proxied by the S&P 500. Hence, the second analysis contributes to the first analysis by providing information on the utilising of carry trades.

To investigate the carry trade, a VECM is employed to analyse the long- and short-run relationship between the Futures, Forwards and spot currency pairs. In the first analysis, the Vector Error Correction Model model inspired by Johansen (1991) is employed to investigate the carry trade activity. In the second analysis, the Dynamic Conditional Correlation model inspired by Engle (2000) is employed in the currency futures and S&P 500 returns.

This study finds evidence of carry trade of the traditional manner revealed in the Futures data of the USD/CAD, USD/EUR and USD/YEN however the USD/AUD reveals existence of "anti" carry trade, meaningly the interest rate differential is not used in the traditional manner, but rather in a reverse manner. Furthermore, this study finds evidence of hedging, where the YEN is revealed to be used as safe-haven vis the S&P 500, the EUR showed to oscillate around zero on average, while the other currencies are trending with S&P 500, they fall and rise with S&P 500.

The paper is constructed as followed, part 1; The literature review, which provides information about previous research regarding carry trade, similar studies that have applied the same method. Part 2; The data and methodology employed in this paper, background information surrounding the data and carry trading followed by explanation of the Vector Error Correction Model and the Dynamic Conditional Correlation and their employment in this study. Part 3; Presentations of the results and discussion. Lastly, part 4; The conclusion.

1. Literature review

The research surrounding carry trade is rich on well-established findings of the downward bias in the unbiasedness hypothesis, [2] also known as the forward premium puzzle[3] coined by Fama (1984). The Fama regression illustrates the term.

$$s_{t+k} - s_t = \alpha + \beta(fp_t^k) + \varepsilon_{t+k} \qquad (1)$$

Where s_t (s_{t+k}) is the natural log of spot exchange rate at time *t (t+k)*, fp_t^k is the natural log forward premium/discount (difference of k-period between forwarded spot rate at time *t)* with the error term ε_{t+k}. The null hypothesis is $\alpha = 0$, $\beta = 1$ and ε_{t+k} is a white noise process. Thus, the RHS equals LHS, which implies that the expected return is zero, i.e. no excessive returns.

Notably, the well-documented finding is that β tends to be less than unity and more often negative (Clarida, et al., 2009), which implies excessive currency return can be achieved by trading on interest rate differential, i.e. trading on the carry. Interestingly, carry trade has shown to outperform

[2] The hypothesis stats that given conditions of rational expectations and risk neutrality, the forward exchange rate is an unbiased predictor of the future spot exchange rate, i.e. it is a random walk
[3] Or the Fama Puzzle

on average in terms of return, e.g. with a better Sharpe ratio compared to stock and bond markets (Menkhoff, et al., 2012; Byrne, et al., 2017; Hochradl & Wagner, 2010).

Previous studies surrounding carry trade has evaluated the carry trade between lower-yielding currency Developed Market (DM) and much higher-yielding currencies, e.g. Emerging Market (EM) currencies (Pappa, 2014). Where the lower-yielding currency is the funding currency, and the higher-yielding is the target currency. The carry trade between high-yield and low-yield goes under several definitions, one is the naïve carry trade strategy since it naively to assume expected return to be positive (Jorda, et al., 2012; Burnside, et al., 2007). The strategy is consistent with CIP, since there are expectations of the higher-yielding currency to appreciate vis the lower-yielding currency.

The typical funding currency is developed market currencies such as YEN, CHF and the USD, while typical target currencies have been emerging market currencies such as Brazilian Real, Mexican Peso and Indian Rupee. Burnside, et al. (2007) found that payoff from a portfolio consisting of developed and emerging market currencies yielded a better Sharpe ratio than a portfolio consisted of exclusively developed market currencies. However, since the aftermath of the financial crisis 2007-08 this relation has somewhat changed, where anti-carry[4] trades have become more frequent, which is more in line with UIP, i.e. expectations that the lower-yielding currency will appreciate vis the lower-yielding currency (Menkhoff, et al., 2012; Byrne, et al., 2017).

The reason varies Goodfriend (2014) and Aizenman, et al., (2014) stress the role of unconventional monetary policy as an enabler for carry trade. The unconventional monetary policy introduced a new game in town which financial market defines as the "*The era of cheap money*", where compressed yields in the developed world induced a global search for yield, thus increasing the flow to riskier assets typically found in EM markets.

This study is related to the research providing evidence of carry trade activity, e.g. Gabriele & Michael (2004) found evidence of momentum trading[5], which is a form of bandwagon strategy, where traders join existing trends that further reinforce the appreciation of currencies. Since the

[4] Carry trade used in the reversed manner, taking a long position in the lower-yielding currency vis the higher-yielding currency.
[5] Momentum trading is defined also known as trend trading, trend followers i.e. trend traders

common trend is the naïve strategy, the momentum strategy, where the implementation of trend strategies is on the naïve strategy. Furthermore, the study found a substantial increase in FX turnover[6] between 2001-2014, which seemed to be driven by trend strategies in a bid for a search for yield. In a similar study Galati, et al., (2007) found evidence of carry trading resulting in volatility shocks in markets, due to massives unwinding of long positions in target currencies. Which, implies that unexpected events can lead to volatility surge in either direction of the carry trade position, funding position aswell. Much like Galati, et al., (2007), this study finds evidence of currency unwinding leading to surge in volatility, specifcally increased uncertainty in the funding positions which in leads to volatility surge.

This study ought to capture evidence of carry trade, i.e. the behaviour of carry trade seen in exchange rates markets, Zivot (2000) of evidence of cointegration relationship existing between forwards and spot exchange rates, which is no surprise. Cointegration implies VECM analysis is possible. This study takes inspiration from Shehadeh, et al., (2016), where the study uses VECM to provide evidence of USD carry trade[7]. The study finds interesting anomalies, where it finds carry trade between USD and EM, i.e. short positions[8] in the lower-yielding currency (U.S) and long positions[9] in the higher-yielding currency (EM). However, it found the reverse, i.e. anti-carry trade between USD and DM, i.e. long positions in the lower-yielding currency (U.S) and short positions in the higher-yielding currency (DM). Where the carry trade in the first premises is in line with CIP and the anti-carry trade is in line with UIP. Thus, it is of interest to evaluate this relationship more in detail, what is the behaviour of this carry trade positions linked to the U.S market, i.e. the stock market, what is the dynamic linkages (the correlation).

Moreover, much like Shehadeh, et al., (2016) this study finds evidence of carry trade and anti-carry trade. their study is surrounded by the carry trade return portfolio much like previous research, e.g. Burnside, et al. (2007). While this study is not ought to investigate the portfolio return, but rather the hedging characteristics.

No paper provides any discussion regarding homoscedasticity, normality and autocorrelation, since if the variable is integrated by I(1), utilising a VECM will difference the variables, hence if

[6] FX is an acronym used in markets for the word currency, FX and currency is used through out the paper
[7] USD as the funding currency
[8] Short positions; funding
[9] Long positions; target

one is working with natural log in the VECM, the difference will transform it to returns. Returns are by nature nonhomogenetic and currencies also being substantial nonhomogenetic. So this study, much like previous research, considers the existence of nonhomogeneity in the variable when performing the VECM. (Burnside, et al., 2007; Zivot, 2000; Engel, 1996).

Many papers use the DCC approach to model the linkage between financial and economic variables, e.g. Cappiello, et al., (2006) analyse the global equity and bond markets correlation following the introduction of the Euro with an Asymmetric Generalized DCC (AG-DCC). The models extend on previous specifications along two dimensions; it allows the impact of series-specific news and smoothing of parameters. Furthermore, it permits conditional asymmetries in the correlation dynamics. The studies find a near-perfect correlation among bond return within the EMU, which is not a surprise considering the harmonisation of monetary policies. However, equity correlation increases both within the EMU and outside. This study does not find any near-perfect correlation on average, in some instances due to the correlation being time-variant, the correlation reaches high, but not sufficient enough to state near perfect.

However, this study is interested in evaluating the time-varying correlation from a hedging perspective, much similar to Ciner, et al., (2013), where the study uses a DCC model inspired by Engle (2000) which is the model used by this paper also. The paper investigates the return relation between major assets (stocks, bonds, gold, oil and exchange rates) for the US and the UK. The analysis presents if any of the assets classes characterise safe-haven characteristics, i.e. which assets class shows hedging characteristics, where results regard gold as safe-haven in both markets.

Similar to Ciner, et al., (2013), Dua & Tuteja (2016) investigate the dynamic linkages across international stock and currency markets during financial crisis i.e. the 2007-08 and European debt crisis in China, Eurozone, India, Japan and the U.S. The study makes use of the term flight to quality which is not necessarily hedging, yet it is a form of hedging. The study finds evidence of flight to quality in times of financial stress, the study much like Ciner, et al., (2013) and this study applied the DCC approach inspired by Engle (2000). Much like Ciner, et al., (2013) and Dua & Tuteja (2016), this study finds evidence of hedging, however, the data differs from the studies to this study, specifically the sample period. This study stands out from previous research, due to its sample period, June 2014 – April 2019, hence it captures recent events which may be more relevant today.

Furthermore, this study takes inspiration from González-Serrano & Jiménez-Martín (2011), where their study makes use of FX futures contracts to evaluate currency hedging. The study estimates four multivariate volatility models, where one is a DCC model, much like the aforementioned studies and this study. Their study is also similar to this study due to their use of near-month future contracts[10]. They found evidence of FX Futures, specifically near-futures to be a good tool for hedging compared to Futures which were longer from near-month[11].

This study is unique in different ways; firstly, there are no studies with a combined similar approach, i.e. a cointegration and a DCC approach on exchange rates and stock market[12] together. There are a set of studies with a similar approach independently or combined with different data. The purpose of combining both methods is to provide information past the carry trade, i.e. the carry trade may not be used as carry trade just because, perhaps it is the characteristics of the currency, e.g. safe-haven or commodity currencies. This study differs from previous studies which tend to evaluate developed market versus Emerging markets and focuses on four developed market currencies since the interest is to provide evidence of carry trade at the margins (low-interest rate differential). Furthermore, this study is ought to providence evidence of hedging patterns between FX Futures and the USD market proxied by SPX.

2. Data and method

This section starts with presenting the theoretical considerations around carry trades and FX traders, followed by basic information surrounding the variables to illustrate why they are of interest, subsequently markets events during the time frame that contains valuable information. The market events also argue for the choice of the sample period. The VECM empirical model used to analyse the carry trade activity is presented, followed by the DCC empirical model used to analyse the return relation between the FX futures and SPX[13], this illustrates how the carry trade behave in times of uncertainty throughout the time frame.

[10] Futures contracts that are close to expiration date
[11] The futures contracts used in this study is approximately 2 months away from expiration date
[12] Not that I know of at the time of writing
[13] From here on the denotation S&P 500 will jump between SPX and S&P 500

2.1 Data

The empirical analysis of this paper is drawn on financial data obtained from Bloomberg and Thomson Reuters Data Stream. For the analysis this study employs daily 3-month FX forwards and Spot data, moreover 5y FX futures are used as a proxy for the Commitment of Traders[14]; lastly, daily data from S&P 500 is used in the latter part of the empirical analysis. The data ranges between 2014-06-13 – 2019-04-30, i.e. 1273 observations.

The currencies of interest are the Australian dollar (AUD), Canadian dollar (CAD), Euro (EUR) and Japanese Yen (YEN)[15]. The currency is quoted as USD/X, i.e. the USD is the base currency and the other mentioned currency as the quote currency (BASE/QUOTE). The natural log of the exchanges is used in the first part of this study, i.e. the analysis of carry trade activity with the VECM framework. The second part with the DCC analysis makes use of natural log return of the 5y FX Futures and SPX to investigate the dynamic correlation between the futures and SPX, hence, illustrating hedging/flight to quality. E.g. when the SPX is trending downwards what is the effects on the USD/AUD FX Futures, vice versa. However, to understand why there would be a negative/positive relation between SPX and the FX Futures requires an understanding of the theoretical considerations of FX traders' strategies and subsequently the underlying exchange rates, i.e. what the FX traders are trading on.

2.1.2 Covered/Uncovered Interest Rate Parity

As mentioned in section in the intro and section 1, the Cover Interest rate Parity (CIP) implies that the higher-yielding currency is expected to appreciate against the lower-yielding currency, this has become associated with the naïve carry trade (Jorda, et al., 2012; Burnside, et al., 2007). Hence, traders[16] are covered when they use the lower-yielding currency as a funding currency and target the higher-yielding currency since the expected direction favours the higher-yielding. The Yen carry trade has become a common phenom due to the low yields in Japan, i.e. traders' funds in yen and target a higher-yielding currency, e.g. the USD. As such traders assume the CIP holds when they utilise the naïve carry trade. Thus, the return for holding a long position in USD/YEN with

[14] This is explained more in detail in section 2.1.4
[15] From here on the exchange rate will be denoted by their short acronym e.g. USD
[16] Traders is an acronym for market actors in this paper

USD being the base currency (i_t^*), Yen the quote (i_t), spot (S_t) and forward (F_t) at time t can be expressed as

$$r_{t+1} = (1 + i_t^*)\frac{S_{t+1}}{S_t} - (1 + i_t) \approx S_{t+1} - S_t + (i_t^* - i_t) \qquad (2)$$

Now if CIP holds, the strategy can be implemented by using a forward contract[17], the return for holding a long position in the USD is as follow.

$$r_{t+1} = \frac{S_{t+1} - F_k}{S_t} = \frac{S_{t+1}}{S_t} - \frac{F_t}{S_t} \approx s_{t+1} - s_t + (f_t - s_t) \qquad (3)$$

Eq. 2 and Eq. 3 implies that interest differential is equal to a forward discount[18] in this case;

$$i_t^* - i_t \approx s_t - f_t \qquad (4)$$

Where the USD/Yen forward is at a discount[19] (see Figure 1). Therefore, excess return for holding a long position in USD/Yen can be expressed as;

$$r_{t+1} = s_t - f_t + s_{t+1} - s_t \approx s_{t+1} - f_t \qquad (5)$$

Hence, traders achieve excessive currency return through the interest rate differential, as mentioned in section 2 by the Fama equation (Eq.1)). The traders to this by trading, i.e. taking a long position in USD vis the YEN as mentioned above, since the interest rate differential implies an expected appreciation of the higher-yielding currency vis the lower-yielding currency.

Thus, when the CIP holds the Eq. 5 holds, and traders behave in accordance with CIP, however when CIP fails, i.e. traders behave non-accordingly to CIP. They believe the lower-yielding currency is likely to appreciate vis the higher-yielding and not the other way around; this is the Uncovered Interest rate Parity (UIP). Traders do not act on the naïve carry trade, rather they act against it, i.e. anti-carry trade (Shehadeh, et al., 2016). Furthermore, traders may not necessarily fund in higher-yielding currency; however, they may avoid it, which in return implies no appreciation in the higher-yielding currency due to lower demand. Since the lower-yielding currency is expected to appreciate versus the higher-yielding currency, it is not in line with

[17] This study assumes the reader has basic knowledge of currency forward contract, if not Investopedia is a good source for explanation
[18] Forward discount; Spot > Forward, Forward premium; Spot < Forward
[19] At the time of writing, the USD/YEN forwards are trading at a discount

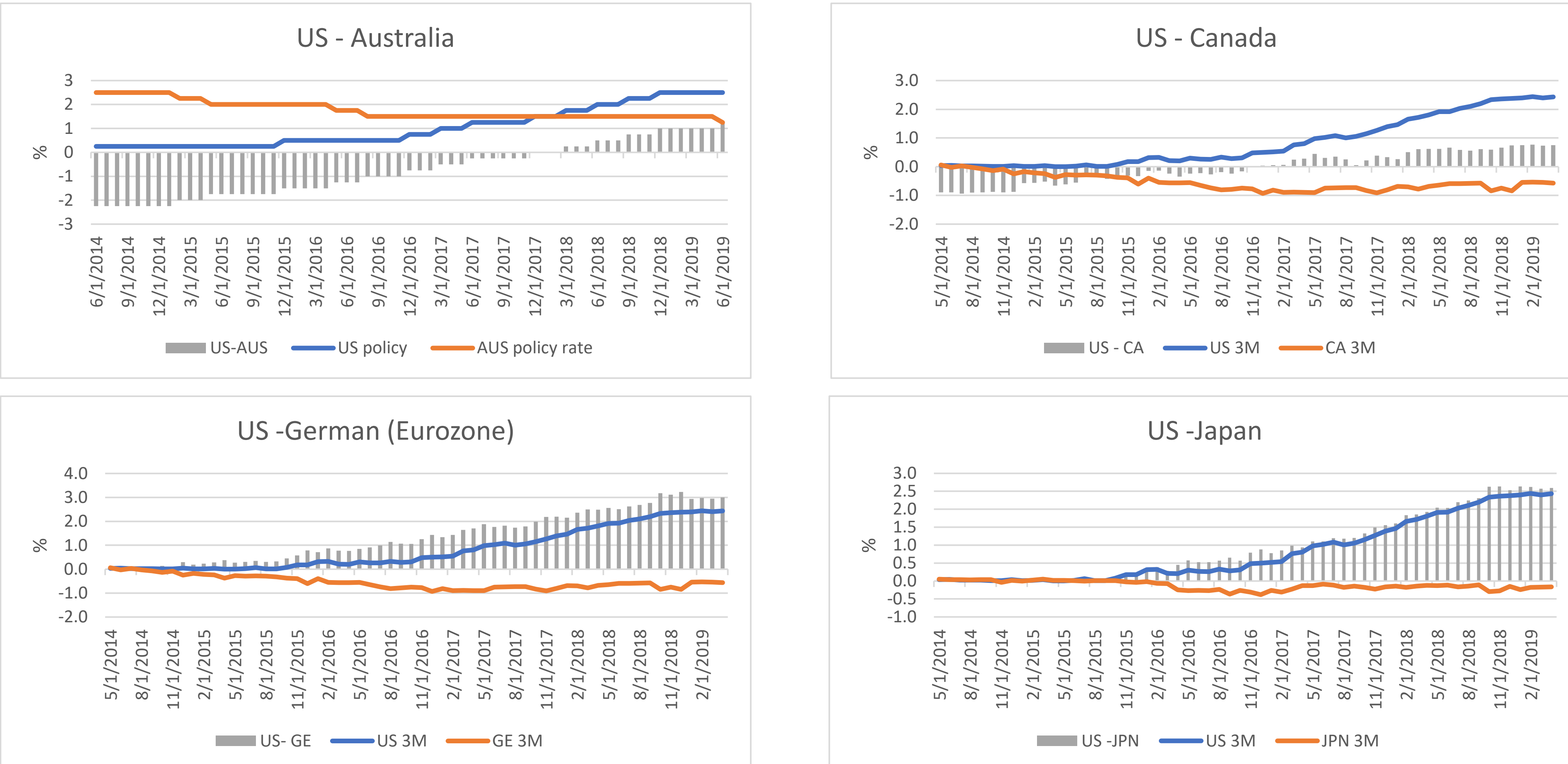


Figure 1; interest rate differential; The interest rate differential between the 3-month bond/treasury, the Australia case presents the difference of policy rates theoretical expectations due to interest rate differentials, i.e. a trade position are not covered but rather uncovered (Mantzura & Schreiber, 2019).

Traders, specifically bonds and FX traders, are trend followers since it is naively easy to follow the trend strategy, i.e. the naïve carry trade, as such their actions are consistent with CIP. Where the naïve strategy has played well prior to the financial crisis 2007-08, however, as mentioned in section 1, the relation has altered post-2007-08 crisis in the era of cheap money[20]. Thus, the typical trend strategy, i.e. the naïve carry trade, has also somewhat changed. There are trend strategies then there is the fundamentals-based strategy, where the trend strategy is associated with the CIP, the fundamental-based is associated with UIP. The fundamental-based strategy implies that due to fundamentals, the naïve picture does not hold, e.g. due to macroeconomic factors, the lower-yielding currency should appreciate vis the higher-yielding.

However, Spronk, et al., (2013) demonstrates depending on the dominant strategy in markets, the common trend traders can be in the same camp as the common fundamentalist traders. This study evaluates these premises by evaluating the carry trade activity, since theoretically the trend strategy in accordance with CIP should be the dominant strategy. However, due to the fundamentals and market uncertainties, this might not be the case (Smit & Polakow, 2018) (Pappa, 2014). Hence, the following sections will present the key factors behind the currencies such as their linkages to different markets and market events, i.e. key drivers behind the fundamentals that are in return key drivers behind the trend and fundamental-based strategies.

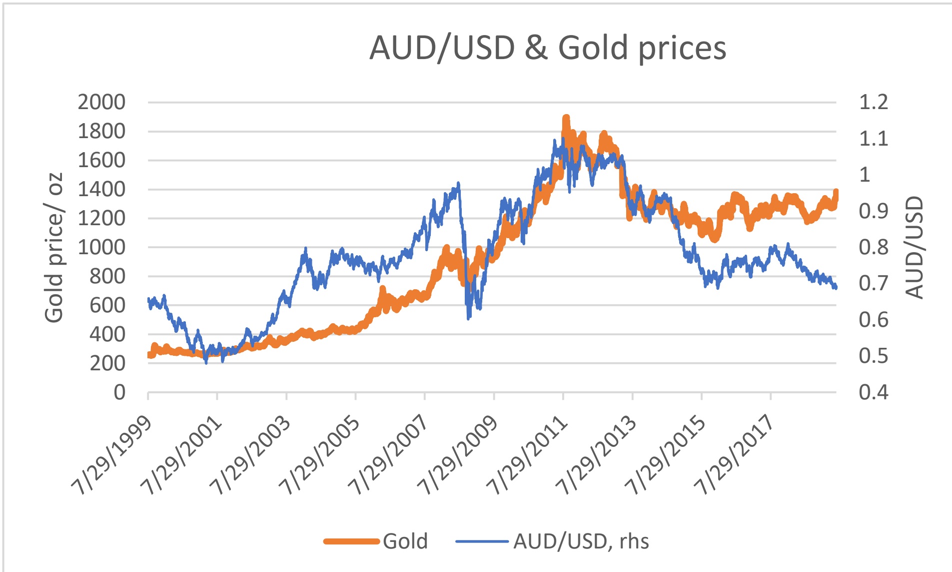
2.1.3 The identities of the currencies

The currency of interest is DM currencies due to their characteristics as DM currencies, hence their trading characteristics where DM are characterised as safe-havens and funding currencies, in some instances even as commodity currencies. Furthermore, due to the low-interest rates world, DM currencies is interesting since the low-interest rate differential is at the margins.

The USD is considered to be the number one safe-haven; however, traders move to safe-haven in depending on the timing and market environment Spronk, et al., (2013). Commodity currencies are most often associated with EM currencies such as Brazil, Russia and South Africa. However, Australia, Canada and Norway are examples of economies that are commodity-driven. Byrne, et

[20] Due e.g. Quantitative easing, lower yields and generally lower R* in the developed world

al., (2017) shows that commodity prices influences carry trade returns, as such being commodity currency the AUD and CAD has a positive correlation with the major commodity export in respective country which is illustrated by figure 2.



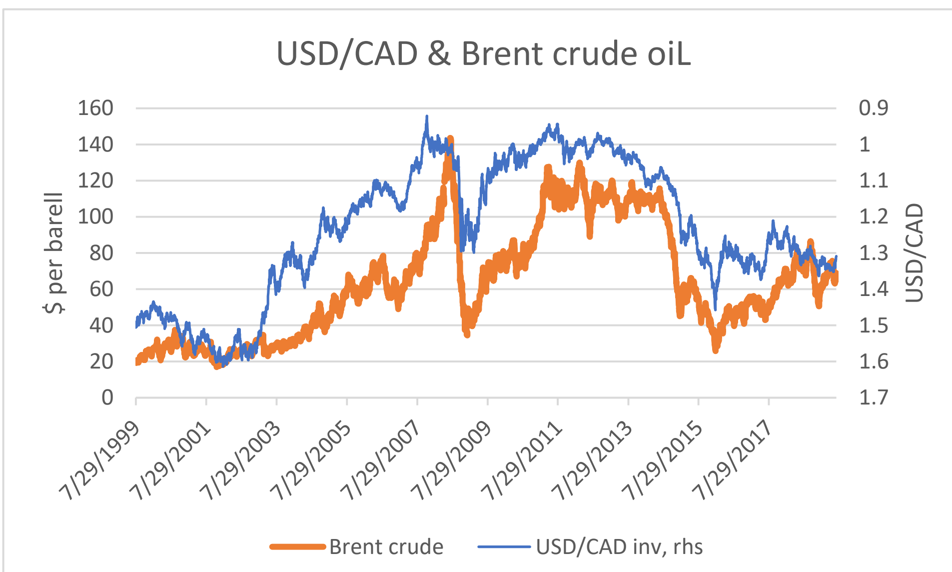


Figure 2; Developed commodity-linked currencies. Australia is 2nd biggest producer of gold in the world, while Canada, being a non-OPEC country, is the 3rd largest oil exporter. These commodities are major components of the their GDP and has historically illustrated the exchange rate movement well.

The Yen and Euro, on the other hand, are not commodity currencies; however they are considered to be safe-haven currencies like the USD (Tachibana, 2018). Masujima (2017) shows that safe-haven currency may explain the UIP, i.e. why traders choose to invest in the lower-yielding currency in the time of uncertainty. The study shows that the Yen is the most robust safe-haven, which motivates the analysis of this study, i.e. where do trader invest when volatility and uncertainty arise in the U.S SPX (i.e. the U.S stock market), in the number one safe-haven market U.S.A. With the EUR/USD being the most dominant trading pairs, it is given to include the EUR in any analysis, also this one.

2.1.4 Markets events during the sample period

The time frame of interest is partially due to the accessibility and availability of futures data on public/student databases, the futures used in this study is provided by Bloomberg, which is 5y futures with start date 2014-06-13 and with maturity in June 2019. Since this study is interesting in the carry trade activity, one has to capture data that reflects the activity. The use of FX Futures is the closest proxy for the actual number of positions taken by traders[21] in the futures market, this illustrates the Commitment Of Traders (COT) (see figure 3). Previous research has also used public data, e.g. FX turnover and FX future positions report and statistics from Bank for International Settlements (BIS) (Curcuru, et al., 2011; Galati, et al., 2007). Others have used options data as a proxy to illustrate the trading activity amongst traders (Bhansali, 2007; Grobys & Heinonen, 2017).

This study makes use of FX forwards and FX Futures, which are very similar, however there is a distinct difference between them. Both involve the agreement between two parties to buy and sell an asset at a specified price by a certain date. Forwards are privately agreed, i.e. Over The Counter (OTC) and settled at the end of the agreement. While a futures contract is traded on an exchange and settled daily until the end of the contract. The forward is used primarily for hedging with the purpose to cut down volatility, while the futures are used by speculators who bet on where the price of assets will move[22]. This study is interested in evaluating the trading activity and the return relation to SPX, as such the use of FX futures as they reveal the number of positions taken as illustrated by figure 3 (Herwartz & Schlüter, 2016).

Furthermore, the sample period was shown to be a fortunate incident since it contains vivid

[21] In order to investigate carry trade activity, one has to measure the number of position taken i.e. how many long and short contracts. This is reported by the Chicago Mercantile Exchange (CME) on a weekly basis and it is known as the Commitment of traders (CoT), it is the number of non-commercial position takers long/short in currency futures traded on CME.

[22] Futures and forwards are explained by (Jarrow & Oldfield, 1981) or any simple financial website

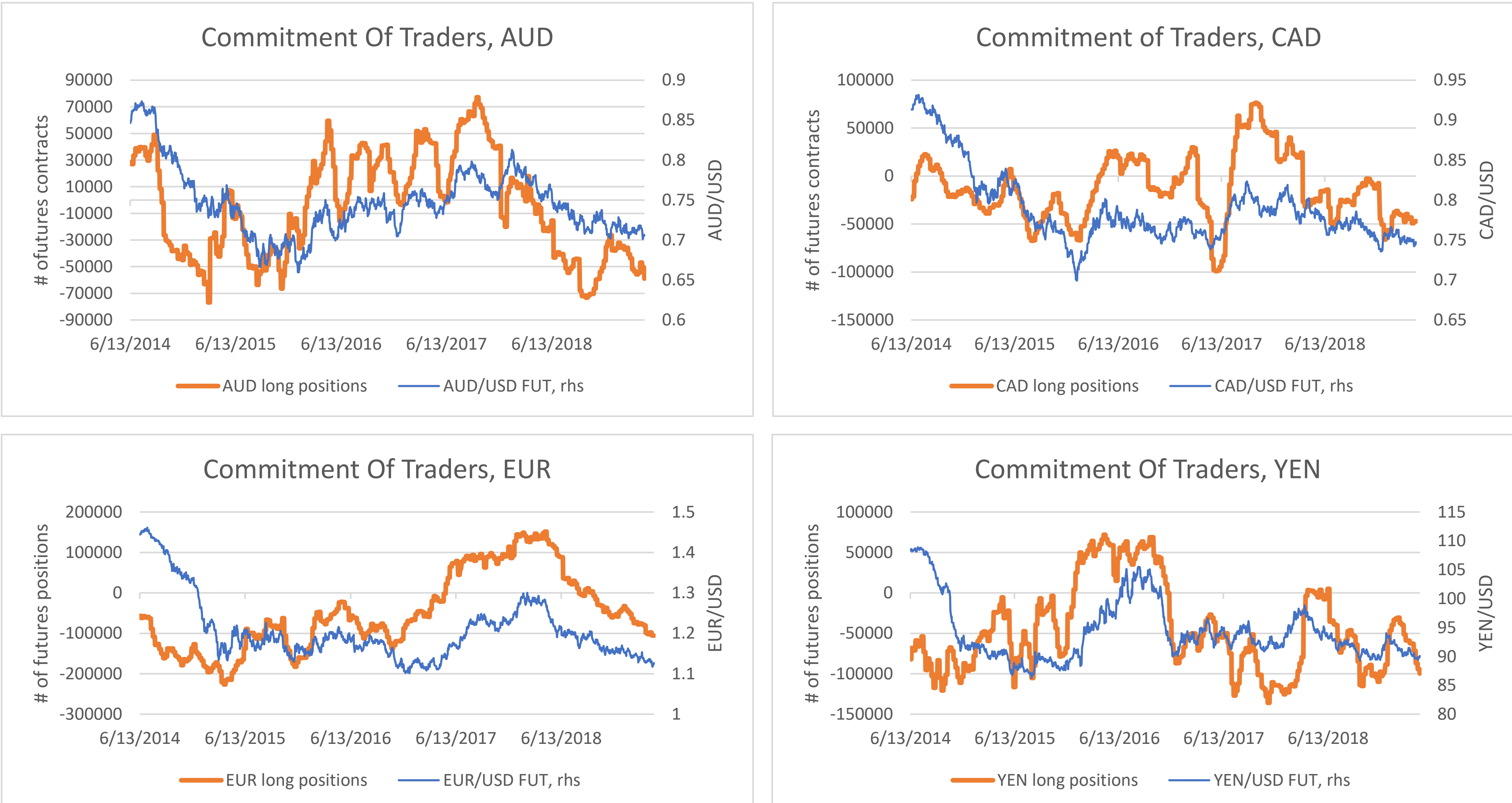
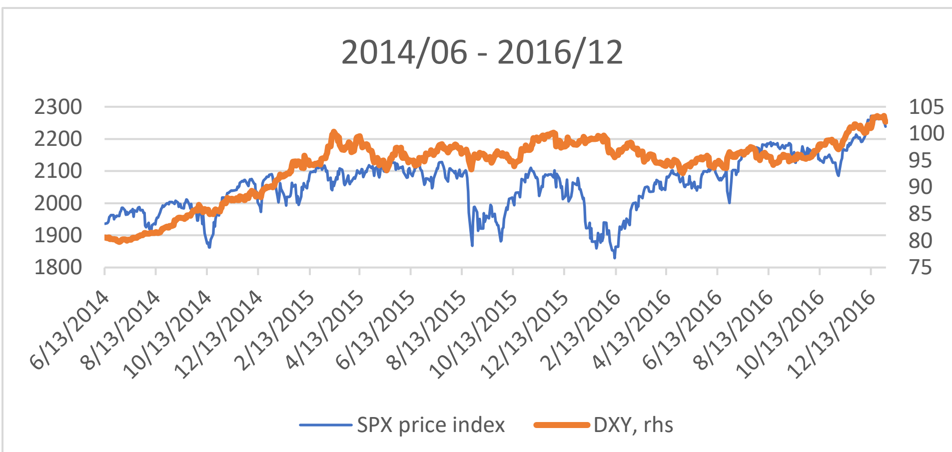


Figure 3; Commitment Of Traders; CoT is reported by the Chicago Mercantile Exchange (CME) on a weekly basis, the report publish the number of number of non-commercial position takers long/short in currency futures traded on CME. Each position i.e. each contract is valued around $100 000. The above illustrations is number of long position takers and illustrates the exchange rates movement well, since the position takers are the underlying force behind the movements economic events which are of interest of this study or any study for the matter. The sample period captures events such as the oil price slump during 2014, where Brent crude oil prices plunged approximately 56% from $112 per barrel to $49 between June 14 and Dec 14.

Furthermore, 2015 was a hectic year for markets with big currency movements e.g. due to the Swiss National Bank (SNB) shock move by de-pegging the CHF to EUR, the Greek crisis and the 2015 election regarding leaving the Euro or not. However, 2015 was a much more tumults year for Central Banks where Bank of Canada (BoC), Royal Bank of Australia (RBA) and ECB amongst others expanded/eased monetary policy due to economic uncertainty and economic contraction. However, it was the U.S Fed who stole the headline by finishing 2015 with a rate hike and communicated to the markets that further rate hikes were coming already 2016. The sample period also presents an interesting paradigm shift of co-movements (see figure 4), between 2014-



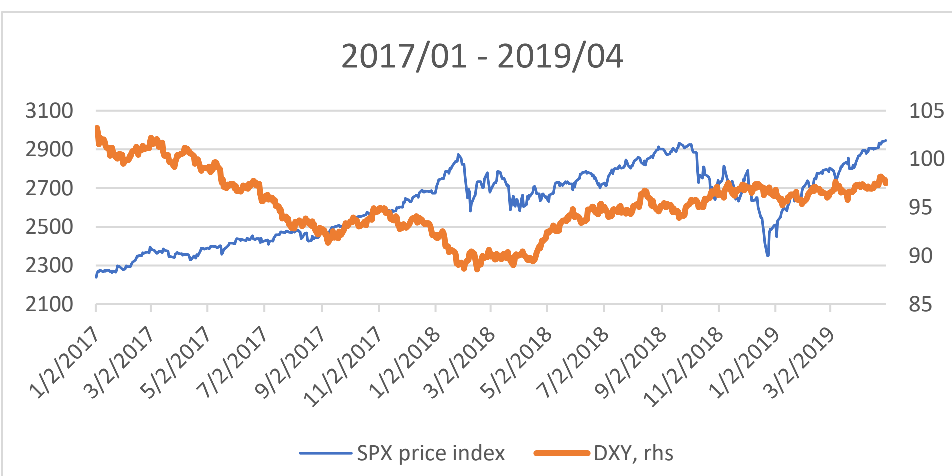


Figure 4; DXY & S6P500 relationship; The positive relationship between the two seems to break down at the beginning of 2017

2019 the DXY[23] rose more-or-less in parallel with the SPX, this relationship appears to have broken down in 2017. The reasons for the observed paradigm shift may be due to changes in the fundamentals, as mentioned before. Thus, this prompt for robustness check between the two periods 2014-2016 – 2017-2019 presented in Appendix A and B. The next section will present the empirical tools used in this study.

2.2 Method

In this section, the econometric models used to analyse the carry trade activity and the return relation between FX Futures and SPX are derived. The first part presents the VECM model, followed by the model used to estimate the DCC.

2.2.2 Cointegration

Cointegration is grounded on the idea that a set of variables are individually nonstationary; however, there exists a linear combination that may result in a stationary outcome (Johansen, 1991). Thus, evidence of cointegration implies there is a long-run statistical relationship between the set of variables. Furthermore, it implies that short-term movements of the variable are affected by lagged deviation from the long-run relationship, i.e. the deviation returns to the long-run.

Given the close nature of the relationship between spot and forward exchange rate, Luintel & Paudyal, (1998) argues that the same underlying stochastic process drives both variables. Hence, spot and forward exchanges rates cannot evolve independently of the other, subsequently nor can FX futures.

Previous test of cointegration between forward and spot i.e. f_t and s_t has overwhelmingly found in favour of cointegration between the variables. Interestingly, studies find that forward premium/Discount to be stationary which suggest f_t and s_t to be cointegrated with a vector of (1, -1) (Zivot, 2000; McMillan, 2005; Luintel & Paudyal, 1998; Kutan & Zhou, 2002)

The existence of cointegration relationship between spot and forward implies there exist a long-run equilibrium, hence it suggests imperative insights to their dynamic behaviour. Thus, multivariate Johannsen cointegration test is employed to analyse the relationship between USD/X Futures (Fut), spot exchange rate (S) and forward exchanges (F)[24]. The intention is to investigate

[23] Index of trade weighted USD vis a basket of developed market currency
[24] Recall that all variables are defined as natural log

if there exists a cointegration relationship, then to high light what the cointegration relationship implies for currency trading activity. The cointegration setup provides the long-run overview regarding the relationship of the variables, however not the different possible short deviations. However, it is the long run, which is the focal part; the VECM framework highlights the short-run deviation to detailed.

Given that there is significant long-run equilibrium relationship between the variables of this study a VECM can be estimated according to the equations below

$$\Delta LogFut_t = \phi_1 + \lambda_1 \hat{e}_{t-1} + \sum_{i=1}^{k} \Upsilon_{1i} \Delta\, Log\, Fut_{t-i} + \sum_{i=1}^{k} \varphi_{1i} \Delta\, Log\, F_{t-i} + \sum_{i=1}^{k} \psi_{1i} \Delta\, Log\, S_{t-i} + \varepsilon_{1i} \quad (6)$$

$$\Delta LogF_t = \phi_2 + \lambda_2 \hat{e}_{t-1} + \sum_{i=1}^{k} \Upsilon_{2i} \Delta\, Log\, FUT_{t-i} + \sum_{i=1}^{k} \varphi_{2i} \Delta\, Log\, F_{t-i} + \sum_{i=1}^{k} \psi_{2i} \Delta\, Log\, S_{t-i} + \varepsilon_{2i} \quad (7)$$

$$\Delta LogS_t = \phi_3 + \lambda_3 \hat{e}_{t-1} + \sum_{i=1}^{k} \Upsilon_{3i} \Delta\, Log\, FUT_{t-i} + \sum_{i=1}^{k} \varphi_{3i} \Delta\, Log\, F_{t-i} + \sum_{i=1}^{k} \psi_{3i} \Delta\, Log\, S_{t-i} + \varepsilon_{3i} \quad (8)$$

Where ϕ are constants, λ are adjustment coefficients, and $\hat{e}_{t-1}$ is the error correction term and lastly the error terms ε. The focal part of the analysis will be the cointegration coefficients normalised on the Log Futures, i.e. the long-run relationship, as given below.

$$\hat{e}_{t-1} = \Upsilon_{1i} Log\, FUT_{t-i} - \varphi_{1i}\, Log\, F_{t-i} - \varphi_{1i}\, Log\, S_{t-i} - \phi_1 \quad (9)$$

Hence, Eq. 9 is built upon Eq. 5, thus, providing information regarding carry activity. However, the adjustment coefficient λ is of interest due to since it reveals if the short-run significantly responds to deviation from the long-run, i.e. are traders acting on short-run deviations.

2.2.3 Dynamic Conditional Correlations

The Dynamic Conditional Correlations is an extension of Constant Conditional Correlations developed by Baillie & Bollerslev (1990). The DCC used in this study is grounded on the VARMA-EGARCH version of the DCC model developed by Engle, (2000). Previous studies similar to this study has researched the contagion/flight to quality premises exacerbated between markets through currency channels with the help of DCC. Previous studies by and made use of the DCC approach on similar data, which argues for the DCC approach in this study (Cappiello, et al., 2006; Tachibana, 2018; González-Serrano & Jiménez-Martín, 2011; Ciner, et al., 2013).

The bivariate GARCH model with Dynamic Conditional Correlations (DCC) is being utilised to analyse the relationship between daily FX futures and SPX returns in this study. Hence, the daily natural log return of the two[25] variables can be assumed to follow a VAR(p) structure, i.e. the mean equations can be written as

$$r_t = y_0 + \sum_{i=1}^{p} y_i \, r_{t-i} + \varepsilon_t \tag{10}$$

Where r_t is 2 *x* 1 vectors of daily log return at time *t*, y_0 and $y_i$are 2 *x* 1 and respectively 2 *x* 2 vector of constants. Subsequently, ε_t is 2 *x* 1 vector of zero-mean error terms with a 2 *x* 2 conditional variance-covariance matrix H_t.

The DCC model estimation procedure is a two-step procedure where the first step is to estimate the conditional variance by a univariate GARCH model. In this study, the univariate GARCH model is VARMA-EGARCH as mentioned above, which is written as

$$Log(h_{it}) = c_{ii} + \sum_{j=1}^{2} \alpha_{ij} \frac{\varepsilon_{jt-1}}{h_{jt-1}^{1/2}} + \phi_i \left| \frac{\varepsilon_{it-1}}{h_{it-1}^{1/2}} \right| + \sum_{j=1}^{2} b_{ij} \log(h_{jt-1}) \tag{11}$$

Where $h_{it}$is the conditional variance of asset *i* (FX futures)[26] at time *t* and c_{ii} is an intercept. The ARCH and GARCH effects are captured by α_{ii} and respectively by b_{ii}, where the short- and long-run volatility spillover effects between *i* and *j* are captured by α_{ij} and b_{ij}. The model of the kind as given in Eq.11 allows for asymmetric effects through α_{ii} and ϕ_i, where the sign of α_{ii} determines the existence of asymmetric effects. E.g. for a positive shock in the standardised residual $\frac{\varepsilon_{it-1}}{h_{it-1}^{1/2}}$ the effect on $Log(h_{it})$ is $\alpha_{ii} + \phi_i$ and negative shock $-\alpha_{ii} + \phi_i$, thus a negative sign implies leverage effects, while positive shocks yield higher volatility than negative shocks. Insignificant or zero α_{ii}implies no existence of asymmetric effects. ϕ_i only captures a shock in the residuals in absolute terms, hence it strengthens the presence of positive/negative shock which given by α_{ii}, thus asymmetric effects requires only significant α_{ii}

[25] The analyze is done pairwise i.e. USD/AUD with SPX, USD/CAD with SPX and etc.
[26] Hence, *j* is SPX

The following step, i.e. the second step the conditional correlations are estimated by equation

$$H_t = H_t C_t H_t \quad D_t = diag(h_{1t}^{1/2} \dots h_{2t}^{1/2}) \tag{13}$$

Where C_t is the matrix of conditional correlations at time *t*, however the DCC defines $C_t$as

$$C_t = diag(q_{1t}^{-1/2} \dots q_{2t}^{-1/2}) Q_t diag(q_{1t}^{-1/2} \dots q_{2t}^{-1/2}) \tag{14}$$

Where Q_t is a positive definite symmetric matrix defined as

$$Q_t = (1 - \psi_1 - \psi_2)\bar{Q} + \psi_1 \Theta_{t-1}\Theta_{t-1}' + \psi_2 Q_{t-1} \tag{15}$$

Where $\Theta_{t-1}$is a 2 *x* 1 vector of standardised residual at time *t – 1* with 2 *x* 2 unconditional correlation matrix $\bar{Q}$. The two scalar parameters $\psi_1 and\ \psi_2$ are non-negative and limited so that $\psi_1 + \psi_2 \leq$, i.e. if the sum of the parameters is close to unity, it more relevant to consider the conditional correlations instead of the unconditional.

Together Eq.14 and Eq.15 imply that the conditional correlation between FX futures and SPX at time *t* can be defined as

$$\rho_{12} = \frac{(1 - \psi_1 - \psi_2)\bar{q}_{12} + \psi_1 \Theta_{1t-1}\Theta_{2t-1} + \psi_2 q_{12t-1}}{\sqrt{((1 - \psi_1 - \psi_2)\bar{q}_{11} + \psi_1 \Theta_{t-1}^2 + \psi_2 q_{11t-1})((1 - \psi_1 - \psi_2)\bar{q}_{22} + \psi_1 \Theta_{2t-1}^2 + \psi_2 q_{22t-1}))}} \tag{16}$$

Where the model is estimated by Quasi-Maximum Likelihood Estimation using the BFGS algorithm[27]

As mentioned in section 2.1.4, the sample period shows a paradigm shift coming into 2017. Thus, a robustness check between 2014-16 – 2017-19 is conducted to check if and how results differ.

3. Results

The first section presents the results providing evidence of the carry trade activity with the employment of the VECM. The following section presents the evidence of hedging between the SPX returns and FX Futures returns. The variables differ between the sections, as the first part works with the natural log of the variable, while the second sections work with the natural log return.

[27] The procedure was done in RATS software

3.1 Carry trade activity

ADF-GLS unit root testing presented the variables non-stationary at the levels but stationary in the 1st difference, thus, the variables are I(1). Employing the Schwarz information criterion (SIC) for different VAR(p) specification results in the optimal lag length, VAR(4) for all variable except the CAD where the optimal lag length results in VAR(5). The Johansen cointegration test results in significant existence of cointegration in all cases.

3.1.2 Cointegration

Previously in section 2.1.2, the forward discount was defined with the USD/YEN example, with the higher-yielding currency being the base FX and the lower-yielding Quote (BASE/QUOTE) in the example. However, the EUR/USD[28] forward is trading at a premium, with EUR being the lower-yielding currency[29] and EUR being the base FX. Hence, a forward discount partially grounded whether is the base or quote FX, that just how it will be translated, however, it is the interest rate differential which defines whether it is a premium or a discount.

Normalised cointegrating coefficients

AUD FUT	FDW AUD	SPOT AUD
1	-9.062449	8.086575
	(-0.58289)	(-0.57161)
CAD FUT	FWD CAD	SPOT CAD
1	5.062562	-5.894612
	(-1.10517)	(-1.08738)
EUR FUT	FWD EUR	SPOT EUR
1	7.730758	-8.755925
	(-0.58671)	(-0.58481)
YEN FUT	FWD YEN	SPOT YEN
1	12.01811	-13.05473
	(-0.54702)	(-0.55436)

Table 1; The estimates from the cointegration equation with coefficients normalised on the FX futures, standard error in (), all are significant at the 1% level.

Thus, a long-run relationship meeting the interest rate differential condition illustrated as the premium or a discount provides evidence of traders behaviour. Table 1[30] presents the cointegration coefficients normalised on the FX Futures, in accordance with Eq. 9. However, results vary in respect to FX futures with the forwards and spot normalised on the Futures.

[28] Recall that all FX in this paper a defined as USD/X i.e. with USD as base FX
[29] At the time of writing EUR/USD forwards are trading at premium
[30] Statistical software Eviews was employed, negative/positive sign are reversed when interpreting from Eviews

Table 2 present illustrates what the cointegrations equations imply for carry trade, combined with figure 1 it illustrates if the cointegration equations meet the current condition of forward discount/forwards for each currency.

	LOG FWD	LOG SPOT	FWD premium/discount
AUD	9.062449	-8.08658	17.149024
CAD	-5.06256	5.894612	-10.957174
EUR	-7.73076	8.755925	-16.486683
YEN	-12.0181	13.05473	-25.07284

Table 2; The cointegration equations rearranged to illustrated the carry trade activity, with the FWD premium/discount being the Log FWD – Log Spot

E.g. the USD/YEN case, Forwards – Spot (as explained by Eq. 5 and Eq. 9) reveals that the USD/YEN is trading at a discount, as it should and as it is at the time of writing, hence it meets the condition. The cointegration vector is of the form.

USD/YEN Futures = Log Forward -12.02 + Log Spot 13.06

Which is equal to -25,07, i.e. Forward Discount, the above premises can be rearranged to

USD/YEN Futures = Log (Spot 13.06 / Forward 12.02)[31]

Which implies that the USD/YEN Futures increases (decreases) with the RHS, i.e. when the USD/YEN discount increases (decreases), i.e. it increases (decreases) with the interest rate differential. Thus, an increase in USD/YEN Futures means traders are utilising the interest rate differential in a naïve carry trade manner, thus, the CIP holds.

Employing the same steps on the USD/AUD results in a different outcome

USD/AUD = Log (Forward 9.06 / Spot 8.09)

Forward premium instead of discount as in the previous case, it being a premium is just consistent with the condition and what it trades at writing moment. However, the USD/AUD Futures increasing with the premium (i.e. the rhs) is the elephant in the room.

Recall that the USD is lower-yielding currency since USD/AUD is at a premium, however, the USD/AUD Futures increases with the premium, i.e. the interest rate differential increasing (AUD

[31] Due to laws of logarithms

– USD), should be favouring the AUD, not the USD. Hence the USD/AUD Futures should be decreasing with the premium, yet it is increasing, which is evidence of anti-carry trade.

The results are consistent with Spronk, et al., (2013) who presents evidence of traders following a fundamental-based strategy due to, e.g. increased uncertainty. Shehadeh, et al., (2016) also finds evidence of anti-carry trade, specifically between developed markets, they argue that the narrow interest rate differential is not enough to compensate for sudden volatility change. Sudden volatility changes may erode the gains by the position. Thus, one has to consider the size of the position taken and not only the direction of the position, hence the naïve-carry trade is not sufficient where the fundamental-based strategy takes this more into consideration.

From a fundamentalist perspective, the anti-carry trade can be explained by the RBA monetary policy becoming more accommodative between 2014-2018, while the Federal Reserve responded to inflationary pressure by hiking rates. Hence, resulting in a increases interest rate differential in favour for the USD, thus, despite rates being higher in Australia, the macro outlook favoured the US. Moreover, the carry trade activity can be explained by the fall of gold prices illustrated in section 2.1.4 previously. Ciner, et al., (2013) argues that gold should be considered as a monetary asset rather than a commodity asset, where gold historically has been a safe-haven asset and should, therefore, be considered as anti-dollar. Ciner, et al., (2013) view of gold can possibly shed some light on the results of the anti-carry trade in this paper.

Contrary to the AUD the CAD (also a commodity FX)[32] is trading at a discount (USD/CAD) where the results reveal a carry trade rather than an anti-carry trade, the same applies to the USD/EUR case. Hence, the results are consistent with the CIP, where there is evidence of carry trade, i.e. the traditionally carry trade, thus, the results are consistent with previous research (Burnside, et al., 2007; Pappa, 2014; Clarida, et al., 2009; Goodfriend, 2014).

Thus, only the USD/AUD shows anti-carry trade patterns, i.e. traders utilising the fundamental-based strategy, hence the UIP holds. For the other three currency pairs, the traders are utilizing the trend strategy, i.e. the naïve carry trade, consistent with CIP. Overall, the results reveal a dollar story.[33] Robustness check presented in Appendix A

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[32] However, rates are/where higher in the U.S at the time of writing
[33] Market term, indicating that the dollar is favored currency

3.1.3 VECM

Adjustment coefficient			
AUD	Δ AUD FUT	Δ FDW AUD	Δ SPOT AUD
	0.001705	0.031957	0.017383
	[0.07344]	[1.32664]*	[0.72170]
CAD	Δ CAD FUT	Δ FWD CAD	Δ SPOT CAD
	-0.039008	-0.010576	0.000916
	[-1.72186]*	[-0.43710]	[0.03721]
EUR	Δ EUR FUT	Δ FWD EUR	Δ SPOT EUR
	0.025775	0.04281	0.051466
	[1.31514]*	[2.02885]**	[2.44460]***
YEN	Δ YEN FUT	Δ FWD YEN	Δ SPOT YEN
	0.00504	0.014032	0.026565
	[0.28218]	[0.70512]	[1.34034]*

*Table 3; Adjustment coefficient, speed of adjustment from the short-run deviation back to the long-run equilibrium. T-stats in [ ], *0.10,**0.05 ***0.01 significance*

Table 3 presents the speed of adjustment captured by λ in Eq.6, 7 and 8. Significant speed of adjustment coefficients implies that in the short-run the variables respond significantly to departure from the long-run equilibrium relationships. In the case of EUR, all the three variables have significant adjustments coefficients, which implies that in the short-run, they respond significantly to departure from the long-run equilibrium relationship. However, in the rest, only one variable responds significantly to short-run deviation, the Forwards, the Futures and spot, in the following manner.

However, the results raise the next question, what is the return relation between the FX Futures and SPX, since increased uncertainty has an impact on fundamentals as shown in the USD/AUD case. The USD happens to be the higher-yielding currency vis the other three, hence it is well-positioned for a naïve carry trade, however the next section will shed light on the return relations between the SPX and the FX Futures more in detail.

3.2 Hedging characteristics

Employing the SIC for different VAR(p) specifications results in VAR(1) as mean equation, Engle's ARCH test rejects the null hypothesis of the residuals of VAR(1) being homoscedastic[34].

[34] Statistical software Matlab was employed for tests

Hence, the residuals motivate further research of conditional variance with the use of GARCH models.

3.2.2 Parameters estimates

Table 4 presents the estimation results from Eq. 11 and Eq. 15. The sum of ψ_1 and ψ_2 are close to unity in all cases, which is validation for the use of DCC and not unconditional. In all cases b_{ii}(i.e. B(1,1) and B(2,2))[35] i.e. the GARCH effects are significant, this implies that own past volatilities are important in determining the future volatilities. Furthermore, the coefficient is close to one, which implies the degree of volatility clustering is high. The coefficient A(1,1) is significant in all cases, indicating the existence of asymmetric effects in the volatilities, however, in the AUD instance, the coefficient is negative which implies leverage effect, hence negative shocks have a greater impact than positive shocks. For the other three cases, it is vice versa since the coefficients are positive. However, only ϕ_2 is significant for all cases and as mentioned it only strengthens the existence of asymmetric effects when α_{ii} is significant. Moreover, only the YEN shows significant short- and long-run volatilities

The presentation of the coefficients above are of interest, yet it is the volatility spillover, which is the focal part for the evidence of hedging. The spillover materialised by the ARCH and GARCH effects, i.e. the short- and long-run volatility spillover as mentioned earlier. Where all long-run volatilities are significant. The coefficient is positive only in the AUD case, meaningly volatility spillover between AUD/USD Futures and SPX leads to volatility increases in both. On the other hand, in the CAD, EUR and YEN cases, volatility spillover is negative, i.e. increased volatility in the three mentioned results in negative spillover in the SPX, vice versa. However, this does not provide outright evidence regarding the correlation between the assets, and it provide evidence of existence interconnectedness.

[35] Hence, $\alpha_{ii}$is denoted by A(i,i)

AUD	Coefficient	P-value	CAD	Coefficient	P-value	EUR	Coefficient	P-value	YEN	Coefficient	P-value
A(1,1)	-0.01	0.01	A(1,1)	0.02	0.00	A(1,1)	0.07	0.00	A(1,1)	0.11	0.00
A(1,2)	-0.01	0.89	A(1,2)	0.00	0.79	A(1,2)	0.00	0.79	A(1,2)	0.07	0.00
A(2,1)	0.18	0.42	A(2,1)	-0.03	0.30	A(2,1)	-0.01	0.30	A(2,1)	0.34	0.00
A(2,2)	0.01	0.69	A(2,2)	-0.01	0.00	A(2,2)	-0.07	0.00	A(2,2)	-0.03	0.00
B(1,1)	0.80	0.00	B(1,1)	0.97	0.00	B(1,1)	0.74	0.00	B(1,1)	0.78	0.00
B(1,2)	0.13	0.04	B(1,2)	-0.01	0.01	B(1,2)	-0.08	0.01	B(1,2)	-0.10	0.00
B(2,1)	0.26	0.03	B(2,1)	-0.01	0.00	B(2,1)	-1.24	0.00	B(2,1)	-0.25	0.00
B(2,2)	0.80	0.00	B(2,2)	0.81	0.00	B(2,2)	0.88	0.00	B(2,2)	0.78	0.00
φ(1)	0.01	0.27	φ(1)	-0.01	0.91	φ(1)	0.00	0.91	φ(1)	-0.07	0.03
φ(2)	0.13	0.00	φ(2)	0.28	0.00	φ(2)	0.26	0.00	φ(2)	0.16	0.00
ψ(1)	0.74	0.02	ψ(1)	0.04	1.00	ψ(1)	0.00	1.00	ψ(1)	0.60	0.00
ψ(2)	-0.05	0.00	ψ(2)	0.90	0.00	ψ(2)	0.73	0.00	ψ(2)	0.15	0.52

Table 4; GARCH DCC estimates of FX futures and SPX return, with 1 being FX Futures and 2 being SPX, rounded values. A; ARCH effects, i.e. short-run volatility, B; GARCH effects, i.e. long-run volatility. Hence, B(1,2) implies volatility spillover from FX Futures to SPX. Recall that the FX Futures are defined as, e.g. USD/AUD.

3.2.3 Conditional volatilities

Fig 5 displays the conditional volatilities estimated by the model over the sample period, where the most volatile period is between 2014 and mid-2016, followed by a substantially decreased volatility for the remainder of the sample period.

Some notable dates stand out across all figures differently, e.g. 2015 volatility in the EUR can be explained by the impact of Greece and the renewed quantitative easing program by the ECB. While, volatility in the YEN pickups dramatically when the IMF pulled out negotiations with Greece which sent a downturn winds through global markets, where SPX Futures fell over 10.7%. Simultaneously Peoples Bank of China (PBoC) responded to the slowdown in the Chinese economy, combined the increased uncertainty in global markets led to increased volatility in the Yen[36], assuming that the YEN worked as a hedge.

2016-06-24, Brexit crashes the markets, Sterling collapsed by over 20% as markets were left shocked by the outcome of the vote, the Brexit event is captured across all figures with volatility spikes. 2017 recorded the lowest volatility in decades where quantitative easing by several developed economy central banks killed of volatility. However, volatility returned with a vengeance at the start of 2018, the event became to be known as "*Volmageddon*", this is captured in all figures at the beginning of 2018.

Furthermore, the indecisive volatility recorded in the YEN at the beginning of the sample period, i.e. Q3 2013, was probably due to Japan unexpectedly falling into a recession. Which was also followed by political instability as the Prime Minister Shinzo Abe called for snap elections, this, of course, would have an impact on traders who used the YEN as the funding currency in their carry trade. More on this in the next section. Robustness check presented in Appendix B

[36] The next section is ought to present the hedging evidence

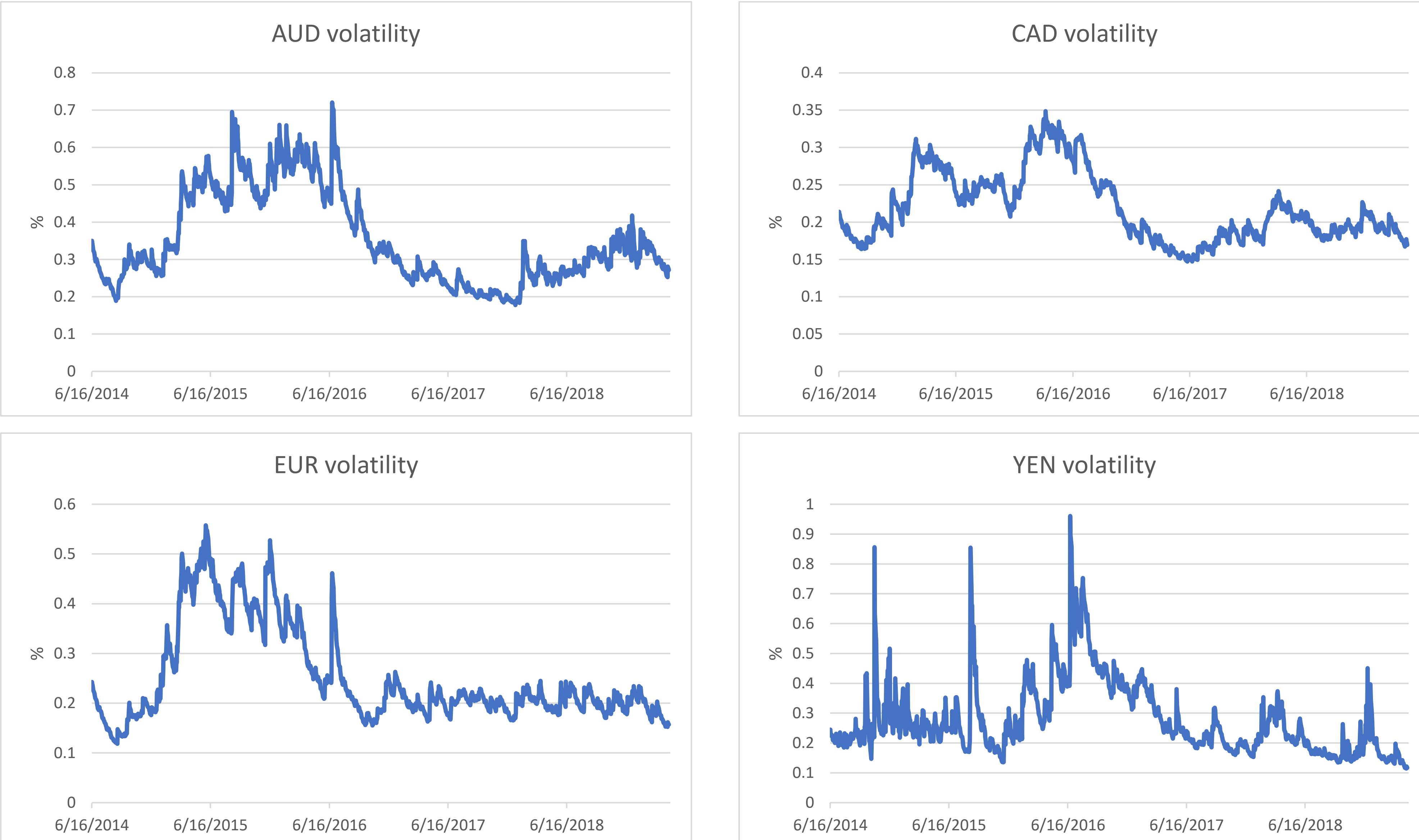

Figure 5; Conditional volatilities of the FX Futures, the conditional volatilities of the SPX is not of interest since the behaviour of the FXs' are focal. As mentioned events such as Brexit is observed as volatility spike (2016-06-24) through all FX. Some events impact across the board while some are locally

3.2.4 Conditional Correlations

Figure 6 displays the conditional correlations in accordance with Eq. 16. In the AUD case, the correlation is negative throughout the sample period; however, the figure illustrates a negative correlation between the USD/AUD Futures returns and the SPX returns. Hence, when the USD/AUD Futures return increases, the return in the SPX falls; however it also means that when the USD/AUD falls the SPX increases. Thus, it illustrates a dollar story since it implies that the laterally reversed AUD/USD has a positive correlation with the SPX.

Again, the USD/AUD, according to fig 5, displays a negative correlation with SPX; on the other hand, it implies that the laterally reversed AUD/USD has a positive correlation with SPX. Again, the negative correlation between SPX and USD/AUD implies a negative correlation with the base currency, however a positive correlation with the quote currency. Thus, the USD/AUD reveals hedging characteristics, since a fall in SPX return implies an increase in USD/AUD, i.e. a rise in base currency, but a fall in the quote currency, being the AUD. Which are proof of hedging characteristics.

The same relationship is observed for the CAD and the EUR, however, the USD/YEN has a positive correlation with the SPX. Hence, SPX has a positive correlation with USD (base currency) and a negative correlation with the YEN (quote currency), this implies that YEN is used to hedge for downturns in the SPX. Hence, it explains the volatility increases captured in figure 5, when the Greece crisis and the China slowdown contributed to global uncertainty, the YEN was used a hedge.

As mentioned above, the indecisive volatility at the beginning of the sample period recorded in the YEN is captured in the DCC figure of YEN. Japan slipped into an unexpected recession, which meant trouble for traders having a short position in the YEN. Hence, an unexpected event may lead to a surge in volatility in the funding/target currency as stressed by Galati, et al., (2007) who found evidence of volatility surge due to massive unwinding of the target currency, where this study finds evidence of volatility surge in the funding currency YEN. Hence, the results are consistent with Galati, et al., (2007), but also with Masujima (2017) who found evidence of the YEN being the favoured sage-haven alternative, since the results, provide evidence of YEN hedging vis the SPX. Again, the impact of Brexit is obvious throughout, was the YEN shows increased of hedging, while the others do not.

Interestingly the correlations of the EUR are inconclusive, inconclusive in way that the correlation is positive but very weak, 0.02 on average. Events such as Brexit results in a substantial turn to negative correlation between the USD/EUR Futures and SPX (positive as EUR/USD). With the EUR/USD being the most liquid exchange rate pair involving two of the three biggest economies, and with it being very volatile as illustrated by figure 5 above, it should come as no surprise. The EUR is impacted by, e.g. the SNB surprise de-pegging in the begin of 2015, the Greek crisis summer 2015, Brexit one year later, these events are captured as the moments where correlation reaches -0.4.

Overall the commodity currencies, reveals a negative correlation, which implies the reversely, i.e. a positive correlation between AUD/USD and SPX, CAD/USD and SPX, thus the currencies increases and falls with the SPX. The SPX consisting of the biggest names of in the commodity sector just reveals that the SPX illustrates the economies very well. However, they are not considered as safe-havens, but rather the USD is considered as safe-haven. Since the USD/AUD has a negative correlation with the SPX, the USD higher when SPX falls, simultaneously the AUD and the CAD falls with the SPX. Despite the AUD being the higher-yielding currency vis, the USD and the YEN being the lower-yielding currency vis the USD. Hence, the results reveal that interest rate differential does not matter when traders fleeing to quality, the interest rate differential may matter for the hedge, since if traders hedge in the AUD vis the USD, they are paying the interest rate differential. Nonetheless, this study cannot say if the interest rate differential matters for the hedge, but only that there exist hedging characteristics.

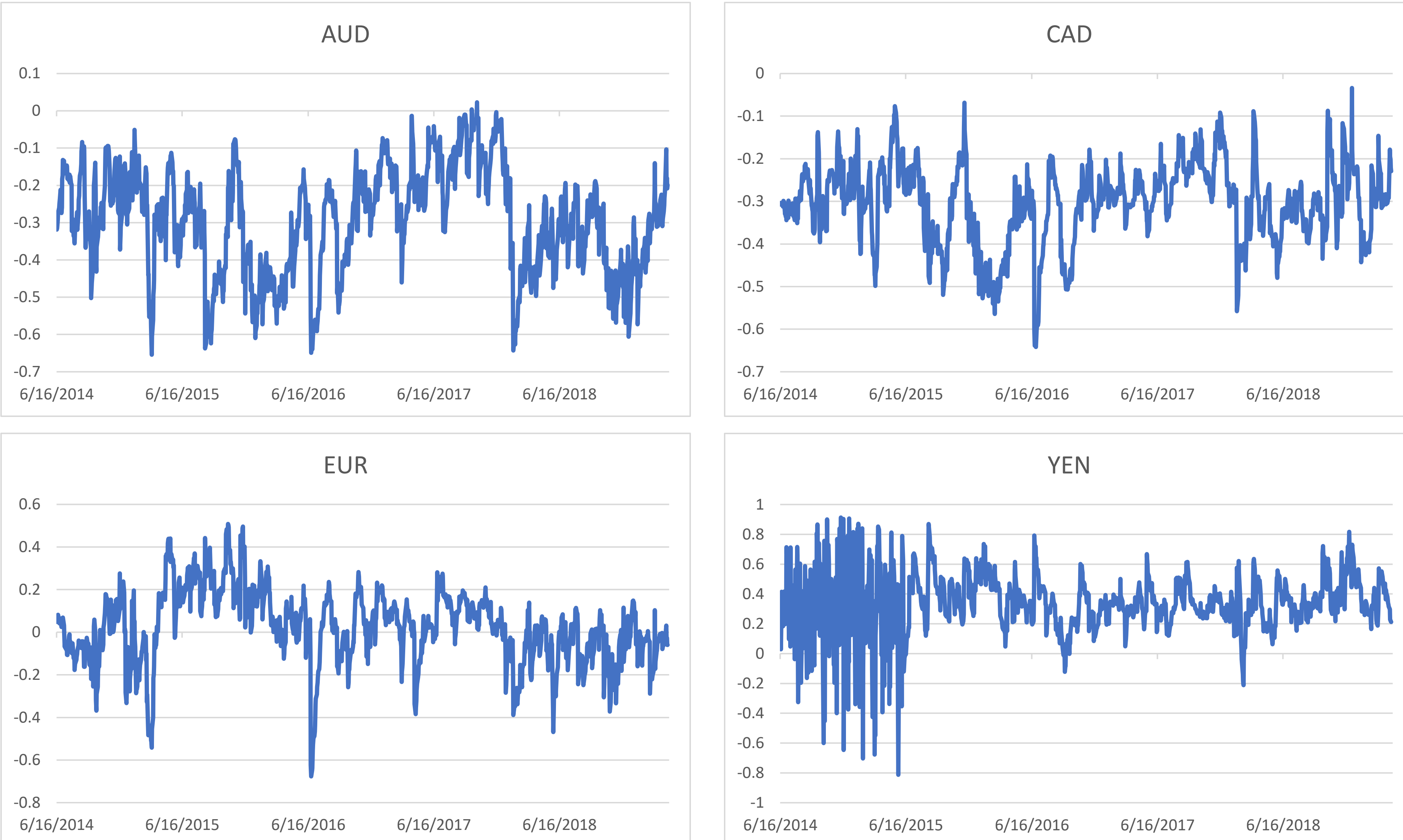

Figure 6; Conditional Correlations between the FX Futures and SPX returns. Note a positive correlation as illustrated above means a positive correlation between, e.g. USD/AJD and SPX, however the reverse holds for AUD/USD and SPX, which implies negative correlation

4. Conclusion

This study analysed the existence and behaviour of carry trade activity and four developed market currencies, due the narrow interest rate differential between developed market currencies, the AUD, CAD, EUR and YEN was chosen, all vis the USD as base currency (e.g. USD/EUR). In the first analysis, the FX futures, Forwards and spot was used. The first analysis employed a Vector Error Correction Model analysis to find evidence of carry trade, the variables were analysed in categories, i.e. the USD/CAD independently etc. The forwards and the spot were normalised on the futures, as the futures were used a proxy for the Commitment Of Traders.

‘The results show evidence of carry trade in all currencies, except for the USD/AUD, which shows evidence of anti-carry trade, i.e. carry trade in the reverse manner that is not utilising the interest rate differential which is the normal praxis of the carry trade. The three other currency pairs which show evidence of carry trade implies that the CIP holds, while the AUD case reveals that the UIP holds, with the former revealing characteristics of trend following strategies and the former revealing fundamental-based strategies characteristics. Hence, the carry trade was in favour of USD and revealed as USD story.

The EUR was the only case that presented significant adjustment coefficients for all variables, while the AUD, CAD and YEN reported only one significant adjustment coefficient, in the following manner the Forward, The Futures and the spot.

The second analysis studied the dynamic interdependencies between the FX Futures and S&P 500 returns. Thus, the second analysis employed Dynamic Conditional Correlations analysis, again categorically independently. Providing results regarding the behaviour of the carry trade, hence, evidence of hedging characteristics between the FX Futures and S&P 500. The results show evidence of hedging between USD/YEN and S&P 500, were the YEN was used for hedging, i.e. flight to quality. The EUR case revealed on average almost zero correlations, this was due to the correlation turning between positive and negative through the sample period. The commodity-linked currencies, the AUD and CAD, both trended with the SPX, however, the USD showed hedging characteristics vis the both of them. Concluding, that the YEN was the number one safe-haven. Futures research should if possible use a longer sample period, or/and uses data that directly reflects the actual positions taken in respective currency pairs.

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APPENDIX A

Normalized cointegrating coefficients		
AUD FUT	FDW AUD	SPOT AUD
1	-10.28109	9.350742
	(0.77576)	(0.76709)
CAD FUT	FWD CAD	SPOT CAD
1	25.52439	-26.10268
	(2.92180)	(2.88530)
EUR FUT	FWD EUR	SPOT EUR
1	7.206863	-8.181469
	(1.11865)	(1.10520)
YEN FUT	FWD YEN	SPOT YEN
1	13.63375	-14.67049
	(1.03571)	(1.04198)

Table 5; Robustness check on sample period 2014-06 – 2016-12, recall that the test was employed in the statistical program Eviews, so for interpretation the negative/positive signs are reversed. The results are not much different from the whole same test, where the conditions mentioned in table 1 and 2 still holds. Standard error in (), all significant at 1%

Normalized cointegrating coefficients		
AUD FUT	FDW AUD	SPOT AUD
1	-7.288094	6.186688
	(-0.87161)	(-0.85565)
CAD FUT	FWD CAD	SPOT CAD
1	13.29092	-14.09958
	(-1.81891)	(-1.8039)
EUR FUT	FWD EUR	SPOT EUR
1	12.87798	-13.99709
	(-1.3659)	(-1.38164)
YEN FUT	FWD YEN	SPOT YEN
1	10.36375	-11.48364
	(-0.98392)	(-0.99751)

Table 6 ; Robustness check on sample period 2017-01 – 2019-04, as in above, and as in above the results does differ much and the conditions mentioned in table 1 and 2 holds. Standard error in (), all significant at 1%

APPENDIX B

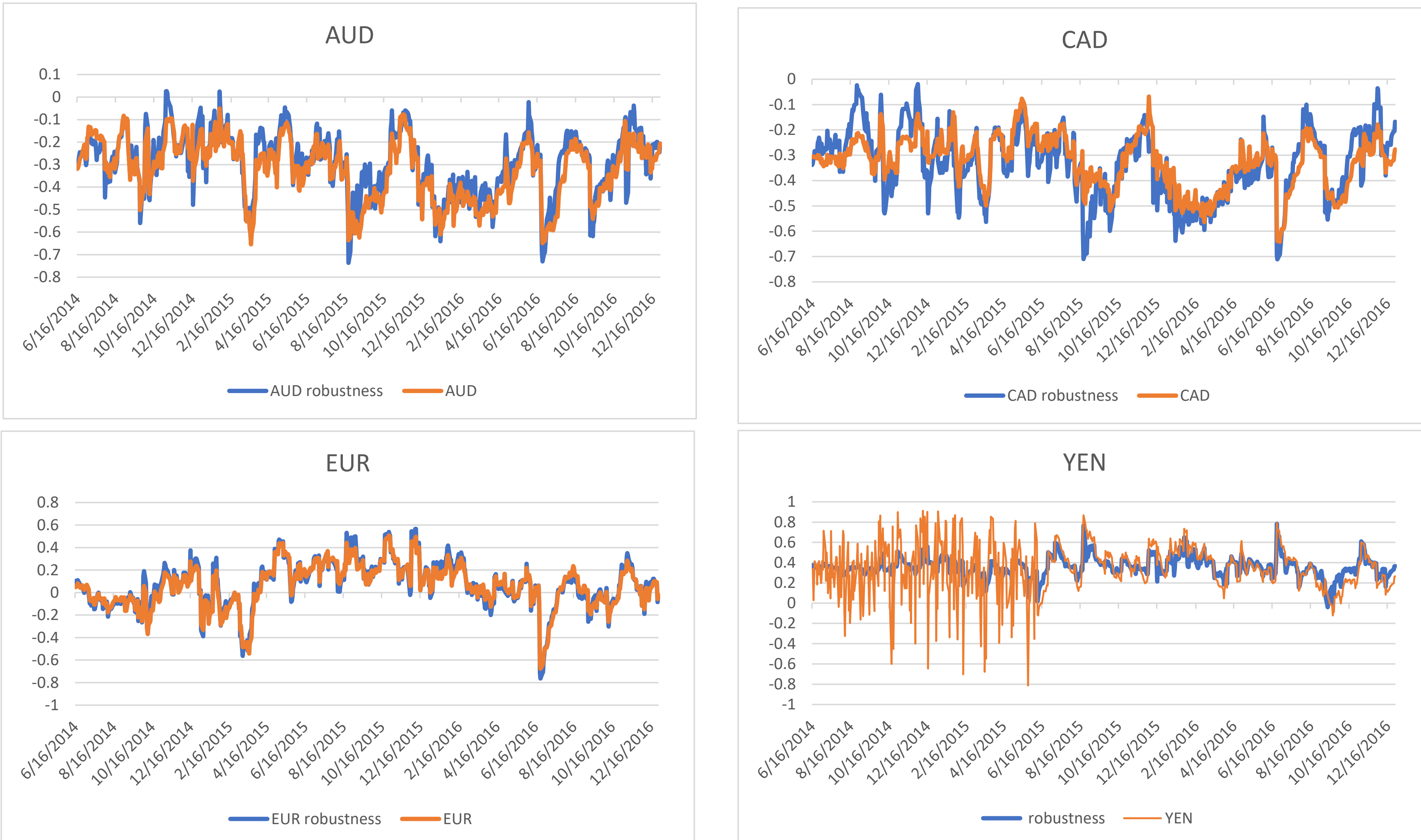

Figure 7; Robustness check of 2014-06 – 2016-12, GARCH DCC employed on the sample period 2014-06 – 2016-12 (robustness) vis the DCC of whole sample period. The above figures reveals a close to identical between the robustness and the whole period. Only the YEN shows other anomalies in the beginning of sample period but is consistent for the remainder.

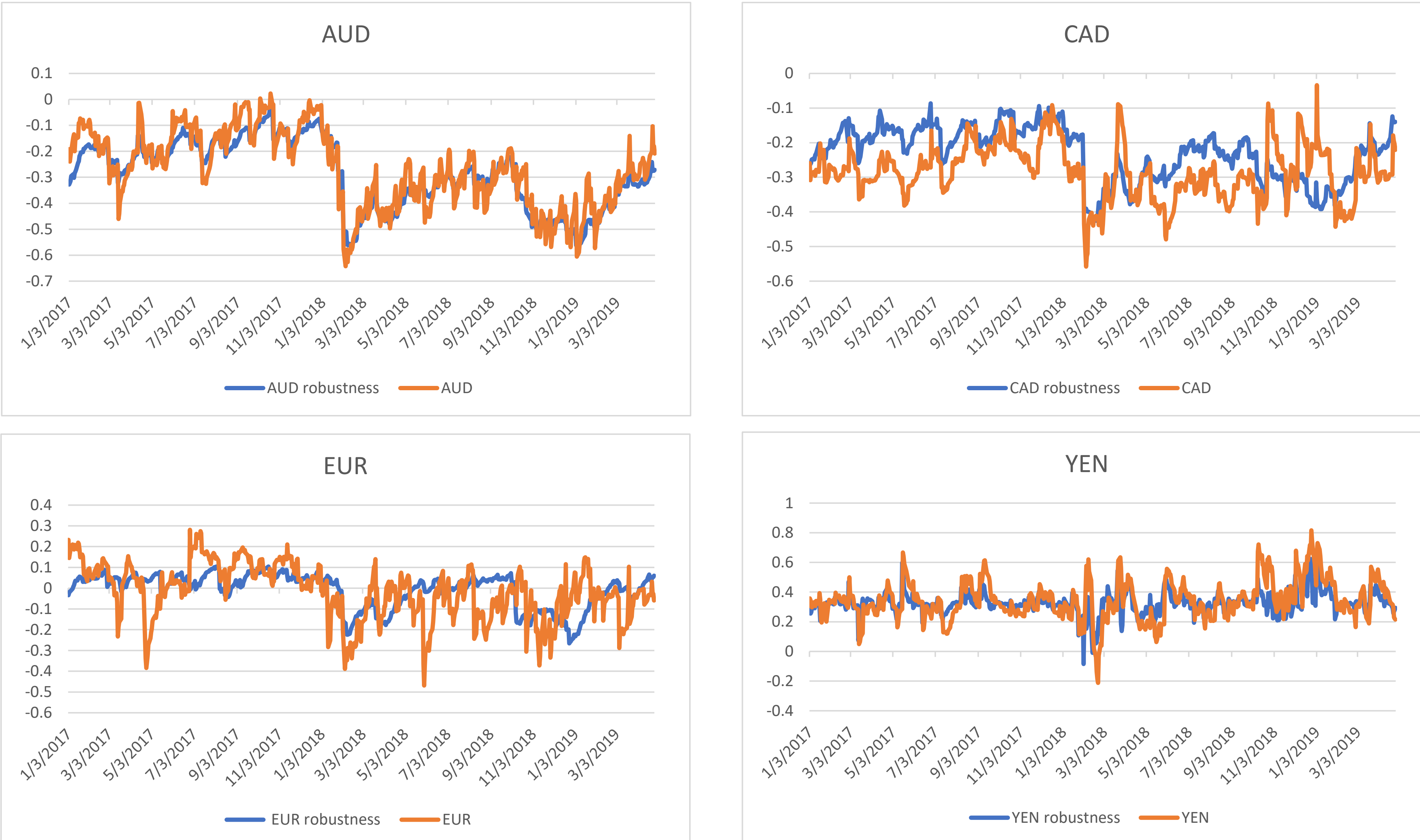

Figure 8; Robustness check as in figure 7 above, however, on the sample period 2017-01 – 2019-04. Again the Robustness being on the shorter sample period vis the entire sample period. The figure illustrate a near identical pattern, in some instance e.g. the CAD it is a little bit off, however the general concepts of negative correlation holds.