CURRENCY CARRY TRADE AND EXCHANGE RATE VOLATILITY
EVIDENCE FROM ASEAN+3 and G10

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Arts Program in International Economics and Finance
Faculty of Economics
Chulalongkorn University
Academic Year 2014

ธุรกรรมการกู้เงินเพื่อการเก็งกำไรและความผันผวนของอัตราแลกเปลี่ยน หลักฐานจากกลุ่มประเทศอาเซียน+3 และจี 10

นางสาวปิยะกุล สมสิริวงศ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาศิลปศาสตรมหาบัณฑิต
สาขาวิชาเศรษฐศาสตร์และการเงินระหว่างประเทศ
คณะเศรษฐศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2557

Thesis Title	CURRENCY CARRY TRADE AND EXCHANGE RATE VOLATILITYEVIDENCE FROM ASEAN+3 and G10
By	Miss Piyakul Somsiriwong
Field of Study	International Economics and Finance
Thesis Advisor	Pongsak Luangaram, Ph.D.

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ปิยะกุล สมสิริวงศ์ : ธุรกรรมการกู้เงินเพื่อการเก็งกำไรและความผันผวนของอัตราแลกเปลี่ยนหลักฐานจากกลุ่มประเทศอาเซียน+3 และจี 10 (CURRENCY CARRY TRADE AND EXCHANGE RATE VOLATILITYEVIDENCE FROM ASEAN+3 and G10) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: อ. ดร.พงศ์ศักดิ์ เหลืองอร่าม, 75 หน้า.

วิทยานิพนธ์ฉบับนี้มีจุดมุ่งหมายเพื่อศึกษาปัจจัยที่ส่งผลกระทบต่อผลตอบแทนที่ได้รับจากธุรกรรมการกู้เงินเพื่อการเก็งกำไร (currency carry trade) ในกลุ่มประเทศอาเซียน+3 และ จี 10 โดยจะศึกษาข้อมูลในช่วงไตรมาสแรกของปี 2544 ถึงไตรมาสแรกของปี 2557 วิทยานิพนธ์นี้มี 2 วัตถุประสงค์หลัก ได้แก่ การศึกษาผลกระทบของความผันผวนของอัตราแลกเปลี่ยนต่อผลตอบแทนที่ได้รับจากธุรกรรมการกู้เงินเพื่อการเก็งกำไร และ การศึกษาผลกระทบของปัจจัยที่เกี่ยวข้องกับความสัมพันธ์ของผลตอบแทน(อัตราดอกเบี้ย)กับช่วงเวลาของการลงทุน (yield curve) ต่อผลตอบแทนที่ได้รับจากธุรกรรมการกู้เงินเพื่อการเก็งกำไร โดยวิทยานิพนธ์ฉบับนี้จะอ้างอิงโมเดลของ Clarida, Davis, and Pederson (2009) ในการศึกษาผลกระทบที่กล่าวไว้ข้างต้น ผลการศึกษาพบว่า ความผันผวนของอัตราแลกเปลี่ยนแปรผกผันกับผลตอบแทนที่จะได้รับจากธุรกรรมการกู้เงินเพื่อการเก็งกำไร ในส่วนของปัจจัยที่เกี่ยวข้องกับความสัมพันธ์ของผลตอบแทน(อัตราดอกเบี้ย)กับช่วงเวลาของการลงทุน พบว่า หากผลกระทบที่เกิดขึ้นส่งผลให้อัตราดอกเบี้ยเพิ่มขึ้นอย่างถาวร ผลตอบแทนจากธุรกรรมการกู้เงินเพื่อการเก็งกำไรจะเพิ่มขึ้น ในทางตรงข้าม หากผลกระทบที่เกิดขึ้นส่งผลให้อัตราดอกเบี้ยเพิ่มขึ้นเพียงชั่วคราวหรืออัตราดอกเบี้ยเพิ่มขึ้นจากการคาดการอัตราเงินเฟ้อที่เพิ่มสูงขึ้น ผลตอบแทนจากธุรกรรมการกู้เงินเพื่อการเก็งกำไรจะลดลง นอกจากนี้ยังพบว่า พอร์ตโฟลิโอของการลงทุนที่สามารถเลือกลงทุนในสกุลเงินของกลุ่มของประเทศอาเซียน+3 และจี10 รวมกัน จะให้ผลตอบแทนดีกว่าการแยกลงทุนโดยเลือกได้เพียงสกุลเงินในกลุ่มใดกลุ่มหนึ่ง

สาขาวิชา เศรษฐศาสตร์และการเงินระหว่างประเทศ ลายมือชื่อนิสิต .....

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ปีการศึกษา 2557

5685608629 : MAJOR INTERNATIONAL ECONOMICS AND FINANCE
KEYWORDS: CARRY TRADE / EXCHANGE RATE VOLATILITY / CAPITAL FLOW / UNCOVERED INTEREST PARITY

PIYAKUL SOMSIRIWONG: CURRENCY CARRY TRADE AND EXCHANGE RATE VOLATILITYEVIDENCE FROM ASEAN+3 and G10. ADVISOR: PONGSAK LUANGARAM, Ph.D., 75 pp.

The purpose of this paper is to find various risk factors that affect currency carry trade return in interested groups of ASEAN+3 and G10 country during the period of 2001Q1 and 2014Q1. This study has two objectives. The first objective of this paper is to analyze the effects of exchange rate volatility on the carry trade return. The second objectives is to see whether yield curve level factors and yield curve slope factors affect carry trade return. This paper follows Clarida, Davis, and Pederson's model in 2009. I find that carry return and exchange rate volatility are negatively related or this can be implied that return on carry trade strategy will be higher in low volatility environment. The results for the second objective show that yield curve level factors positively affect carry trade return while yield curve slopes factors are negatively correlated with carry return. Additionally, this study find that investing in the merged groups of ASEAN+3 and G10 yields better carry trade returns comparing to in separated group of only ASEAN+3 or G10.

Field of S udy: International Economics and Finance Student's Signature .....
Advisor's Signature .....

Academic Year: 2014

ACKNOWLEDGEMENTS

I would never have been able to finish my thesis without the guidance of my MAIEF committee members, help from friends, and support from my family.

In completing my master degree thesis, I am greatly indebted to my advisor, Pongsak Luangaram, PhD., who has supported me throughout my thesis with his patience and immense knowledge while leaving me room to work in my own way. I attribute my master degree level to his encouragement and supports and, without him; this thesis would not have been completed.

Apart from my advisor, I would like to express my sincere thankful to Sothitorn Maltikamas, Ph.D., Assoc,prof., Danupon Ariyasajjakorn, Ph,D., and Somchai Rattanakomut, Ph.D., Asoc.prof., my thesis committee for their insightful comments and productive questions. During almost one year working on this thesis, my MAIEF friends have been involved in the thesis by spending time discussing and giving me some suggestions for my problems. I also would like to thank all my friends for their cordial helps, strong encouragement, and precious time.

Last but not least, I am indebted to all my teachers, friends, family, and most importantly my parents for supporting me throughout all my studies at Chulalongkorn University.

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CHAPTER 1
INTRODUCTION

1.1 Statement of Problem

One of the most popular trade strategies in this decade is the currency carry trade which is the process of borrowing a low interest rate currency by shorting the certain currency and at the same time investing in a high interest rate currency by longing the foreign currency in order to earn profit. There are many trade strategies that take place in the international market and these investment activities play a big role as supported by the data from BIS (2013) showing that trading in foreign exchange market reached 5.3 trillion USD per day compared to global trade in goods and services which reached 50 billion USD per day. It implies that shifting goods and services around the world moves currencies less than shifting capital do.

Currency carry trade consists of two components: 1) the cost of borrowing the low-yielding currencies (the short cost) and 2) the return in investment in high-yielding currencies (the long return). The currency carry trade is profitable if the interest rate differential is not completely offset by a depreciation of the high interest rate currency. Carry trade strategy has generated positive average returns since the 1980s, but only in the past decade has it become popular amongst individual investors and traders. The profitability in carry trade activity implies that the uncovered interest parity does not hold in reality. There are many researches proving that the UIP does not hold (i.e. (Fama, 1984)). The proof of violation in the UIP suggests that the macroeconomic model may not fit in estimating the change in exchange rate as the dynamic stochastic general equilibrium (DSGE) model generally assumes UIP.

From an investor's point of view, currency carry trade is found to be interesting as the strategy has generated positive return on investment over the last 3 decades. If we consider the carry trade as a portfolio, the higher Sharpe ratio gives investors higher profits. An increase in exchange rate volatility which is the major risk of carry trade activities decreases the amount earned by investor as it causes the Sharpe ratio to go down. Clarida, Davis, and Pedersen (2009) is one of many

researches which documents that the carry trade activity is more attractive in low volatility environment rather than in a highly volatile one. Therefore, the low volatility environment will result in high currency trade activities.

Should a central bank concern about high carry trade activity? Central bank may view huge carry trade activity as a harmful situation for the country. In particular, a central bank of export dependent country with high yielding currency may try to avoid a large amount of carry trade activity as it will cause the country currency to appreciate. However, the central bank intervention over the exchange rate will make the exchange rate less volatile and the carry trade activities become more attractive. Hence, the control over the exchange rate policy from central bank may result in more currency carry trade activities to that country. Carry trade results in capital inflow which will cause an appreciation in the exchange rate of the recipient country. If the country is an export dependent country, central bank will have to bear the cost of intervening with exchange rates. This is because the government of that country will not allow the appreciation of exchange rate to affect and cause damage to the export sector. The exchange rate intervention again makes the environment more attractive for investors and so on.

Recent researches in the area of carry trade mostly consider the developed G10 countries while very few studies are found to be those of developing countries in Asia. Campbell and Clarida (1987) states that variables used to predict term structure excess returns[1] can also affect cross-currency excess return. Clarida et. al. (2009) documents that "yield curve level factors are positively correlated with carry trade excess return while yield curve slope factors are negatively correlated with carry trade excess return." The findings imply that factors that drive bond yield also affect carry trade return in those of G10 countries.

Attentions are drawn to group of countries in ASEAN+3 because the data not only suggest positive cumulative return (or compound annual growth rate: CAGR) of

[1] The amount by which the yield-to-maturity of a long term bond exceeds that of short term bond as one collects coupons for longer period of time.

around 6.28%-11.39% but also high Sharpe ratios[2] of around 0.91-1.28 for investing in ASEAN+3 currencies in the first half of the decade. To compute the carry trade return and the cumulative return index as shown in figure 1, daily data of three-month deposit rate and spot exchange rate are used. The fund flowing to group of emerging markets may be a consequence of the triggers occurring in the United States; the dot-com bubble during 1995-2001, the housing bubble in 1998, the US subprime mortgage crisis which developed during 2007 and 2008, followed by the European Sovereign debt crisis in the late 2009. As a result, investors in international market then seek for new sources of investment and emerging markets are one of the reasonable choices.

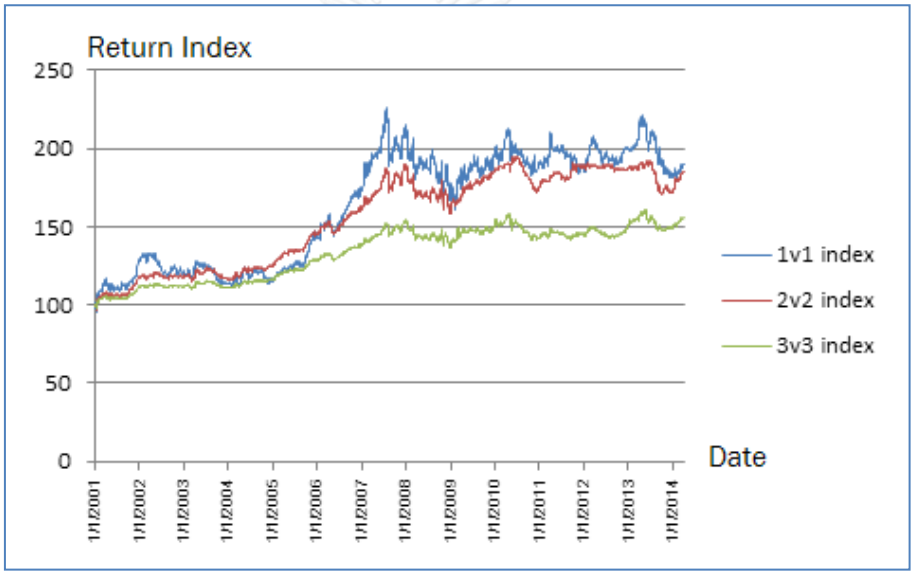

Figure 1 Return indices for ASEAN+3 1v1, 2v2, and 3v3 portfolios

From the above graph, 1v1 index, 2v2 index, and 3v3 index are the cumulative return index for 1v1 portfolio[3], 2v2 portfolio[4], and 3v3 portfolio[5] respectively. (The calculation can be seen in appendix)

[2] The ratio measures risk-adjusted return which determines extra reward per unit of risk. It is calculated using excess return and standard deviation.

[3] 1v1 portfolio consists of a long position in the highest yielding currency and a short position in the lowest yielding currency at any specific time.

[4] 2v2 portfolio consists of equal weighted long positions in the two highest yielding currencies and short positions in the two lowest yielding currencies.

[5] 3v3 portfolio consists of equal weighted long positions in the three highest yielding currencies and short positions in the three lowest yielding currencies.

When there are opportunities to make profit from currency carry trade activity in some specific situations, this paper would like to find the factors that affect carry trade return. This study firstly aims to find the effect of exchange rate volatility on currency carry trade return as it is the main risk associated with carry trade activity. Furthermore, the study tries to answer whether other risk factors affect the carry trade returns. The two major risk factors taken into account are yield curve level factor which is a proxy for permanent movement in real interest rate and/or inflation and yield curve slope factor which is a proxy for business cycle. These two factors cause the change in short term interest rate or/and inflation of a country which then affect exchange rate and the carry trade returns.

1.2 Objectives

The main objective of this paper is to find the various risk factors that affect currency carry trade return. This paper then tries to find out answers to meet the following sub-objectives:

1.2.1 To find the effects of exchange rate volatility on the carry trade return.

1.2.2 To find the effects of yield curve level factors and yield curve slope factors on currency carry trade returns.

1.3 Scope of the study

This paper will firstly focus on the data from ASEAN+3 countries. The countries include Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar (Burma), Philippines, Singapore, Thailand, Vietnam, China, Japan and South Korea. The time period of the study is between 2001Q1 and 2014Q1. However, some currencies in the basket of ASEAN+3 have to be eliminated due to the restrictions. Data of Brunei, Cambodia, Laos, Myanmar, and Vietnam are not available while China does not offer free capital flow policy. The carry trade strategy for group of ASEAN+3 in this paper will consider only seven countries which are Indonesia (Rupiah, IDR), Malaysia (Ringgit, MYR), Philippine (Peso, PHP), Singapore (Dollar, SGD), Thailand (Baht, THB), Japan (Yen, JPY), and South Korea (Won, KRW). Secondly, group of developed countries (G10); Australia (Dollar, AUD), Canada (Dollar, CAD), Switzerland (Franc, CHF), European Union (EUR), Great Britain (Pound, GBP),

Japan (Yen, JPY), Norway (Krone, NOK), New Zealand (Dollar, NZD), Sweden (Krona, SEK), and the United States (Dollar USD), during the same period of 2001Q1-2014Q1 will be discussed. Finally, these two groups of countries will be merged and discussed as it makes more sense in reality.

The currency carry returns are computed from daily data of spot exchange rate (in terms of US dollar per unit of foreign currency) and three-month deposit rate of each interesting country during the first quarter of 2001 and the first quarter of 2014.

As there was a global financial crisis in 2008, including such period would cause a structural break in the data set. This paper, therefore, separates the data into 2 groups which are the period before the global financial crisis (2001Q1 – 2007Q4) and the period after the global financial crisis (2009Q1 – 2014Q1), where year 2008 is the cutting point.

CHAPTER 2
LITERATURE REVIEW

2.1 Literature Review

Carry trade strategy which borrows the low interest rate currency and invests in the high interest rate currency without hedging for exchange rate risk is one of the most popular trade strategies in this decade. Carry trade among developed countries has been profitable since the 80s while carry trade among emerging market's currencies improves a lot in this decade. Carry trade strategies are profitable when the interest rate differential is not completely offset by an appreciation of the low interest rate currency.

Many literature reviews found that the currency carry trade is profitable because the high interest rate currency tends to appreciate against the low interest rate currency so return on carry trade increases (Backus, Foresi, & Telmer, 2001; Burnside C., Eichenbaum M., Kleshchelski I., & R., 2006; Kaizoji, 2010; Menkhoff, Sarno, Schmeling, & Schrimpf, 2012). This evidence is known as the forward premium puzzle (Fama, 1984) which is the situation that violates the uncovered interest parity (UIP). Fama (1984) also gives explanation to this puzzle as it is believed that there exists the time-varying risk premia[6], hence carry trade is profitable for a long period of time (Menkhoff et al., 2012). This is supported by Berge, Jorda and Taylor (2010) suggesting that the excess returns on carry trade are linked with time-varying risk premium. The findings imply that excess returns on carry trade exist to compensate for risks that can change over time (Burnside C., Eichenbaum M., & R., 2011). Investor's returns depend on both exchange rate movement and the difference between the borrowing and deposit rate, thus exchange rate volatility is the main risk for carry trade investors. This is because appreciations or depreciations of the currency pair directly affect the returns on carry trade. High carry trade return can be explained as compensation for the volatility risk.

[6] Extra return on bearing risks that may change over time

Burnside et. al. (2006) states that the Sharpe ratio for currency speculation can be explained by considering the carry trade as a risky strategy whereby its payoff is correlated with risk factors. Curcuru, Vega , and Hoek (2010) bring the concept of Sharpe ratio to measure the amount of carry trade activity. The paper suggests that Carry-to-risk ratio; risk-adjusted profitability of carry trade return based on interest rate differential adjusted for risk of future exchange rate movement[7] can be used to measure carry trade activity. Burnside et. al. (2006) also finds that the currency-speculation strategies yield high Sharpe ratio; however, their payoffs are uncorrelated with standard risk factors. Even the statistical data confirm strong violation on uncovered interest rate parity, the profit that can be made from the currency-speculation strategies seems to be very small.

Carry trade tends to take place when exchange rate volatility is low. This is confirmed by Menkhoff et. al. (2012) that the global foreign-exchange volatility risk and currency excess returns have negative relationship with each other; high interest rate currency yields higher excess return when the volatility risk is low and vice versa. High yielding currencies and the innovation in global foreign exchange volatility have negative relationship (or it gives low return in unexpected high volatility environment) while low yielding currencies offer positive return seen as a hedge in high volatility environment. Clarida et. al. (2009) also finds the negative relationship between carry return and exchange rate volatility.

As investors continue to invest in carry trade strategy for many decades, Teisei Kaizoji (2010) has pointed out that the carry-traders' herd behavior causes the currency bubble and this carry trading prolongs the bubble. When the carry-traders' herd behavior approaches the stationary state, the appreciation of the high interest rate currency against the low interest rate currency slows down. As a result, the return on currency carry trade begins to decrease. This unwinding of carry trade leads to the currency crush and the latest financial crisis of 2007-2009 (Brunnermeier, Nagel, & Pederson, 2008; Kaizoji, 2010). Brunnermier et. al. (2008) additionally documents

[7] Measuring risk using the option-implied volatility of exchange rate

that the currency crashes increase the market volatility and decrease the carry trade activities as high volatility results in less available speculator capital.

Carry trade strategies associated with risks become the major concern for financial regulators and policymakers (Curcuru et al., 2010). Many literatures have found that excess returns on carry trade activity have no relationship with standard risk factors[8] (Berge et al., 2010; Burnside, 2011; Burnside C., Eichenbaum M., Kleshchelski I., & R., 2008); however, there are many factors that have impacts on carry trade return. Menkhoff et. al. (2012), for instance, states that global foreign exchange rate volatility considered as a systematic risk[9] is used to explain carry trade return. Moreover, carry trade return shows some sensitivity to macroeconomic conditions. This is the support of Burnside et. al. (2006); monetary policy can generate time-varying risk premia and then affects the return on carry trade. Campbell and Clarida (1987) have proposed that different investment strategies give different time-varying excess return. Since excess return depends on various risk factors, the use of factor model is recommended. This is also because the use of linearized general equilibrium open-economy models is not proper when UIP does not hold.

The model for joint determination of yield curve term premium[10] and carry trade risk premium has been set up by Campbell and Clarida (1987) as the expectation for short-term interest rate directly affects the expected return on carry trade. Variables used to predict term structure excess returns[11] can also affect cross-currency excess return. Berge, Jorda and Taylor (2010) has also found that the information drawn from the forward yield curve partly affects the excess returns on carry trade. Gurkaynak, Sack, and Swanson, (2005) document that there are effects of

[8] The standard risk factors mentioned in the paper of Berge, Jorda and Taylor (2010) consist of the excess return to the value-weighted U.S. stock market (CAPM), the three Fama and French factors, U.S. industrial production growth, the federal fund rate, the term premium (the spread between 10-year treasury bonds and 3-month treasury bills, the Postor and Stambaugh (2003) two liquidity measures and the measure of market volatility.

[9] The risk is an un-diversifiable risk and inherent to the entire market

[10] The amount by which the yield-to-maturity of a long term bond exceeds that of short term bond as one collects coupons for longer period of time

[11] Term structure excess return is the yield curve term premium

macroeconomics and monetary policy on the term structure of interest rate[12]. The shocks have temporary effect on the interest rate and after a period of time it will return back to steady state. In the short run, shocks cause the interest rate to move in line with the macroeconomic theory. In the long run, interest rate moves opposite to macro model because private sector adjusts its expectations of long-run inflation in response to macro and monetary shocks, thus it is difficult to capture behavior in long-run where expected inflation response to macro and monetary surprises. Moreover, recent BIS working paper by Demosthenes and Nikola A. (2012) suggests that systemic monetary policy especially a forward-looking CPI-based rule expresses strong UIP violation. However, these can be concluded that macroeconomics and monetary policy variables affect returns on carry trade via the effects on yield curve.

When high carry trade activity becomes a concern of the central bank, the question about the appropriate exchange rate regime is raised up. Alfaro and Kanczuk (2013) suggest that the optimal exchange rate regime of a country when the carry trade activity plays an important role in the international sector depends on the type of shock to an economy. The flexible exchange rate regime is optimal for the domestic shocks while the fixed exchange rate regime is optimal for the economy that is hit by foreign real shocks. Also the authors find that the traditional fixed exchange rate regime is not sustainable. The crucial point is that the flexible exchange rate regime can be used to reduce exchange rate volatility by issuing the local currency bonds, the policy is called "pseudo-flexible regime" according to the author. This pseudo-flexible exchange rate regime can improve the welfare level if it is implemented in conjunction with reserve accumulation.

[12] Term structure of interest rate (or yield curve) is the curve showing relation between the level of interest rate and time to maturity

2.2 Conceptual Framework

2.2.1 The uncovered interest parity and the carry trade return

The well-known equation of the uncovered interest parity (UIP) suggests that the depreciation of exchange rate depends on the interest rate differential. This is presented by the following equation.

$$\Delta x_{t+1} = i^* - i$$

Where, x_t = log of nominal exchange rate (unit of foreign currency per domestic currency)

i^* = log of foreign interest rate

i = log of domestic interest rate

When the UIP holds, it says that the interest rate differential is completely offset by the depreciation of foreign currency against domestic currency. However, many literature reviews prove that the statement mentioned earlier is wrong; it implies that the UIP does not hold in reality. The failure of UIP allows investors to seek for some profit from carry trade activity. We can denote the r_t as the excess return from currency carry trade activity as written in the equation below.

$$r_t = (i^* - i) - \Delta x_{t+1}$$

Hence, the excess return on currency carry trade activity is the net of interest rate differential and the depreciation of foreign currency against domestic currency.

2.2.2 Volatility as a risk factor in foreign exchange

Menkhoff et. al. (2012) has proposed that positive volatility innovation (i.e. unexpected high volatility) causes the investor's risk-return tradeoff go worse, thus it gives negative volatility risk premium. Investors are concerned about change in future investment opportunities, as a result the volatility risk premium turns out to be negative in value. The negative premium in unexpected high volatility lowers the return on investment. In other words, assets with a higher sensitivity to volatility risk do earn lower returns. The paper mention the use of the covariance of return with market volatility as a priced source of risk and the coskewness is mentioned as follows.

$$coskew = \frac{E[(r_k - \mu_k)(r_m - \mu_m)^2]}{\sigma(r_k)\sigma^2(r_m)}$$

Where, r_k = return of portfolio k

r_m = return of market (as benchmark)

μ and σ denote the mean and standard deviation, respectively.

The idea is that portfolios with high coskewness; portfolios that yield high return in high volatility environment, are viewed as a hedge against volatility, hence the lower returns from the portfolios are received. This concept can be brought to consider the cross-section of foreign exchange risk premium.

2.2.3 Forward premium and the expected interest rate differential

According to Fama (1984), the forward exchange rate can be split into an expected future spot rate and a premium as written below.

$$F_t = E(S_{t+1}) + P_t \quad (1)$$

Where, $F_t = lnf_t$; f_t = forward exchange rate

$S_{t+1} = lns_{t+1}$; s_{t+1} = future spot exchange rate

The model describing the determinant of premium (P_t) is set up by the following steps below.

From (1), the difference between the forward rate and the current spot rate is

$$F_t - S_t = P_t + E(S_{t+1} - S_t) \quad (2)$$

The following equations are regressed and the value of coefficients (β_1, β_2) are found to be significantly non-zero.

$$F_t - S_{t+1} = \alpha_1 + \beta_1(F_t - S_t) + \varepsilon_{1,t+1} \quad (3)$$

$$S_{t+1} - S_t = \alpha_2 + \beta_2(F_t - S_t) + \varepsilon_{2,t+1} \quad (4)$$

Equation 4 uses term forward-spot differential ($F_t - S_t$) to predict future change in spot rate ($S_{t+1} - S_t$).

Equation 1 can be rewritten as

$$F_t - S_{t+1} = P_t + E(S_{t+1}) - S_{t+1} \quad (5)$$

Where, $E(S_{t+1}) - S_{t+1}$ is the random error of rational forecast$E(S_{t+1})$.

When equation 2 and 3 are taken into consideration, it can be implied that the premium component of $F_t - S_t$ (in equation 2) partly determines the difference between forward rate and future spot rate ($F_t - S_{t+1}$).

The paper assumes that the expected future spot rate ($E(S_{t+1})$) in the forward rate is rational, the estimated coefficients of $\beta_1 and\ \beta_2$ are

$$\beta_1 = \frac{cov(F_t - S_{t+1}, F_t - S_t)}{\sigma^2(F_t - S_t)} = \frac{\sigma^2(P_t) + cov(P_t, E(S_{t+1} - S_t))}{\sigma^2(P_t) + \sigma^2(E(S_{t+1} - S_t)) + 2cov(P_t, E(S_{t+1} - S_t)} \quad (6)$$

$$\beta_2 = \frac{cov(S_{t+1} - S_t, F_t - S_t)}{\sigma^2(F_t - S_t)} = \frac{\sigma^2(E(S_{t+1} - S_t) + cov(P_t, E(S_{t+1} - S_t)}{\sigma^2(P_t) + \sigma^2(E(S_{t+1} - S_t)) + 2cov(P_t, E(S_{t+1} - S_t)} \quad (7)$$

In the case that P_t and $E(S_{t+1} - S_t)$ are not correlated, the coefficients β_1 and β_2 separate the variance of $F_t - S_t$ into two part which are the variance

of the premium (P_t) and the variance of the expected change in the spot rate ($E(S_{t+1} - S_t)$). However, the above simple case does not occur in reality, the term $cov(P_t, E(S_{t+1} - S_t)$ shown in equation 6 and 7 then play a big role in estimating coefficients β_1 and β_2.

When equation 3 and 4 are sum up, sum of the intercept must be zero ($\alpha_1 + \alpha_2 = 0$), and sum of the coefficients must equal to one ($\beta_1 + \beta_2 = 1$). The point is that equation 3 and 4 contain information about variance of the components of $F_t - S_t$ which are P_t and $E(S_{t+1} - S_t)$. The value of coefficient β_2 in equation 4 of the change in spot rate ($S_{t+1} - S_t$) on forward-spot differential ($F_t - S_t$) is mostly found to deviate from 1 due to the time-varying premium in forward rate. Fama (1984) suggests that the deviation is "a direct measure of the variation of the premium in forward rate. Hence, the paper has proposed that the variation in forward rate is mostly the variation in premiums.

Interest Parity Condition: $$f_t^{ij} / s_t^{ij} = (1 + R_{it})/(1 + R_{jt}) \qquad (8)$$

Where, f_t^{ij} and s_t^{ij} are the forward and spot exchange rate at time t (units of currency i per unit of currency j), R_{it} and R_{it} are the nominal interest rate on bonds in country i and j at time t with zero default risk and same maturity as f_t^{ij}.

Taking natural log in equation 8, the below equation is obtained.

$$F_t^{ij} - S_t^{ij} = r_{it} - r_{jt} \qquad (9)$$

In words, from equation 9, the premium in forward rate which is the forward-spot differential can be explained in terms of the interest rate differential. The example is given where PPP and Fisher equation are assumed to hold.

Assuming that V_{it} and V_{jt} are the price levels in country i and j, $\Delta_{i,t+1} = \ln(V_{i,t+1}/V_{i,t})$, $\Delta_{j,t+1} = \ln(V_{j,t+1}/V_{j,t})$, $r_{i,t+1}$ and $r_{j,t+1}$ are real interest rate on nominal bonds of country i and j.

Taking natural log in equation 8 and applying Fisher equation, the following equation is achieved.

$$F_t^{ij} - S_t^{ij} = \left[E\left(r_{i,t+1}\right) + E\left(\Delta_{i,t+1}\right)\right] - \left[E\left(r_{j,t+1}\right) + E\left(\Delta_{j,t+1}\right)\right] \quad (10)$$

Equation 10 can be rearranged into

$$F_t^{ij} - S_t^{ij} = \left[E\left(r_{i,t+1}\right) - E\left(r_{j,t+1}\right)\right] + \left[E\left(lnV_{i,t+1}\right) - E\left(lnV_{j,t+1}\right)\right] - [lnV_{i,t} - lnV_{j,t}] \quad (11)$$

The PPP condition says that the spot exchange rate is the ratio of the price levels in the two countries; $S_t^{ij} = V_{it}/V_{jt}$.

Applying PPP condition to equation 11 and get

$$F_t^{ij} = \left[E\left(r_{i,t+1}\right) - E\left(r_{j,t+1}\right)\right] + E(S_{t+1}^{ij}) \quad (12)$$

Equating equation 1 and 12, the following condition is reached.

$$P_t = E\left(r_{i,t+1}\right) - E\left(r_{j,t+1}\right) \quad (13)$$

In words, the variables that determine the difference between the expected real returns on the nominal bonds also explain the premium on forward rate.

2.2.4 Factor Model

Computing the expected return of an investment involves the estimated level of return (or the risk-free return) and the premium for the risk of loss. Risk and return model in finance tries to find the factors that affect risk and translate the risk measured into a risk premium.

Factor model assumed that the rate of return of an asset is given by random variables called factors; represented by the following equation. The factors are chosen depending upon the type of assets being considered.

$$r = a + b_1 f_1 + \ldots + b_k f_k + \varepsilon$$

Where, r is the return of an investment.

$f_1 \ldots f_k$ are the factors chosen to determine the return.

ε is the mean zero error term

Many researches document that high return on currency carry trade strategies can be explained as a compensation for the volatility risk. Burnside et. al. (2006) states that when carry trade is considered as a risky strategy, its return is correlated with risk factors. The use of asset pricing model is brought to compute the return on carry trade, for example, Clarida, Davis, and Pedersen (2009) used the concept of factor model to explain the carry trade return, where the return of carry trade is a function of related risk factors. The most recent work of Menkhoff et. al. (2012) also confirms the use of risk factor to calculate carry trade return as it was found that global foreign exchange volatility is the key risk factor that drives the premia on carry trade return.

CHAPTER 3
METHODOLOGY

3.1 Methodology

The methodologies below, stemming from Clarida et. al. (2009), are conducted to answer the two main objectives of this paper. The first objective is to find the effects of exchange rate volatility on carry trade returns, and the second objective is to find the effects of factors driving bond yield on carry trade returns.

3.1.1 To answer the first sub-objective on how the exchange rate volatility affects carry trade returns, the relationship between currency carry trade return and exchange rate volatility will be examined by using the following steps.

Step 1: Graph the Z-scores of realized return and realized return volatility (in log-inverse) to see the correlation.

Given r_t = the carry trade return

σ_t = the realized return volatility

μ_t = the realized return

The carry trade returns are calculated using the daily data of spot exchange rate and three-month deposit rate of the group of countries we are interested. (In-depth calculation can be seen in Appendix)

The data of daily carry trade returns (r_t) are volatile so we smooth the data by using exponentially weighted moving averages to obtain the realized return (μ_t).

Where, $\sigma_t = \frac{\Sigma_{i=0}^{T}\lambda^i(r_{t-i}-\bar{r})^2}{\Sigma_{i=0}^{T}\lambda^i}$ and $\mu_t = \frac{\Sigma_{i=0}^{T}\lambda^i r_{t-i}}{\Sigma_{i=0}^{T}\lambda^i}$

λ = given value of exponential decay parameter

To make comparison simple, we compute the Z-score using the following series to get the same standard series and to depict both positive and negative value of series.

$$Z_{\mu} = \frac{\mu_t - \bar{\mu}}{s_{\mu}}, \; s_{\mu}^2 = \frac{1}{N-1}\sum(\mu_t - \bar{\mu})^2$$

$$Z_{\sigma_L} = \frac{\sigma_{L,t} - \bar{\sigma}_L}{s_{\sigma_L}}, \; s_{\sigma_L}^2 = \frac{1}{N-1}\sum(\sigma_{L,t} - \overline{\sigma_L})^2$$

Finally, Z_{μ} and -Z_{σ_L} are graphed to examine the relationship between carry return and exchange rate volatility, where exchange rate volatility here is proxy by the realized return volatility.

Step 2: To further confirm the relationship between carry return and exchange rate volatility, we divide the samples into 4 groups according to realized volatility calculated using the formula in the first step. The first group; the lowest volatility group, includes the return in which its realized volatility is below the 25th percentile of volatility distribution. The second and the third groups are those returns in which the volatilities lie in the 2nd and the 3rd quartile, respectively. The last group; the highest volatility group, includes the return in which its volatility is higher than 75th percentile of volatility distribution. The returns on those different volatility states are compared where, in this paper, the low volatility group is expected to have higher return and vice versa.

Step 3: For more solid backup, the exponential Garch models (Nelson(1991)) of return on carry trade is estimated whereby the variance (volatility) is brought into the equation of carry return. Carry trade return is now a function of volatility of exchange rate and the relationship can be simply seen by looking at the coefficient of the volatility (vol_t).

Model: $r_t = \alpha + \beta r_{t-1} + \theta vol_t + u_t$

$$logh_t = c + a|u_{t-1}|h_{t-1}^{-1/2} + blogh_{t-1} + du_{t-1}h_{t-1}^{-1/2}$$

Where, r_t = carry trade returns

h_t = conditional variance of u_t based on t-1 information

vol_t = realized volatility

The negative sign of coefficient θ is expected to reconfirm the negative relationship between carry return and exchange rate volatility.

Step 4: Estimate the following regression

$$\Delta x_{t+1} = \alpha + \beta(i_t^H - i_t^L) + \varepsilon_t$$

Where, x_t = log of spot exchange rate (high i currency/low i currency)

Δx_{t+1} = depreciation of high yield currency against low yield currency

$i_t^H - i_t^L$ = yield difference

Note: $\alpha = 0$ is assumed

If $\beta = 1$, UIP holds (Investor cannot make any profit from carry trade)

If $\beta < 1$, investor profits from carry trade

If $\beta > 1$, investor losses from carry trade

The sample is divided into 2 groups according to realized volatility estimated in the first step; the groups of sample with lowest-volatility and highest-volatility states, and separately regress the above equation where the depreciation of high interest rate currency against low interest rate currency is a function of lagged interest rate differential. The lowest-volatility group is expected to have less than one value of beta (β) while the highest-volatility group is expected to have value of beta (β) greater than one; value of α estimated is expected to be zero. This implies that the low volatility group yields higher return relative to those with high volatility.

3.1.2 To answer the second objective on the determinants of carry trade return and whether yield curve level factor, yield curve slope factor, and VIX index influence the carry trade return, a model is conducted in order to test the significance of variables included in the model.

$$return_t = (i^H - i^L) + \beta_L Y_L + \beta_S Y_S + \beta_V VIX + \varepsilon_t$$

Where,

$return_t$	is	carry trade return
Y_L	is	yield curve level factor which is the relative change in levels in high yield currency country relative to low yield currency; level is defined as the average of 5-year, 7-year, and 10-year treasury yield.
Y_S	is	yield curve slope factor which is the relative change in slope in high yield currency country relative to low yield currency; slope is defined as 10 year minus 2 year treasury yield.
VIX	is	volatility Index which is the Chicago Board Options Exchange Volatility Index that measures the stock market's expectation on volatility over the next 30 days on S&P index.

The currency carry trade return consists of two parts which are the difference in interest rate of the two interesting countries and the depreciation in exchange rate of high interest rate currency against low interest rate currency. As the difference in interest rate of the two countries alone is not enough to capture the return on carry trade, hence other risk factors that affect the change in exchange rate are taken into account in order to better capture the return. Those factors are yield curve level factor, yield curve slope factor and VIX. The VIX is often used in measuring the global investors risk aversion. All these three factors indirectly determine carry trade return.

The financial model is chosen to compute the return from currency carry trade activities because the model is a better fit than the use of macroeconomic model. According to several literature reviews, the use of macroeconomic models in estimating expected change in exchange rate do not give the result that gets along with the real world; for example, the UIP is mostly violated.

3.2 Expected signs of independent variables

Dependent variable: Carry Trade Return

Table 1 Expected signs of independent variables

Variables	Expected Sign	Supporting Theory
Exchange rate volatility	Positive (for expected return), Negative (for realized return)	For positive correlation, an increase in exchange rate volatility implies an increase in risk. Hence, the higher return on portfolio is expected. For the negative correlation, unexpected high volatility worsens the investor's risk-return tradeoff, thus it gives negative volatility risk premium as investors are concerned about change in future investment opportunities. The negative premium in unexpected high volatility lowers the return on investment and vice versa.
VIX index	Negative	The VIX is a widely used measure of market risk and is often referred to as the "investor fear indicator". An increase in VIX is associated with depreciation of high yielding currency and the lower carry return and vice versa. When investors' fear goes up due to an increase in VIX index, demand for investing in carry trade goes down. The lower the demand for high yielding currency causes depreciation in a certain currency.
Yield curve level factor	Positive	Yield curve level factor is a proxy for permanent movement for real interest rate or/and inflation. An increase in yield curve level factor means that the yield curve of high yield currency is relatively higher than those of low yield currency due to the permanent increase in inflation of high currency (given that the low yield currency's inflation is unchanged), thus nominal exchange rate of high yield currency appreciates against those of the low yield currency, the return on carry trade then goes up, and vice versa.

Variables	Expected Sign	Supporting Theory
Yield curve slope factor	Negative	Yield curve slope factor is a proxy for business cycle. Steeper yield curve slope implies that the expected future short term interest rate of the high interest rate currency goes up as expected inflation increases (due to an easing monetary policy during the expected economic contraction). High expected inflation causes both an increase in nominal interest rate which increases carry trade returns and an exchange rate depreciation which decreases carry trade returns. When an effect of exchange rate depreciation is greater than an effect of an increase in nominal exchange rate, investors will receive lower return from carry trade activities (negative correlation). In case that an effect of an increase in nominal exchange rate is greater than an effect of exchange rate depreciation, investors will receive higher return from carry trade activities (positive correlation).

3.3 Measurement and Data sources

Table 2 Definition, Measurement, and Sources of variables

Variable	Definition	Measurement	Sources
Currency carry trade return	A return of a strategy in which an investor sells a currency with a relatively low interest rate then uses that amount of money to buy another currency that yields a higher interest rate.	The **"carry return"** (or the excess return) equals to the return on investment (or the long return) in high-yielding currencies less the cost of borrowing (or the short cost) in low-yielding currencies, all in U.S. dollar term.	Bloomberg and author calculation. (See the calculation in Appendix)

Variable	Definition	Measurement	Sources
Exchange rate volatility	The fluctuation of exchange rate refers to the tendency for foreign currencies to appreciate or depreciate in value, thus affecting the profitability of foreign exchange trades.	Realized volatility is proxy by the carry trade return volatility; using the exponentially weighted moving averages in calculation.	Bloomberg and author calculation.
VIX Index	The Chicago Board Options Exchange Volatility Index that measures the stock market's expectation on volatility over the next 30 days on S&P index.	It is calculated based on the weighted average of the implied volatilities for a wide range of strikes; 1st and 2nd month expirations are used until 8 days from expiration, then the 2nd and 3rd are used. (Quoted as percentage point)	Bloomberg
Yield curve level factor	Relative change in levels in high yield currency country relative to low yield currency; level is defined as the average of 5-year, 7-year, and 10-year treasury yield. Yield curve level factor is a proxy for permanent movement for real interest rate or/and inflation.	A spread between the change in average of 5-year, 7-year, and 10-year treasury in the high yield currency and the change in 5-year, 7-year, and 10-year treasury in low yield currency during period t and period t-1	Bloomberg and author calculation.
Yield curve slope factor	Relative change in slope in high yield currency country relative to low yield currency; slope is defined as 10 year minus 2 year treasury yield. Yield curve slope factor is a proxy for business cycle.	A spread between the change in high yield currency slope and the change in low yield currency slope during period t and period t-1, where the slope is equal to the difference between the 10-year treasury yield and 2-year treasury yield.	Bloomberg and author calculation.

Table 3 Data used to generate variables

Variable	**Data used to generate variables**
Currency carry trade return	✓ three-month deposit rate of each interesting currency ✓ spot exchange rate (in terms of USD per unit of foreign currency) ❖ assume 260 business days in a year
Exchange rate volatility	✓ currency carry trade return
Yield curve level factor	✓ 5-year, 7-year, and 10-year treasury yield of each interesting country
Yield curve slope factor	✓ 10-year treasury yield of each interesting country ✓ 2-year treasury yield of each interesting country

CHAPTER 4
RESULTS AND ANALYSIS

4.1 Data Analysis

Currency carry trade is the strategy in which investors borrow money (go short) in low-yielding currencies and then invest (go long) those funds in high-yielding currencies. Hence, carry return consists of two components; 1) the cost of borrowing in low-yielding currencies (the short cost) and 2) the return in investment in high-yielding currencies (the long return).

Daily data of three-month deposit rates and spot exchange rates are used to compute the returns on carry trade strategy by following the steps shown in Appendix. The data used for calculation in this step is from the first quarter of year 2001 to the first quarter of year 2014.

4.1.1 Group of ASEAN+3

Carry trade strategy, from the scope of study, firstly considers basket of ASEAN+3 currencies including Brunei Dollar (BND), Cambodian Riel (KHR), Indonesia Rupiah (IDR), Laotian Kip (LAK), Malaysian Ringgit (MYR), Myanmar Kyat (MMK), Philippine Peso (PHP), Singapore Dollar (SGD), Thai Baht (THB), Vietnamese Dong (VND), Chinese Renminbi (CNY), Japanese Yen (JPY), and South Korea Won (KRW). It is found that the data of Brunei, Cambodia, Laos, Myanmar, and Vietnam are not available; hence, these countries will not be taken into account. Another country that has to be eliminated is China as the country does not offer free capital flow policy. Finally, the strategy will from now on consider only seven countries which are Indonesia (Rupiah), Malaysia (Ringgit), Philippine (Peso), Singapore (Dollar), Thailand (Baht), Japanese (Yen), and South Korea (Won).

4.1.1.1 Returns for 1v1, 2v2, and 3v3 portfolios.

Carry trade returns on 1v1, 2v2, and 3v3 portfolios invested in group of ASEAN+3 are shown in figure 2. The 1v1 CARRY, 2v2 CARRY, and 3v3 CARRY are the returns for 1v1, 2v2, and 3v3 portfolios, respectively. The

carry returns fluctuate and have both positive and negative value in different specific time.

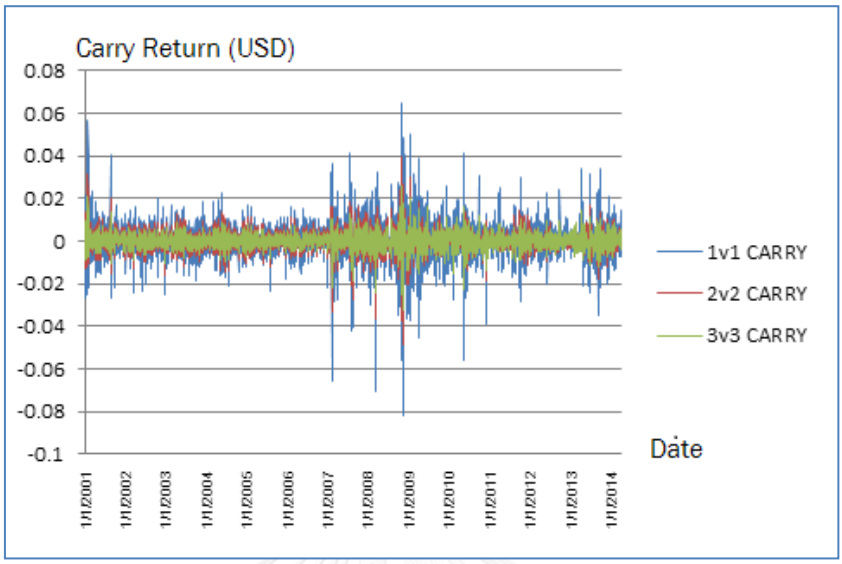

Figure 2 ASEAN+3 daily returns on 1v1, 2v2, and 3v3 portfolios.

The returns of these three portfolios follow the same trend so they can be explained together as a group. During 2001 and 2007, carry returns are presented in the range between -0.02 and 0.02 US dollar. The returns tend to move wider in the range between -0.06 and 0.04 US dollar during 2007 and mid 2010. From mid 2010, they appear in the range between -0.04 and 0.04 US dollar. The graphs show that returns on carry trade strategy fluctuated the most during 2008 and mid 2009. One of the reasons may be due to a global financial crisis (GFC). Furthermore, the 3v3 portfolios yielding less fluctuate returns compared to 2v2 and 1v1 portfolios may result from risk diversification.

4.1.1.2 Returns for pair currency portfolios: shorting JPY and longing KRW, PHP, SGD, and THB, respectively.

After considering 1v1, 2v2, and 3v3 portfolios, the more specific 1v1 portfolios of pair currency in group of ASEAN+3 will be taken into account. By shorting Japanese Yen (JPY) and longing South Korea Won (KRW), Philippine Peso (PHP), Singapore Dollar (SGD), and Thai Baht (THB), respectively, the graphs of returns are shown in figure 3.

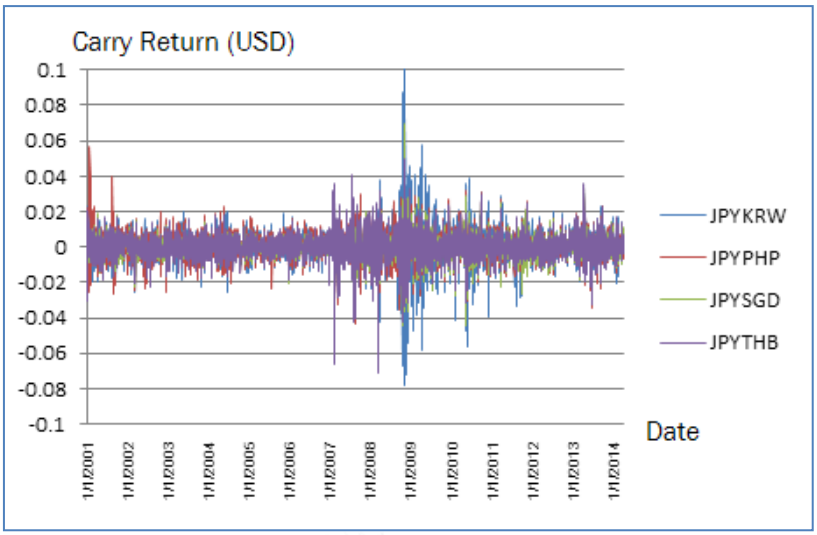

Figure 3 Daily returns on pair currency where JPY is shorted and KRW, PHP, SGD, and THB are longed.

The JPYKRW, JPYPHP, JPYSGD, and JPYTHB are the returns for portfolios shorting JPY and longing KRW, PHP, SGD, and THB, respectively. Graph of returns is most fluctuated during 2008 and 2010, especially those of JPYKRW portfolio. Apart from this period, the returns move in the range between -0.04 and 0.04 US dollar.

4.1.1.3 Return indices for 1v1, 2v2, and 3v3 portfolios.

The daily return data is now brought to calculate the cumulative return index for 1v1, 2v2, and 3v3 portfolios. By following the formula presented in Appendix, the below graph (figure 4) are arrived at, where 1v1 index, 2v2 index, and 3v3 index are cumulative return indices for 1v1, 2v2, and 3v3 portfolios, respectively.

Figure 4 shows that carry trade strategies considering group of ASEAN+3 currencies have generated positive returns on average since the beginning of 2001, thus ASEAN+3 carry trade activity seems to be attractive in the latest decade. Let's consider the period before the global financial crisis (2008), those three indices gradually increased during 2001 and 2005, dramatically rose during 2005 and 2007, and skyrocketed during 2007 and 2008. However, the difference between increases in 1v1, 2v2, and 3v3 indices are not equal. Where 1v1 index elevated from about 175 to 215, 2v2 index

inclined from about 160 to 190, and 3v3 index moved from 140 to 155. For the period after the global financial crisis, 1v1, 2v2, and 3v3 indices fluctuated at different levels. Where 1v1 index is most volatile around 160-220, 2v2 index is moved between 160 and 195, and 3v3 index is quite stable around 150.

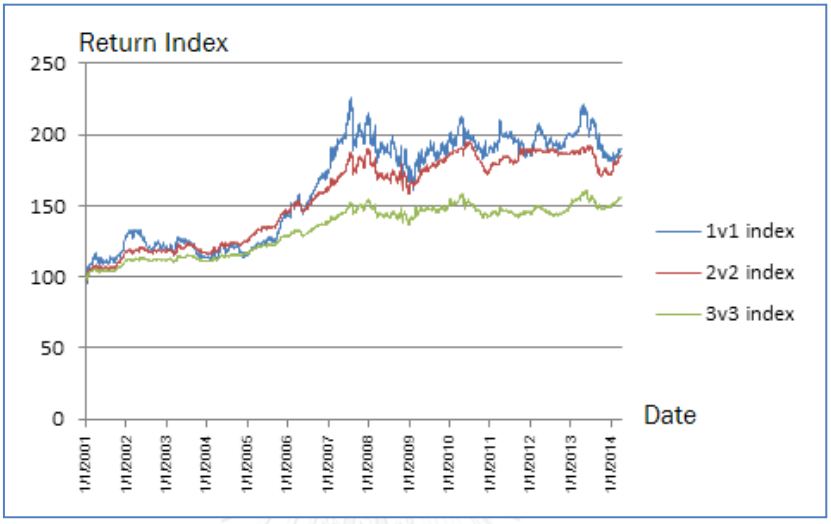

Figure 4 ASEAN+3 cumulative return indices for 1v1, 2v2, and 3v3 portfolios

4.1.1.4 Return indices for currency pair portfolios: shorting JPY and longing KRW, PHP, SGD, and THB, respectively.

Let's now look at the more specific portfolios of pair currency, graphs of cumulative return indices are shown in figure 5. For the period before the global financial crisis, return indices of these four portfolios steadily fluctuate at mostly the same level during 2001 and 2005, and gradually increase with different amount during 2005 and 2007. The indices dramatically rise in the period between 2007 and 2008, except for JPYSGD portfolio. After the global financial crisis, the indices again steadily move but at different level during 2009 and 2012. It is possible that after the global financial crisis, it was the time for economic recovery. The cumulative indices have immediately gone up since the mid 2012.

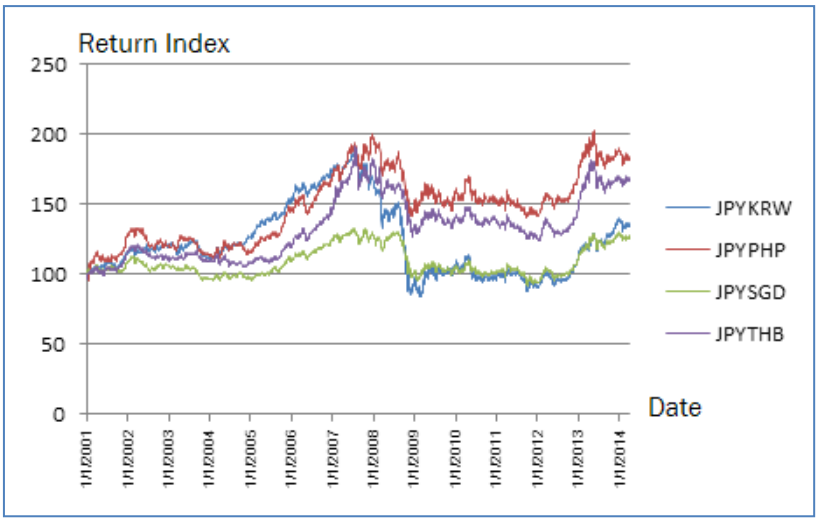

Figure 5 Cumulative return indices for portfolios shorting JPY and longing KRW, PHP, SGD, and THB, respectively

4.1.1.5 Gripping Statistics: Average Return, Standard Deviation, and Sharpe Ratio

4.1.1.5.1 The whole period of study (01 Jan 2001 – 31 Mar 2014)

Carry trade strategies, overall, give positive annual returns during the first quarter of 2001 and the first quarter of 2014 as shown in Table1. The 1v1 portfolio seems to yield higher annual return than the 2v2, and 3v3 portfolio respectively; however, it has the lowest Sharpe ratio because of its highest standard deviation.

In general, 1v1, 2v2, and 3v3 baskets have average returns of around 3.39% - 4.96%, standard deviations of around 5.97% - 14.89%, and Sharpe ratios of around 0.33 – 0.60. In comparison, the more specific 1v1 portfolios of pair currency have average returns of around 1.87% - 4.72%, standard deviations of around 10.57% - 16.50%, and Sharpe ratio of around 0.14 - 0.37. The JPYKRW basket, where JPY is shorted and KRW is longed, yields the highest average return of 4.72% and Sharpe ratio of 0.37; compared to other 1v1 portfolios. For JPYTHB portfolio, average return, standard deviation, and Sharpe ratio are 4.05%, 11.92%, and 0.34, respectively.

Table 4 Statistics for the whole period of study

Basket	Average return	Standard deviation	Sharpe ratio
1v1	4.96%	14.82%	0.33
2v2	4.72%	7.81%	0.60
3v3	3.39%	5.97%	0.57
JPYKRW	2.39%	16.50%	0.14
JPYPHP	4.72%	12.62%	0.37
JPYSGD	1.87%	10.57%	0.18
JPYTHB	4.05%	11.92%	0.34

4.1.1.5.2 Period before global financial crisis (01 Jan 2001 – 31 Dec 2007)

For the period before the global financial crisis, all portfolios clearly yield higher average returns of around 6.28% - 11.39% and Sharpe ratios of around 0.75 – 1.28, except for JPYSGD portfolio. The JPYSGD portfolio has an average return of 3.59%, standard deviation of 7.93%, and Sharpe ratio of 0.45.

Table 5 ASEAN+3 statistics for period before global financial crisis

Basket	Average return	Standard deviation	Sharpe ratio
1v1	11.39%	12.56%	0.91
2v2	9.46%	7.37%	1.28
3v3	6.28%	4.91%	1.28
JPYKRW	7.56%	10.15%	0.75
JPYPHP	10.10%	11.42%	0.88
JPYSGD	3.59%	7.93%	0.45
JPYTHB	8.91%	11.05%	0.81

4.1.1.5.3 Period after the global financial crisis (01 Jan 2009 – 31 Mar 2014)

After the global financial crisis, it seemed to be the period of economic recovery. As a result, average returns and Sharpe ratios are significantly lower comparing to the period before global financial crisis. In this period, JPYKRW portfolio yields the highest average return of 6.50% while JPYTHB gives the highest Sharpe ratio of 0.44.

Table 6 Statistics for period after global financial crisis

Basket	Average return	Standard deviation	Sharpe ratio
1v1	2.57%	14.30%	0.18
2v2	2.98%	6.36%	0.47
3v3	2.51%	6.28%	0.40
JPYKRW	6.50%	16.57%	0.39
JPYPHP	4.48%	12.58%	0.36
JPYSGD	4.39%	11.54%	0.38
JPYTHB	4.86%	11.09%	0.44

4.1.2 Group of Developed Countries (G10)

Let's move on to the carry trade strategy in group of developed countries (G10) consisting of Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), Great Britain Pound (GBP), Japanese Yen (JPY), Norwegian Krone (NOK), New Zealand Dollar (NZD), Swedish Krona (SEK), and US Dollar (USD) currencies.

4.1.2.1 Returns for 1v1, 2v2, and 3v3 portfolios.

The below graph in figure 6 shows carry trade returns on 1v1, 2v2, and 3v3 portfolios invested in group of G10. The 1v1 CARRY, 2v2 CARRY, and 3v3 CARRY are the returns for 1v1, 2v2, and 3v3 portfolios, respectively. The carry returns fluctuate and have both positive and negative value in different specific time.

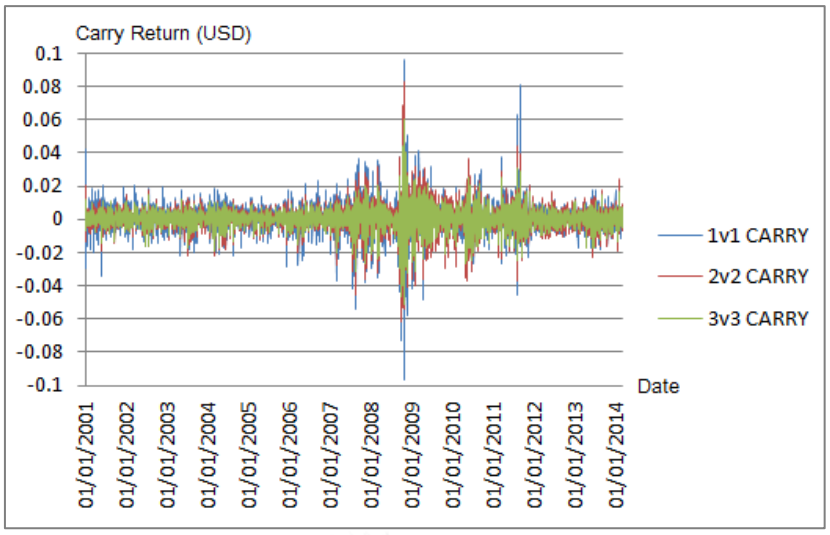

Figure 6 G10 daily returns on 1v1, 2v2, and 3v3 portfolios

During 2001 and 2007, carry returns are presented in the range between -0.02 and 0.02 US dollar. The returns tend to move wider in the range between -0.1 and 0.1 US dollar during 2007 and mid 2011. From mid 2011, they appear in the range between -0.02 and 0.02 US dollar. The graphs show that returns on carry trade strategy fluctuated the most during 2008 and mid 2011. The 3v3 portfolios again yield less fluctuate returns compared to 2v2 and 1v1 portfolios may result from risk diversification.

4.1.2.2 Returns for pair currency portfolios: shorting JPY, CHF and longing AUD, NOK, and NZD.

The more specific 1v1 portfolios of pair currency in group of G10 countries are taken into account. By shorting Japanese Yen (JPY) and Swiss Franc (CHF) and longing Australian Dollar (AUD), Norwegian Krone (NOK), and New Zealand Dollar (NZD), respectively, the graphs of returns are shown in figure 7.

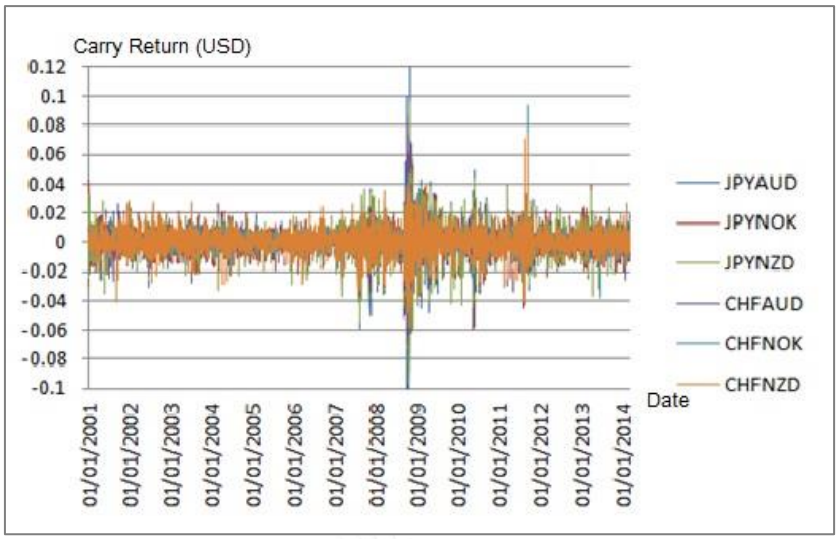

Figure 7 Daily returns on pair currency where JPY and CHF are shorted and AUD, NOK, and NZD are longed

The JPYAUD, JPYNOK, JPYNZD, CHFAUD, CHFNOK and CHFNZD are the returns for portfolios shorting JPY and CHF and longing AUD, NOK, and NZD, respectively. Graph of returns is most fluctuated during 2008 and mid 2011, especially those of JPYAUD portfolio. Apart from this period, the returns move in the range between -0.04 and 0.04 US dollar.

4.1.2.3 Return indices for 1v1, 2v2, and 3v3 portfolios.

Figure 8 shows that carry trade strategies considering group of G10 currencies have generated positive returns on average since the beginning of 2001. Considering the period before the global financial crisis (2008), the three indices gradually increased during 2001 and 2005, rose at a higher degree during 2006 and 2007. However, a decreasing trend began in 2008 where 1v1 index plunges down dramatically. 2v2 index and 3v3 index began to decrease as well but at a lower rate compared to 1v1 index. Then from 2009, the three indices picked up an increasing trend again and continue to rise from 150 to a range of about 200-240 in 2014.

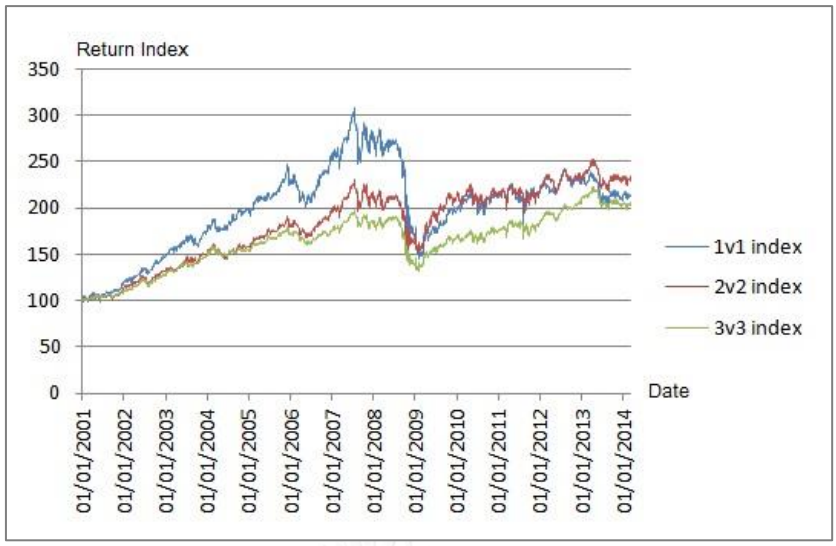

Figure 8 G10 cumulative return indices for 1v1, 2v2, and 3v3 portfolios

4.1.2.4 Return indices for currency pair portfolios: shorting JPY, CHF and longing AUD, NOK, and NZD, respectively.

For the period before the global financial crisis, return indices of these six portfolios shows a fluctuating but at the same time increasing trend from 2001 onwards till 2007. The indices become relatively steady during mid 2007 to mid 2008. Then they plummeted down to their original 100 in the end of 2008, with JPYNZD being the index which has plummeted the most. However at the beginning of 2009, most indices picked up an increasing trend. JPYNZD and JPYAUD demonstrates the most dramatic increase. JPYNOK, CHFAUD, and CHFNZD demonstrates quite a stable trend in the range of 150, and CHFNOK demonstrates a slightly declining trend.

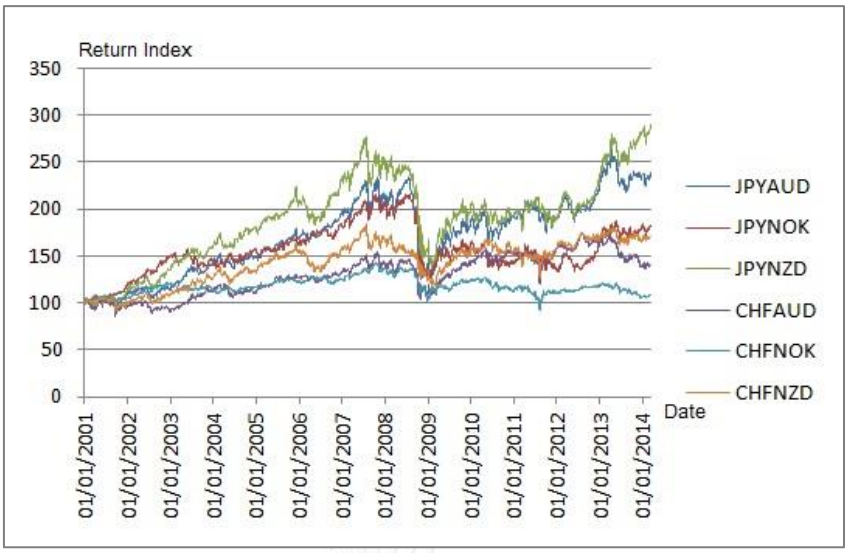

Figure 9 Cumulative return indices for portfolios shorting JPY and longing KRW, PHP, SGD, and THB, respectively

4.1.2.5 Gripping Statistics: Average Return, Standard Deviation, and Sharpe Ratio

4.1.2.5.1 The whole period of study (01 Jan 2001 – 31 Mar 2014)

In general, 1v1, 2v2, and 3v3 baskets of G10 have average returns of around 5.62% - 6.65%, standard deviations of around 10.28% - 15.84%, and Sharpe ratios of around 0.38 – 0.55. The 2v2 portfolio seems to yield higher annual return than the 1v1, and 3v3 portfolio.

In comparison, the more specific 1v1 portfolios of pair currency have average returns of a wide range around 0.55% - 8.37%, standard deviations of around 10.34% - 17.53%, and Sharpe ratio of around 0.05 - 0.49. The JPYNZD basket, where JPY is shorted and NZD is longed, yields the highest average return of 8.37% and Sharpe ratio of 0.49; compared to other 1v1 portfolios.

Table 7 G10 statistics for the whole period of study

Basket	Average Return	Standard Deviation	Sharpe Ratio
1v1	5.95%	15.84%	0.38
2v2	6.65%	13.30%	0.50
3v3	5.62%	10.28%	0.55
JPYAUD	6.80%	17.53%	0.39
JPYNOK	4.69%	15.30%	0.31
JPYNZD	8.37%	17.23%	0.49
CHFAUD	2.61%	13.91%	0.19
CHFNOK	0.55%	10.34%	0.05
CHFNZD	4.12%	13.96%	0.30

4.1.2.5.2 Period before global financial crisis (01 Jan 2001 – 31 Dec 2007)

For the period before the global financial crisis, all portfolios clearly yield higher average returns of around 4.55% - 15.55% and Sharpe ratios of around 0.48 – 1.22. Among specific 1v1 portfolios, the JPYNZD portfolio yields the highest average return of 13.87%, standard deviation of 13.63%, and Sharpe ratio of 1.02.

Table 8 G10 statistics for period before global financial crisis

Basket	Average Return	Standard Deviation	Sharpe Ratio
1v1	15.55%	13.03%	1.19
2v2	11.34%	9.69%	1.17
3v3	9.08%	7.44%	1.22
JPYAUD	11.36%	12.40%	0.92
JPYNOK	10.72%	11.48%	0.93
JPYNZD	13.87%	13.63%	1.02
CHFAUD	5.13%	10.64%	0.48
CHFNOK	4.55%	6.89%	0.66
CHFNZD	7.65%	11.91%	0.64

4.1.2.5.3 Period after the global financial crisis (01 Jan 2009 – 31 Mar 2014)

After the global financial crisis, it seemed to be the period of economic recovery. As a result, average returns and Sharpe ratios are significantly lower comparing to the period before global financial crisis. In this period, JPYNZD portfolio yields the highest average return of 12.36% and also gives the highest Sharpe ratio of 0.70.

Table 9 G10 statistics for period after global financial crisis

Basket	Average Return	Standard Deviation	Sharpe Ratio
1v1	4.92%	14.97%	0.33
2v2	7.07%	14.08%	0.50
3v3	7.68%	10.98%	0.70
JPYAUD	10.68%	17.56%	0.61
JPYNOK	6.45%	16.81%	0.38
JPYNZD	12.36%	17.73%	0.70
CHFAUD	4.57%	14.08%	0.32
CHFNOK	0.64%	12.62%	0.05
CHFNZD	6.10%	14.61%	0.42

4.1.3 Merged Group of ASEAN+3 and G10

This paper finally puts ASEAN+3 and G10 countries together to make more realistic environment, hence Philippine Peso (PHP), Singapore Dollar (SGD), Thai Baht (THB), South Korea Won (KRW), Japanese Yen (JPY), Australian Dollar (AUD), Canadian Dollar (CAD), Swiss Franc (CHF), Euro (EUR), Great Britain Pound (GBP), , Norwegian Krone (NOK), New Zealand Dollar (NZD), Swedish Krona (SEK), and US Dollar (USD) currencies will be considered from now on.

4.1.3.1 Returns for 1v1, 2v2, and 3v3 portfolios.

Carry trade returns on 1v1, 2v2, and 3v3 portfolios invested in a merged group of ASEAN+3 and G10 are shown in figure 10. The 1v1 CARRY, 2v2 CARRY, and 3v3 CARRY are the returns for 1v1, 2v2, and 3v3 portfolios, respectively.

During 2001 and 2006, carry returns are presented in the range between -0.02 and 0.02 US dollar. The returns tend to move wider in the range between -0.06 and 0.06 US dollar during 2007 and mid 2011. From mid 2011, they appear in the range between -0.02 and 0.02 US dollar. The graphs show that returns on carry trade strategy fluctuated the most during 2008 and mid 2009. However, the 3v3 portfolios do not present the clear picture for the risk diversification profit as 1v1, 2v2, and 3v3 seem to fluctuate at quite the same level.

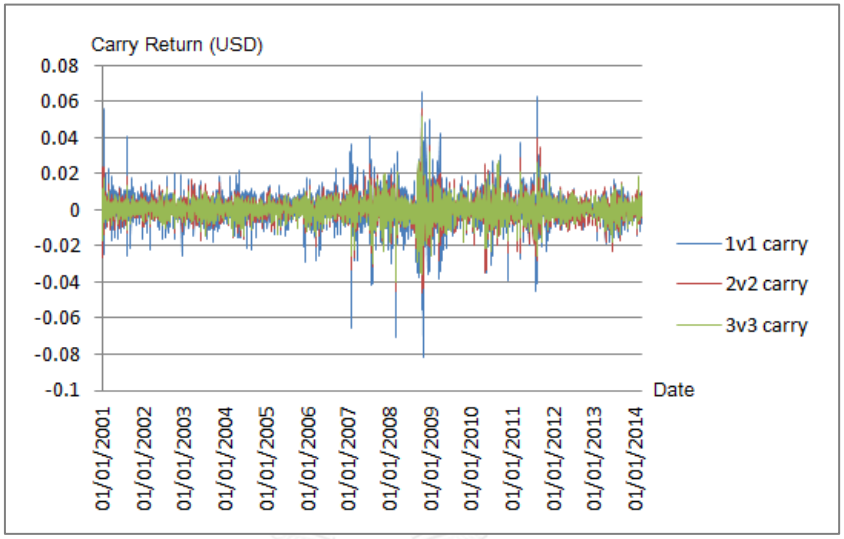

Figure 10 Merged group daily returns on 1v1, 2v2, and 3v3 portfolios

4.1.3.2 Returns for pair currency portfolios: shorting JPY, CHF, SGD, USD and longing AUD, NZD, PHP and THB, respectively.

The 1v1 portfolios of pair currency for merged group are taken into account. By shorting Japanese Yen (JPY), Swiss Franc (CHF), Singapore Dollar (SGD), and United States Dollar (USD) and longing Australian Dollar (AUD), New Zealand Dollar (NZD), Philippine Peso (PHP), and Thai Baht (THB) respectively, the graphs of returns are shown below. The graphs will be divided into four figures according to the shorted currencies which are Japanese Yen (JPY) in Figure 11, Swiss Franc (CHF) in Figure 12, Singapore Dollar (SGD) in Figure 13, and United States Dollar (USD) in Figure 14 respectively.

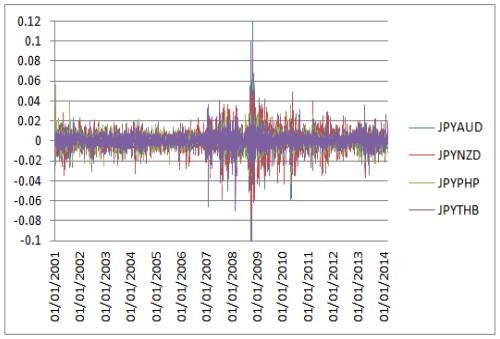

Figure 11 Daily returns on pair currency where JPY is shorted and AUD, NZD, PHP, and THB are longed.

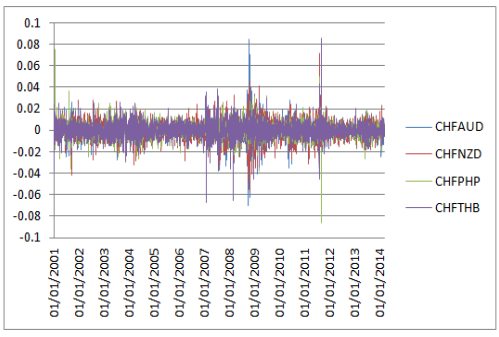

Figure 12 Daily returns on pair currency where CHF is shorted and AUD, NZD, PHP, and THB are longed.

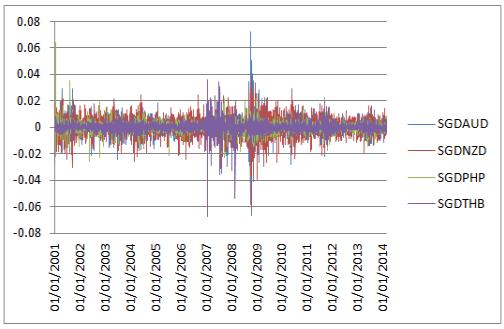

Figure 13 Daily returns on pair currency where SGD is shorted and AUD, NZD, PHP, and THB are longed.

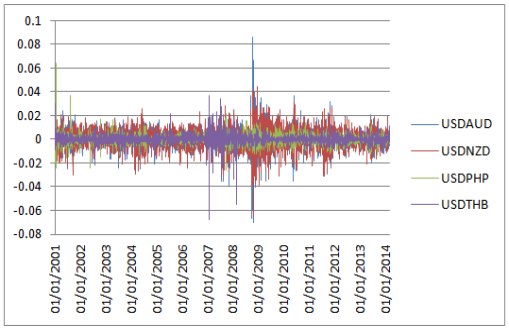

Figure 14 Daily returns on pair currency where USD is shorted and AUD, NZD, PHP, and THB are longed.

The JPYAUD, JPYNZD, JPYPHP and JPYTHB are the returns for portfolios shorting JPY and longing AUD, NZD, PHP and THB, respectively. Graph of returns is most fluctuated during 2008, especially those of JPYAUD portfolio. Apart from this period, the returns move in the range between -0.04 and 0.04 US dollar.

The CHFAUD, CHFNZD, CHFPNP, and CHFTHB are the returns for portfolios shorting CHF and longing AUD, NZD, PHP and THB, respectively. Graph of returns is most fluctuated during 2009 and 2011, especially those of CHFAUD portfolio in 2009. In 2011, CHFTHB portfolio reached the highest point at 0.08 and CHFPHP reached the lowest point at -0.08. Apart from this period, the returns move in the range between -0.04 and 0.04 US dollar.

The SGDAUD, SGDNZD, SGDPNP, and CHFTHB are the returns for portfolios shorting SGD and longing AUD, NZD, PHP and THB, respectively. Graph of returns is most fluctuated during 2008, especially those of SGDAUD portfolio. Apart from this period, the returns move in the range between -0.02 and 0.02 US dollar.

The USDAUD, USDNZD, USDPNP, and USDTHB are the returns for portfolios shorting USD and longing AUD, NZD, PHP and THB, respectively. Graph of returns is most fluctuated during the last quarter of 2008, especially those of USDAUD portfolio. Apart from this period, the returns move in the range between -0.02 and 0.02 US dollar. The USDTHB portfolio yields the least fluctuated returns during the consideration period.

4.1.3.3 Return indices for 1v1, 2v2, and 3v3 portfolios.

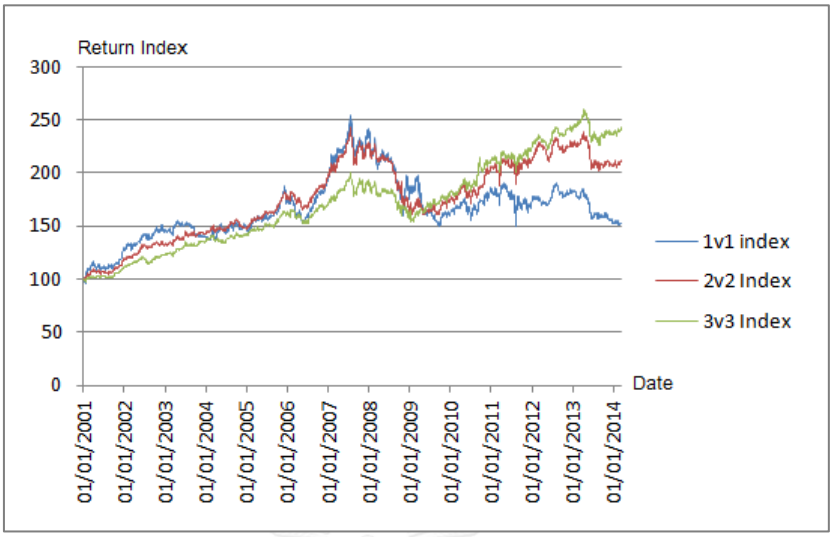

Figure 15 Merged group cumulative return indices for 1v1, 2v2, and 3v3 portfolios.

Figure 15 shows that carry trade strategies considering of a merged group of ASEAN+3 and G10 currencies have generated positive returns on average since the beginning of 2001. Before the global financial crisis (2008), those three indices gradually increased during 2001 and 2007, the highest rate of increase is during 2006 and 2007. The indices began to decrease from 2008 onwards and all the way through till mid 2009. From then on, the indices began to shows an increasing trend again, with 1v1 index showing the slowest rate of increase and 3v3 index showing the highest rate of increase.

4.1.3.4 Return indices for currency pair portfolios: shorting JPY, CHF, SGD, USD and longing AUD, NZD, PHP and THB, respectively.

The 1v1 portfolios of pair currency for merged group are taken into account. By shorting Japanese Yen (JPY), Swiss Franc (CHF), Singapore Dollar (SGD), and United States Dollar (USD) and longing Australian Dollar (AUD), New Zealand Dollar (NZD), Philippine Peso (PHP), and Thai Baht (THB) respectively, the graphs of returns are shown below. The graphs will be divided into four figures according to the shorted currencies which are Japanese Yen (JPY) in Figure 16, Swiss Franc (CHF) in Figure 17, Singapore

Dollar (SGD) in Figure 18, and United States Dollar (USD) in Figure 19 respectively.

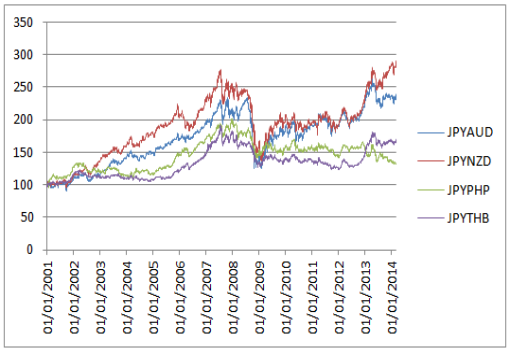

Figure 16 Cumulative return indices for portfolios shorting JPY and longing AUD, NZD, PHP and THB.

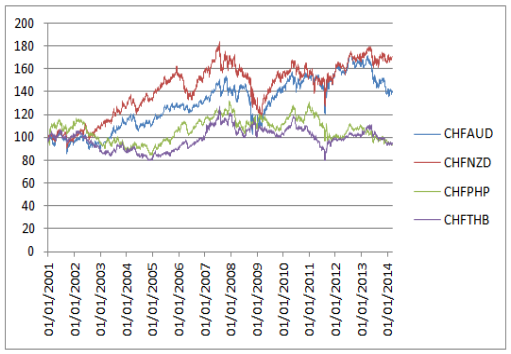

Figure 17 Cumulative return indices for portfolios shorting CHF and longing AUD, NZD, PHP and THB.

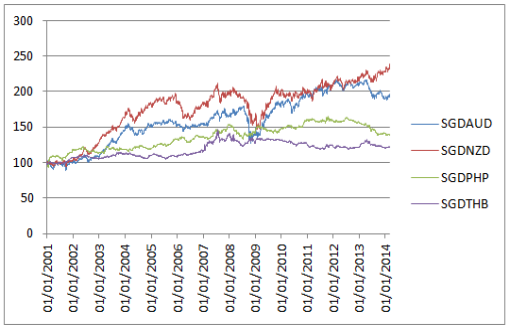

Figure 18 Cumulative return indices for portfolios shorting SGD and longing AUD, NZD, PHP and THB.

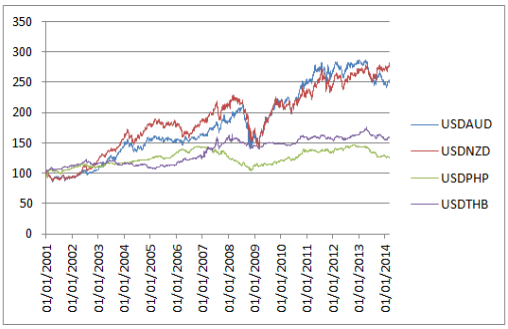

Figure 19 Cumulative return indices for portfolios shorting USD and longing AUD, NZD, PHP and THB.

For the period before the global financial crisis, return indices of these portfolios shows a fluctuating but at the same time increasing trend from 2001 onwards till 2007. The indices become relatively steady during mid 2007 to mid 2008. Then they plummeted down to about 150 in the end of 2008, with JPYNZD and JPYTHB being the indices which has plummeted the most. However at the beginning of 2009, most indices picked up an increasing trend. JPYNZD and JPYAUD demonstrate the most dramatic increase.

The return indices of these four portfolios demonstrate quite a fluctuating pattern throughout the whole period of study. There are three main period of decline in this figure, precisely during the period of year 2006, 2008, and 2011. The longest period of an overall incline was from 2001 to 2006. The CHFAUD and CHFNZD indices clearly demonstrate higher values than the CHFPNP and CHFTHB indices. In 2014, CHFAUD was at 170; CHFNZD

was at 140, whereas both CHFPNP and CHFTHB were both at about almost 100, which were lower than what they were originally at in 2001.

The return indices of these four portfolios show a fluctuating but an overall increasing trend. From 2001 onwards, the indices show an inclining pattern. In 2005, only SGDNZD seems to show a clear decrease. A sharp decline is seen in 2008 for SGDAUD and SGDNZD indices but not for SGDPHP and SGDTHB indices. From 2008 onwards, the two former indices demonstrate a clear increasing pattern whereas the latter two demonstrates a stable and slightly decreasing pattern.

There seems to be a clear-cut distinction between the two pairs of indices. USDAUD and USDNZD behave similarly and shows similar pattern. The same scenario is true for USDPHP and USDTHB as well. For the period before the global financial crisis, return indices of these four portfolios demonstrates an increasing pattern, where USDAUD and USDNZD shows a much higher increase than USDPHP and USDTHB. From 2001 to 2008, the return indices for USDAUD and USDNZD have gone up from 100 to over 200 whereas the return indices for USDPHP and USDTHB have only gone up from 100 to only about 150. In 2008, the USDAUD and USDNZD shows a plunging decline, down to 150, but recovers in 2009 and increases sharply back to the same level again. In this same period of time, the USDPHP and USDTHB were relatively much more stable. From 2009 onwards, the four indices shows an increasing pattern, but again with the USDAUD and USDNZD indices increasing up to 250 and over whereas USDPHP and USDTHB only increases to only about 150.

4.1.3.5 Gripping Statistics: Average Return, Standard Deviation, and Sharpe Ratio

4.1.3.5.1 The whole period of study (01 Jan 2001 – 31 Mar 2014)

For this merged group, in general, 1v1, 2v2, and 3v3 baskets have average returns of around 3.25% - 6.93%, standard deviations of around

8.94% - 14.73%, and Sharpe ratios of around 0.22 – 0.78. The 3v3 portfolio yields the highest annual return compared to the 1v1, and 2v2 portfolio.

In comparison, the more specific 1v1 portfolios of pair currency have average returns of -0.53% - 8.37%, standard deviations of 6.99% - 17.53%, and Sharpe ratio of -0.04 - 0.59. There are two baskets which yield negative average returns, namely the CHFPHP (-0.46%) and CHFTHB (-0.53%). They are also the only two baskets with negative Sharpe ratio value as well (both -0.04). The JPYNZD basket, where JPY is shorted and NZD is longed, yields the highest average return of 8.37% and Sharpe ratio of 0.48; compared to other 1v1 portfolios.

Table 10 Merged group statistics for the whole period of study

Basket	Average Return	Standard Deviation	Sharpe Ratio
1v1	3.25%	14.73%	0.22
2v2	5.83%	10.60%	0.55
3v3	6.93%	8.94%	0.78
JPYAUD	6.80%	17.53%	0.39
JPYNZD	8.37%	17.23%	0.48
JPYPHP	2.12%	12.63%	0.17
JPYTHB	4.01%	11.93%	0.34
CHFAUD	2.61%	13.91%	0.19
CHFNZD	4.12%	13.36%	0.31
CHFPHP	-0.53%	12.58%	-0.04
CHFTHB	-0.46%	12.57%	-0.04
SGDAUD	5.24%	11.60%	0.45
SGDNZD	6.79%	11.79%	0.58
SGDPHP	2.59%	7.31%	0.35
SGDTHB	1.58%	7.37%	0.21
USDAUD	7.30%	13.88%	0.53
USDNZD	8.14%	13.82%	0.59
USDPHP	1.74%	6.99%	0.25
USDTHB	3.58%	7.17%	0.50

The results, nevertheless, are different when we consider the data separately; before and after global financial crisis. As we can see, carry trade returns are very high and also give extremely high Sharpe ratio during the period before global financial crisis while it turns out to have lower return and Sharpe ratio in the period after global financial crisis.

4.1.3.5.2 Period before global financial crisis (01 Jan 2001 – 31 Dec 2007)

For the period before the global financial crisis, all portfolios yield average returns of around 2.74% - 13.87% and Sharpe ratios of around 0.22 – 1.40. The JPYNZD portfolio yields the highest average return of 13.87%, standard deviation of 13.63%, and Sharpe ratio of 1.02.

Table 11 Merged group statistics for period before global financial crisis

Basket	Average Return	Standard Deviation	Sharpe Ratio
1v1	13.29%	12.86%	1.03
2v2	12.34%	8.84%	1.40
3v3	9.64%	7.26%	1.33
JPYAUD	11.36%	12.40%	0.92
JPYNZD	13.87%	13.63%	1.02
JPYPHP	10.11%	11.41%	0.89
JPYTHB	8.92%	11.03%	0.81
CHFAUD	5.13%	10.64%	0.48
CHFNZD	7.65%	11.91%	0.64
CHFPHP	3.63%	12.24%	0.30
CHFTHB	2.74%	12.55%	0.22
SGDAUD	7.45%	10.00%	0.75
SGDNZD	10.07%	11.14%	0.90
SGDPHP	6.14%	7.70%	0.80
SGDTHB	4.96%	7.96%	0.62
USDAUD	9.13%	11.02%	0.83
USDNZD	11.24%	12.08%	0.93
USDPHP	3.41%	7.18%	0.47
USDTHB	7.02%	8.15%	0.86

4.1.3.5.3 Period after the global financial crisis (01 Jan 2009 – 31 Mar 2014)

After the global financial crisis, average returns and Sharpe ratios are significantly lower comparing to the period before global financial crisis. Before the global financial crisis, none of the baskets yield negative returns. After the global financial crisis, six baskets reportedly yield negative returns, which are namely 1v1, JPYPHP, CHFPHP, CHFTHB, SGDPHP, and SGBTHB. In this period, JPYNZD portfolio yields the highest average return of 12.36% whereas USDNZD gives the highest Sharpe ratio of 0.73.

Table 12 Merged group statistics for after global financial crisis

Basket	Average Return	Standard Deviation	Sharpe Ratio
1v1	-2.63%	13.73%	-0.19
2v2	5.28%	11.01%	0.48
3v3	8.73%	9.30%	0.93
JPYAUD	10.68%	17.56%	0.61
JPYNZD	12.36%	17.73%	0.70
JPYPHP	-1.98%	12.61%	0.16
JPYTHB	4.78%	11.12%	0.43
CHFAUD	4.57%	14.08%	0.32
CHFNZD	6.10%	14.61%	0.42
CHFPHP	-2.79%	12.27%	0.23
CHFTHB	-1.44%	11.50%	0.13
SGDAUD	6.56%	10.13%	0.65
SGDNZD	8.07%	11.28%	0.72
SGDPHP	-0.08%	6.25%	-0.01
SGDTHB	-0.66%	5.44%	-0.12
USDAUD	8.83%	13.70%	0.64
USDNZD	10.42%	14.32%	0.73
USDPHP	2.27%	6.32%	0.36
USDTHB	1.83%	4.64%	0.39

4.1.4 Overview

The returns on all portfolios; in ASEAN+3, G10, and merged group, are most fluctuated during 2008 and 2009. One of the possible reasons for this highly volatile return might be the global financial crisis (GFC) in 2008. Also, all portfolios show very clear-cut picture of cumulative return indices in 2008. This is supported by the statistics from those two periods that carry trade strategy yields higher average returns and Sharpe ratios in the period before global financial crisis. After GFC, the strategy gives pretty low average returns and Sharpe ratio comparing to the period mentioned earlier. Considering 1v1, 2v2, and 3v3 portfolios investing in different groups of ASEAN+3, G10, and merged group, it is found that carry trade strategy in the merged group of ASEAN+3 and G10 yield higher Sharpe ratios for all periods; whole period, before, and after crisis. When the best Sharpe ratios in each period are picked and compared, the ratio for the merged group is 30%, and 41.82% higher than those of ASEAN+3 and G10, respectively.

4.2 Results

The results for this paper will be separated into two parts in order to answer the two sub-objectives which are the effect of exchange rate volatility and yield curve factors on carry trade returns.

4.2.1 Carry return and exchange rate volatility

To examine the relationship between carry return and exchange rate volatility following the steps shown in methodology, these results are reached.

4.2.1.1 Graph Z-score of realized return and realized volatility (in log-inverse) and Correlation Tables

The results in this part are analyzed by using the 3v3 and specific 1v1 portfolios in group of ASEAN+3, G10, and the merged group, respectively.

To see the relationship between the realized return and the realized return volatility, the data ($(Z_\mu)\ and\ (-Z_{\sigma L})$) are generated by using returns on portfolios with the method of exponentially weighted moving averages (EWMA) as follows:

$$\sigma_t = \frac{\Sigma_{i=0}^{T}\lambda^i(r_{t-i}-\bar{r})^2}{\Sigma_{i=0}^{T}\lambda^i} \text{ and } \mu_t = \frac{\Sigma_{i=0}^{T}\lambda^i r_{t-i}}{\Sigma_{i=0}^{T}\lambda^i}$$

Where, λ is set to be 0.95 (14-day half-life)

$$Z_\mu = \frac{\mu_t - \bar{\mu}}{s_\mu},\ s_\mu^2 = \frac{1}{N-1}\sum(\mu_t - \bar{\mu})^2$$

$$Z_{\sigma_L} = \frac{\sigma_{L,t} - \bar{\sigma}_L}{s_{\sigma_L}},\ s_{\sigma_L}^2 = \frac{1}{N-1}\sum(\sigma_{L,t} - \overline{\sigma_L})^2$$

Where, $\sigma_{L,t} = \log(\sigma_t)$

4.2.1.1.1 Group of ASEAN+3

To compute realized return (Z_μ) and realized volatility (in log-inverse) $(-Z_{\sigma L})$, daily returns of 3v3 and specific 1v1 portfolios are used. From the assumption, carry return and exchange rate volatility are expected to be

negatively correlated; $(Z_\mu)\ and\ (-Z_{\sigma L})$ should have significantly positive correlation, but it conflicts with the result.

When looking at the z-score graphs of realized return and realized volatility (in log-inverse) in figure 20, the graphs indicate that the realized return of carry trade sometimes move against the realized return volatility but it sometimes move along with the realized return volatility. The two graphs do not closely track each other.

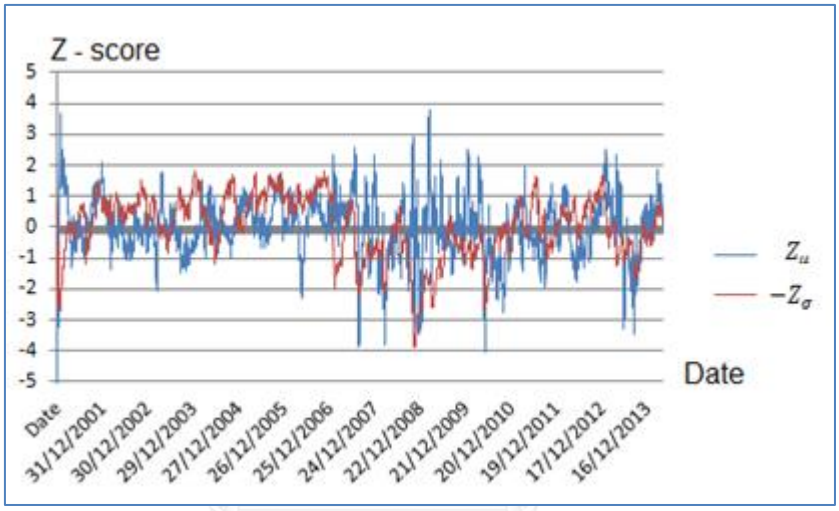

Figure 20 Graph Z-score of realized return and realized volatility (in log-inverse) for ASEAN+3 3v3 portfolio

4.2.1.1.2 Group of G10

As for the 3v3 portfolio under G10 countries, the graph above indicates the patterns of realized return (Z_μ) and realized volatility over time. According to the assumption, the relationship between the realized return and the realized volatility is expected to be negatively related. However, the actual result failed to agree with such assumption. By plotting the graph, there seems to be a negative relationship between the two from year 2001 to year 2004, 2006 to 2009, 2010 to 2012 and 2013 to 2014. On the other hand, a positive relationship can be seen in the graph during the period of 2005 to 2006, clearest at 2009 to 2010 and 2012 to 2013. Therefore, the result failed to conclude that the assumption is true.

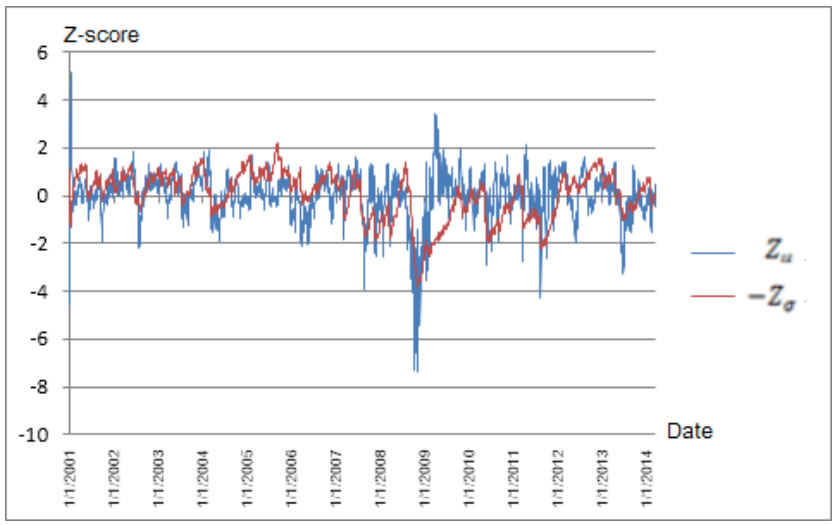

Figure 21 Graph Z-score of realized return and realized volatility (in log-inverse) for G10 3v3 portfolio

4.2.1.1.3 Merged Group: ASEAN+3 and G10

The same goes for the graph of realized return and realized volatility for ASEAN + G10 3v3 portfolio. Although the trends of the realized return of carry trade sometimes move against the realized return volatility but it sometimes move along with the realized return volatility. Also, the two graphs do not closely track each other. The actual result cannot prove the assumption that they are negatively related.

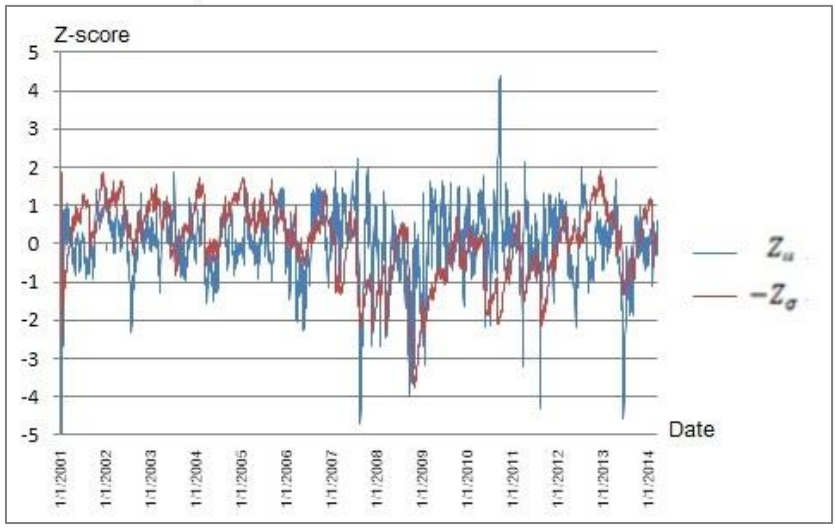

Figure 22 Graph Z-score of realized return and realized volatility (in log-inverse) for merged group 3v3 portfolio

4.2.1.1.4 Correlation Tables

According to statistical analysis, the absolute value of correlation must be greater than or equal to 0.5 to be significant in explaining the relationship. Nevertheless, from the results of the study, absolute values of correlation are found to be insignificant; less than 0.5. Hence, the results again suggest that there is no clear relation between carry returns and realized volatility.

Table 13 Correlation between Z_μ and $-Z_\sigma$ for 3v3 portfolio

Period	Correlation		
	ASEAN+3	G10	Merge
2001Q1 – 2014Q1	0.14	0.40	0.27
2001Q1 – 2007Q4	-0.04	0.39	0.28
2009Q1 – 2014Q1	0.08	0.13	0.05

In group of ASEAN+3, value of correlations for the whole period of study is 0.14, which emphasize the insignificant of the relationship. In addition, when the data is separated into two periods; before and after global financial crisis, the correlation values of the two periods are -0.04 and 0.08, respectively. These results also reconfirm that the relationship between realized return and realized volatility are insignificant.

Providing the correlation values at different periods on the above table, it suggested that the returns and volatility are positively related under G10 and Merge in every period, overall, before and after the financial crisis. However, all values of correlations lie below 0.5, and do not well confirm the relationship between the two.

Table 14 Correlation between Z_μ and $-Z_\sigma$ for currency pair portfolios

Pair Currency	2001Q1 – 2014Q1	2001Q1 – 2007Q1	2009Q1 – 2014Q1
ASEAN+3			
JPYKRW	0.37	0.20	0.12
JPYPHP	0.17	0.03	-0.03
JPYSGD	0.29	0.19	0.13
JPYTHB	0.19	0.08	-0.07
G10			
JPYAUD	0.35	0.28	0.06
JPYNOK	0.33	0.12	0.10
JPYNZD	0.36	0.29	0.10
CHFAUD	0.24	0.30	-0.03
CHFNOK	0.24	0.21	0.00
CHFNZD	0.28	0.29	0.04
Pair Currency	2001Q1 – 2014Q1	2001Q1 – 2007Q1	2009Q1 – 2014Q1
Merge			
JPYAUD	0.35	0.28	0.06
JPYNZD	0.36	0.29	0.10
JPYPHP	0.17	0.03	-0.03
JPYTHB	0.19	0.08	-0.07
CHFAUD	0.24	0.30	-0.03
CHFNZD	0.28	0.29	0.04
CHFPHP	0.06	-0.10	0.22
CHFTHB	0.04	0.02	-0.04
SGDAUD	0.20	0.21	-0.17
SGDNZD	0.24	0.34	-0.04
SGDPHP	-0.15	-0.14	-0.21
SGDTHB	-0.02	-0.06	-0.09
USDAUD	0.20	0.30	-0.10
USDNZD	0.28	0.42	0.02
USDPHP	0.02	-0.02	-0.06
USDTHB	-0.16	-0.25	0.14

The results from pair currency again suggest that there is no clear relation between carry returns and realized volatility. As for the pair correlation, we can clearly see that the correlation values are positive in overall period for ASEAN+3 and G10. All of the pair currencies realized returns are negatively correlated but insignificant both before and after the crisis except JPYPHP, JPYTHB, CHFAUD and CHFNOK with correlations of -0.03, -0.07, -0.03 and 0.00 after the crisis.

Under merged group, there are some with negatively correlated values in the overall period: SGDPHP, SGDTHB and USDTHB. When separated into a period before and a period after the crisis, many of the pair currencies show a negative correlation values after crisis: JPYPHP, JPYTHB, CHFTHB, SGDAUD, SGDNZD, SGDPHP, SGDTHB, USDAUD, USDPHP and USDTHB. Few of them also resulted in a negative correlation value before the crisis: CHFPHP, SGDPHP, SGDTHB, USDPHP and USDTHB. However, absolute values of all these correlations lie below 0.5 which cannot be used to confirm any relationship.

4.2.1.2 Bar charts of annual returns in different volatility states

The following bar charts will present annual returns on each portfolio in different volatility states.

4.2.1.2.1 Group of ASEAN+3

The bar chart in figure 23 shows that 3v3 portfolio yields the highest annual return of 7.23% in the lowest volatility state but the lowest return of 0.49% in the highest volatility state. Additionally, the chart suggests that the annual returns tend to decrease when volatility goes up.

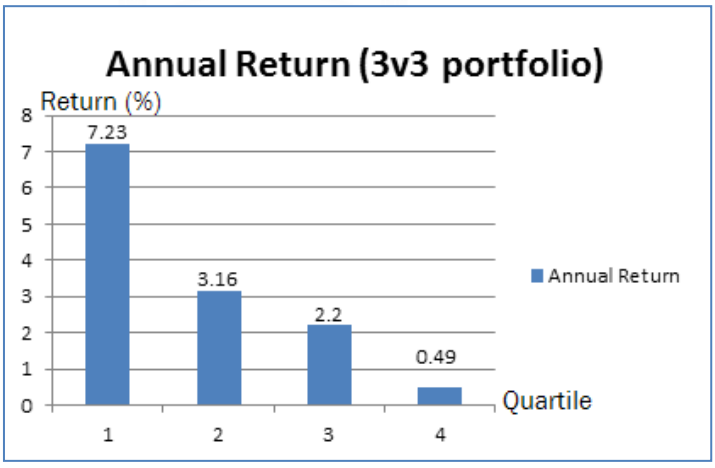

Figure 23 Annual returns for ASEAN+3 3v3 portfolios in different states of volatility

For pair currency portfolios where JPY is shorted and PHP, KRW, THB, and SGD are longed, figure 7 also reconfirms that in the low volatility environment, carry trade strategies yield higher annual returns comparing to

environment with high volatility. Furthermore, it is found that average returns in the first quartile (the lowest volatility state) are clearly higher than any other states. The JPYKRW portfolio seems to be the most sensitive to volatility as the average returns dramatically fall in high volatility environments.

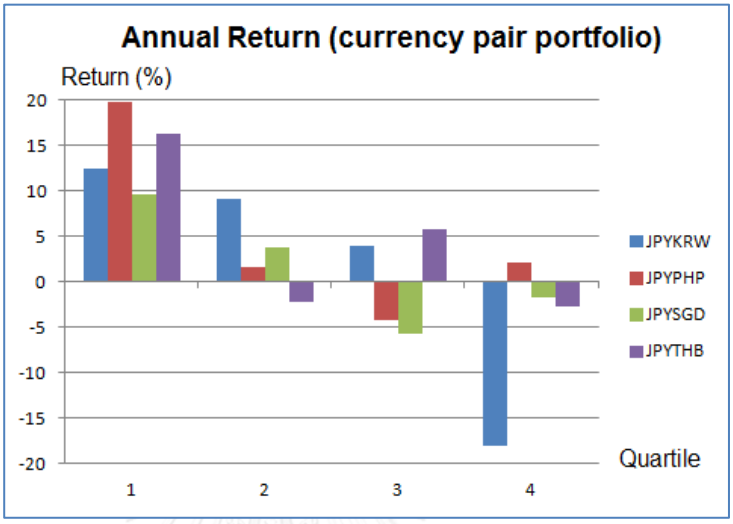

Figure 24 Annual returns in different volatility states for portfolios shorting JPY and longing KRW, PHP, SGD, and THB, respectively

4.2.1.2.2 Group of G10

Below figure is the bar chart for G10 countries on their annual returns for 3v3 portfolios, fluctuating in a big magnitude in different volatility levels. The assumption is that the highest return should be gained at the lowest volatility level and vice versa. The result shows that the highest can be observed in the lowest volatility at 14.19, following with 10.38 in the higher level of volatility. The annual return then turned negative in the second lowest volatility level, plummeting at the lowest to -3.74 but then the return recovered back to -2.71 at the highest volatility although it is expected to be at its lowest return. The two highest volatility states yield higher positive returns while the two lowest volatility states give negative returns. Negative relationship between carry returns and realized volatility can be concluded from the results in this part.

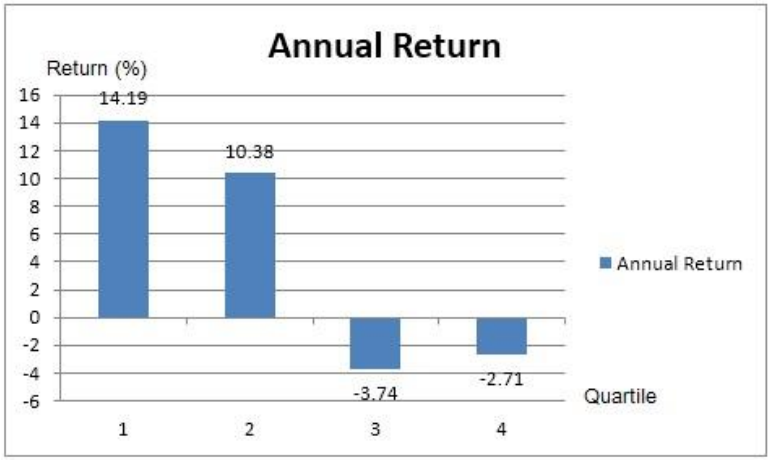

Figure 25 Annual returns for G10 3v3 portfolios in different states of volatility

According to the bar chart below, most of pair currencies go in line with the assumption as for the lower levels of volatility where the return is highest at the lowest level. The only pair currency that went against such assumption is CHFNOK where the return is increasing on the second level instead of decreasing compared to the first level. But when observing from the overall levels, many of the pair currencies do not strictly confirm such assumption. CHFNOK and CHFNZD returns were rose up on third level of volatility and at the highest volatility level, JPYNZD and JPYAUD returns are higher than at their third level. The only pair currency that strictly confirms the assumption is JPYNOK.

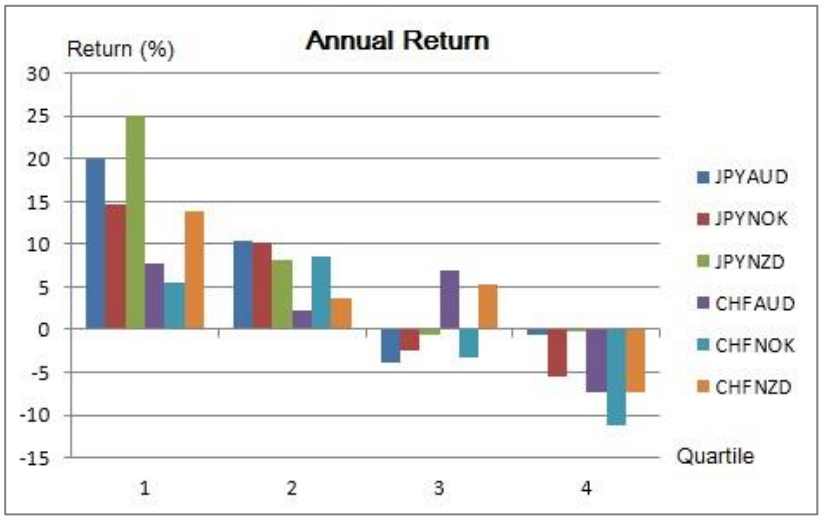

Figure 26 Annual returns in different volatility states for portfolios shorting JPY, CHF and longing AUD, NOK, and NZD, respectively

4.2.1.2.3 Merged Group: ASEAN+3 and G10

Similar patterns can be observed under the ASEAN + G10 sample. The highest return, in this case, resulted in the second level of volatility at 12.91 instead of the lowest volatility level at 10.97. For the third level of volatility, the annual return yields -2.27 which go in line with the prediction. Although the highest level of volatility suggests an annual return of 1.89 which turns out to be positive, it still has lower returns compared with the two lowest volatility stages.

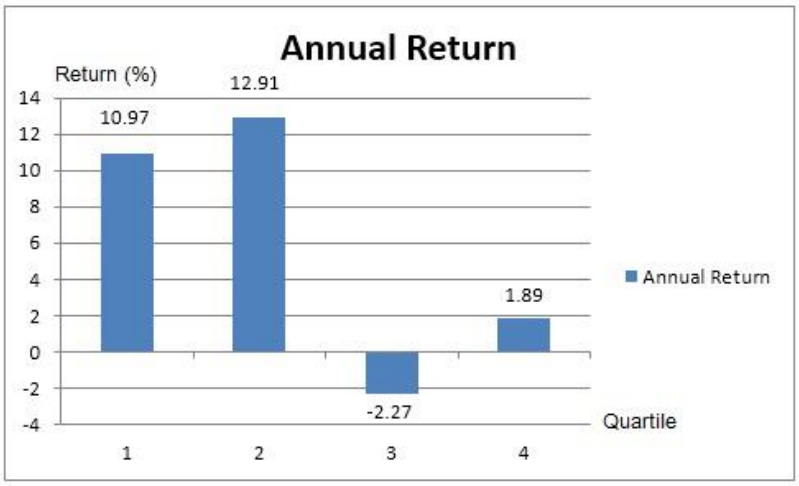

Figure 27 Annual returns for merged group 3v3 portfolios in different states of volatility

Moving on to the merged group of ASN + G10, the results are shown in the bar chart above. The pair currencies that agreed with the assumption are JPYNZD, CHFAUD and SGDNZD. However, the results, overall, demonstrate the negative relationship between realized return and realized volatility as the returns are mostly high in low volatility stage and vice versa.

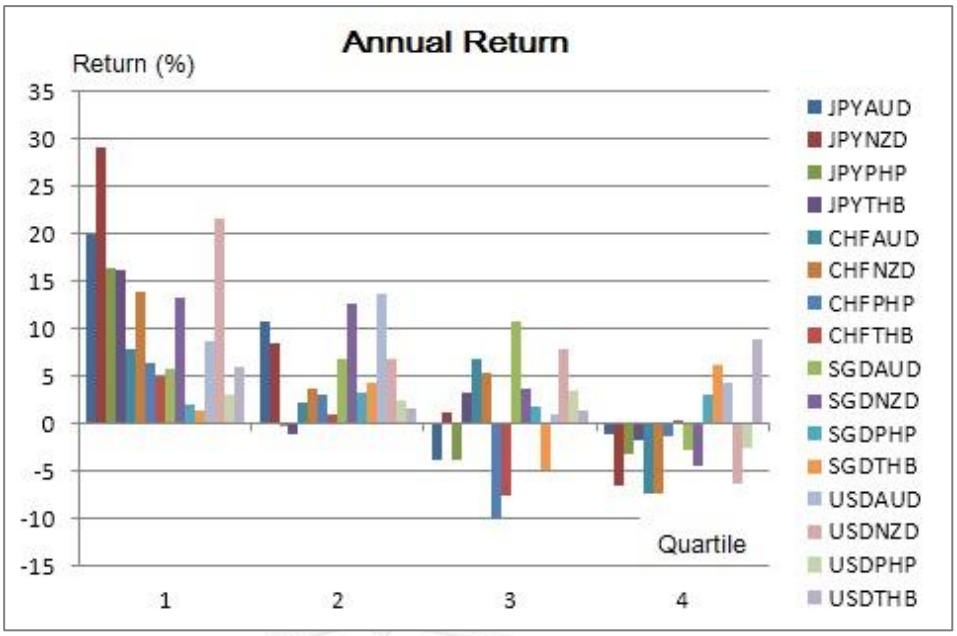

Figure 28 Annual returns in different volatility states for portfolios shorting JPY, CHF, SGD, USD and longing AUD, NZD, PHP and THB, respectively

To make clearer picture, the results are separated into 8 groups by shorting and longing currencies. The first four groups shown below are categorized by shorting currencies which are JPY in figure 29, CHF in figure 30, SGD in figure 31, and USD in figure 32. Another four groups are classified by longing currencies which are AUD in figure 33, NZD in figure 34, PHP in figure 35, and THB in figure 36.

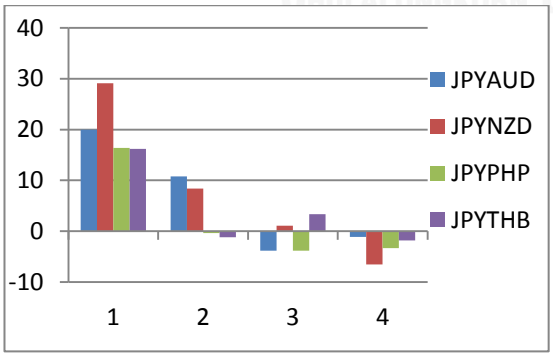

Figure 29 Annual returns in different volatility states for portfolios shorting JPY and longing AUD, NZD, PHP, and THB.

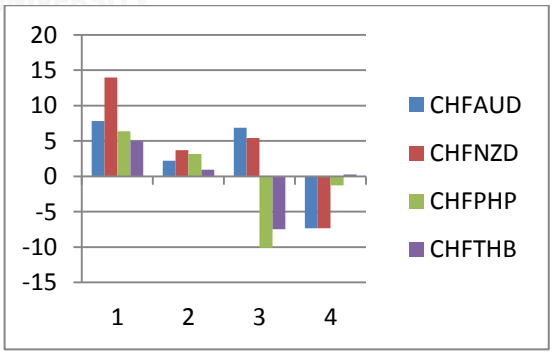

Figure 30 Annual returns in different volatility states for portfolios shorting CHF and longing AUD, NZD, PHP, and THB.

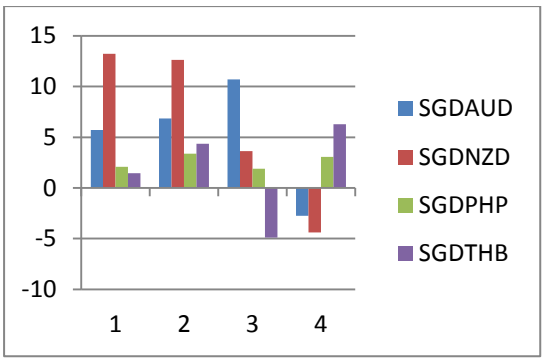

Figure 31 Annual returns in different volatility states for portfolios shorting SGD and longing AUD, NZD, PHP, and THB.

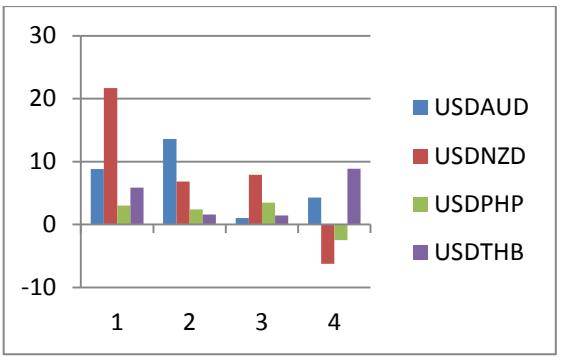

Figure 32 Annual returns in different volatility states for portfolios shorting USD and longing AUD, NZD, PHP, and THB.

Annual returns with different volatility levels with shorting JPY at different longing of AUD, NZD, PHP and THB are shown in the bar chart above. The pattern is clearly agreed with the assumption when observing JPYNZD. The rest of the samples can be used to reach the conclusion that there is a negative relationship between the return and volatility level as the high return in low volatility is shown as a result.

Same conclusion can also be reached in shorting CHF against other currencies that the higher the volatility, the lower the returns. However, the result cannot provide clear-cut evidence since some of the returns at the highest levels are not at the lowest.

The only pair currency that follows the assumption in this comparison is SGDNZD where it yields clear result of highest return at lowest volatility and lowest return at the highest volatility level. The rest resulted in a little conflict against the assumption.

The results become very scattered under shorting USD with different longing currencies, no clear relationship can be concluded between the annual returns and volatility levels.

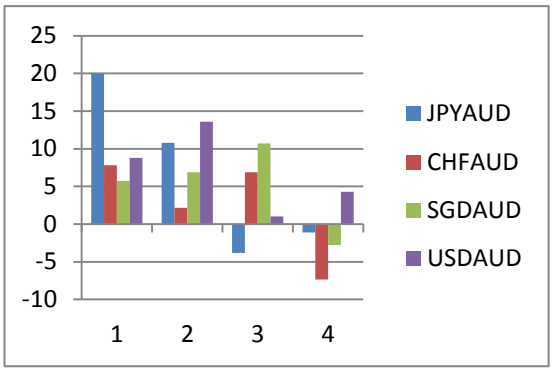

Figure 33 Annual returns in different volatility states for portfolios longing AUD and shorting JPY, CHF, SGD, and USD.

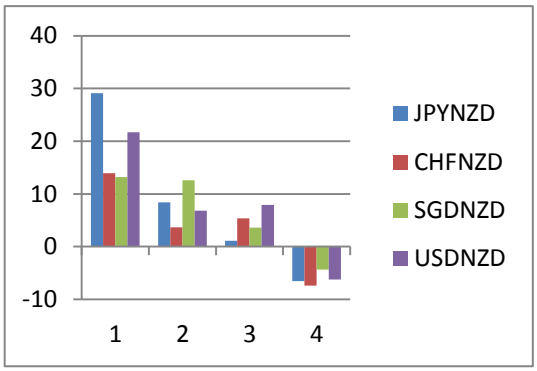

Figure 34 Annual returns in different volatility states for portfolios longing NZD and shorting JPY, CHF, SGD, and USD.

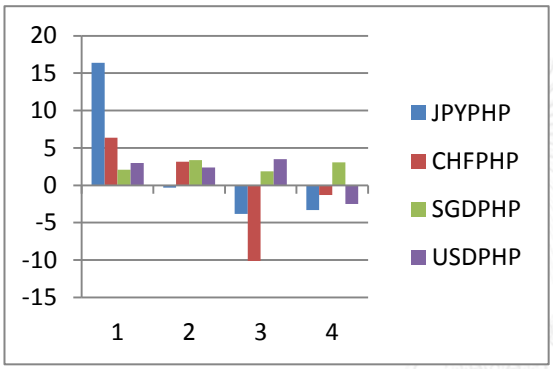

Figure 35 Annual returns in different volatility states for portfolios longing PHP and shorting JPY, CHF, SGD, and USD.

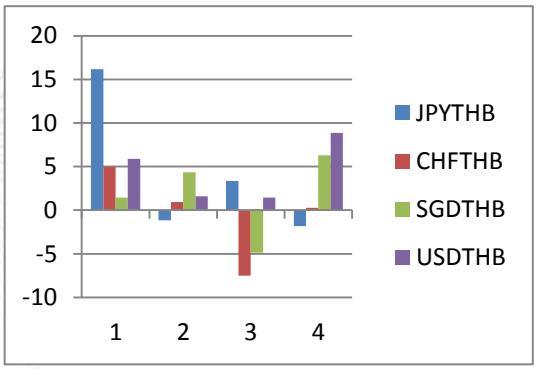

Figure 36 Annual returns in different volatility states for portfolios longing THB and shorting JPY, CHF, SGD, and USD.

By fixing a long of AUD with different short, the results do not suggest a clear-cut relationship between the annual return and volatility on different pair currency to be predicted. However, on average, the two lowest volatility states yield higher average returns compared with the two highest volatility states. With longing NZD, a clear negative relationship between the return and volatility can be observed from the bar chart above. With one exception of USDNZD, the pair currencies yield highest returns at lowest volatility and lowest returns at highest volatility. With longing PHP, the results suggested that higher volatility does influence the return negatively but does not provide a clear-cut result as can be observed from spikes in the bar chart. Align with the group of longing AUD results provided earlier; there is no clear relationship to be concluded in longing THB against shorting different currencies.

4.2.1.2.4 Summary Table

Table 15 Summarized annual returns for all portfolios in different volatility states

Portfolios and Quartiles	1st	2nd	3rd	4th
ASEAN+3				
3v3	7.23	3.16	2.20	0.49
JPYKRW	12.41	9.11	3.88	-18.12
JPYPHP	19.79	1.67	-4.14	2.12
JPYSGD	9.70	3.86	-5.71	-1.73
JPYTHB	16.32	-2.15	5.76	-2.72
G10				
3v3	14.19	10.38	-3.74	-2.71
JPYAUD	19.98	10.35	-3.88	-0.51
JPYNOK	14.64	10.10	-2.44	-5.53
JPYNZD	25.15	8.10	-0.67	-0.18
CHFAUD	7.80	2.18	6.86	-7.36
CHFNOK	5.49	8.49	-3.19	-11.12
CHFNZD	13.96	3.69	5.39	-7.36
Portfolios and Quartiles	1st	2nd	3rd	4th
Merged Group				
3v3	10.97	12.91	-2.27	1.89
JPYAUD	19.98	10.78	-3.82	-1.09
JPYNZD	29.08	8.42	1.11	-6.5
JPYPHP	16.37	-0.33	-3.84	-3.3
JPYTHB	16.17	-1.14	3.34	-1.82
CHFAUD	7.80	2.18	6.86	-7.36
CHFNZD	13.96	3.69	5.39	-7.36
CHFPHP	6.37	3.16	-10.11	-1.28
CHFTHB	4.97	0.95	-7.50	0.27
SGDAUD	5.72	6.86	10.7	-2.76
SGDNZD	13.21	12.62	3.62	-4.37
SGDPHP	2.09	3.36	1.88	3.07
SGDTHB	1.46	4.34	-4.88	6.28
USDAUD	8.79	13.59	1.02	4.27
USDNZD	21.67	6.81	7.92	-6.24
USDPHP	3.00	2.40	3.48	-2.50
USDTHB	5.88	1.58	1.44	8.85

All these statistic results are computed and compared to confirm the robustness of the relationship between realized return and realized volatility on ASEAN+3 carry trade strategy. Both 3v3 and JPYKRW portfolios suggest strong negative relationship between annual return and realized volatility as

the returns go down when the volatilities go up. Moreover, all portfolios yield the highest return in the lowest volatility environment.

As summarized on the table above, most of the pair currencies under G10 suggested that the higher volatility would cause the returns to decline. JPYNOK shows a very clear-cut result that aligns with the assumption as the lowest level of volatility provided a highest return of 14.64 whereas the 4th level yielded as lowest as -5.53. All of the portfolios except CHFNOK also resulted in the highest returns at the lowest volatility level.

The above table summarizes 3v3 and pair currency portfolios of ASN + G10 countries. The portfolios that agreed with the assumption are JPYAUD and JPYNZD where the highest annual returns are at the first level of volatilities and decreases as the level becomes higher. From the results, it cannot be now concluded that the assumption is true as most of the samples do not provide similar patterns.

4.2.1.3 EGARCH Model

The EGARCH models are estimated to further confirm the negative relationship between carry trade realized returns and its realized volatility. According to the assumption, coefficient of volatility variable should be negative to report the negative correlation.

4.2.1.3.1 Group of ASEAN+3

Considering portfolios in group of ASEAN+3, all portfolios confirm negative relationship between realized returns and realized volatility by presenting the negative value of volatility coefficients. The strongest evidence comes from the 3v3 portfolios which yields the most significant negative value of volatility variable. This is followed by JPYKRW, JPYTHB, JPYSGD, and JPYPHP portfolios, respectively.

Table 16 EGARCH model results for group of ASEAN+3

Variables and Portfolios	Constant	Return(-1)	Volatility	C(4)	C(5)	C(6)	C(7)
3v3	**0.000262** (3.60)	**-0.1090** (-6.74)	**-8.9500** (-1.81)	**-0.3610** (-9.54)	**0.1810** (18.63)	**-0.0111** (-1.75)	**0.9804** (313.95)
JPYKRW	**0.000430** (3.18)	**-0.1314** (-7.49)	**-2.5719**** (-1.75)	**-0.3115** (-10.47)	**0.1866** (15.31)	**-0.0561** (-7.29)	**0.9826** (373.52)
JPYPHP	**0.000406** (2.29)	**-0.0695** (-4.03)	-3.2171* (-1.23)	**-0.3019** (-7.96)	**0.1329** (12.07)	**-0.0281** (-3.87)	**0.9797** (282.19)
JPYSGD	**0.000239** (2.04)	**-0.0482** (-2.64)	-3.7435* (-1.38)	**-0.3337** (-9.11)	**0.1641** (15.87)	**-0.0576** (-7.02)	**0.9798** (297.95)
JPYTHB	**0.000427** (3.21)	**-0.0751** (-4.54)	**-3.5369**** (-1.63)	**-0.1924** (-7.93)	**0.1310** (15.14)	**0.0129** (2.34)	**0.9907** (454.99)

Variance Equation:
LOG(GARCH) = C(4) + C(5)*ABS(RESID(-1)/@SQRT(GARCH(-1))) + C(6)*RESID(-1)/SQRT(GARCH(-1)) + C(7)*LOG(GARCH(-1))

4.2.1.3.2 Group of G10

For group of G10, most of portfolios yield negative value of volatility coefficients except for those of CHFAUD portfolio which gives positive value of 0.8799. However, the only two portfolios which are 3v3 and JPYNZD portfolios show significantly negative effect of volatility on carry trade returns.

Table 17 EGARCH model results for group of G10

Variables and Portfolios	Constant	Return(-1)	Volatility	C(4)	C(5)	C(6)	C(7)
3v3	**0.000367** (3.75)	0.0271* (1.57)	-4.6952** (-1.80)	**-0.3448** (-10.32)	**0.1922** (14.67)	**-0.0394** (-4.66)	**0.9811** (344.87)
JPYAUD	**0.000340** (2.34)	0.0195 (1.07)	-1.1573 (-0.84)	**-0.3417** (-12.68)	**0.1924** (15.69)	**-0.0674** (-8.48)	**0.9793** (406.20)
JPYNOK	**0.000326** (1.95)	0.0160 (0.92)	-2.13 (-1.81)	**-0.3269** (-10.27)	**0.1574** (13.20)	**-0.0613** (-7.51)	**0.9785** (336.61)
JPYNZD	**0.000637** (3.68)	0.0117 (0.68)	**-3.6890** (-2.27)	**--0.3860** (-9.95)	**0.1886** (14.24)	**-0.0458** (-5.49	**0.9741** (280.22)
CHFAUD	0.000059 (0.44)	0.0218 (1.28)	0.8799 (0.52)	**-0.2985** (-9.37)	**0.1537** (13.86)	**-0.0632** (-8.94)	**0.9812** (343.77)
CHFNOK	0.000091 (0.95)	**-0.0334** (-1.92)	-0.8873 (-0.40)	**-0.2570** (-8.72)	**0.1488** (12.30)	**-0.0587** (-8.09)	**0.9863** (399.55)
CHFNZD	0.000255* (1.46	0.0078 (0.48)	-1.2776 (-0.61)	**-0.3009** (-8.20)	**0.1421** (12.63)	**-0.0382** (-5.55)	**0.9802** (287.94)

4.2.1.3.3 Merged Group

The below table presents the results of EGARCH model for portfolios in the merged group of ASEAN+3 and G10. The evidences suggest that more than half of all portfolios yield negative value of volatility coefficients except for those of CHFAUD (0.8799), SGDAUD (0.5198), SGDPHP (18.0051), SGDTHB (0.8741), and USDPHP (6.3560) portfolios. Only three portfolios including 3v3, JPYNZD, and USDNZD significantly report negative effect of volatility on carry trade returns. It is interesting that those of SGDPHP and USDPHP portfolios present positive effect of volatility on carry returns.

Table 18 EGARCH model results for the merged group

Variables & Portfolios	Constant	Return(-1)	Volatility	C(4)	C(5)	C(6)	C(7)
3v3	**0.000427** (4.55)	-0.0124 (-0.74)	**-6.9975** (-2.32)	**-0.2647** (-10.30)	**0.1631** (15.27)	**-0.0233** (-3.79)	**0.9868** (460.05)
JPYAUD	**0.000340** (2.34)	0.0195 (1.07)	-1.1573 (-0.84)	**-0.3417** (-12.68)	**0.1924** (15.69)	**-0.0674** (-8.48)	**0.9793** (406.20)
JPYNZD	**0.000637** (3.68)	0.0117 (0.68)	**-3.6890** (-2.27)	**-0.3860** (-9.95)	**0.1886** (14.24)	**-0.0458** (-5.49)	**0.9741** (280.22)
JPYPHP	0.000222* (1.24)	**-0.0574** (-3.31)	-3.1751* (-1.23)	**-0.2808** (-7.76)	**0.1304** (11.81)	**-0.0216** (-3.19)	**0.9815** (300.04)
JPYTHB	**0.000417** (3.10)	**-0.0770** (-4.62)	-3.3534* (-1.53)	**-0.1998** (-7.97)	**0.1324** (15.16)	**0.0126** (2.29)	**0.9901** (439.13)
CHFAUD	0.000059 (0.44)	0.0218 (1.28)	0.8799 (0.52)	**-0.2985** (-9.37)	**0.1537** (13.86)	**-0.0632** (-8.94)	**0.9812** (343.77)
CHFNZD	0.000255* (1.46)	0.0078 (0.48)	-1.2776 (-0.61)	**-0.3009** (-8.20)	**0.1421** (12.63)	**-0.0382** (-5.55)	**0.9802** (287.94)
CHFPHP	0.000141 (0.89)	**-0.0870** (-5.26)	-2.6128* (-1.25)	**-0.1423** (-6.61)	**0.0980** (12.08)	**-0.0215** (-4.00)	**0.9932** (549.98)
CHFTHB	0.000157 (1.07)	**-0.0990** (-6.14)	-1.85 (-0.93)	**-0.1702** (-8.95)	**0.1327** (17.32)	**0.0199** (4.03)	**0.9929** (577.47)
SGDAUD	0.000162* (1.35)	**-0.0362** (-2.17)	0.5198 (0.22)	**-0.2526** (-8.85)	**0.1423** (12.14)	**-0.0414** (-6.08)	**0.9860** (411.91)
SGDNZD	0.000435 (2.51)	-0.01224 (-0.7365)	-3.5110 (-1.16)	**-0.2367** (-7.203)	**0.1136** (10.30)	**-0.0196** (-2.80)	**0.9851** (341.80)
SGDPHP	-0.000191 (-2.49)	**-0.1766** (-11.42)	**18.0051** (7.74)	**-0.3007** (-7.67)	**0.1465** (17.79)	**0.0119** (2.19)	**0.9826** (301.12)
SGDTHB	0.000105** (1.79)	**-0.0901** (-5.39)	0.8741 (0.34)	**-0.2793** (-11.00)	**0.1870** (19.49)	**0.0542** (9.14)	**0.9875** (498.83)
USDAUD	**0.000274** (1.93)	-0.0217 (-1.27)	-0.1123 (-0.06)	**-0.2395** (-8.25)	**0.1411** (10.83)	**-0.0382** (-5.0122)	**0.9868** (400.05)
USDNZD	**0.000645** (3.19)	0.0065 (0.39)	**-5.18** (-1.96)	**-0.2309** (-6.92)	**0.1168** (9.30)	**-0.0256** (-3.40)	**0.9856** (335.14)
USDPHP	0.000028 (0.47)	**-0.1094** (-6.54)	**6.3560** (2.58)	**-0.5330** (-10.44)	**0.2296** (18.29)	**-0.0142** (-2.20)	**0.9674** (230.49)
USDTHB	**0.000227** (4.30)	**-0.0370** (-2.23)	-2.37 (-0.99)	**-0.6023** (-16.07)	**0.2859** (24.87)	0.0120** (1.80)	**0.9653** (341.27)

4.2.1.3.4 Summary

Overall, results from EGARCH model of volatility on carry trade return reconfirm the negative relationship between realized return and realized volatility by resulting in negative volatility coefficients. The volatility of exchange rate which in this paper is proxy by the realized return volatility has negative impact on carry return. In other words, the returns tend to decrease in the environment with higher volatility. However, portfolios that long Philippine Peso (PHP) seem to show some conflict by presenting significantly positive volatility coefficients. Philippines remittances might be one possible reason for these outcomes[13]. Burgess and Haksar (2005) state that Philippines is a major exporter of labor; having high rate of emigration, so large remittance flows have become an outstanding feature of Philippines economy for many decades. As a result, these remittances can offset sharp reduction of capital inflows during high exchange rate volatility periods. Philippines peso does not depreciate against other currency; therefore, carry returns do not go down during high volatility periods.

[13] I would like to thank Associate Professor Somchai Rattanakomut, Ph.D.; my thesis committee, for pointing this out.

4.2.1.4 UIP Equation

The well-known UIP equation is estimated in this last step to further check the effect of volatility on carry returns. From the assumption, value of slopes estimated in low volatility states should be less than one to confirm the profit from carry trade activity. For those estimated in high volatility state can be either greater than value of slope mentioned earlier to show the lower profit or greater than one to present loss from carry trade activity.

According to the results shown in above table, most of the portfolios go in line with the assumptions except for JPYKRW, JPYPHP, USDAUD, and USD PHP portfolios. The results can be roughly separated into two groups. For the first group including JPYNOK, JPYNZD, JPYSGD, CHFNOK, CHFNZD, SGDAUD, SGDNZD, and USDNZD portfolios, all portfolios are profit in low volatility state by giving negative value of slope except for JPYNZD portfolio (0.55). Comparing to high volatility state, the portfolios give positive and greater than one slope coefficients which imply the losses from carry trade activity. The second groups of JPYAUD, JPYTHB, CHFAUD, CHFPHP, CHFTHB, SGDPHP, SGDTHB, and USDTHB portfolios, the slopes in low volatility state are lower than those in high volatility. Value of the slopes for these portfolios are less than one which imply profits from carry trade activity except for those of JPYAUD.

In conclusion, carry trade strategy, overall, generates positive returns or investor can make profit from this investment strategy. By longing New Zealand Dollar (NZD), no matter which currencies are shorted, investor will earn profits when exchange rates are less volatile but loss when they are highly fluctuated. By longing Philippine Peso (PHP), and Thai Baht (THB), no matter which currencies are shorted, investor will earn profits both from low and high volatility states; benefit more in low volatility environment.

Table 19 UIP equation table

portfolios	Slope			Constant		
	All	Low Vol.	High Vol.	All	Low Vol.	High Vol.
JPYAUD	0.84	1.56	2.10	-0.0004	-0.0009	-0.0009
	0.32	1.53	0.98	0.0002	0.0008	0.0004
JPYNOK	0.19	-0.12	2.36	-0.0000	-0.0000	-0.0005
	0.17	0.20	1.13	0.0000	0.0001	0.0002
JPYNZD	0.43	0.55	2.81	-0.0003	-0.0004	-0.0009
	0.18	0.40	1.18	0.0001	0.0002	0.0003
JPYKRW	0.16	0.55	0.00	0.0000	-0.0002	0.0000
	0.24	0.33	0.70	0.0000	0.0001	0.0001
JPYPHP	-0.14	0.07	-0.14	0.0001	-0.0000	-0.0000
	0.12	0.20	0.32	0.0001	0.0001	0.0002
JPYTHB	0.02	-0.26	0.33	-0.0000	-0.0000	-0.0000
	0.07	0.11	0.14	0.0000	0.0000	0.0001
JPYSGD	-0.06	-0.08	2.78	-0.0000	-0.0000	-0.0002
	0.20	0.22	1.59	0.0000	0.0001	0.0001
CHFAUD	0.11	-0.40	0.42	-0.0000	0.0001	-0.0002
	0.27	0.62	0.74	0.0000	0.0003	0.0003
CHFNOK	0.23	-0.05	2.28	-0.0000	-0.0000	-0.0005
	0.15	0.11	0.92	0.0000	0.0000	0.0002
CHFNZD	0.30	-0.06	2.69	-0.0001	0.0000	-0.0008
	0.17	0.22	0.67	0.0001	0.0000	0.0002
CHFPHP	0.06	0.03	0.36	0.0000	0.0000	-0.0002
	0.06	0.17	0.17	0.0000	0.0000	0.0000
CHFTHB	0.04	-0.19	0.11	0.0000	0.0000	0.0000
	0.08	0.18	0.18	0.0000	0.0000	0.0000
SGDAUD	0.37	-0.05	1.28	-0.0002	0.0000	-0.0005
	0.20	0.27	0.64	0.0001	0.0001	0.0002
SGDNZD	0.40	-0.72	1.93	-0.0002	0.0003	-0.0006
	0.16	0.84	0.57	0.0001	0.0004	0.0001
SGDPHP	0.02	-0.22	0.09	0.0000	0.0000	-0.0000
	0.03	0.12	0.08	0.0000	0.0000	0.0000
SGDTHB	0.05	0.08	0.13	-0.0000	-0.0000	-0.0000
	0.04	0.08	0.07	0.0000	0.0000	0.0000
USDAUD	-0.04	0.14	-0.11	-0.0000	-0.0000	0.0000
	0.25	0.33	0.58	0.0001	0.0000	0.0002
USDNZD	0.27	-0.01	3.75	-0.0001	-0.0000	-0.0010
	0.30	0.40	1.63	0.0001	0.0001	0.0004
USDPHP	0.03	0.06	-0.01	-0.0000	-0.0000	0.0000
	0.04	0.07	0.08	0.0000	0.0000	0.0001
USDTHB	-0.04	-0.18	0.01	-0.0000	-0.0000	0.0000
	0.06	0.26	0.12	0.0000	0.0000	0.0001

4.2.1.5 Summary

According to the results earlier analyzed using graphs of Z-score and correlation tables in part 4.2.1.1, bar charts of annual returns in part 4.2.1.2, EGARCH model in part 4.2.1.3, and UIP equation in part 4.2.1.4, the negative relationship between returns on currency carry trade and realized volatility is arrived at. Results of those analyzing are quite compatible where annual returns of carry trade strategies are high in low volatility states compared to those in high volatility states. Investors expect high returns when they face high risk, for example, in high volatility environment. As a result, current price of asset falls and lower realized return received for an investment strategy including currency carry trade. When the violation of UIP suggests extra return for carry trade strategy, there should exist some extra risk factors to compensate for those extra returns.

4.2.2 Carry return and yield curve factors

This part documents the results that examine the effect of yield curve factors; level and slope, on carry trade returns. According to Clarida, Davis, and Pedersen (2009), yield curve level factors are positively related with carry return, yield curve slope factors, on the other hand, negatively affect carry returns. In this step, the samples are separated into three groups consisting of the whole period, period before and period after global financial crisis.

Considering the whole period results presented in table 20, all volatility indices (VIX) have negative coefficients except for those of SGDPHP portfolio. For yield curve level factors, half of the portfolios yield significantly positive coefficients; some of them have insignificantly negative coefficients. The point is that coefficient of those portfolios longing Philippine Peso (PHP) turn out to be negative and significant. About half of portfolios give significantly negative coefficients of yield curve slope factors but most of portfolios longing PHP and THB move against those majorities by giving significantly positive coefficients.

For the period before global financial crisis, VIX again has negative coefficients; the only portfolio yielding insignificantly positive coefficient is SGDPHP portfolio. Looking at yield curve factors, more than half of coefficients are found to be positive and significant; however, portfolios longing PHP again yield significantly negative coefficients. Yield curve slope factors in this period have both positive and negative coefficients where coefficients of JPYAUD, JPYNZD, SGDAUD, and SGDNZD portfolios are significantly negative. On the other hand, coefficients of JPYPHP, CHFTHB, and USDPHP portfolios are significantly positive.

Finally, results in period after global financial crisis are quite alike. VIX factors mostly have negative coefficients except for CHFAUD, CHFTHB, and SGDPHP portfolios. About half of the portfolios yield significantly positive yield curve level factors and negative yield curve slope factors. Portfolios that

long PHP repeat negative coefficient of yield curve level and positive coefficient of yield curve slope.

To sum up, VIX factor, form the results, has a clear-cut negative relationship with carry trade returns. According to Whaley (1993, 2000), the Chicago Board Options Exchange's Market Volatility Index (VIX) is well-known as investor fear gauge because it captures the market's expectation of future stock market volatility over the next 30 days. In other words, the forward-looking measure of future stock market volatility can be viewed as the index of fear. When investors' fear goes up; high VIX index, high yielding currencies tend to depreciate according to low capital inflow, and carry returns go down. Yield curve level factors positively affect carry returns while yield curve slope factors negatively affect carry returns. However, results of portfolios longing Philippine Peso (PHP) are quite strange as yield curve level and yield curve slope factors affect carry returns in the opposite direction compared to the majority portfolios. The reason might be that a permanent increase in interest rate; proxy by yield curve level factors, induces more capital inflow to high yielding currency countries. As a result, investors receive higher returns due to an appreciation in high yielding currency. Yield curve slope factor which is a proxy of business cycle affects both nominal exchange rates and changes in exchange rates via expected inflation. High expected inflation causes both an increase in nominal interest rate which induces more carry trade activities and an exchange rate depreciation which reduces carry trade activities. Negative yield curve slope factors imply that an effect of exchange rate depreciation is greater than an effect of change in nominal exchange rate. As a result, expected high inflation causes losses in carry trade activities. This situation goes for most of the portfolios except for those longing Philippine Peso. For portfolios longing Philippine Peso, it is possible that an effect of change in nominal interest rate is greater than an effect of exchange rate depreciation, thus investors still earn some profit from carry trade activities.

Table 20 Results for Factor Model (Coefficients with t-stat)

Portfolio	Whole Period			Before GFC			After GFC		
	VIX	YCL	YCS	VIX	YCL	YCS	VIX	YCL	YCS
JPYAUD	**-0.0297****	**0.0787****	**-0.0546****	**-0.0211***	**0.0419****	**-0.0293****	-0.0174	**0.0936****	**-0.0614****
	-3.56	**12.46**	**-6.67**	**-1.72**	**5.91**	**-2.78**	-1.27	**9.92**	**-4.69**
JPYNZD	**-0.0452****	**0.0709****	**-0.0233****	**-0.0202**	**0.0493****	**-0.0216****	**-0.0294****	**0.1143****	**-0.0247****
	-5.09	**8.70**	**-3.17**	**-1.43**	**5.02**	**-2.06**	**-1.95**	**8.51**	**-2.44**
JPYKRW	**-0.0188****	-0.0060	**-0.0102****	**-0.0243****	-0.0020	0.0020	**-0.0633****	**-0.0508****	-0.0006
	-2.38	-1.04	**-2.24**	**-2.64**	-0.47	0.44	**-4.41**	**-3.42**	-0.07
JPYPHP	**-0.0270****	**-0.0078****	-0.0007	**-0.0194***	**-0.0021****	**0.0015****	-0.0147	**-0.0176****	-0.0026
	-4.18	**-4.07**	-0.40	**-1.80**	**-1.04**	**0.83**	-1.23	**-2.44**	-0.68
JPYTHB	**-0.0327****	-0.0027	-0.0031	**-0.0291****	-0.0059	0.0050	-0.0140	-0.0017	**-0.0234****
	-5.21	-0.57	-0.62	**-2.63**	-1.06	0.85	-1.30	-0.18	**-2.32**
JPYSGD	**-0.0371****	0.0055	**0.0149****	**-0.0186****	**0.0105***	0.0062	**-0.0312****	-0.0169	**0.0328****
	-6.81	0.90	**2.28**	**-2.28**	**1.64**	0.87	**-2.93**	-1.00	**2.04**
CHFAUD	**-0.0170****	**0.0536****	**-0.0084**	**-0.0352****	**0.0438****	-0.0105	0.0165	**0.0483****	**-0.0458****
	-2.39	**8.84**	**-1.47**	**-3.25**	**5.94**	-1.32	1.31	**5.31**	**-4.14**
CHFNZD	**-0.0257****	**0.0330****	0.0033	**-0.0327****	**0.0317****	-0.0022	-0.0006	**0.0527****	-0.0051
	-3.49	**4.76**	0.64	**-2.59**	**3.29**	-0.27	-0.05	**4.74**	-0.61
CHFPHP	**-0.0100***	**-0.0034****	**0.0031****	**-0.0236****	**-0.0037***	0.0016	-0.0045	**-0.0117****	**0.0065****
	-1.60	**-1.90**	**1.96**	**-2.18**	**-1.83**	0.91	-0.40	**-1.77**	**1.85**
CHFTHB	-0.0043	**-0.0135****	**0.0116****	**-0.0312****	**-0.0182****	**0.0111****	**0.0235****	-0.0066	0.0124
	-0.69	**-3.15**	**2.75**	**-2.74**	**-3.41**	**2.09**	**2.21**	-0.76	1.33
SGDAUD	**-0.0081**	**0.0471****	**-0.0342****	-0.0084	**0.0357****	**-0.0166****	0.0064	**0.0419****	**-0.0421****
	-1.49	**11.70**	**-8.33**	-0.90	**6.10**	**-2.55**	0.77	**7.83**	**-7.11**
SGDNZD	**-0.0196****	**0.0446****	**-0.0176****	-0.0070	**0.0428****	**-0.0191****	-0.0088	**0.0586****	**-0.0209****
	-3.24	**9.05**	**-3.99**	-0.65	**5.82**	**-2.69**	-0.85	**7.16**	**-3.33**
SGDPHP	0.0007	**-0.0025****	**0.0015***	0.0003	**-0.0027****	0.0010	**0.0036****	-0.0040	**0.0019****
	0.22	**-2.75**	**1.87**	0.04	**-2.43**	1.05	**0.68**	-1.36	**1.16**
SGDTHB	-0.0017	-0.0021	**0.0052****	-0.0097	-0.0031	0.0007	**0.0084***	0.0005	**0.0066***
	-0.48	-0.84	**2.10**	-1.36	-0.93	0.21	**1.65**	0.11	**1.67**
USDAUD	**-0.0238****	**0.0431****	**-0.0509****	**-0.0261****	**0.0275****	-0.0123	-0.0091	**0.0426****	**-0.0746****
	-3.44	**7.70**	**-8.31**	**-2.36**	**4.03**	-1.32	-0.82	**5.25**	**-9.35**
USDNZD	**-0.0349****	**0.0313****	**-0.0177****	**-0.0230****	**0.0206****	-0.0057	**-0.0271****	**0.0611****	**-0.0379****
	-4.65	**5.28**	**-3.19**	**-1.84**	**2.67**	-0.68	**-2.04**	**5.97**	**-4.39**
USDPHP	**-0.0054***	**-0.0058****	**0.0018****	-0.0075	**-0.0045****	**0.0024****	-0.0064	**-0.0127****	0.0011
	-1.65	**-6.47**	**2.21**	-1.37	**-4.68**	**2.62**	-1.08	**-4.23**	0.61
USDTHB	**-0.0075****	-0.0019	0.0006	**-0.0160****	-0.0012	-0.0008	-0.0043	0.0002	-0.0044
	-1.99	-0.86	0.26	**-1.99**	-0.38	-0.23	-0.88	0.06	-1.12

** = Significant at 5% Confidence Interval, * = Significant at 10% Confidence Interval, Bold = Significant at 15% Confidence Interval

CHAPTER 5
CONCLUSIONS

This study was set to explore the factors that affect the returns on currency carry trade strategies as the strategies were drawn to be one of the most popular trade strategies in this decade. The paper focused on countries in group of ASEAN+3 and G10 during the first quarter of 2001 and the first quarter of 2014. Stemming from previous study of Clarida (2009), this paper has firstly documented on empirical relationship between returns on carry trade activities and realized exchange rate volatility. In addition, the well-known uncovered interest parity (UIP) equation was estimated over the low and high volatility periods. The results from each method got along with each other, hence the robustness of the negative relationship between carry trade returns and exchange rate volatility were arrived at. Empirical results indicated that carry trade strategies yielded high returns in low volatility states and became lower in higher volatility states. Moreover, the EGARCH model resulted in negative coefficients of volatility factors on carry returns. In particular, the UIP equation also confirmed the negative relationship between carry returns and realized volatility. Regressions of realized exchange rate depreciation on the lagged interest rate differentials gave either less than one or negative values of slope coefficients in low volatility states. On the other hand, in high volatility states, they yielded either greater than one or higher value of coefficients compared to those in low volatility states. One possible reason for this relationship might be that investors expect high returns when they face high exchange rate risk. As a result, current price of asset falls to provide larger price gap for higher future profits. Hence, lower realized returns are received for an investment strategy including currency carry trade. Another possible reason relates to transaction cost. Transaction cost may be higher in high exchange rate volatility environment and result in lower returns.

The paper next discussed about the effects of yield curve factors on carry trade returns. The evidences, overall, can be concluded that yield curve level factors positively affect carry trade returns while yield curve slope factors negatively affect the returns except for portfolios longing Philippine Peso. These correlations

were quite robust as the results in whole period, period before and after global financial crisis get along with each other. On the other hand, Bank of Thailand paper of Thawornkraowong and Anonchan (2013) suggested that interest rate differential has very little impact; saying 3%, on capital inflows in Thailand. Three main factors that greatly affect capital inflows are investors' fear, value of Thai Baht, and Thai economic growth, respectively. The result is not compatible with this paper result where yield curve factors do have some effect on carry return. One possible reason is that there are two main different regimes; high and low volatility periods, in the real market. Interest rate differential may not play an important role during high exchange rate volatility environments; however, it may play bigger role during low exchange rate volatility environments.

Important point to be noted is that this study considered currencies in groups of ASEAN+3 and developed G10 countries. Nevertheless, some currencies in these two groups of countries have not been taken into account due to some restrictions. In computing return on currency carry trade strategies, this paper assumed free capital flow policy and no transaction cost for all the target countries. Hence, further study might go into more details about the capital flow policy of each interesting country and transaction costs of carry trade activities to make the results be more realistic. Another point to be concerned is that the empirical results from this study suggested the correlations between carry trade returns and yield curve factors though many previous researches stated that carry returns were not affected by macro and standard risk factors. Future study in this field should, therefore, consider some monetary policy related factors which might play some roles on currency carry trade returns.

Nowadays currency carry trade, one of the most popular trade strategies, plays an important role in the global economy; hence policymaker of a country should give some concerns on this activity. Considering emerging countries with high interest rates, carry trade strategies result in capital inflow which leads to currency appreciation, thus carry trade activities may be harmful to export sector in emerging countries. Empirical results document that low volatility environments induce more carry trade activities to a country. In other words, carry trade is more attractive under state of low exchange rate volatility, thus policymakers should let exchange rate be

flexible to avoid high amount of carry trade activities. However, export sector of a country may be damaged if the exchange rate is too volatile. On the other hand, less volatility of exchange rate will induce more carry trade activities which accelerate exchange rate appreciation and finally do harms for export sector.

As carry trade activities can be considered as purely speculative flows, policy implementation from central bank aims to avoid huge amount carry trade activities. In case of Thailand, central bank operates under manage-float exchange rate policy in order to slow down the speed of appreciation to help export sector. Nevertheless, the more the exchange rate interventions are, the less the exchange rate volatility is. Too many interventions per se may induce more carry trade while no intervention may badly affect export sectors. Hence, policymaker has to find right balance for exchange rate volatility in order to make good environments for an economy.

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APPENDIX

Computing Carry Returns

According to Bloomberg Calculation, to compute carry return, the following currencies will be shorted JPY, CHF, and SEK and longed NZD, AUD, and USD.

The daily cost of borrowing (or the short cost) is estimated as:

SHORT (t) = { [(1+(JYI3M[t]/(100*260))) * (JPYUSD[t]/JPYUSD[t-1]) * WGT_Short1]

+ [(1+(CHFI3M[t]/(100*260))) * (CHFUSD[t]/CHFUSD[t-1]) * WGT_Short2]

+ [(1+(SEKI3M[t]/(100*260))) * (SEKUSD[t]/SEKUSD[t-1]) * WGT_Short3] } -1

The return on investment (or the long return) is estimated as:

LONG (t) = { [(1+(AUDI3M[t]/(100*260)))*(AUDUSD[t]/AUDUSD[t-1])*WGT_Long1]

+ [(1+(NZDI3M[t]/(100*260))) * (NZDUSD[t]/NZDUSD[t-1]) * WGT_Long2]

+ [(1+(USDRC[t]/(100*260))) * WGT_Long3] } -1

The **"carry return"** (or the excess return) equals to the return on investment (the long return) in high-yielding currencies less the cost of borrowing (or the short cost) in low-yielding currencies, all in U.S. dollar term.

CARRY (t) = LONG (t) – SHORT (t)

NOTE: In computing CARRY (t), we use the three-month deposit rate of each interesting currency, spot exchange rate (in terms of USD per unit of foreign currency), and assume 260 business days in a year.

CARRY (t) is the daily return on carry trade strategy and we can calculate the **"cumulative return index"** by using the following equation.

INDEX (t) = INDEX (t-1) * (1 + CARRY (t))

Where, INDEX (t-1) is defined as 100

The average annual excess return (or the annualized return) is estimated as:

Annualized return = [INDEX (t) / INDEX (0)]^(1/Number of Years)

Where, Number of years = N/260; N = number of days between start and end date.

The annualized standard deviation is calculated as follow:

Annualized standard deviation = square root (V*260)

Where, V is the variance of the daily return between start and end date.

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