A Turbulence Resistant Carry Trading Strategy

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Abstract

In this paper, we propose a turbulence resistant currency carry trading strategies. This strategy trades 13 developed market (DM) and emerging market (EM) currencies and employs the high-minus-low portfolio construction strategy to maintain market neutrality. We develop a currency Turbulence Index that signals market stress during unusual episodes. This indicator will be used as a strategy conditioner for the carry portfolio we constructed and we stop trading carry signals when a spike in turbulence is observed. This strategy outperforms the DM,EM and Global carry portfolio, and yields a Sharpe ratio of 0.97, annul excess return of 2.64%, annual volatility of 2.68% and drawdown of 4.31% during 1993-2016.

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1 Introduction

A carry trade is a strategy of entering long positions of high interest currencies and short positions of low interest rate currencies. Unlike a trade against the deviation from the covered interest rate parity (CIP), this trade is not an arbitrage trade. It is a speculation since there should not be a market or economic force to ensure this trade to make profit. The investor or speculator can earn a positive return if the positive carry from the interest rate differential is not offset by the adverse movement of the spot rates in the future.

It is bit bizarre however, people have discovered that this speculative trade have become very reliable in generating positive returns and the notion of using expected return to describe a carry trade strategy statistically is not uncommon. The carry trades however typically perform badly during stressed period and large drawdowns make the return distribution significantly left skewed. This study will explore different carry trade strategies from simple portfolios to more optimized ones. Since it is well known that the curry trades can make money, it is our goal to try to mitigate potential big losses and construct carry trade strategies to justify the returns in a risk adjusted basis.

2 Currency Forward Bias and Carry Trade

It has been long documented that carry trade between many currency pairs works. Any students who has taken an international finance course should know that carry trade should not work. In theory, if one currency has higher interest rate than another, uncovered interest parity (UIP) implies that the exchange rate should move to the direction where the profit from the positive carry (interest differentials) should be canceled out leaving no expected profit on the table. Equivalently, this means the market is systematically mis-pricing the currency forwards in one-direction. Empirical works have shown this persistent bias and it is called FX forward rate bias (FRB).

Many studies have shown that the carry trade can keep working for a very long time, it is apparent that some market inefficiency allows FRB continue to exist. Does this mean all the active currency managers have found a reliable source of alpha? Not necessarily.

There are researches on this topic claim that carry trade works because there is a risk premium for holding high yielding currencies. As we will show latter in the study, Australian dollar generates very good carry trade returns but does this mean AUD is a more risky currency than the Japanese Yen? Probably, but it seems unlikely that AUD is inherently this so much riskier than Yen given the currency does not adjust adjust its relative exchange rate for a long time. Rather, a more likely scenario is it is self-fulfilling. In other words, A positive feedback mechanism that the existence of FRB gives the high interest rate currency investors positive returns and over the time, more and more investor piles into the trade buy more high yielding currencies and sell more low yielding currencies, the crowding effect keeps the gap from closing. Due to the persistence of this "inefficiency", probably all the currency managers are paying close attention in any possible carry trade opportunities and are likely in the similar positions at a given period.

Either way, the FRB and returns from a carry trade looks more like a systematic risk, beta, rather than an alpha. This reminds us that certain risk, although may be not well captured by traditional risk metrics, is borne by the investors who go into this trade. One obvious example can be the procyclical unwinding of certain FX positions or the EM currency fire sale during extreme market conditions like "Brexit" or 2008. These risks are particularly relevant in the carry trade settings precisely due to the factors just mentioned such as traders going into similar positions and want to unwind at similar periods of time.

This study pays special attention to the riskiness of the carry trade strategy and aim to explore possible remedy to reduce risk involved during stressed period. In the next few sections, we will first show some examples of carry trade strategy using different portfolios with developed market currencies and emerging market currencies. Then a strategy of combining all currencies are tested and analyzed. In Chapter 4, a custom-built Turbulence Index is introduced for the purpose of portfolio construction. In Chapter 5, we used the concept of the Financial Stress Index (FSI) to study whether FSI can explain some of the carry trade returns from the FX portfolios, especially during the periods of market stress. In chapter 6, the optimal allocation between the carry trade based on Currency Turbulence Index are explored.

The goal is to improve the robustness of the carry trade strategy during turbulent market conditions.

3 Data, Portfolio Construction, and Backtests

3.1 Data

In this study, the data used for constructing the carry trade portfolios are interest rates and FX spot rates, both of which were obtained from the Bloomberg Terminal. We studied a set of most traded currencies by the global investors including nine currencies from the developed countries and four emerging market currencies. Similar to Melvin's approach (2014, Michael Melvin) [2], two separate portfolios were constructed, each corresponds to the developed market (DM) and emerging market (EM). The DM includes the following countries: Australia (AUD), Canada (CAD), Switzerland (CHF), Euro (EUR), United Kingdom (GBP), Japan (JPY), Norway (NOK), New Zealand (NZD) and Sweden (SEK). The EM includes Colombia (COP), Hungary (HUF), Poland (PLN), and South Africa (ZAR).

As a step further, a hybrid global portfolio that consists of all twelve currencies was also constructed to investigate a more diversified carry trade strategy. All currencies are also included in the more complex risk-based portfolios which will be introduced in the next section.

3.2 Portfolio Construction Methodology

There are three basic portfolios including DM, EM and Global hybrid constructed in this study. The analysis on the performance of carry trade is carried out using these three portfolios.

To optimize allocation between twelve currencies, a portfolio responsive to the market condition was devised. We constructed a portfolio based on a Turbulence Index. After ranking the currency, the weight on each currency invested is adjusted based on the Turbulence Index. From the previous studies, carry trades typically are prone to the tail risk and a big drawdown may wipe out many year's return. These risk adjusted portfolios are constructed from a risk management/risk adjusted perspective. Analysis will be performed to see whether carry trade performance (e.g.Sharpe Ratio, Maximum Drawdown etc.) can be improved through optimal allocation.

All above portfolios are constructed using a similar method introduced in Melvin's working paper (2014, Michael Melvin) [2]. Briefly, the currencies in each portfolio universe are ranked based on the interest rates. Each month, depending on the number of positions we pre-defined (ranging from 2 to 10), the portfolios are re-balanced to take the long positions in the high interest currencies and short positions in the low interest currencies. Using Melvin's notation, the monthly market-to-market return on each long positions for a foreign currency is as the follows:

$$r^i_{t+1} = i^i_t - i^u_t - (s^i_{t+1} - s^i_t)$$

where i^i and i^u are the interest rates for foreign currency and USD, s^i denotes the exchange spot rate.

For each portfolio, the number of long positions is equal to the number of short positions and each long and short legs are equally weight. For the DM, EM and Global hybrid portfolio, this ensures that the investor in dollar neutral in terms of the total investment.The optimized portfolios using the Turbulence Index on the other hand usually will not lead to a dollar neutral position. This is because the positions in each currency invested no longer remain the same. All positions are normalized to have a gross leverage/exposure of one, considering both long and short legs.

3.3 Developed Market (DM)

The backtests of the DM currency portfolios span from 1983 to 2016.Figure 1 shows that carry trade using eight DM currencies makes money no matter the choice of number of long-short positions. Using the additional information in Table 1, the strategy that employs only one long position and one short for a given month (CARRY(1,1)) gives the best backtest results, both in terms of annualized average return (2.72 %) and the Sharpe ratio (0.70). However it is worth noting that allowing two long positions and two short positions for a given month (CARRY(2,2)) gives the same Sharpe ratio (0.70) but much smaller maximum drawdown (-3.89 % vs. -8.60 %) compared with CARRY(1,1). Also the

drawdown period is much shorter.This seems to suggest there is value to diversify the carry trade portfolio in addition to stay dollar neutral (from the long short strategy). Figure 2 and Table 2 show the return attribution from each currencies and the relevant statistics. AUD is the biggest contributor of the total returns of the DM portfolio. AUD has been appreciating and the Australia's economic achievement over the past years may underlie the sustained carry opportunity of its currency. Figure 3 shows the position changes during the 30 year period. We can see that the positive carry trade profit from AUD is by longing AUD for the most of the times while the profit from the GBP trade is from short positions.

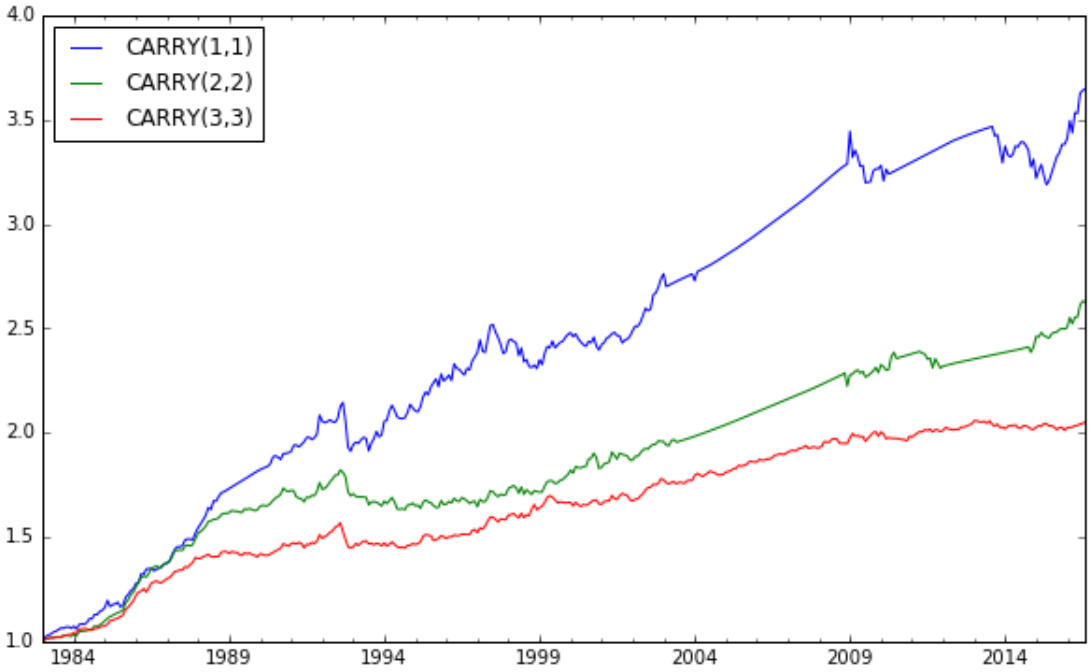

Figure 1: Cumulative Return of Carry Trade in Developed Market

	Ann_Ret	Ann_Vol	Sharpe	MaxDD	DD_Start	DD_End	Var(95)	ES(95)	TR(95)
CARRY(1,1)	2.72	3.77	0.70	-8.60	1997-07-01	1998-12-01	5.81	8.33	1.70
CARRY(2,2)	1.93	2.71	0.70	-3.89	2000-10-01	2000-12-01	3.68	5.88	1.93
CARRY(3,3)	1.42	2.06	0.68	-3.03	1999-05-01	2000-05-01	2.96	3.91	0.65

Table 1: Performance Summary of 8-Currency DM Portfolio

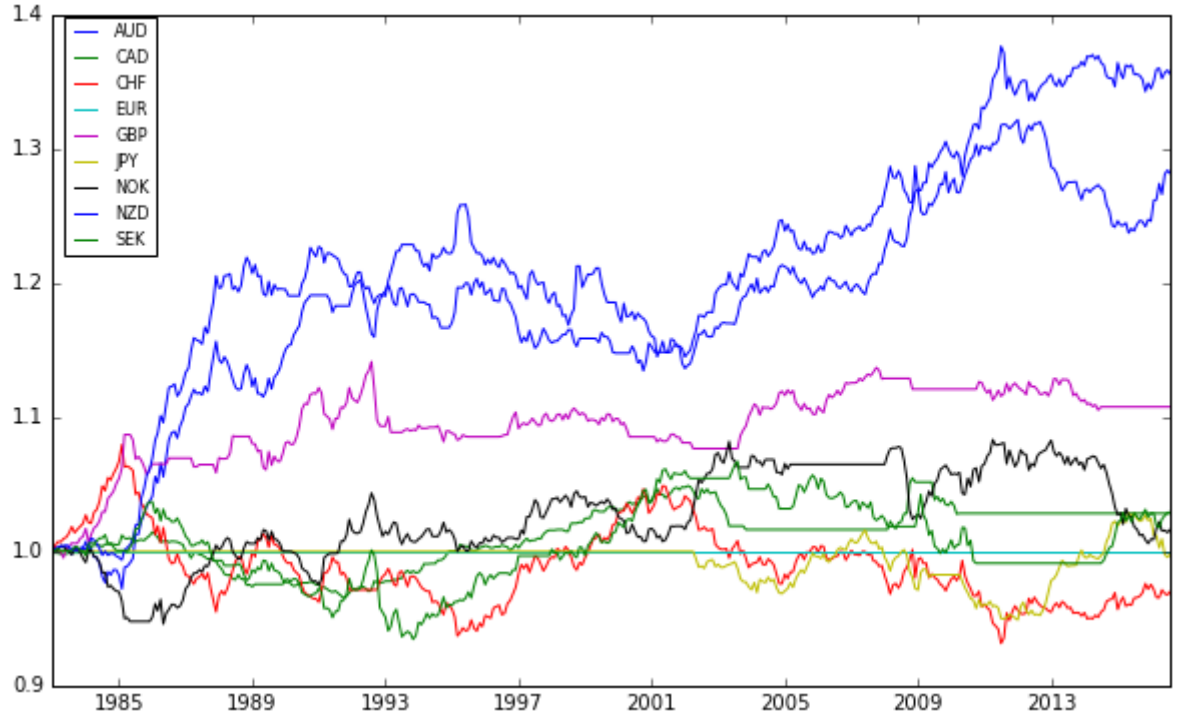

Figure 2: Currency-wise Cumulative Return of Carry Trade in DM Currencies

	Ann_Ret	Ann_Vol	Sharpe	MaxDD	DD_Start	DD_End	Var(95)	ES(95)	TR(95)
AUD	0.56	1.70	0.32	-5.83	1995-10-01	2000-10-01	2.39	3.24	1.16
CAD	0.21	0.82	0.26	-3.16	2002-02-01	2003-11-01	1.03	1.76	0.85
JPY	0.00	1.17	-0.01	-6.75	2007-06-01	2012-01-01	1.97	2.87	0.73
NZD	0.21	1.80	0.11	-10.06	1995-06-01	2002-01-01	2.84	3.68	0.74
NOK	0.04	1.67	0.01	-7.34	2011-04-01	2015-12-01	2.78	3.94	1.28
CHF	-0.05	1.78	-0.04	-11.71	2001-05-01	2011-07-01	2.73	4.03	1.08
GBP	0.08	0.96	0.08	-2.79	2007-10-01	2014-06-01	1.46	2.15	0.61
SEK	0.37	1.48	0.25	-7.26	2003-08-01	2010-10-01	2.89	3.77	0.76

Table 2: Currency-wise Performance Summary of 8-Currency DM Portfolio

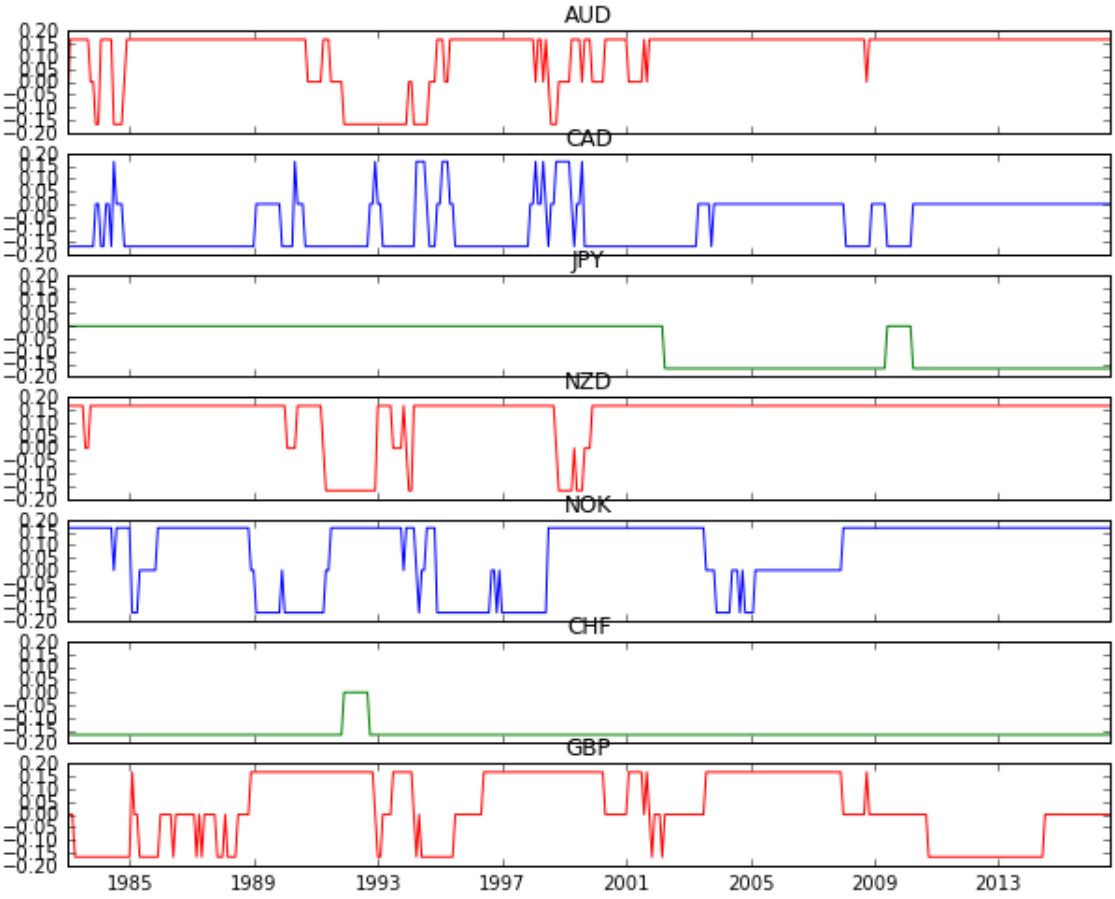

Figure 3: Currency-wise Position in DM Carry Trade

3.4 Emerging Market (EM)

The backtests of the EM currency portfolios is much shorter which cover the period from 1993 to 2016. Figure 4 shows that carry trade using four EM currencies also make money, especially during the first ten years of the backtests. From Table 3, CARRY(1,1) yielded higher return than CARRY(2,2) (3.47 % vs. 2.69 %), but again, a more diversified strategy seem to reduce the severity of the drawdown significantly (-18.46 % vs. -36.77 %).

Since the largest drawdown seen around the period building up to the 2007-8 global financial crisis, the EM portfolio seem to have a hard time to recover from the loss. Did Carry Trade suddenly stop working after seen a smooth upward trend in the first 10 years of the backtest? We can only speculate that the investors and currency managers may have switched their risk appetite and no longer hold currencies purely for carry purposes.

Figure 5 shows the return attribution from each currencies. South African rand (ZAR) is the biggest contributor of the total returns of the EM portfolio. The positions of the carry trades seems to often fluctuate a lot indicating the more volatile nature of the emerging market currencies. Compared to DM portfolio, EM portfolio had much bigger volatility and drawdowns. Although the returns generated by the EM portfolio outperformed DM, the total return suffered greatly due to those big losses during extreme market times (Sharpe ratio 0.5).

Figure 4: Cumulative Return of Carry Trade in Emerging Market

	Ann_Ret	Ann_Vol	Sharpe	MaxDD	DD_Start	DD_End	Var(95)	ES(95)	TR(95)
CARRY(1,1)	3.47	7.38	0.43	-36.77	2004-04-01	2008-03-01	12.19	15.08	2.60
CARRY(2,2)	2.69	4.83	0.53	-18.46	2006-02-01	2016-02-01	6.55	9.48	2.42

Table 3: Performance Summary of 4-Currency EM Portfolio

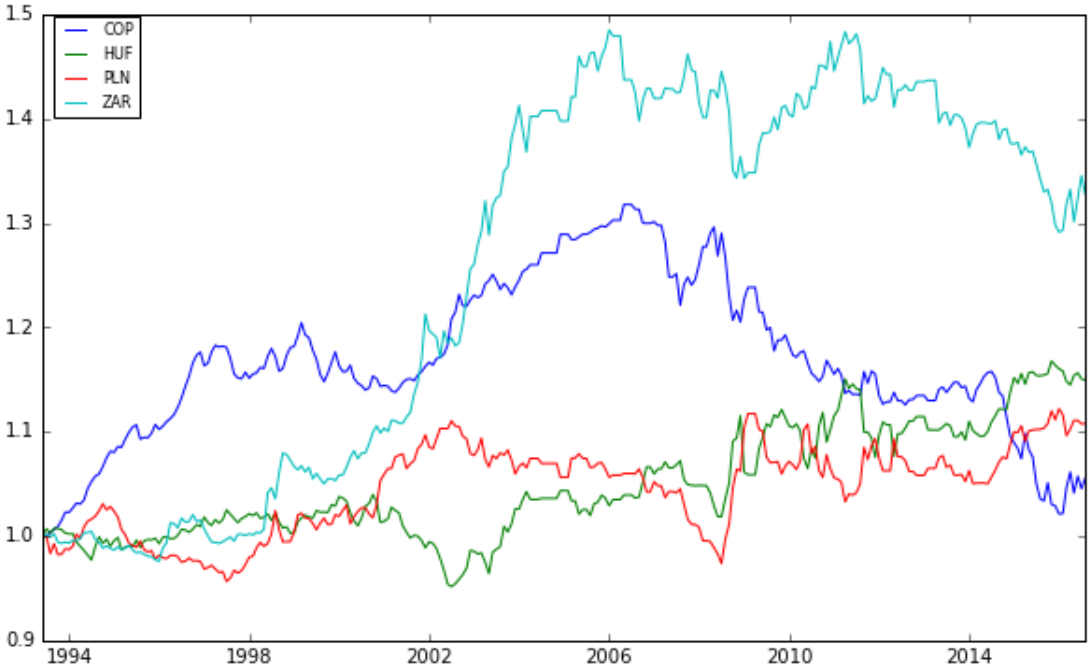

Figure 5: Currency-wise Cumulative Return of Carry Trade in EM Currencies

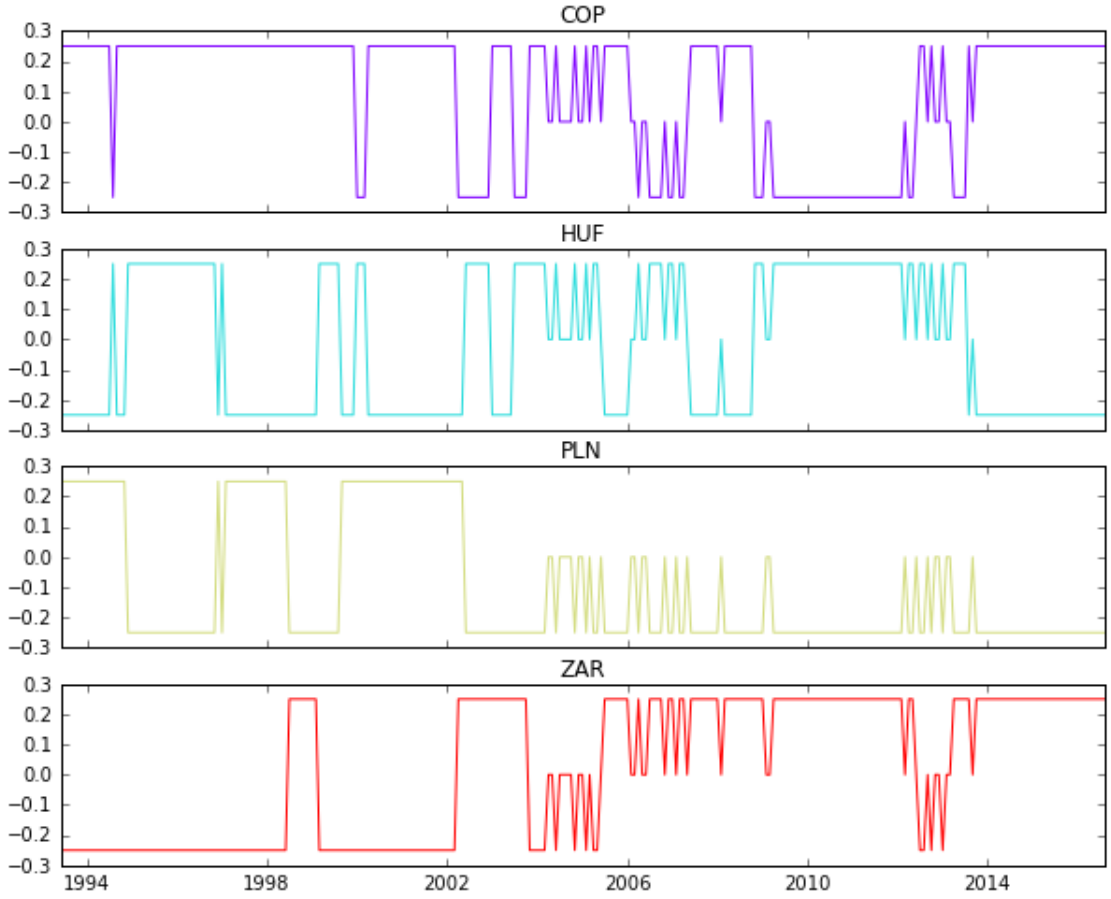

Figure 6: Currency-wise Positions in CARRY(2,2) EM Trade

3.5 Global Currencies Combining DM and EM

Observing the benefits from expanding the number of positions allowed, DM and EM portfolios are combined as a Global portfolio to test whether diversification across markets can provide additional reduction in volatility and drawdown. Figure 7 shows that indeed, there is some improvement, accordingly, the CARRY(2,2) strategy gives better Sharpe ratio (0.61) compared the original EM portfolios. Admittedly, the improvement is marginal however, the strategy tend to heavily allocate to the EM currencies as they typically have higher interest rates and the overall performance suffers from the big drawdowns in the EM universe around the financial crisis and stayed flat after that.

In the next two chapters, we will explore two new indicators (Currency Turbulence Index and Financial Stress Index) to reflect the market-wise stress levels. We hope these measure helps to explain the negative returns from the carry trade portfolio and shed lights on how more robust portfolio can be constructed.

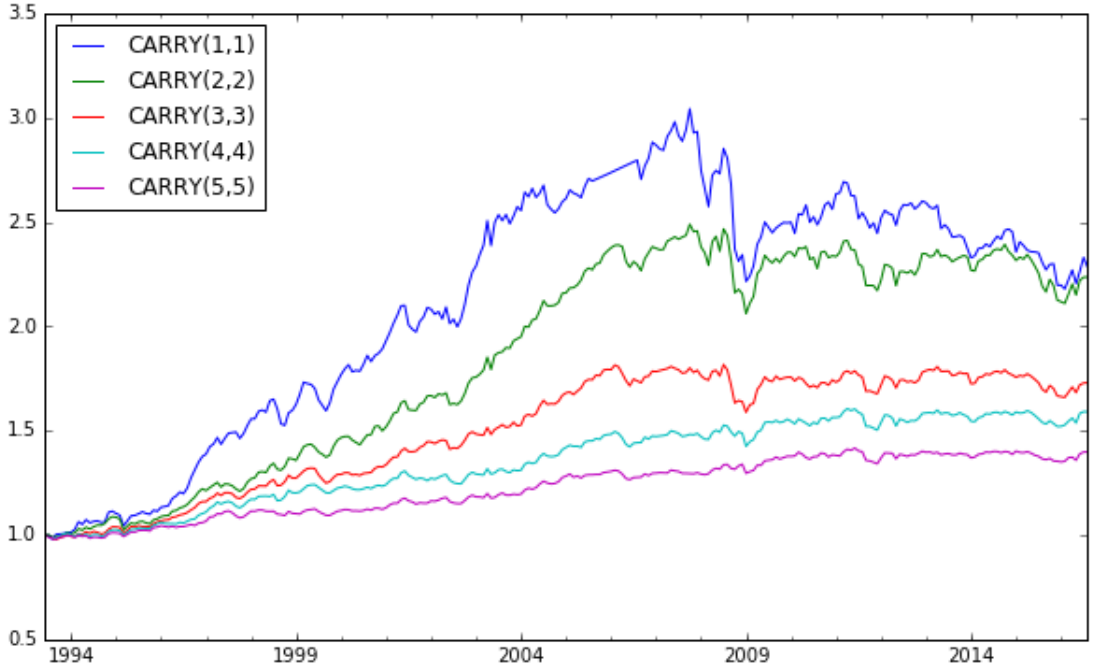

Figure 7: Cumulative Return of Carry Trade in Global Currencies

	Ann_Ret	Ann_Vol	Sharpe	MaxDD	DD_Start	DD_End	Var(95)	ES(95)	TR(95)
CARRY(1,1)	3.83	7.35	0.48	-30.43	2007-10-01	2016-02-01	12.19	17.49	6.68
CARRY(2,2)	3.63	5.64	0.61	-18.04	2007-10-01	2009-01-01	9.61	13.12	3.80
CARRY(3,3)	2.45	4.21	0.56	-13.17	2008-07-01	2009-01-01	6.15	9.75	3.12
CARRY(4,4)	2.06	3.55	0.56	-6.74	2008-07-01	2009-01-01	4.62	7.53	2.81
CARRY(5,5)	1.48	2.79	0.52	-5.38	2011-06-01	2011-12-01	3.95	5.80	2.18

Table 4: Performance Summary of 13-Currency DM-EM Hybrid Portfolio

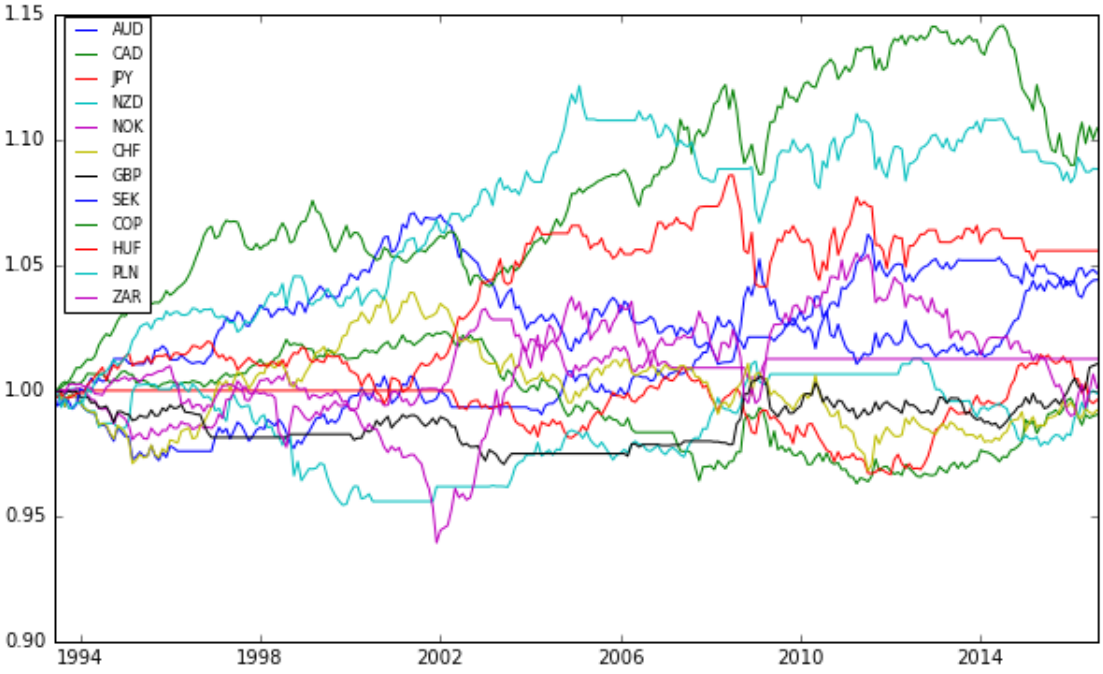

Figure 8: Currency-wise Cumulative Return of Carry Trade in Global Currencies

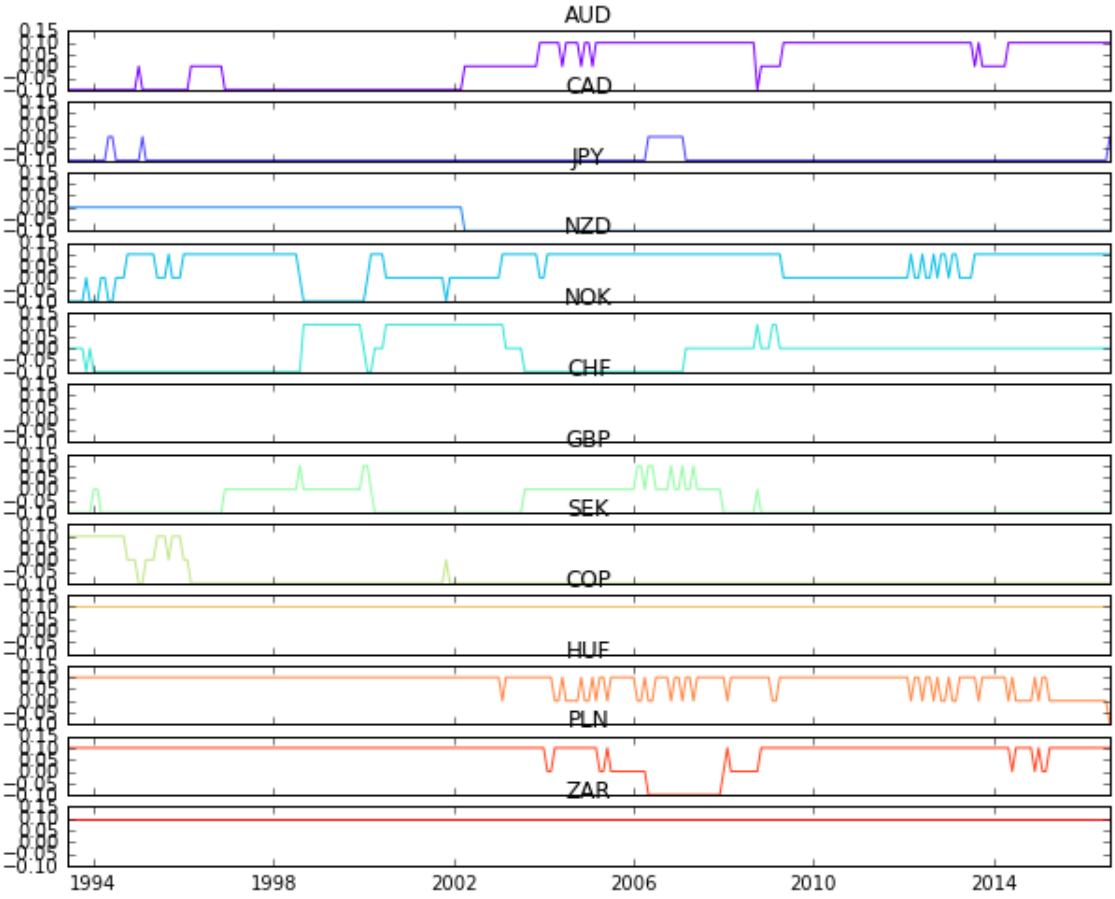

Figure 9: Currency-wise Positions in CARRY(5,5) EM Trade

4 Turbulence Index

We form the hypothesis that drawdown can be mitigated by reducing trading of carry strategy during stressful and unusual episodes. Such episodes can be driven by sentiments, fundamentals or macro events. To facilitate the identification of such periods, we utilize the concept of Turbulence Index (TI) proposed by (2010, Mark Kritzman)[1], which is a measure of financial unusualness:

$$\text{Turbelence Index} = (y - \bar{y})^T \Sigma^{-1} (y - \bar{y})$$

Where y is vector of p asset returns, $\bar{y}$ is the sample mean of asset returns and Σ is the sample exponentially weighted covariance matrix:

$$\Sigma_{ik} = \frac{\sum_{J=0}^{J} \cdot [r_i(t-j) - \bar{r_i}] \cdot [r_k(t-j) - \bar{r_k}]}{\sum_{j=0}^{J} (\frac{1}{2})^{\frac{j}{24}}}$$

This measure can be further decomposed into two orthogonal components: correlation surprise and volatility surprise. The volatility surprise is computed by assuming zero correlation among risky assets, thus turning the covariance matrix into a diagonal matrix.

$$\text{Volatility Surprise} = (y - \bar{y})^T D^{-1} (y - \bar{y})$$

And the correlation surprise is computed as the ratio defined below:

$$\text{Correation Surprise} = \frac{\text{Turbelence Index}}{\text{Volatility Surprise}}$$

4.1 Currency Turbulence Index

We construct a Turbulence Index based on a basket of risky assets. Specifically, we find that TI constructed from volatile currencies are more predictive empirically.The currencies returns used in this construction are AUD, NZD, NOK, COP,

HUF, PLN and ZAR, and the lookback window used is 1.5 years. The TI readings since 1997 are shown in Figure 10 below, and we notice that the start of financial crisis is associated with a spike in volatility.

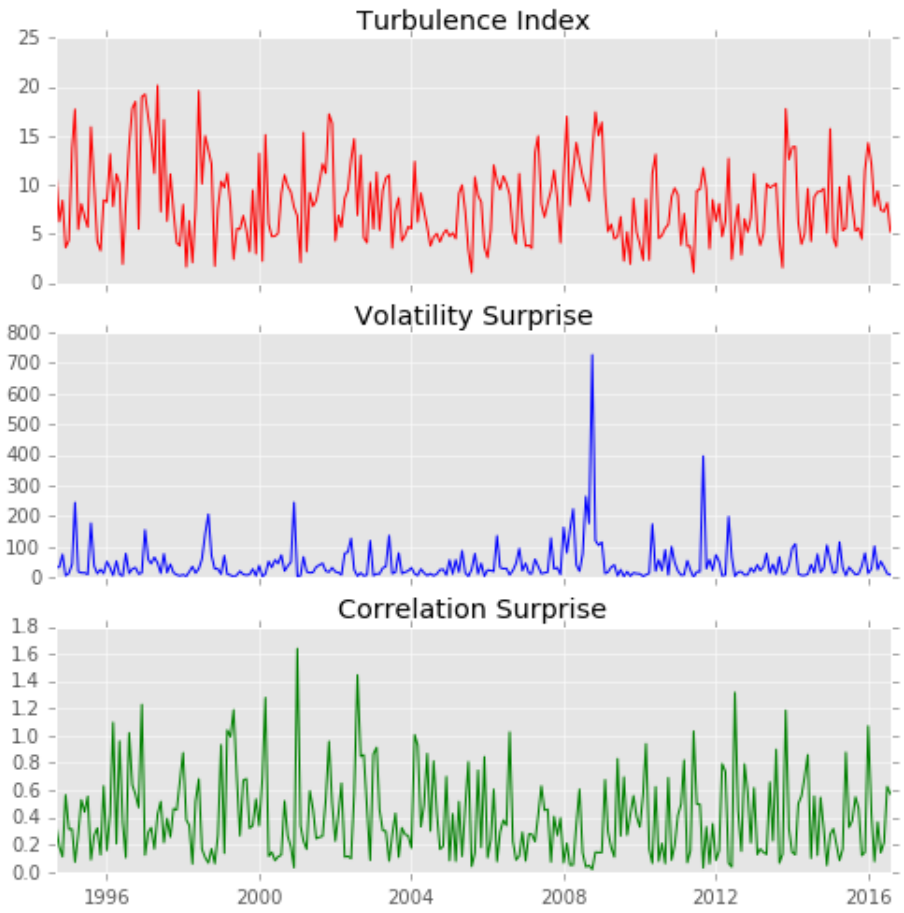

Figure 10: Currency Turbulence Index Constructed from Volatile Currencies

4.2 Regression Analysis

In order to examine the predictive power of currency TI, we regress the one-month forward return of the carry portfolio[1] on the current one-month change in TI readings. Consistent with the intuition, the regression has significantly negative t-stats (-3.08), indicating that potential losses can be avoided by skipping trading carry signals when positive spikes in TI reading is observed.

[1] We used a portfolio that is equally weighted on DM and EM carry strategies.

Dep. Variable:	EW	**R-squared:**	0.035
Model:	OLS	**Adj. R-squared:**	0.031
Method:	Least Squares	**F-statistic:**	9.480
Date:	Fri, 07 Oct 2016	**Prob (F-statistic):**	0.00230
Time:	23:53:01	**Log-Likelihood:**	890.03
No. Observations:	262	**AIC:**	-1776.
Df Residuals:	260	**BIC:**	-1769.
Df Model:	1		

	coef	**std err**	**t**	**P>|t|**	**[95.0% Conf. Int.]**
const	0.0019	0.001	3.861	0.000	0.001 0.003
TI_Diff(1)	-0.0003	0.000	-3.079	0.002	-0.001 -0.000

Omnibus:	14.641	**Durbin-Watson:**	2.113
Prob(Omnibus):	0.001	**Jarque-Bera (JB):**	25.003
Skew:	0.322	**Prob(JB):**	3.72e-06
Kurtosis:	4.369	**Cond. No.**	4.97

Table 5: OLS Regression Results: one-month forward return on TI changes

5 FSI and Carry Trade

Financial Stress Index (FSI) is created by Melvin and Taylor (2009) using IMF variables (E.g. Bankbeta, TEDspread, Yieldslope, Marketreturn, Marketvol) to incorporate various measures of risk, volatility, and market returns.
To explore whether FSI is closely related to the carry trade performance, we choose the carry trade strategy monthly returns as the independent variable, monthly FSI information as the dependent variables. More specifically, we use three versions of dependent variable: EM, DM, Global; one version of FSI information (independent variable): recent two lags of FSI (as used by Melvin and Taylor in 2009).

Dep. Variable:	CARRY(2,2)	**R-squared:**	0.102
Model:	OLS	**Adj. R-squared:**	0.096
Method:	Least Squares	**F-statistic:**	15.27
Date:	Sat, 08 Oct 2016	**Prob (F-statistic):**	5.25e-07
Time:	16:28:38	**Log-Likelihood:**	742.76
No. Observations:	271	**AIC:**	-1480.
Df Residuals:	268	**BIC:**	-1469.
Df Model:	2		

	coef	**std err**	**t**	**P>|t|**	**[95.0% Conf. Int.]**
const	0.0030	0.001	3.150	0.002	0.001 0.005
STLFSI	-0.0194	0.004	-5.410	0.000	-0.026 -0.012
STLFSI(1)	0.0198	0.004	5.514	0.000	0.013 0.027

Omnibus:	26.296	**Durbin-Watson:**	2.056
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	49.458
Skew:	-0.533	**Prob(JB):**	1.82e-11
Kurtosis:	4.801	**Cond. No.**	7.35

Table 6: OLS Regression Results: Carry return on contemporary and lagged FSI Levels

The results above are mostly aligned with the results of Melvin and Taylor (2009). DM and EM returns and FSI variables do not have a significant relationship; while Global market has a statistical significant relationship between the current

and one-month lagged FSI and global carry returns. Note that the absolute value of the coefficients of the two lags are almost the same around 0.0195. The difference of FSI is significantly correlated with global returns with t-stats of -5.517. Therefore, the increase in FSI reading (increasing stress) is strongly linked with underperformance of global carry trades. However, FSI is only good at explaining the contemporary returns of carry strategy but not predicting the forward carry returns (consistent with Melvin's result). Empirically, the Currency turbulence index we developed delivers superior predictive power.

6 Building Optimal Portfolios

6.1 Correlation Analysis

We analyze the correlation among the DM, EM and Global carry portfolios. It is shown that the DM and EM portfolio are lowly correlated ($\rho = 0.0.03$), suggesting that diversification benefits can be exploited by proportionally combining these two portfolios. DM portfolio has a moderate correlation ($\rho = 0.16$) with the Global model, and the EM and global model are relatively highly correlated ($\rho = 0.58$)

	DM_CARRY(2,2)	EM_CARRY(2,2)	GLOBAL_CARRY(2,2)
DM_CARRY(2,2)	1.00	0.03	0.16
EM_CARRY(2,2)	0.03	1.00	0.58
GLOBAL_CARRY(2,2)	0.16	0.58	1.00

Table 7: Correlation Matrix among DM, EM and Global Carry Portfolios

6.2 Turbulence Resistant Portfolio

We start with an allocation strategy that equally weights on DM and EM carry portfolios. Given the low correlation, such setting reduced the drawndown significantly and all other performance metrics are enhanced. Next, we incorporate the currency Turbulence Index introduced in Chapter 4 as our strategy conditioner. Concretely, we track the one month change of the TI reading, and we strategically switch off the trading during periods of rising turbulence. Such a TI based binary switching scheme enhanced the performance metrics of all carry models[2] significantly, which also further smoothed out the performance of equally weighted DM and EM portfolios. The detailed performance metrics are shown in Table 8.

[2]All carry portfolio listed trades 2 long legs and 2 short legs to main market neutrality

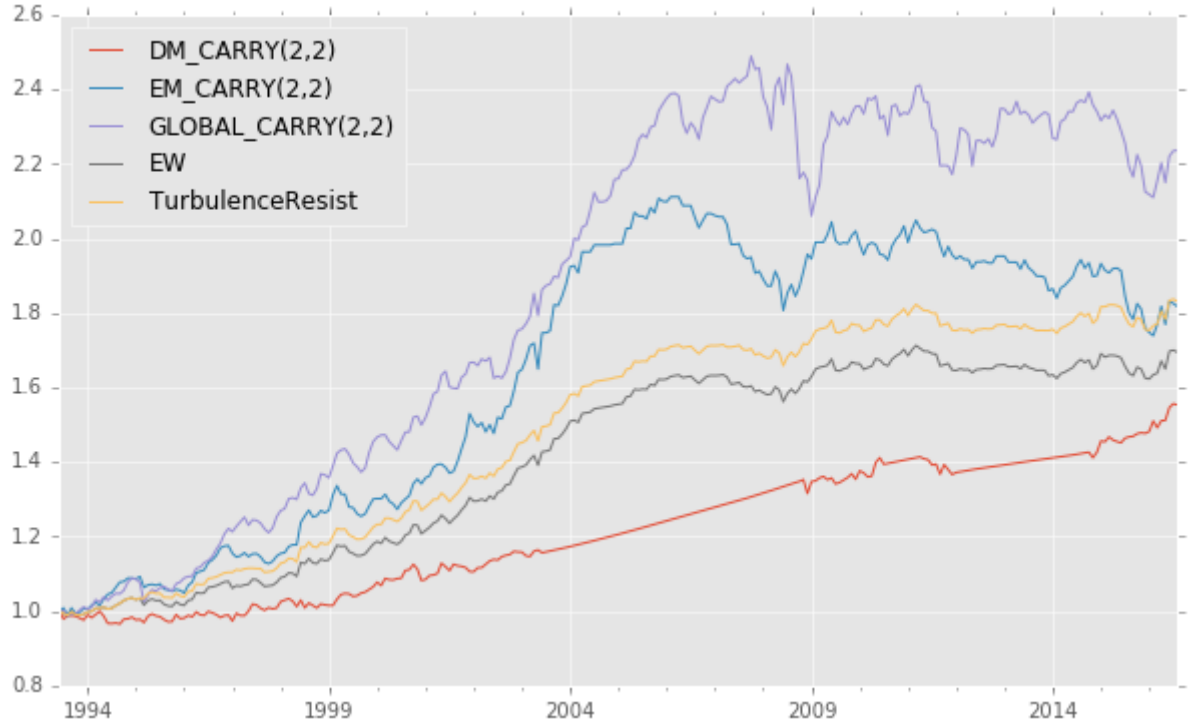

Figure 11: Currency Turbulence Index

	Ann_Ret	Ann_Vol	Sharpe	MaxDD	DD_Start	DD_End	Var(95)	ES(95)	TR(95)
DM_CARRY(2,2)	1.93	2.71	0.70	-3.89	2000-10-01	2000-12-01	3.68	5.88	1.93
EM_CARRY(2,2)	2.69	4.83	0.53	-18.46	2006-02-01	2016-02-01	6.55	9.48	2.42
GLOBAL_CARRY(2,2)	3.63	5.64	0.61	-18.04	2007-10-01	2009-01-01	9.61	13.12	3.80
EqualWeight	2.31	2.80	0.81	-5.28	2011-03-01	2016-01-01	3.67	5.48	0.98
TurbulenceResistant	2.64	2.68	0.97	-4.31	2011-03-01	2014-02-01	3.57	5.10	1.17

Table 8: Cumulative Returns of Optimal Carry Portfolios

7 Conclusion

Currency managers typically enter carry trades using a spectrum of currencies to improve the Sharpe ratio. We found that indeed diversification is effective in DM, EM and Global portfolios however, it is less effective in guarding potential big losses during market stressed period.

In this paper, we propose a turbulence resistant currency carry trading strategies. First, we introduced the portfolio construction methodology. Based on it, we implemented a market-neutral currency carry strategy trading developed market (DM) and emerging market (EM) currency basket. During the backtesting period (1994-2016), Carry generated significantly positive returns for both the DM and EM market (1.93% and 2.69% annually, respectively). However, EM currencies suffered from significant drawdowns (18.36%) since 2006 and has still not recovered since then. We then extended the same model to trade global currencies (13 currencies) covering both DM and EM. The global strategy return is dominated by EM currencies and thus is also associated with large drawdowns.

Having developed reasonable carry strategy for both DM and EM market, we then built optimal portfolios trading these two models. Noting that DM and EM carry strategies are historically lowly correlated (($\rho = 0.03$), we construct a portfolio that is equally weighted on EM and DM carry strategies to achieve diversification results. This strategy enhanced the Sharpe ratio significantly to 0.81 and reduced the drawdown incurred by the EM portfolio from 18.46% to 5.28%.

Following Melvin and Taylor's research in 2009, we identify that Financial Stress Index is significantly correlated with the returns generated from global currency trading strategy. This may provide an alternative way to improve our trading strategy.

In order to guard against sudden market dislocations associated with volatility or correlation surprise, we employ the Turbulence Index (TI) as a measure for financial unusualness in the currency market. Regression analysis shows that the one-month change in TI is significantly negatively correlated with the one-month forward carry return. Based on the TI reading, we develop a regime switching model that switches off the strategy conditional on positive TI spikes (i.e., turbulent regime). This scheme significantly improves each of the existing trading strategie [3] (i.e., DM_CARRY(2,2), EM_CARRY(2,2),etc.) and further improved the equally weighted portfolio to realize a Sharpe of 0.97, annul excess return of 2.64%, annual volatility of 2.68% and drawdown of 4.31%.

References

[1] Mark Kritzman and Yuanzhen Li. Skulls, financial turbulence, and risk management. *Financial Analysts Journal*, 66(5):30–41, 2010.

[2] Michael Melvin and Duncan Shand. When carry goes bad: The when, how, and why of currency carry unwinds.

[3] We also developed a regime switching model based on FSI reading, but TI-based model is more effective.