CURRENCY RETURNS AND LIQUIDITY PREMIUMS. EVIDENCE FROM HIGHER MOMENTS PORTFOLIO SORTING: VARIANCE, SKEWNESS, AND KURTOSIS

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ABSTRACT

The currency return has been investigated throughout the literature. However, we look at a different approach using realized variance and higher moments; skewness and kurtosis, to test for the size of return. Introducing these moments, we are able to detect the currency return and the size is pronounced. Then, we investigate further whether liquidity premium exists in currency market by sorting based on higher moments. We find, in fact, that liquidity premium is almost non-existing using skewness and kurtosis measure while using variance can detect the amount of liquidity premium, which is 5.51% per annum. Testing further for liquidity premium during the financial crisis period, we find the size is higher for variance portfolio sorting while skewness and kurtosis sorting does not show any improvement.

Keywords: Foreign Exchange; Liquidity; Portfolio Sorting; Financial Crisis; Higher Moments
JEL Classification: F31; G01; G11; G12; G15

INTRODUCTION

Currency market is one of the most traded markets in the world with the daily trading of $5.1 trillion (Bank of International Settlements, 2016)[i]. Although, many have attempted to explain the currency return in foreign exchange (FX) market[ii], there is a need to investigate deeper to see what could drive the change in currency return.

In this paper, we provide an empirical evidence to the currency portfolio construction using realized variance to proxy for the risk in the currency market. The realized variance is typically used in equity market[iii] as it measures the risk associated with the movement of the change in the stock returns. We also investigate further using higher moments such as skewness and kurtosis to see whether sorting portfolio based on these moments can yield the positive return[iv]. Typically, currencies show fat left-tail[v] as making it harder for investors to predict the movement in the currency market.

We sort portfolios based on size of realized variance. As expected, the most volatile portfolio depicts the loss while the least volatile portfolio incurs the positive return. The result can be explained by the characteristics of the currencies in portfolio sorting since developing currencies are more volatile and provide unstable return unlike in developed currencies. We find the size of this trading strategy can yield an approximate 65 basis point monthly or 7.84% annually. This result is interesting since most of the literatures in currency markets are focused on the carry trade portfolio approach[vi] and the strategy yields substantial positive return regardless the risk (volatility) involved. We present in this paper that using realized variance can actually provide substantial return for investors taking risk (volatility) of currencies into account.

Then, we test using higher moments such as skewness and kurtosis to see whether these higher moments sorting can depict a potential positive return. At first, we observe the characteristics of the portfolios and find that currency portfolios provide negative skewness and high kurtosis. Consistent with literature, currencies with high interest rate differential provide a negative skewness and high positive kurtosis (Brunnermeier, Nagel, and Pedersen, 2008). With negative skewness and high kurtosis, currencies, in fact, show the long left-tail distribution as providing the potential currency crashes and positive return. Sorting portfolios based on skewness and kurtosis, we find that the higher moments sorting provides a positive return suggesting a potential currency gain in the higher moments.

Then, we test further to see which risk-factors can explain the change in return of portfolio sorting, namely variance, skewness, and kurtosis. We find that these factors are statistically significant with the change in currency return. The positive return also suggests the presence of currency return in the higher moments sorting portfolios. The plausible explanation of the result can be either shocks or information asymmetry in currency characteristics that cause the left-skewed distribution.

We also present the discussion on liquidity premium in this paper. We use the modification of liquidity measure from Evans and Lyon (2002) and Pástor and Stambaugh (2003) to test for the order flow and lagged order flow[vii] to the change in return. The lagged order flow is classified as the proxy for the return reversals (Banti, Phylaktis, and Sarno, 2012). Then, we expect the negative coefficient from the lagged order flow to indicate the reversals and the price impact. We find that the lagged order flow is negative supporting the presence of reversals as suggested by Pástor and Stambaugh (2003) that the price impact can influence the return of an asset.

Once the lagged order flow is determined, we estimate the liquidity premium based on the risk associated with the order flow. The risk measure is the realized variance of the currencies as we have determined in the first step. We find that the liquidity premium is pronounced as investors require to receive higher return to compensate their investment in risky currencies. After that, we sort portfolios based on sensitivity of liquidity to the market risk, classified as the realized variance of currencies. We find that more sensitive portfolios provide a greater need for liquidity than less sensitive portfolios. This result is consistent with Banti, Phylaktis, and Sarno (2012) indicating that the need for liquidity is higher for currencies with more sensitive to the risk associated to the market.

Then, we test for the liquidity premium during the great financial crisis (GFC)[viii]. We hypothesize that during the GCF period the size of liquidity premium should be more pronounced than during a stable state. As expected, we find that the size of liquidity premium is higher as investors require greater return from risky investment[ix]. Meanwhile, sorting based on skewness and kurtosis show no improvement in liquidity premium. Then, only realized variance can be used to capture the presence of premium, not skewness nor kurtosis.

The main contributions to this paper are (i) we provide an empirical evidence on currency return using higher moments sorting and find that there is a potential positive return on higher moments sorting portfolio, (ii) we present the liquidity premium using higher moments and the results show that the premium exists in variance sorting while using skewness and kurtosis sorting the size of premium is relatively small, and (iii) the presence of financial crisis, in fact, shows the higher premium using variance portfolio sorting; however, skewness and kurtosis sorting do not show any improvement in the size of premium.

LITERATURE REVIEW

Currency Risk and Return

There are numerous studies investigating the risk and return of the foreign exchange (FX) market. Adler and Dumas (1984) provide the measurement of risk associated in currencies. They argue that the change in economic variables impact the change in the exchange rates. His work has been providing an enormous impact on literatures to investigate the impact of economic variables to the change in risk and return of currencies. Also, there are literatures providing evidence based on other aspects of the variables that affect the change in currency risk and return such as the consumption growth (Jorion, 1995), the presence of institutional investors (Froot and Ramadorai, 2005), the price options (Lustig and Verdelhan, 2007), global risk (Brunnermeier and Nagel, 2008), and funding constraints (Banti and Phylaktis, 2015).

We are interested to look beyond the second moment (variance) of currency portfolio sorting since there is not much literatures exploring the higher moment sorting on currencies, unlike in equity markets[x]. There are substantial evidences of the positive returns from portfolio sorting[xi]. Typically, these literatures focus on the risk involved in a carry trade strategy; however, there is a lack of evidence supporting the role of higher moments, namely skewness and kurtosis sorting. The argument provided in this paper is that if currencies are seen as another type of asset, we should be able to observe the left-skewed distribution. Then, the investors should expect to receive positive returns from such investment strategy. However, there is an argument by Menkhoff et al. (2012) that crashes can potentially be used to explain the carry trade return that is high during the crisis period. Then, if their argument is true, we should be able to observe even higher return based on volatility, skewness, and kurtosis portfolio sorting during the crisis period. Moreover, Engle (2011) provides an empirical evidence of high negative skewness during the financial crisis using asymmetric volatility model.

Liquidity Premium in Currency Market

The presence of liquidity premium is important to determine the change in currency risk and return[xii]. Higher liquidity means higher risk associated with the return and investors prefer to receive higher return to compensate to such risk (Archarya and Pedersen, 2005; Pástor and Stambaugh, 2003). Banti, Phylaktis, and Sarno (2012) test for the presence of global liquidity risk in FX market. Using order flow to test for the return reversals, they conclude that the currencies are sensitive to the presence of the risk and funding constraint factors. Their work provides an interesting result since, instead of using carry trade approach, they sort the currencies based on the sensitivity with the finding of liquidity premium of 4.7% per annum. Their finding has motivated us to investigate further whether the size of liquidity premium can be explained by using variance, skewness, and kurtosis sorting.

The severely funding constraints and risks are causing higher liquidity premium in currency market. Mancini, Ranaldo, and Wrampelmeyer (2013) provide the solid work testing for the change in FX liquidity. They observe the major currencies using high frequency data to determine the liquidity risk and the size of liquidity premium. Using order flow as a determination of exchange rate liquidity, their result suggests that during the financial crisis the liquidity premium is higher, and the liquidity risk factor has a strong impact on the carry trade return during the same period. Their work indicates that VIX spread[xiii] has a significant impact on the change in FX liquidity as investors expect to receive a higher return during the liquidity dry-up period such as financial crisis or sudden market shocks. This finding is also supported by Karnaukh, Ranaldo, and Soderlind (2015) that the liquidity in FX market depends highly on funding constraints and global risk. In this paper, we are testing for the presence of GFC to the change in FX liquidity and providing empirical framework on how to measure the liquidity premium size with and without financial constraints.

The paper is organized as follows: next section we provide data and methodology used in this paper. We describe the summary statistics as well as the measurement of variance, skewness, and kurtosis for portfolio sorting. Then, we present our empirical results. We also discuss on the liquidity premium topic under this section. Lastly, we show the conclusion and remarks.

DATA AND METHODLOGY

Data

The data are collected through Thompson and Reuters for the currency returns while Bloomberg Terminal is used to get bid, ask, and mid quotes, and supplemented for the sample. To be included in the sample, each currency must contain at least 5 years spanning period and be traded at 16 GMT[xiv]. Also, we exclude pegged currencies since these currencies have different microstructure than other currencies and they can cause the potential bias results. Furthermore, currencies must be traded based on the volume recorded by the Bank of International Settlement (BIS).

In the end, we have 43 currencies in our sample spanning from December 1984 to December 2015. The exchange rate is defined as foreign currency against USD as foreign currency is a numerator while USD is a denominator[xv]. To preserve the space, we provide the list of the currencies in the appendix section.

Excess Return Estimation

Once we collect the currency data, now we estimate the return of each currency using the difference in future spot rate and today's forward rate. The estimation assumes that the interest rate parity condition holds[xvi].

$$er_{i,t} = In\left(s_{i,t+1}\right) - In(f_{i,t}) \quad (1)$$

where $er_{i,t}$ is excess return of currency i from period t to t+1, S is spot rate of currency i at time t+1, and f is forward rate of currency i at time t. The estimation is proposed by Akram, Rime, and Sarno (2009)[xvii] that the effect of interest rate differential is minimal and covered interest rate parity does hold during the short horizon.

Table 1 shows the summary statistics of our sample. As expected, developed currencies provide lower mean returns and standard deviation while emerging currencies show higher standard deviation. The result is consistent with many literatures (Mancini, Ranaldo, Wrampelmeyer, 2013; Banti and Phylaktis, 2015; Menkhoff et al., 2012) that the emerging currencies are more volatile than developed ones providing opportunities for investors to take investment strategies on these currencies.

Table 1

The summary statistics of 43 currencies spanning period from December 1984 to December 2015. The excess return is estimated from equation (1): $er_{i,t} = In(s_{i,t+1}) - In(f_{i,t})$, where $er_{i,t}$ is excess return of currency i from period t to t+1, S is spot rate of currency i at time t+1, and f is forward rate of currency i at time t. Mean and Standard Deviation (Stdev) are also reported.

No.	Country	Excess Return	
		Mean	Stdev
1	Australia	0.0023	0.0344
2	Austria	-0.0011	0.0298
3	Belgium	-0.0011	0.0298
4	Brazil	0.0055	0.0445
5	Bulgaria	-0.0005	0.0305
6	Canada	0.0005	0.0212
7	Croatia	0.0004	0.0312
8	Cyprus	-0.0008	0.0304
9	Denmark	0.0006	0.031
10	Egypt	0.0095	0.0144
11	Euro	-0.0004	0.0298
12	Finland	-0.0012	0.0298
13	France	0.0045	0.0323
14	Germany	0.0032	0.0334
15	Greece	-0.0002	0.0302
16	Hongkong	-0.0002	0.0019
17	Hungary	0.0029	0.0408
18	Iceland	0.0009	0.0441
19	India	0.0011	0.0214
20	Indonesia	0.0138	0.089
21	Israel	0.0016	0.025
22	Italy	0.0043	0.0329
23	Japan	0.001	0.0325
24	Kuwait	0.0005	0.0069
25	Malaysia	0.0032	0.0608
26	Mexico	0.0026	0.0289
27	Netherlands	0.0034	0.0334
28	Norway	0.0018	0.0317
29	Poland	0.0027	0.0425
30	Portugal	-0.001	0.0297
31	Russia	-0.0015	0.0433
32	Saudi Arabia	0.0001	0.0011
33	Singapore	0.0002	0.0161
34	Slovakia	0.004	0.0332
35	Slovenia	-0.0009	0.0305
36	South Africa	0.0052	0.0485
37	South Korea	0.0017	0.0335
38	Spain	-0.001	0.0297
39	Sweden	0.0014	0.0326
40	Switzerland	0.0013	0.0338
41	Taiwan	-0.0015	0.0161
42	Thailand	0.0005	0.0326
43	UK	0.0001	0.0244

Realized Variance

The realized variance estimation is using an approximation of n trading days in each month. The conditional volatility is used to construct the next period portfolio (1-month period) as using the past realized variance to determine the next period portfolio variance to form the portfolio[xviii].

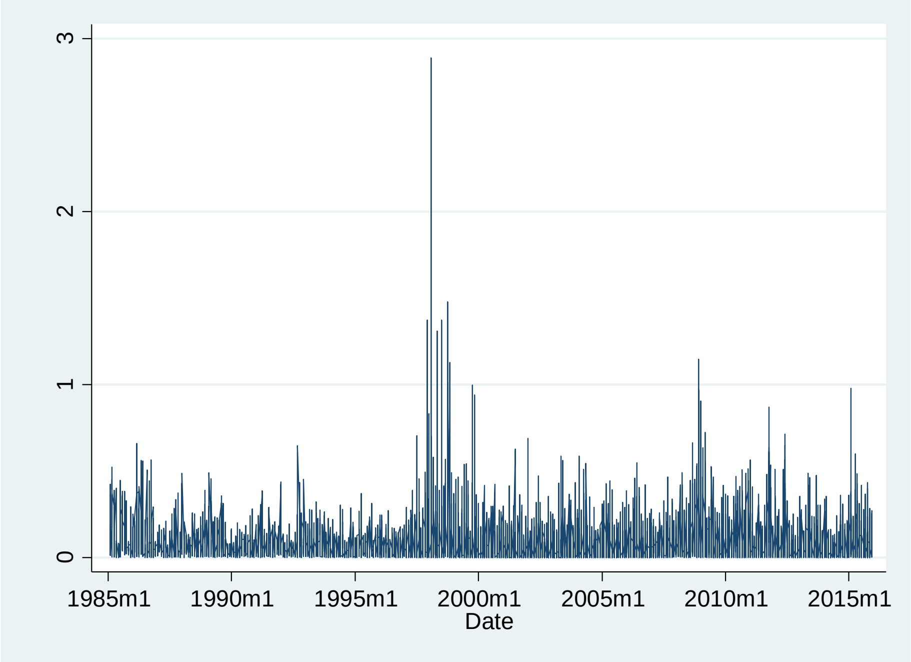
$$\sigma_t^2(f) = RV_t^2(f) = \sum_{d=1/n}^{1}(f_{t+d} - \frac{\sum_{d=1/n}^{1} f_{t+d}}{n})^2 \quad (2)$$

$$f_{t+1}^{\sigma} = \frac{c}{\sigma_t^2(f)} f_{t+1} \quad (3)$$

where f_{t+1} is the one period buy-and-hold portfolio excess return, $f_{t+1}^{\sigma}$is the one-period portfolio volatility, $\sigma_t^2(f)$is the proxy for the conditional variance of the portfolio, and c is a constant arbitrary number to measure the scaling conditional volatility[xix].

We report the realized variance of all currencies in figure 1. As expected, the realized variance is high during the financial crisis period such as great financial crisis (GCF), and the collapse of Lehman Brothers. Then, realized variance is a good proxy to forming portfolio for the next period. We will provide evidence of realized variance to form portfolio under the empirical results section.

Figure 1
Realized Variance of 43 currencies spanning period from December 1984 to December 2015. The realized variance is estimated by equation (2): $\sigma_t^2(f) = RV_t^2(f) = \sum_{d=1/n}^{1}(f_{t+d} - \frac{\sum_{d=1/n}^{1} f_{t+d}}{n})^2$.



Higher Moments: Skewness and Kurtosis

Observing higher moments is very common in equity market. However, for the currency market, higher moments are not much investigated. The closest work to observe the higher moments in the currency market is done by Brunnermeier and Nagel (2008). They test for the carry trades and currency crashes with the probability of having left-skewed distribution. They find that carry trade has the left-tailed distribution with high negative skewness. Motivated by their finding, we are interested to test the portfolio sorting based on the higher moments. The estimation of skewness and kurtosis is shown below[xx]:

$$RSkew_t = \frac{\sqrt{n}\sum_1^n er_{i,t}^3}{\{RV_t^2(f)\}^{3/2}} \quad (4)$$

$$RKurt_t = \frac{n\sum_1^n er_{i,t}^4}{\{RV_t^2(f)\}^2} \quad (5)$$

where $er_{i,t}$ is the excess return estimation of currency i at time t.

The third and fourth moments are being scaled by the number of trading days in each month as denoted by n. The scaling of $RSkew_t$ and $RKurt_t$ by $\sqrt{n}$ and n is to ensure the estimation of skewness and kurtosis are corresponding to the daily frequency.

Explaining Currency Return Based on Moments

We measure the innovation based on the differences of market movement as suggested by Chang et al. (2013). The approximation of the innovation is done by ARMA (1,1)[xxi]. Also, the difference can help removing autocorrelation that may occur in the dataset. The innovation of these moments is defined as follows:

$$\Delta RV_t = RV_t - RV_{t-1} \quad (6)$$

$$\Delta Skew_t = 100 * (RSkew_t - 0.9916 * RSkew_{t-1} + 0.3361 * \Delta RSkew_{t-1}) \quad (7)$$

$$\Delta Kurt_t = 100 * (RKurt_t - 0.9954 * RKurt_{t-1} + 0.4413 * \Delta RKurt_{t-1}) \quad (8)$$

We can see that the AR(1) coefficients are close to -1 meaning that we can use MA(1) model on the first differences to obtain the innovations for both Skewness and Kurtosis. We reports ARMA(1,1) result in table 2.

Table 2

Risk Factors: Variance, Skewness and Kurtosis. The table reports the innovation from ARMA(1,1) for variance, skewness, and kurtosis. We also report the size of AR(1) and MA(1) to use for constructing portfolio.

Risk Factor	AR(1)	MA(1)	Correlation		
			ΔRV	ΔSkew	ΔKurt
ΔRV	-1	0	1	0.28	-0.16
ΔSkew	-0.9916	0.3361		1	-0.78
ΔKurt	-0.9954	0.4413			1

The correlation between these variables is also reported in table 2. ΔSkew and ΔKurt are highly negatively correlated indicating the fat-left tail distribution. Also, we can imply that currency has negative skewness on average.

Once we determine these moments, we sort portfolios based on these risk factors. In literature of asset pricing to determining the risk factors, the substantial empirical results indicate the presence of volatility in equity market[xxii]. However, the presence of skewness and kurtosis is left unexplored. We incorporate the use of higher moments to determine the portfolio sorting. The closet work to our paper is from Chang et al. (2013) investigating higher moments in the stock returns. We, however, focus on the use of higher moments to test for currency return and sort portfolio based on these factors. Although we are lacking empirical support of the presence of risk factors in currency market, we provide an empirical test to see whether currency return can be explained by these higher moment risk factors.

Once we determine risk factors, we test with regression model as follows:

$$er_{i,t} = a_i + b_1\Delta RV_{i,t} + b_2\Delta RSkew_{i,t} + b_3\Delta RKurt_{i,t} + X_t BA_{i,t} + \varepsilon_{i,t} \quad (9)$$

where BA is the bid and ask spread of currency i at time t.

We argue that since currencies reply heavily on the presence of liquidity[xxiii] and the liquidity measure is measured by bid-ask spread, then we use it as the control variable in this regression model.

We then sort the currency return based into quintiles based on these coefficients, namely b1, b2, and b3. We present this regression result under the empirical result section.

Liquidity Measure and Liquidity Premium

Liquidity premium is an important factor for investors to take such positions in financial markets. When liquidity premium is high, investors demand a higher return to compensate for a higher illiquidity in the market. An additional compensation is required to compensate for a greater risk. Amihud and Mendelson (1986), Eleswarapu and Reinganum (1993), Pástor and Stambaugh (2003) explain the impact of liquidity premium to the change in the returns.

We estimate the potential return reversals. Pástor and Stambaugh (2003) provide empirical evidence of reversals to predict the liquidity. The change in order flow and lagged order flow are used as the indicators for return reversals. Then, we expect the lagged order flow to be negative while the order flow to be positive to show the reversals.

The order flow estimation is calculated as follows:

$$er_{i,t} = a_i + \beta_i \Delta X_{i,t} + \gamma_i \Delta X_{i,t-1} + \varepsilon_t \quad (10)$$

where $\Delta X_{i,t}$ is the change in order flow or information flow.

Evan and Lyons (2002), and Banti, Phylaktis, and Sarno (2012) estimate the change in the order flow to investigate the time-varying liquidity in FX market. Gamma (γ) or the lagged order flow coefficient can explain the change in behavior of risk-adverse market makers that they are trying to increase their returns in order to take such trading position in illiquid currencies.

Once we obtain the result showing the presence of the reversals, we now use it as the change in liquidity measure (γ) as the proxy for liquidity changed in currency. Then, we incorporate the use of liquidity measure with the realized variance to sort portfolios based on the sensitivity to the presence of realized variance. The result reports under the empirical result section.

EMPIRICAL RESULTS

Realized Variance Portfolio Sorting

We sort portfolio based on the sensitivity of conditional variance into quintiles ranking on the least volatile to the highest volatile portfolio. Table 3 reports our result. As expected, the least volatile portfolio (Portfolio 1) contains the positive mean return while the highest volatile portfolio (Portfolio 5) incurs losses. Grouping up portfolios based on volatility does separate the developed and emerging currencies since emerging currencies depict high volatility than developed ones.

Table 3

Quintile portfolio sorting based on realized variance. The realized variance is estimated in equation (2): $\sigma_t^2(f) = RV_t^2(f) = \sum_{d=1/n}^{1}(f_{t+d} - \frac{\sum_{d=1/n}^{1} f_{t+d}}{n})^2$ while equation (3): $f_{t+1}^{\sigma} = \frac{c}{\sigma_t^2(f)} f_{t+1}$ is used to form portfolios. f_{t+1} is the one period buy-and hold portfolio excess return, $f_{t+1}^{\sigma}$is the one-period portfolio volatility, $\sigma_t^2(f)$is the proxy for the conditional variance of the portfolio, and c is a constant arbitrary number to measure the scaling conditional volatility. Portfolio 1 indicates the least volatility portfolio while portfolio 5 shows the highest. We also report mean, median, standard deviation (Stdev), Sharpe ratio (SR), Skewness, and Kurtosis. 1-5 is the difference between least volatility portfolio and highest volatility portfolio. Sharpe Ration is return per unit risk of each portfolio and it is calculated by dividing excess return (mean) with standard deviation (Stdev).

Portfolio	1	2	3	4	5	1-5
Mean	0.0037	0.0031	0.0023	0.0003	-0.0028	0.0065
Median	0.0033	0.0031	0.003	0.0012	-0.0034	0.0021
Stdev	0.023	0.0212	0.0234	0.0314	0.0571	0.0297
SR	0.1618	0.1445	0.0966	0.0112	-0.0492	0.2201
Skewness	-0.9118	-1.1044	-0.2897	-0.1573	-4.7282	-0.4857
Kurtosis	13.7634	11.5104	6.1008	4.5039	7.7558	9.1856

We also report Sharpe ratio[xxiv], skewness, and kurtosis of realized variance portfolio sorting. The least volatile portfolio shows the highest Sharpe ratio and Sharpe ratio is lowest at the most volatile portfolio. This finding is consistent with Menkhoff et al. (2012) that volatile currency portfolio should provide negative return and negative Sharpe ratio while least volatile portfolio mainly in developed currencies should indicate the positive return; hence, higher Sharpe ratio is pronounced.

The difference between portfolios or the return based on differences in realized variance is also reported in table 3 as 1-5. The size of the return is higher and Sharpe ratio increases.

Higher Moments Portfolio Sorting

Our argument in this paper is that using higher moment sorting the strategy should provide a significant positive return. Before we proceed into sorting based on skewness and kurtosis, we test for normality of our sample whether our data set depict the normality assumption. We follow the test of D'Agostino, Belanger, and D'Agostino (1990)[xxv] for normality test.

Table 4 reports the result. The null hypothesis is the normally distributed assumption. We find that all the portfolios show the rejection of normality distributed assumption as p-value for both skewness and kurtosis is shown 0 supporting the presence of non-normal distribution.

Table 4

Skewness and Kurtosis Testing. The table presents the test on skewness and kurtosis based on D'Agostino, Belanger, and D'Agostino (1990) normality testing. We test with realized variance sorting portfolio as presented in table 3. Portfolio 1 indicates the least volatile portfolio while portfolio 5 shows the highest. 1-5 is the difference between least volatility portfolio and highest volatility portfolio. The tests on probability of skewness and kurtosis are reported under Pr(Skewness) and Pr(Kurtosis) with null hypothesis of normally distribution.

Portfolio	Pr(Skewness)	Pr(Kurtosis)
1	0.0000	0.0000
2	0.0000	0.0000
3	0.0000	0.0000
4	0.0000	0.0000
5	0.0000	0.0000
1-5	0.0000	0.0000

We provide our sorting based on skewness and kurtosis in table 5. Panel A reports the skewness sorting while Panel B shows the kurtosis sorting. It is interesting that sorting based on skewness and kurtosis provide a very consistent result. Portfolio 1 shows the greatest return while portfolio 5 indicates the lowest return, as we find in sorting based on variance. The difference between portfolio 1 and 5 indicates the highest Sharpe ratio for both skewness and kurtosis sorting.

With the result, we can argue that the distribution of currency is left-skewed distribution. Investors seek to take position on such investment strategy to receive a positive return (Brunnermeier, Nagel, and Pedersen, 2008). The positive return also suggests the presence of currency return in the higher moment portfolio sorting.

Since there is no literature to support our methodology used in this paper, we would like to offer various explanations of this finding. Firstly, the presence of emerging currencies can drive the left-tail skewed distribution. Campa, Changb, and Reiderc (1998) and Bakshi, Carr, and Wu (2008) provide empirical evidences and discussions on the impact of currency trading. The shocks from emerging currencies, in fact, provide an opportunity for investors to hedge and take trading position in developing currencies. Then, the shocks or market crashes in currency market may depict the left skewed distribution. Another explanation is that the information asymmetry of traders in currency market in perceiving the risks. Menkhoff (1998) offers the test on information asymmetry issues in currency market and concludes that there is an issue related to information flow in currency market.

Table 5

Portfolio Sorting based on Skewness and Kurtosis. This table reports sorting based on skewness and kurtosis using equation (4): $RSkew_t = \frac{\sqrt{n}\sum_1^n er_{i,t}^3}{\{RV_t^2(f)\}^{3/2}}$ and equation (5): $RKurt_t = \frac{n\sum_1^n er_{i,t}^4}{\{RV_t^2(f)\}^2}$. We also report mean, median, standard deviation (Stdev), and Sharpe ratio (SR). 1-5 in panel A is the difference between the least skewness portfolio and the highest skewness portfolio. 1-5 in panel B reports the differences between the least kurtosis portfolio and the highest kurtosis portfolio. Sharpe Ration is return per unit risk of each portfolio and it is calculated by dividing excess return (mean) with standard deviation (Stdev).

Panel A: Skewness Sorting						
Portfolio	1	2	3	4	5	1-5
Mean	0.004312	0.00356	0.2718	0.0011	-0.0016	0.005912
Median	0.003710	0.003412	0.003111	0.00218	-0.00457	0.00095
Stdev	0.02284	0.02421	0.02688	0.03251	0.04721	0.030963
SR	0.188792	0.147047	10.11161	0.033836	-0.03389	0.190936
Panel B: Kurtosis Sorting						
Portfolio	1	2	3	4	5	1-5
Mean	0.00412	0.003571	0.002621	0.00101	-0.00185	0.00597
Median	0.003822	0.003687	0.002671	0.002019	-0.00378	0.001288
Stdev	0.02478	0.02567	0.024312	0.030113	0.04821	0.03259
SR	0.166263	0.139112	0.107807	0.03354	-0.03837	0.183185

Regression Results

Ang et al. (2006), Fu (2009), Carhart (1997), Lewellen and Nagel (2006) point to the presence of volatility in the change in stock return. We analyze using the regression model from equation (9) adding higher moments, namely skewness and kurtosis to add extra dimensions to see whether currency return can be explained by these moments.

The control variable we use in this paper is bid-ask spread as it is the measure of the change in liquidity of currency (Mancini, Ranaldo, and Wrampelmeyer ,2013; Banti, Phylaktis, and Sarno, 2012). Table 6 shows the result from the regression. All variables are statistically significant. The signs of these coefficients are supported by the presence of literature[xxvi.] The realized variance depicts the risk involved in currency returns as the return would decrease as the volatility increases.

Table 6				
Regression Result. The table provides the regression result from equation (9): $er_{i,t} = a_i + b_1 \Delta RV_{i,t} + b_2 \Delta RSkew_{i,t} + b_3 \Delta RKurt_{i,t} + X \; BA_{i,t} + \varepsilon_{i,t}$, where $\Delta RV_{i,t}$ is the realized variance estimated from equation (6): $\Delta RV_t = RV_t - RV_{t-1}$, $\Delta Skew_t$ is the realized skewness estimated from equation (7): $\Delta Skew_t = 100 * (RSkew_t - 0.9916 * RSkew_{t-1} + 0.3361 * \Delta RSkew_{t-1}$, $\Delta Kurt_t$ is the realized kurtosis calculated from equation (8): $\Delta Kurt_t = 100 * (RKurt_t - 0.9954 * RKurt_{t-1} + 0.4413 * \Delta RKurt_{t-1})$, and BA_t is the bid-ask spread as the control variable. The table reports using one factor a time regression and model (4) shows all the risk factor loading regression. *, and ** indicate 5% and 10% significant level based on Newey and West (1987).				
Model	1	2	3	4
Constant	0.001124	0.001357	0.001296	0.001381
	(2.34)*	(2.18)*	(2.27)*	(2.69)*
ΔRV	-0.00187			-0.00236
	(-2.64)*			(-2.87)*
ΔSkew		0.00471		0.00316
		(1.87)**		(1.96)*
ΔKurt			0.00382	0.00386
			(2.22)*	(2.21)*
ΔBA	0.0047	0.0053	0.0051	0.0064
	(3.16)*	(3.33)*	(3.30)*	(3.45)*

The positive coefficients of skewness and kurtosis support the idea that with the presence of the skewness and kurtosis, investors would expect to receive higher returns[xxvii]. Our evidence shows that the presence of these higher moments provides the change in currency returns. The skewness and kurtosis, in fact, positively related to the change in the returns. These risk factors are important in asset pricing to determine the change in asset return, especially in equity markets. Then, the issue with this testing is that the argument of currency is another type of asset. Although, many believe that currency should not be classified as an asset since the absence of fundamental values. There are substantially literatures testing currency return with the use of asset pricing model[xxviii]. Then, our fundamental assumption for this test is that currency is an asset and risk factors, namely variance, skewness, and kurtosis can be used to explain the currency return.

LIQUIDITY PREMIUM DISCUSSION

Liquidity Measure – Order Flow

We begin our analysis for order flow as described in equation (10). The test for order flow is proposed by Evans and Lyons (2002) indicating that the relation between currency movement and liquidity is observable and the information or order flow can be used to describe this relationship. Our result is reported in table 7. The order flow is, as expected, statistically significant for all the currencies in our sample while the lagged order flow depicts the negative sign indicating the reversals in currency returns. Pástor and Stambaugh (2003) explain that the measure in liquidity can capture the return reversals due to risk averse investors in the market seeking greater liquidity to compensate with a greater return. Then, this finding supports the liquidity as an indicator for the currency return.

Table 7

Order Flow. This table reports the order flow estimated from equation (10): $er_{i,t} = a_i + \beta_i \Delta X_{i,t} + \gamma_i \Delta X_{i,t-1} + \varepsilon_t$, where $\Delta x_{i,t}$ is the change in order flow or the estimated return. We expect the signs differences between β and ϒ to support the presence of the reversals in our sample.

No.	Country	α	β	ϒ
1	Australia	-0.00548	0.01232	-0.00044
2	Austria	-0.00137	0.00547	-0.00018
3	Belgium	-0.00028	0.00124	-0.00056
4	Brazil	-0.00722	0.02567	-0.00017
5	Bulgaria	-0.00581	0.00321	-0.00078
6	Canada	-0.00356	0.00663	-0.00027
7	Croatia	-0.0067	0.00871	-0.00054
8	Cyprus	-0.0013	0.002497	-0.00024
9	Denmark	-0.00334	0.00054	-0.00045
10	Egypt	-0.00783	0.00678	-0.00015
11	Euro	-0.00334	0.00295	-0.00048
12	Finland	-0.00128	0.00276	-0.00059
13	France	-0.00318	0.00361	-0.00079
14	Germany	-0.00221	0.00158	-0.00036
15	Greece	-0.00631	0.00783	-0.00103
16	Hong Kong	-0.00447	0.00028	-0.00089
17	Hungary	-0.00291	0.00476	-0.00047
18	Iceland	-0.00246	0.00101	-0.00042
19	India	-0.00538	0.00037	-0.00052
20	Indonesia	-0.00671	0.00087	-0.00057
21	Israel	-0.00589	0.00013	-0.00048
22	Italy	-0.00397	0.00213	-0.00012
23	Japan	-0.00322	0.01469	-0.00027
24	Kuwait	-0.00447	0.00541	-0.00027
25	Malaysia	-0.00491	0.00079	-0.00051
26	Mexico	-0.00203	0.02443	-0.00052
27	Netherlands	-0.00081	0.00054	-0.00038
28	Norway	-0.00349	0.00845	-0.0005
29	Poland	-0.00104	0.00114	-0.00082
30	Portugal	-0.00487	0.00543	-0.00078
31	Russia	-0.00876	0.003798	-0.00022
32	Saudi Arabia	-0.00312	0.003895	-0.00073
33	Singapore	-0.00216	0.00222	-0.00019

34	Slovakia	-0.00542	0.008725	-0.00033
35	Slovenia	-0.00557	0.00157	-0.00048
36	South Africa	-0.00115	0.15263	-0.00041
37	South Korea	-0.00138	0.0108	-0.00047
38	Spain	-0.00499	0.009815	-0.0001
39	Sweden	-0.00326	0.00268	-0.00048
40	Switzerland	-0.00466	0.00459	-0.00027
41	Taiwan	-0.00312	0.009051	-0.00021
42	Thailand	-0.00316	0.06991	-0.00034
43	UK	-0.00075	0.00355	-0.00047

Explaining Liquidity Premium

The sources of liquidity premium have been a main discussion in empirical studies. Prior empirical studies show that there are many factors that can explain the change in liquidity. To determine the change in liquidity, we cannot simply use the proxy of liquidity as the dependent variable since it is just a proxy of the liquidity that occurs when the change in excess returns happens. Thus, the proper way to measure the liquidity premium is to use excess return as the dependent variable (Mancini, Ranaldo, and Wrampelmeyer, 2013; Banti et al., 2012; Brunnermeier and Pedersen, 2009).

With funding constraints, investors would be worse off and the liquidity in financial markets will become illiquid. Brunnermeier, Nagel, and Pedersen (2008) test for several funding constraint factors and find that TED spread, the proxy for the level of credit risk and funding liquidity in financial markets, increases when the market becomes illiquid. Therefore, we take into consideration that TED spread may influence the liquidity premium.

VIX index, as defined by the Chicago Board Option Exchange (CBOE), is the measure of market expectation of near-term volatility conveyed by stock index option prices. Bekaert and Hoerova (2014) document that the change in VIX index can have an impact on the S&P 500 option prices. Also, Mancini, Ranaldo, and Wrampelmeyer (2013) define VIX as a proxy for investors' fear and uncertainty in financial markets. They test the change in VIX and conclude that the change in liquidity can be influenced by the volatility index.

The change in liquidity in the FX market can be seen as the order flow of the currencies trading in the market. This provides the need for investors to receive higher returns and expect to liquidate the currencies. Baker et al. (2012) test investor sentiments with several market indices. They find that investor sentiment can be used to predict returns. We, however, hypothesize that investor sentiments may not have any influence in changes in the currency premium since investor sentiment is mainly used in equity literature, which differs from currency literature.

We also observe the change in risk-free rates, as it is proposed by Fama-French (1996) that the change in risk-free rate can be used as a proxy for the change in asset pricing. In this paper, however, we do not go into any further analysis of book-to-market and size as parts of measuring the change in liquidity, since we are not focusing on determining return predictability. The change in risk-free rate, as we expect, must have some impact on the change in liquidity.

We perform the regression with these factors as follows:

$$er_{i,t} = a + b_1\gamma_{i,t} + b_2\Delta SEN_t + b_3\Delta TED_t + b_4\Delta VIX_t + b_5\Delta Rf_t + \varepsilon_{i,t} \quad (11)$$

where $\gamma_i$is our liquidity proxy obtained from equation (11), ΔVIX_t is the change in VIX spread, ΔTED_t is the change in TED spread, $\Delta SEN_t$is the change in investor sentiment, and $\Delta Rf_t$is the change in risk-free rate.

Table 8 reports the result. We add one factor at a time to test for the consistency of independent variables. We use Gamma (γ_i) as the control variable to test for the presence of liquidity. We find that the proxy for liquidity (ϒ) is statistically negative capturing the presence of the change in excess return that occurs when there is a change in liquidity.

Table 8

Regression Result. The table reports the sources of liquidity of 34 currencies using equation (11): $er_{i,t} = \alpha_i + \beta_1\gamma_i + \beta_1\Delta bid\_ask_i + \beta_2\Delta VIX_t + \beta_3\Delta TED_t + \beta_4\Delta SEN_t + \beta_5\Delta Rf_t + \varepsilon_i$. $er_{i,t}$is excess return used as the dependent variable. $\gamma_i$is the liquidity proxy. $\Delta bid_ask_i$is the change in bid-ask spread. $\Delta VIX_t$is the change in VIX spread. $\Delta TED_t$is the change in TED spread. $\Delta SEN_t$is the change in investor's sentiment index. $\Delta Rf_t$is the change in risk-free rate. T-test is reported using Newey and West (1987) in parentheses. *, ** indicate 10% and 5% level of significance.

Model	1	2	3	4	5	6
Constant	-0.011305	-0.01208	-0.01121	-0.01046	-0.0113	-0.11332
	(-7.06)	(-7.83)	(-7.26)	(-6.55)	(-7.29)	(-7.11)
ϒ	-0.13721	-0.15776	-0.15503	-0.13481	-0.15537	-0.13723
	(-3.85) **	(-4.57) **	(-4.46) **	(-3.75) **	(-4.47) **	(-3.85) **
ΔRisk-Free	-0.06420	-0.01116				
	(-1.22)	(-0.02)				
ΔVIX	0.00299		0.002885			0.003431
	(17.24) **		(17.03) **			(16.74) **
ΔTED	0.00082			0.000139		0.000118
	(3.85) **			(4.11) **		(4.51) **
ΔSEN	0.00760				0.0087864	
	(1.20)				(1.38)	

Both VIX and TED are statistically significant indicating that investors are expected to receive higher returns when the market is more volatile. Since these variables are used to measure the funding constraints and risks involved in the market, our result supports that higher liquidity is compensated with higher returns.

Risk-free and Investor Sentiment are not statistically significant. The finding is somehow different from the literatures (Fama and MacBeth 1973; Fama-French 1996; Glosten and Jagannathan, 1993; Bollerslev et. al. 2015) that risk-free and investor sentiment can influence the change in return. These papers test the variables with U.S. equity. Our paper, however, test with the currency return and this may explain the different in findings. Also, the characteristics of equity and currency markets are different from each other (Phylaktis and Chen, 2010, Pasquariello, 2014). Then, our result indicates the different characteristics between equity and currency market.

We also test for only significant variables in model (6). These variables provide the consistency result with other models. The model (6) confirms the earlier regression tests that Gamma, VIX, and TED can be used to explain the change in the currency return.

Size of Liquidity Premium

So far, we have been testing for the presence of liquidity to the change in currency return. We are interested in measuring the size of liquidity. Banti, Phylaktis, and Sarno (2012) describe the use of liquidity sensitivity to sort portfolio and then determine the size of the liquidity premium. In this paper, we look at a different approach. We test for the liquidity size using the variance, skewness, and kurtosis sorting. We test the liquidity premium by using the portfolio sorting of variance, skewness, and kurtosis[xxix] and run a regression based on the portfolios to test for the liquidity premium[xxx].

Table 9 reports the result. Panel A, B, and C show the liquidity premium based on variance, skewness, and kurtosis sorting respectively. As expected from variance sorting (Panel A), we find that the size of liquidity premium is approximately 5.51% per annum. The size of the liquidity premium is similar to Banti, Phylaktis, and Sarno (2012) that the size of premium is approximately 4.65% per annum. They measure the size of the liquidity premium using the sensitivity of currency portfolios. We test for similar methodology; however, we use the realized variance to present the size of the liquidity premium. Then, our finding shows that the liquidity premium exists in currency market using variance portfolio sorting.

Table 9

Liquidity Premium. The table reports the liquidity premium based on variance, skewness, and kurtosis portfolio sorting. Gamma is the liquidity proxy determined in equation (11): $er_{i,t} = \alpha_i + \beta_1\gamma_i + \beta_1\Delta bid\_ask_i + \beta_2\Delta VIX_t + \beta_3\Delta TED_t + \beta_4\Delta SEN_t + \beta_5\Delta Rf_t + \varepsilon_i$. $er_{i,t}$ is excess return used as the dependent variable. γ_i is the liquidity proxy. Δbid_ask_i is the change in bid-ask spread. ΔVIX_t is the change in VIX spread. ΔTED_t is the change in TED spread. ΔSEN_t is the change in investor's sentiment index. ΔRf_t is the change in risk-free rate. 1-5 is the difference between portfolio 1 and 5. The test statistic is reported under the p-value row.

Panel A: Variance						
Portfolio	1	2	3	4	5	1-5
Gamma	-0.05173	-0.08928	-0.08945	-0.09263	-0.10683	0.0551
p-value	0.0015	0.0019	0.0026	0.0027	0.0018	0.0013
Panel B: Skewness						
Portfolio	1	2	3	4	5	1-5
Gamma	-0.09163	-0.09264	-0.09971	-0.01036	-0.10463	0.013
p-value	0.0013	0.0026	0.0029	0.0018	0.0034	0.0027
Panel C: Kurtosis						
Portfolio	1	2	3	4	5	1-5
Gamma	-0.06298	-0.06518	-0.06761	-0.06883	-0.07098	0.008
p-value	0.0035	0.0013	0.0027	0.0038	0.0034	0.0043

Panel B, and C report the sorting based on skewness and kurtosis. Interestingly, we find that the size of premium is 1.3%, and 0.8% per annum using higher moments sorting. The p-value also shows that higher moments sorting is statistically significant. Then, we find an evidence that skewness and kurtosis sorting can be used to predict the amount of liquidity premium. However, the size is substantially small compared to what we find in variance sorting. Understanding that there is no literature support on currency portfolio sorting using skewness and kurtosis. The plausible explanation of the small liquidity premium size based on skewness and kurtosis sorting is the presence of highly skewed in currency markets. Menkhoff et al. (2012) explain the strong negatively skewed in currency markets. Crashes in currency markets can potentially provide substantial benefits for investors to receive such positive returns. Then, investors are expected to predict the change in volatility in currency markets while leaving the highly skewed behavior unexplained.

Financial Crisis

The financial crisis should make currency demanding for higher liquidity premium since investors trade for such a risky period. Investors would prefer to receive higher premium than that of during the normal state. To test for liquidity premium during the financial crisis period, we assign a dummy variable be equal to 1 during January 1996 to December 1999[xxxi], and zero otherwise.

We perform the regression with these factors as follows:

$$er_{i,t} = a + b_1\gamma_{i,t} * (Dummy_t) + b_2\Delta SEN_t * (Dummy_t) + b_3\Delta TED_t * (Dummy_t) + b_4\Delta VIX_t * (Dummy_t) + b_5\Delta Rf_t * (Dummy_t) + \varepsilon_{i,t} \tag{12}$$

where $Dummy_t$ is equal to 1 if the period falls during January 1996 to December 1999, and zero otherwise.

Table 10 shows the result. Using variance sorting, we are able to see the higher liquidity premium, approximately 6.13% per annum. Then, the presence of GFC indicates the need for the premium for investors to trade illiquid currencies during the period. While using skewness and kurtosis portfolio sorting, we, however, do not see the change in liquidity premium, 1.38%, and 1.03% respectively. The presence of liquidity premium using higher moments, namely skewness and kurtosis, is not much higher than during the normal state. The possible explanation of the finding is that currencies are, in fact, having left-skewed regardless of the economy. Then, testing during the financial crisis does not show the improvement of premium size as we see from the variance sorting portfolio.

Table 10

Liquidity Premium during financial crisis. The table reports the liquidity premium based on variance, skewness, and kurtosis portfolio sorting during the Great Financial Crisis (GFC). Dummy variable equals to 1 during January 1996 to December 1999, and zero otherwise. Gamma is the liquidity proxy determined in equation (12):

$$er_{i,t} = a + b_1\gamma_{i,t} * (Dummy_t) + b_2\Delta SEN_t * (Dummy_t) + b_3\Delta TED_t * (Dummy_t) + b_4\Delta VIX_t * (Dummy_t) + b_5\Delta Rf_t * (Dummy_t) + \varepsilon_{i,t}$$

. $er_{i,t}$is excess return used as the dependent variable. $\gamma_i$is the liquidity proxy. $\Delta bid_ask_i$is the change in bid-ask spread. $\Delta VIX_t$is the change in VIX spread. $\Delta TED_t$is the change in TED spread. $\Delta SEN_t$is the change in investor's sentiment index. $\Delta Rf_t$is the change in risk-free rate. The test statistic is reported under the p-value.

	Variance	Skewness	Kurtosis
Gamma	6.13%	1.38%	1.03%
P-value	0.0018	0.0021	0.0038

CONCLUSION AND REMARKS

This paper presents the currency portfolio sorting using variance, skewness, and kurtosis of 43 currencies spanning from December 1984 to December 2015. We find that currency sorting portfolio depicts the left fat-tailed distribution. The return from the portfolio sorting is pronounced. The, investors can seek to invest using higher moments sorting portfolio. The finding supports the literature that currency distribution provides positive return, with negative skewness and high kurtosis.

Then, we test further to see the size of liquidity premium using these portfolio sorting. The realized variance sorting yields the greatest premium of 5.51% per annum while the size of premium using skewness and kurtosis is small. Testing during the financial crisis period also leads to the finding that skewness and kurtosis sorting do not provide a higher premium than during the normal state. However, sorting based on variance does provide higher premium during the financial crisis.

We offer the new approach of currency portfolio sorting based on higher moments, namely skewness and kurtosis. Since there is no support from the literature that using these sorting could potentially provide the positive investment, we find that there is a positive investment in such higher moments sorting.

We, however, are aware of potential issue on our sample. For example, the inclusion of currencies with high interest exposures such as Brazil's may adjust the premium size upward since such currencies are the most volatile in terms of target interest rates provided by the Central Banks. Furthermore, the differences in macro and microstructure between developed and emerging markets can also be used to explain the size of liquidity premium. Since these are not the main testing for this paper, we leave the rest for the further research to explore the possibility of explaining the positive investment from higher moments sorting as well as the size of liquidity premium.

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Appendix **List of Currencies**			
No.	Country	No.	Country
1	Australia	23	Japan
2	Austria	24	Kuwait
3	Belgium	25	Malaysia
4	Brazil	26	Mexico
5	Bulgaria	27	Netherlands
6	Canada	28	Norway
7	Croatia	29	Poland
8	Cyprus	30	Portugal
9	Denmark	31	Russia
10	Egypt	32	Saudi Arabia
11	Euro	33	Singapore
12	Finland	34	Slovakia
13	France	35	Slovenia
14	Germany	36	South Africa
15	Greece	37	South Korea
16	Hong Kong	38	Spain
17	Hungary	39	Sweden
18	Iceland	40	Switzerland
19	India	41	Taiwan
20	Indonesia	42	Thailand
21	Israel	43	UK
22	Italy		

ENDNOTES

[i] https://www.bis.org/publ/arpdf/ar2017e.pdf
[ii] See. De Santis and Gerard (1998), Balvers and Klein (2014).
[iii] See. Andersen et al. (2001), Liu, Patton, and Sheppard (2015).
[iv] Skewness and kurtosis are used to determine the shape of return distribution and to predict returns. See. Harvey and Siddique (1999), Chang, Christoffersen, Jacobs (2013).
[v] Menkhoff et al. (2012) have discussed the potential negative skewness and high kurtosis in currency momentum. Brunnermeier, Nagel, Pedersen (2008) also provided the empirical evidence of negative skewness in currencies using carry trade approach.
[vi] Carry trade portfolio refers to the strategy to sell low interest rate currencies and buy high interest rate currencies to receive the difference in return from such trading strategy. See. Menkhoff et al. (2012), Christiansen, Ranaldo, Soderlind (2011), Archarya and Steffen (2015).
[vii] Order flow and lagged order flow are indicators to determine return reversals in currency markets. The reversals capture the change in returns as the change in liquidity occurs.

[viii] Great financial crisis (GFC) refers to the financial crisis in 1997.
[ix] Karnaukh, Ranaldo, and Soderlind (2015) provide an empirical evidence of variables that affect the change in foreign exchange (FX) liquidity. They conclude that the presence of funding constraints and global risk reduces the liquidity in FX market.
[x] In equity markets, higher moments are observed to see the impact of asset price to the higher moments. See. Harvey and Siddique (2000), Fang and Lai (1997), Carr et al. (2002).
[xi] The portfolio sorting technique called "Carry Trade" strategy – Buying high interest rate portfolio and selling high interest rate portfolio. The strategy provides substantial positive return with high Sharpe ratio. See. Heath, Galati, McGuire (2007), Clarida and Pedersen (2009), Christiansen, Ranaldo, and Soderlind (2011), Archarya and Steffen (2015).
[xii] Stoll (1989) and Bessembinder (1994) explain the use of liquidity (bid-ask spread) to determine the risk and return in equity and foreign exchange market.
[xiii] VIX is a volatility index for S&P 500 options. It indicates the expectation of market participants in equity markets. For more information, see www.cboe.com.
[xiv] Mancini, Ranaldo, and Wrampelmeyer (2013) suggest using closing time at 16 GMT since it is the highest trading period of the day. Also, they suggest that 16 GMT shows the highest correlation between return and liquidity.
[xv] See. Lustig, Roussanov, and Vedelhan (2014), Daniel and Moskowitz (2016).
[xvi] See. Banti, Phylaktis, and Sarno (2012), Evan and Lyon (2002), Pastor and Stambaugh (2003) for the return estimation.
[xvii] Akram, Rime, and Sarno (2009) indicate the use of interest rate differential. Their empirical work shows that during the short-term horizon the covered interest rate parity does hold. The interest rate differential is equal to the forward discount.
[xviii] Moreira and Muir (2017) suggest using realized variance from the previous period (t-1) to form portfolio for the next period (t).
[xix] The arbitrary number, c, is used for approximation of the portfolio construction. In fact, c does not influence the change in portfolio construction. We use c equals to 1 in this paper.
[xx] See. Chang et al. (2013), Amaya et al. (2015).
[xxi] ARMA model is used to forecast future returns. Makridakis and Hibon (1997) explain the use of ARMA models to forecast for future equity returns.
[xxii] See. Ang et al. (2006), Fu (2009), Goyal and Santa-Clara (2003).
[xxiii] See. Mancini, Ranaldo, and Wrampelmeyer (2013), Banti, Phylaktis, and Sarno (2012), Banti and Phylaktis (2015) for the liquidity measure and affect to the change in currency returns.
[xxiv] Sharpe ratio is unit return per risk and is calculated by dividing portfolio's excess return (mean) with portfolio's standard deviation (Stdev).
[xxv] D'Agostino, Belanger, and D'Agostino (1990) test for normality based on the Jaque-Bera test statistics incorporating the skewness and kurtosis with the adjustment of sample size.
[xxvi] See. Ang et al. (2006), Fu (2009), Brunnermeier, Nagel, and Pedersen, 2008.
[xxvii] Aggarwal, Rao, Hiraki (1989), Corrado and Su (1996), Mills (1995), Brown, and Warner (1985) provide empirical evidence on skewness and kurtosis with the return on stock.
[xxviii] See. Stulz (1981), Svensson (1985), Duffie, Pan, Singleton (2000), Bakshi and Panayotov (2013), Harvey and Siddique (2000).
[xxix] The methodology is described by Chang et al. (2013), and Amaya et al. (2015) testing for the presence of variance, skewness, and kurtosis portfolio sorting combining with the test for asset pricing.
[xxx] The measure of the liquidity premium is our gamma, the proxy for liquidity. The difference between gammas from portfolio 1 and 5 is the size of the approximate liquidity premium from the portfolio sorting.
[xxxi] We use long spanning of financial crisis period to have enough number of observations in our testing. Furthermore, the use of these period is supported by literatures. See. Caramazza, Ricci, and Salgado (2004), Lemmon, and Lins (2003), Click and Plummer (2005), Carrieri, Chaieb, and Errunza (2013).