12 May 2015

Master Thesis

Risk Measures of Momentum Strategy And Linkage with Macroeconomic Factors

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1. Abstract

This paper identifies that momentum profits of U.S Equity is a compensation for taking additional downside risk, which is measured by previous period Skewness and previous period asymmetric beta ($\beta^{-} - \beta^{+}$) of (Ang, Chen and Xing 2006). Also, the paper finds a strong link between the two downside risk measures mentioned and several macroeconomic factors. This paper also extends the tests on three other asset classes: International Equity Indices, Currencies, and Commodities. The results show that there is a possibility that risk measures and macroeconomic factors behind momentum profit of different asset classes are different.

2. Acknowledgement

We would like to first express our sincere gratitude to our research supervisor Prof. LANGLOIS Hugues, who spent so much time and effort in this project to advice, comment, and supervise us during the whole research process, which ensures that our research is always on the right direction. In addition, we also thank Prof. LANGLOIS Hugues for sharing his data on momentum portfolio of International Equity Indices, Currencies, and Commodities, which is a crucial source for our analysis.

In addition, we would like to express our gratitude to HEC Library and Wharton Research Data Services for providing access to various database such as CRSP and DataStream, which is very important data source for our analysis. We thank for Kenneth R. French - Data Library for sharing the Momentum Portfolio and Fama French 3 Factor data of the US Equity market.

In the end, we would like to thank Prof. Jacques OLIVIER, Ms. Bernadette GEORGES, Ms. Roselyne MINET, and all the faculty of HEC Paris Grande Ecole and Master of Finance for this amazing program. The 3 years we spent in HEC is both

challenging and rewarding, which will for sure be the best memory of our lifetime.

3. Literature Review

Based on the modern portfolio theory by (Markowitz 1952) and (A. Roy 1952), (Treynor 1961), (Sharpe 1964), (Lintner 1965), and (Mossin 1966) introduce the Capital Asset Pricing Model (CAPM) independently, which becomes one of the leading asset pricing theories ever since. Under the assumptions of CAPM, investors will only hold the optimal portfolio, which is the market portfolio. The return of individual stocks will only be compensated for their exposure to systematic risk (beta) and should follow the Security Market Line (SML). The empirical test followed by (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973) with the well-known Fama-Macbeth Regression on the New York Stock Exchange(NYSE) common stocks confirms the CAPM theory and concludes that they do not find other risk measures, other than portfolio risk, that affect average returns systematically.

Some empirical evidence shows that there is some ‘abnormal return’ associated with specific type of stocks, which cannot be fully explained by CAPM. For instance, (Banz 1981) finds the ‘size effect’ in the NYSE common stocks that smaller stock generates higher risk adjusted return on average compared to larger stock. (Stattman 1980) and (Rosenberg, Reid and Lanstein 1985) find that the average return of U.S stocks is positively correlated to their book-to-market ratio, which is later known as the ‘value effect’. (Fama and French, The cross-section of expected stock returns 1992) confirm the strong power of size and book-to-market equity factor in explaining the stock return. In later research, (Fama and French, Common risk factors in the returns on stocks and bonds 1993) propose a three factor model named Fama–French three-factor model, which, on top of market beta, includes two additional factors – SMB (small market cap stock minus big market cap stock) and HML (high book to market ratio stock minus low book to market ratio stock).

Since then, numerous researches focus on finding additional risk factors. One of the most famous ones is the momentum effect firstly introduced by (Jegadeesh and Titman, Returns to buying winners and selling losers: Implications for stock market efficiency 1993) on U.S stock market. By buying the past winner stocks and selling the past loser stocks, the strategy generates significant excess return. Until today, momentum effect is one of the most heavily studied topics in Capital Market. (Asness, Liew and Stevens, Parallels between the cross-sectional predictability of stock and country returns 1997) discover that momentum effect exists across country equity indices. Besides, the phenomenon is also found in European stock market, proved in (Rouwenhorst, International momentum strategies 1998) and emerging stock markets, proved in (Rouwenhorst, Local return factors and turnover in emerging stock markets 1999). (Griffin, Ji and Martin, Global momentum strategies 2005) provide evidence that momentum is a global effect and exists in almost every stock market. In recent research, (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013) make an extensive analysis and find that the excess return related to momentum strategy can be find in various countries as well as various asset classes including equity, bonds, FX, commodities, etc. The pervasive excess return and high Sharpe ratio indicate that the traditional asset pricing models are not enough to explain the momentum effect.

While the effect is widely recognized, studied and applied by academia and asset managers, the drivers behind this phenomenon remain a big debate. Some theories link momentum effect to behavior reasons: (Daniel, Hirshleifer and Subrahmanyam, Investor psychology and security market under-and overreactions 1998) present a behavior model and link momentum effect to the under reaction and overreaction of investors. (Hong and Stein, A unified theory of underreaction, momentum trading, and overreaction in asset markets 1999) suggest that the effect is due to the inefficiency of the market. The information spreads slowly and the market underreacts to the information when the information comes out. Thus, the momentum traders can profit through trend following trades. Similar reasoning is proposed by (Hong, Lim and Stein, Bad news travels slowly: Size, analyst coverage, and the profitability of momentum strategies 2000). In 2001, (Jegadeesh and Titman, Profitability of momentum strategies: An evaluation of alternative explanations 2001) provide an out sample evidence of momentum effect and conclude that behavior theories are more promising in explaining the phenomenon. (Grinblatt and Han 2005) and (Frazzini 2006) present that the momentum effect is largely driven by disposition effect, which refers to the tendency for investors to sell too quickly the winner stocks and to keep too long the loser stocks.

Other theories mostly link this phenomenon to the additional risks in the portfolio: (Fama and French, Multifactor explanations of asset pricing anomalies 1996) test on market anomalies and find that momentum effect is strong throughout time and cannot be captured by their three factor model. (Carhart 1997) proposes to include momentum as a risk factor and updates the Fama-French three factor model to a four factor model, which improves the explaining power of the model. (Cochrane, Longstaff and Santa-Clara 2008) study a two tree model and indicate that momentum follows because the risk in the portfolio increases. (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013) present that momentum effect exists in different markets and asset classes. Besides, there is a high correlation between the momentum strategies in these markets and asset classes, which indicates that the cause for the effect might be common. Specifically, extensive researches have been performed to test different risk measures to explain the strategy. (Ang, Chen and Xing 2006) show that investors require higher return when bearing higher downside risk. (Lettau, Maggiori and Weber 2014) present that the downside risk CAPM can be applied to various asset classes: stock, currency, commodity and bond. However, neither paper specifically tests the downside risk related to momentum strategy. (Daniel and Moskowitz 2013) define the momentum crashes that the momentum strategy generally perform well but generate large negative return when market rebounds after large decline with high volatility. Besides, they show that momentum strategy is correlated but cannot be fully explained by volatility. (Dobrynskaya 2014) tests the two-beta CAPM model and shows that momentum strategy is subject to market downside risk.

Other researches are trying to find the link between the profit of momentum strategy and the macroeconomic variables. (Chordia and Shivakumar 2002) show that in the US stock market, the momentum profits can be predicted by macroeconomic variables (e.g. YLD, TERM, DEF, etc.) in some sub-periods under conditional test. However, (Griffin, Ji and Martin, Momentum Investing and Business Cycle Risk: Evidence from Pole to Pole 2003) find out that momentum profits among different countries cannot be distinguished by common macroeconomic variables and have weak co-movement among countries, which indicates the risk behind should be country specific. In addition, the authors also conclude that under unconditional test, the momentum profits cannot be explained by the macroeconomic factors introduced by (Chen, Roll and Ross, Economic Forces and the Stock Market 1986). In addition, they test the method used by (Chordia and Shivakumar 2002) on global portfolio but find out that the predictive power of conditional forecasting model with macroeconomic variables cannot be well identified outside US stock market. In the research by (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013), the authors used various macroeconomic variables to explain the momentum profits in both US and global markets across different asset classes and do not find a very strong link. They do find some significant variables such as DEF but with low R-square of around 6%.

In our paper, we start with U.S equity and test both the conventional risk measures such as market risk and volatility as well as downside risk measures such as Skewness and downside/upside market risk, which is a method proposed by (Ang, Chen and Xing 2006) and (Dobrynskaya 2014), on the momentum excess return. We find that downside risk measures are statistical significant in explaining momentum profits in both conditional and unconditional tests, and alpha is statistically insignificant after controlling some downside risk measures. In addition, we manage to link the macroeconomic variables with our risk measures which generates a relatively high R-square in both predictive and contemporaneous scenarios. We then extend the test on 3 additional asset classes: International Equity Indices, Currencies, and Commodities
For the section of measuring the downside risk of momentum strategy, our paper is

different from (Ang, Chen and Xing 2006) in the sense that we apply the two beta method and other downside risk measures specifically to explain the excess return of momentum strategy while in the former paper, the authors mainly focus on finding the excess premium for taking downside risk and use momentum only as a control variable. Also, our paper is different from (Dobrynskaya 2014) in the sense that we focus on the conditional test with time varying risk measures, which are captured from daily return. Besides, the method of constructing upside and downside beta is different as we apply same method as (Ang, Chen and Xing 2006) while (Dobrynskaya 2014) apply multiple regression to estimate asymmetric beta and downside beta at once.

The main contributions of our paper are as following: firstly, we manage to explain the excess momentum return of U.S equity with downside risk measures in both conditional and unconditional tests. Secondly, instead of trying to link the momentum excess return and macroeconomic variables, we manage to find a strong link between macroeconomic variables and downside risk measures of U.S equity momentum portfolio, which gives a much higher R-square. Thirdly, we also manage to have some findings in other asset classes.

The rest of the paper proceeds as following: Section 4 introduces the data source of our paper, including the momentum portfolio of different asset classes and macroeconomic variables. From the Section 5 to Section 7, we will focus our analysis on the US Equity market as it has the largest volume of data available to ensure reliable results. Section 5 shows the momentum effect and the performance of various risk measures in explaining momentum profit under unconditional test (non-time varying risk measures). Section 6 includes the performance of various risk measures in explaining momentum profit under conditional test (time varying risk measures). In section 7, we test the link between our key risk measures, which are identified from the Section 5 and Section 6, and various macroeconomic variables under different scenarios. In Section 8, we extend our tests from Section 5 to Section 7 to other asset classes including international equity index, currencies and commodities. We will make final conclusion on Section 9.

4. Data Source

This section introduces the data source of our paper, including the momentum portfolios and the macroeconomic variables.

For equity market, we test momentum portfolios on individual stocks in United States. We take the daily returns of the value-weighted 10 momentum portfolios provided by Kenneth R. French – Data Library[3] for our tests. The period we consider is 1964 January 2nd to 2014 December 31st, we didn't consider the period before 1964 mainly due to the quality and availability of daily asset returns and of the macroeconomic factors we will consider in our tests. According to the Data Library, the portfolios cover all the individual stocks of NYSE, AMEX and NASDAQ[4] and is constructed on daily basis.

For the momentum portfolios of International Equity Indices, Currencies, and Commodities, we directly get the daily returns from (Langlois 2013). According to the author: A. the International Equity Indices momentum portfolios consist of 16 developed countries/regions equity market indices from DataStream[5]. The 5 momentum portfolios returns are value weighted (lagged market value) and formed based on the 5 quantile of past 12 month returns. The returns are available from 01 February 1974 to 30 April 2013. B. For the currencies momentum portfolio, the author obtains from the DataStream spot rates and 1 month forward rates for currencies of 16 countries[6] (Expressed as USD per unit of foreign currency and from Barclay Bank

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[3] Kenneth R. French – Data Library: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

[4] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_10_port_form_pr_12_2_daily.html

[5] "Australia, Austria, Belgium, Canada, Denmark, France, Germany, Hong Kong, Ireland, Italy, Japan, Netherlands, Singapore, Switzerland, the United Kingdom, and the United States" as described in (Langlois 2013)

[6] "Belgium, France, Germany, Italy, and Netherlands (all replaced by the Euro starting in January 1999), Australia, Canada, Denmark, Hong Kong, Japan, New Zealand, Norway, Singapore, Sweden, Switzerland, and the United Kingdom" as described in (Langlois 2013)

International). The portfolios are equal weighted and formed based on the 5 quantile of previous month average forward discount. The returns are available from 01 November 1984 to 30 September 2013. C. For the commodities momentum portfolios, the author uses the composition of Goldman Sachs Commodity Index (GSCI) as commodity future sample. The 5 momentum portfolios returns are equal weighted and formed based on the 5 quantile of previous month basis. The returns are available from 02 January 1970 to 30 April 2013. For the detailed explanation of how the author constructs the momentum portfolios, please see the Appendix D of the original paper by (Langlois 2013).

Besides, for the section that studies the link between macroeconomic factors and risk measures, we include macroeconomic variables as follow:

- Recession: The factor recession is similar as in (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013). It is used to indicate the business cycle direction (whether the business cycle is going up or going down) rather than the magnitude of economy in U.S. We take the U.S Business Cycle peak and trough dates from National Bureau of Economic Research (NBER)[7]. If the business cycle goes from trough date to peak date (Expansion Period), we indicate the period with 1 and if the business cycle goes from peak to trough (Contraction Period), we indicate the period with 0. The period is between January 1964 and December 2014.

- Market Excess Return (US Equity) and Risk Free Rate: For the Market Excess Return, we use the differences between value weighted all U.S stock returns (listed in NYSE, AMEX, and NASDAQ) and the one month Treasury bill rate (as a proxy of risk free rates). Both Market excess return and the one month Treasury bill rate are taken from Fama/French 3 factors (Daily) returns provided by Kenneth R. French – Data Library[8].

[7] The National Bureau of Economic Research (NBER): http://www.nber.org/cycles.html

[8] Kenneth R. French – Data Library: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

The period is between January 1964 and December 2014.

- DEF: This factor is used as an indicator of default risk perceived by the market. The factor is calculated by the difference between the Yield of Corporate Bonds rated with Baa (lowest investment grade rating) and Yield of Corporate Bonds rated with Aaa (highest rating). The yields are taken from FRED, Federal Reserve Bank of St. Louis[9][10].The period is between January 1964 and December 2014.

- Inflation: For the inflation, we use CPI growth rates in the U.S as a proxy. We first take Consumer Price Index (CPI) for All Urban Consumers: All Items from FRED, Federal Reserve Bank of St. Louis[11]. Then we calculate the growth rates of CPI as proxy for inflation. The period is between December 1989 and December 2014.

- ADS: The factor Aruoba-Diebold-Scotti (ADS) business conditions index is used as a proxy for real business condition. The index is based on the work by (Aruoba, Diebold and Scotti 2009). We take the data from Federal Reserve Bank of Philadelphia[12]. The period is between December 1989 and December 2014.

- TERM: The factor TERM is used as proxy for term structure. The factor is calculated by the difference between 10-year Treasury Constant Maturity Rate (CMR) and 3-month Treasury Constant Maturity Rate. The data are taken from FRED, Federal

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[9] Board of Governors of the Federal Reserve System (US), Moody's Seasoned Baa Corporate Bond Yield© [DBAA], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/DBAA/, April 20, 2015.

[10] Board of Governors of the Federal Reserve System (US), Moody's Seasoned Aaa Corporate Bond Yield© [AAA], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/AAA/, April 21, 2015.

[11] US. Bureau of Labor Statistics, Consumer Price Index for All Urban Consumers: All Items [CPIAUCSL], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/CPIAUCSL/, April 20, 2015.

[12] ADS Business Conditions Index: http://www.philadelphiafed.org/research-and-data/real-time-center/business-conditions-index/

Reserve Bank of St. Louis[13][14]. The period is between January 1964 and December 2014.

- VIX: The factor CBOE Volatility Index: VIX© is used as proxy for market expectation of volatility in short term. We take the data from FRED, Federal Reserve Bank of St. Louis[15]. The period is between January 1964 and December 2014.

- TED Spread: The factor TED Spread is used as proxy for credit risk. The factor is calculated by the difference between interest rate of interbank loan and interest rate of short term government bond. The 3-month LIBOR and 3-month Treasury bill are taken from FRED, Federal Reserve Bank of St. Louis[16][17]. The period is between December 1989 and December 2014.

- Crude Oil Price: The factor Crude Oil Price in US is measured with West Texas Intermediate Cushing Crude Oil Spot Price as proxy. The data is taken from FRED, Federal Reserve Bank of St. Louis[18]. The period is between December 1989 and December 2014.

5. Momentum profits and non-time-varying risk measures

The data for momentum portfolio returns is taken from Kenneth R. French – Data

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[13] Board of Governors of the Federal Reserve System (US), 3-Month Treasury Constant Maturity Rate [DGS3MO], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/DGS3MO/, April 20, 2015.

[14] Board of Governors of the Federal Reserve System (US), 10-Year Treasury Constant Maturity Rate [DGS10], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/DGS10/, April 20, 2015.

[15] Chicago Board Options Exchange, CBOE Volatility Index: VIX© [VIXCLS], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/VIXCLS/, April 21, 2015.

[16] ICE Benchmark Administration Limited (IBA), 3-Month London Interbank Offered Rate (LIBOR), based on U.S. Dollar© [USD3MTD156N], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/USD3MTD156N/, April 21, 2015.

[17] Board of Governors of the Federal Reserve System (US), 3-Month Treasury Bill: Secondary Market Rate [DTB3], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/DTB3/, April 20, 2015.

[18] US. Energy Information Administration, Crude Oil Prices: West Texas Intermediate (WTI) - Cushing, Oklahoma [DCOILWTICO], retrieved from FRED, Federal Reserve Bank of St. Louis https://research.stlouisfed.org/fred2/series/DCOILWTICO/, April 21, 2015.

Library[19]. We use daily returns of the portfolios to ensure that we have sufficient data points to calculate our risk measures, and we use value weighted portfolios to minimize the size effect. According to the Data Library, the 10 portfolios are constructed at daily frequency. At each date t, NYSE stocks are ranked with past stock return from t-250 to t-22 (skip 1 month to avoid reversal effect) and the decile returns are used as breakpoints to construct 10 portfolios which cover the stocks of NYSE, AMEX and NASDAQ[20]. P1 represents the past loser portfolio and P10 represents the past winner portfolio. We take the period from 02 January 1964 to 31 December 2014, which covers 612 months (12 839 days) for our analysis.

To control the risk free rate variation, we consider all the return in this paper in excess term by deducting the risk free rate r_f. The daily excess return for portfolio i ($1 \le i \le 11$) at day t ($1 \le t \le 12\,839$) is denoted by $r_{i,t}^d$, and $r_{11,t}^d = r_{10,t}^d - r_{1,t}^d$ represents the momentum factor Winner minus Loser (WML) at day t. We calculate the excess holding period return (scaled to monthly return) of each portfolio throughout the whole period by compounding the daily excess return: $r_i = [\prod_1^{12\,839}(1 + r_{i,t}^d)]^{1/612}$.

The non-time-varying realized risk measures are calculated throughout the whole testing period based on each portfolio's daily excess return.

We use market beta in CAPM of (Sharpe 1964) and (Lintner 1965), but beta is calculated with excess market and excess portfolio returns, as a proxy of market risk exposure for each portfolio: $\beta_i = \frac{cov\left(r_i^d, r_m^d\right)}{var\left(r_m^d\right)}$.

To measure the asymmetric market risk, we apply the two beta method introduced by (Ang, Chen and Xing 2006) to calculate downside and upside beta for each portfolio.

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19 Kenneth R. French – Data Library: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

20 http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_10_port_form_pr_12_2_daily.html

The upside beta for portfolio i is calculated as: $\beta_i^+ = \frac{cov\left(r_i^d, r_m^d \middle| r_m^d > 0\right)}{var(r_m^d|r_m^d > 0)}$ and downside beta for portfolio i as: $\beta_i^- = \frac{cov\left(r_i^d, r_m^d \middle| r_m^d < 0\right)}{var(r_m^d|r_m^d < 0)}$. Both r_i^d and r_m^d are excess return. Within two beta method framework, the upside beta estimates the portfolio's sensitivity to market when market goes up (upside market risk) and downside beta estimates the portfolio's sensitivity to market when market goes down (downside market risk). As mentioned by (Ang, Chen and Xing 2006), the upside beta and downside beta are correlated by construction, so we also include the 3 additional risk measures as (Ang, Chen and Xing 2006) do in their paper: relative upside beta ($\beta_i^+ - \beta_i$), relative downside beta ($\beta_i^- - \beta_i$), and asymmetric beta ($\beta_i^- - \beta_i^+$). Besides downside beta β_i^-, relative downside beta ($\beta_i^- - \beta_i$), and asymmetric beta ($\beta_i^+ - \beta_i^-$), we also include Skewness as a proxy for the downside risk of each portfolio.

From Table 1 we find the monthly excess return from P1 to P10 increase almost monotonously (with exception P4 and P9). When we long P10 and Short P1, we can get a monthly excess return of 1.07% from 02 January 1964 to 31 December 2014, which is consistent with the original finding by (Jegadeesh and Titman, Returns to buying winners and selling losers: Implications for stock market efficiency 1993), even though we use the portfolio that is rebalanced at daily frequency.

The market beta β shows a smile trend from P1 to P10, which is not fully consistent with the increasing excess return from P1 to P10. In addition, the WML portfolio (long P10 and short P1) reports negative beta. The result confirms the finding originally by (Jegadeesh and Titman, Returns to buying winners and selling losers: Implications for stock market efficiency 1993), that the profitability of the momentum strategy is not due to the market risk.

For the asymmetric market risk measure, since β^+ and β^- are highly correlated with market beta β, to minimize the effect, we will focus more on the ($\beta^- - \beta^+$), ($\beta^- - \beta$), and ($\beta^+ - \beta$). The asymmetric beta ($\beta^- - \beta^+$) in table 1 is strictly increasing from P1 to P10 and highest for WML, which seems to be positive correlated with the return. On the other hand, the relative upside beta ($\beta^{+} - \beta$) is decreasing from P1 to P10, which is negatively related to market return. It indicates that the loser portfolio has higher upside gain after controlling the market risk, and the winner portfolio has lower upside gain. We believe the reason is similar as the findings by (Ang, Chen and Xing 2006) that if two stocks with all the other criteria the same, the stock with higher upside gain will have higher price, thus leading to a lower return. On the other hand, the relative downside beta ($\beta^{-} - \beta$) does not show a clear trend, especially from P3 to P10.

For the other risk measures, while the volatility and kurtosis do not follow a strong trend, we find the Skewness decreases from P1 to P10 and is the lowest for WML.

To see the detail of explanatory power of each variable on momentum returns, we make 2 types of cross sectional regression analysis on the excess return from P1 to P10 with non-time varying risk measures. We do not include the momentum factor WML since it is just a linear combination of P1 and P10.

The first is simple linear regression with the contemporaneous cross sectional data as in Table 1. We use the realized total return (scaled to monthly) of whole period as dependent variable, and use the risk measures in the table, which is calculated from the same period as dependent variable, as our independent variables.

The second is Fama-Macbeth Regression with the method from (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973). Instead of using the realized return of whole period, we calculate the monthly return by compounding daily return for each portfolio as our dependent variables. For the independent variables, we use the risk measures same as before, which is calculated from the whole period. We run the cross sectional regression on the return of each month with non-time varying risk measures to get intercept (alpha) and coefficient (premium) of each risk measures for each month. We perform t test on intercept and coefficient with 12 months lag Newey

West covariance matrix by (Newey and West 1987) to correct autocorrelation and heteroskedasticity.

Figure 1 plots the results from the simple liner regression with P1 to P10 as x axis. The figure compares the observed monthly excess return with fitted excess return according to various risk measures. We find the results are consistent with our observations from Table 1. The market beta β does not fit well as it has the lowest R square of 0.31 among all the risk measures. On the other hand, we find some other risk measures such as Skewness, Positive Beta, Relative Positive Beta, Relative Negative Beta and Asymmetric Beta, to fit much better and have a relatively high R square at least above 0.5.

The Table 2 is the output of the two types of regression. The results show that in both regressions, the market beta is not significant and even has a negative premium. However, the intercept (alpha) is significant in both regression and is quite high (1.45% and 1.91% of alpha per month). The result is again confirming the findings by (Jegadeesh and Titman, Returns to buying winners and selling losers: Implications for stock market efficiency 1993) and other researches which conclude that momentum return is not caused by its exposure to market risk.

Starting from (A. Roy 1952), numerous researches find out that investors care about the downside risk and upside risk differently. More precisely, as mentioned by (Ang, Chen and Xing 2006), investors require compensation for holding assets that is more sensitive to the market when the market goes down than that when the market goes up, as such asset will have lower payoff when the wealth of the investors is low.

The results in the table 2 seems to be consistent with the claim by (Ang, Chen and Xing 2006) in general. The Relative Upside Beta ($\beta^+ - \beta$) is significant in both cases with a negative risk premium. However, Relative Downside Beta ($\beta^- - \beta$) also shows a negative risk measure, which is contradicting to the findings from (Ang, Chen and Xing 2006). According to (Ang, Chen and Xing 2006), the downside market risk should be compensated by higher return. One explanation we can give is that looking at just one side of the risk (either upside or downside) is not sufficient, because an asset with high downside market risk maybe compensated by the fact that it has even higher upside market sensitivity. Another explanation could be that according to (Daniel and Moskowitz 2013), momentum returns suffer crash when the market rebound after huge decline with high volatility. Therefore, the return of momentum strategy is not driven only by its exposure to downside market risk but by its exposure to both downside and upside risk. The results of asymmetric beta ($\beta^{-} - \beta^{+}$) confirm our explanation above. It is significant in both regression, and has a positive premium. After controlling the asymmetric market risk, we only get alpha of 3.43% and 3.65% respectively (although still significant in both cases). It indicates that the momentum return can be at least partially explained by the premium of holding assets that have higher sensitivity to market when it goes down than when it goes up. As such, the strategy should perform poorly especially when the market rebounds along with high volatility, which is consistent with the finding of momentum crash by (Daniel and Moskowitz 2013). Therefore, the asymmetric beta ($\beta^{-} - \beta^{+}$) should be one of the major drivers of momentum returns.

For the risk measures that are related to the momentum portfolios themselves, we find that Skewness performs extremely well. It is significant with negative premium in both regressions, which indicates that momentum strategy is largely exposed as well as compensate by its negative Skewness of return. This is consistent with the finding by various researches such as (Daniel, Jagannathan and Kim, Tail risk in momentum strategy returns 2012), which concludes that momentum strategy has negative Skewness. In addition, after we control the Skewness, the alpha is no longer significant under Fama-Macbeth regression, and it is extremely low in simple regression (1.53%) even though it is still significant. For Kurtosis, it is also significant according to Table 2.

The Table 3 reports the results from same regressions as in Table 2 except we include the Beta as controlled variables. We find the results are similar as in Table 2, and when using Skewness, both controlled variable Beta and Alpha are not significant.

In conclusion, based on our test on momentum returns with non-time varying risk measures, we find out that the market risk indeed cannot explain the momentum returns, The 'abnormal return' of momentum strategy is a compensation partially for its exposure to asymmetric market risk – higher sensitivity to market when the market goes down than when it goes up. In addition, the momentum return itself has a negative Skewness payoff, and the 'abnormal return' is a compensation for such feature. It is important to note that although asymmetric market risk and Skewness are correlated (-86% from the data in Table 1), they still represent two dimensions of risk. The former one is linked to the market and the second one is the characteristic of the portfolios themselves. The negative Skewness of the portfolio returns does not necessarily indicate that portfolio has downside market risk.

6. Momentum profits and time-varying risk measures

Our test in previous section shows that several risk measures such as Skewness, Upside Beta, Relative Upside Beta, Relative Downside Beta, Asymmetric Beta, and Kurtosis are significant in explaining the momentum strategy. Among these risk measures, Skewness and Asymmetric Beta are both statistically significant and economically reasonable in explaining momentum effect.

However, by using non-time-varying risk measures for the whole period, we may average out and therefore miss some important information that is embedded into the time series. In addition, the test with non-time-varying risk measures only gives us a general picture, and we will not be able to see whether our risk measures affect our momentum returns contemporaneously or predictively. For these reasons, in this section, we will use time-varying risk measures to explain time-varying returns for momentum portfolios.

We use 2 types of time varying returns for momentum portfolios at monthly frequency. The first type is to test on return of month t denoted as $r_{i,t}^{M}$: return of portfolio i in month t. It is calculated by compounding the daily return of month t. The second type is to take average monthly return of the following 12 months noted as $r_{i,t}^{Y}$: return (next year) of portfolio i for month t. It is calculated by compounding the daily return of next 12 months from month t to t+11, and then scale to monthly. Therefore, for monthly return (next year), they are actually overlapping. For example, $r_{i,t}^{Y}$ and $r_{i,t+1}^{Y}$ has 11 months overlapping.

To calculate time varying risk measures, we use same formula as in the previous section to define each risk measure but on daily return over 12 months period (we do not use daily return over 1 month period as the number of data points is not enough to calculate time varying risk measures without noise). For example, $Skewness_{i,t}^{M}$ of portfolio i at month t is calculated from the daily return over the following 12 months from month t to t+11. Therefore, same as monthly return (next year), the results are actually calculated from overlapping returns. The risk measure at month t is contemporaneous to the monthly return (next year) at month t as they are both calculated from daily returns during month t to t+11.

We make cross sectional regression for portfolio P1 to P10 for each month t. We use return as response variables and each risk measures as independent variables to get time series intercept (alpha) and coefficient (premium) of each risk measure for each month. We perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. By the time lag between response variable and independent variables, we divide our regression results into 4 scenarios.

Scenario 1: Contemporaneous period. In this scenario, we use our risk measures for month t (which is actually calculated from month t to t+11) to explain the monthly return (next year) at month t. In another word, we use the risk measures calculated from t to t+11 to explain the portfolio return of same period from t to t+11.

Scenario 2: Forward period. In this scenario, we use our risk measures for month t (which is actually calculated from month t to t+11) to explain the monthly return at month t. In another word, we use the forward risk measures calculated from t to t+11 to explain the portfolio return of month t.

Scenario 3: Predictive period. In this scenario, we use our risk measure for month t (which is actually calculated from month t to t+11) to explain the monthly return at month t+12. In another word, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12.

Scenario 4: Predictive 1 year period. In this scenario, we use our risk measure for month t (which is actually calculated from month t to t+11) to explain the monthly return (next year) at month t+12. In another word, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12 to t+23.

Table 4 shows the cross sectional regression results of scenario 1 and 2, and Table 5 shows the results of scenario 3 and 4. By comparing the results of 2 tables, we can find that there is no single risk measure significant in the table 4, and the result is much better in the table 5. In another word, the excess return of the momentum portfolio is not a compensation of the additional risk they take at same period or in the future, but rather a compensation for the additional risk that were taken in the past.

Our understanding about this seemingly unusual results is that momentum strategy is based on historically data (buy past winner and short past loser), when investors make their decision on their exposure to momentum strategy, they have little information about the 'real' future risk of each portfolio. In another word, historical information regarding the risk of each portfolio is more relevant. If a portfolio shows additional risk compared to others, investors will need to price a discount in order to hold them, and thus require a higher return for compensation.

The Table 5 reports the results that using past risk measures to predict future return for momentum portfolios. We find the results are consistent with our finding in the previous section. The market risk β is not significant in both scenarios, which again confirms that momentum profit is not correlated with excess market risk.

On the asymmetric market risk part, although β^{+} or/and β^{-} is significant, we only focus on the asymmetric beta $\beta^{-} - \beta^{+}$ for the reason we mentioned before that since β^{+} and β^{-} are correlated, we cannot consider them separately. The Table 5 shows that asymmetric market risk $\beta^{-} - \beta^{+}$ is significant in both scenarios. Besides, in the scenario of Predictive 1 year period, there is no alpha after we control the asymmetric risk. Therefore, we can conclude that the excess return of momentum portfolio is largely driven by its exposure to the asymmetric market risk in the past.

If we look at the risk measure related to character of the momentum portfolios themselves, we find the Skewness is again extremely significant according to Table 5 in both scenarios. Similarly as asymmetric beta, there's no significant alpha in both scenarios after we control this risk measure.

In addition, we also make a test with same regression as Table 4 and Table 5 but include Beta as control variable when we regress the excess returns of momentum portfolio on the risk Measures asymmetric Beta and Skewness. The results are reported in Table 6, which shows only one significant scenario: using Skewness in predictive 1 year period. The main explanation we give is that the data is much more stable when using 1 year return compared to 1 month return (so the predictive period is not significant). However, we believe that including Beta directly into the regression is not an ideal way of controlling market risk. The reason is that Beta is correlated with both Asymmetric Beta and Skewness. Thus, directly including it into the multiple regression with other risk measures will cause multicollinearity problem and may overstate or understate the importance of other risk measures. In addition, as the regression is based on small sample (10 observations per regression), including additional explanatory variable Beta in each regression may cause the model over fitted (too much explanatory variable compared to limited observations) and lose statistical power. Therefore, combined with the fact that Beta itself is not significant even in single regression as presented in Table 4 and Table 5, we will mainly consider the results of regression without controlling Beta.

In conclusion, the findings in the section somewhat confirm the results in previous section but give some additional information. Firstly, momentum profits is indeed a compensation for its excess exposure to asymmetric market risk as well as negative Skewness of its returns. Secondly, the compensation is based on the additional risk in its previous period rather contemporaneous period. Therefore, we will be able to predict momentum profit for next month or next year with asymmetric beta or Skewness calculated from past 12 month.

7. Regress momentum risk measures on macroeconomic variables

In order to better understand the cause behind momentum effect, we will study its link to some macroeconomic factors in this section. Previous researches such as (Chen, Roll and Ross, Economic Forces and the Stock Market 1986) mostly regress macroeconomic factors on momentum portfolios returns. In our paper, we make regression analysis with macroeconomic factors to explain momentum risk measures that we discovered in the previous sections, which we have proved to be the driver of momentum returns. The risk measures we consider are asymmetric beta $\beta^{-} - \beta^{+}$ and Skewness.

Regarding the selection of macroeconomic variables, there doesn't exist a well-recognized theory or model in explaining the momentum returns. In fact, as we have shown before, most of the researches on this topic fail to find a strong link between the two. However, it would be interesting to see if there is a relation between these macroeconomic variables which are initially tested on momentum portfolios returns with our momentum risk measures.

(Chordia and Shivakumar 2002) test the lagged macroeconomic factors on US equity momentum portfolios returns include the value-weighted market dividend yield, default spread, term spread, and yield on three-month T-bills; (Griffin, Ji and Martin, Momentum Investing and Business Cycle Risk: Evidence from Pole to Pole 2003) tested four factors including unexpected inflation, changes in expected inflation, term spread, and changes in industrial production, which were initially proposed by (Chen, Roll and Ross, Economic forces and the stock market 1986) to explain US stock market. (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013) test on US macroeconomic factors include long-run consumption growth, recession, GDP growth, US equity market excess return, term and default premium. Based on previous researches described above, the macroeconomic variables we consider are recession, default premium, inflation, ADS, oil spot price, TERM, TED spread, US stock market excess return and VIX.

Due to the data availability, we test on 2 different periods: whole period (from 1964/01 to 2014/12), during which only 5 variables are available; and sub-period (from 1989/12 to 2014/12), during which all the selected 9 variables are available. Besides, we also test to understand if the relation between macroeconomic variables and momentum risk measures is contemporaneous or predictive. Based on these 2 criteria, our tests are performed in four different scenarios:

Scenario 1: contemporaneous test within whole period. In this scenario, we use 5 macroeconomic variables, i.e. recession, default premium, inflation, ADS and US stock market excess return, calculated from month t to t+11 (take monthly average) to explain the risk measures calculated from month t to t+11.

Scenario 2: predictive test within whole period. In this scenario, we use 5 macroeconomic variables, i.e. recession, default premium, inflation, ADS and US stock market excess return, of month t-1 to explain the risk measures calculated from month t to t+11.

Scenario 3: contemporaneous test within sub-period. In this scenario, we use all the selected 9 macroeconomic variables calculated from month t to t+11 (take monthly average. For VIX and Oil price, we calculate the average first and then take log of the value) to explain the risk measures calculated from month t to t+11.

Scenario 4: predictive test within sub-period. In this scenario, we use all the selected 9 macroeconomic variables of month t-1 to explain the risk measures calculated from month t to t+11.

In order to avoid the multicollinearity, we test the correlation among the macroeconomic variables for each scenario. Table 7 shows that in scenario 1, ADS and recession has a high correlation of 0.81. Similarly in scenario 3, the correlation between ADS and recession is 0.89 and that between ADS and DEF is -0.83. Therefore, we decide to exclude ADS in our further analysis.

We first create a comparison test by identifying the relationship between macroeconomic variables and the risk measures of 10 Portfolio: P1 to P10. Since the risk measures of P1 to P10 have both cross sectional effect from P1 to P10 and time series effect from month Jan 1964 to Dec 2014, in order to minimize the cross sectional effect, we use fixed effect panel regression with risk measure from P1 to P10 as response variables and all the economic variables as explanatory variables for each of the 4 scenarios. It is important to note that the fixed effect panel regression will subtract the trend of risk measures caused by momentum effect (effect from P1 to P10) in the regression, therefore, the idea of this test is to identify the general link between risk measures of a portfolio that is not expose to momentum effect and macroeconomic variables.

Figure 2 shows the fixed effect from panel regression by using asymmetric beta $\beta^{-} - \beta^{+}$ or Skewness as the dependent variable for 4 scenarios (we should note that the fixed effect is embedded with the intercept of the panel regression). We can find that the in general, asymmetric beta $\beta^{-} - \beta^{+}$ shows an increasing trend in all 4 scenarios, which indicates that P10 is exposed to larger asymmetric market risk compared to P1. On the other hand, Skewness shows a decreasing trend in all 4 scenarios, so the return of P10 has smaller Skewness compared to the return of P1. Therefore, the findings is consistent with our results in previous sections. What we also can find from the Figure 2 is that Skewness shows a much stronger and more stable trend in all 4 scenarios compared to asymmetric beta $\beta^{-} - \beta^{+}$. The latter shows a smile trend in the sub period from 1989/12 to 2014/12. Therefore, Skewness maybe a more stable and persistent risk measure for momentum returns.

Then we select among the macroeconomic variables to get a ‘best fit model’ by using stepwise regression with object of minimize Akaike information criterion (AIC) proposed by (Akaike 1974). As the fixed effect panel regression is the same as non-intercept multiple linear regression with momentum effect P1 to P10 as factor variable, to simplify the process, we make stepwise regression upon the multiple linear regression, and then use the selected variables in our panel regression to get our ‘best fit model’.

By construction (12 month overlapping period to calculate risk measures), our panel data is serial (time series) correlated, which is confirmed by the Breusch–Godfrey test of (Breusch, Testing for autocorrelation in dynamic linear models, Australian Economic Papers 1978) and (Godfrey 1978). In addition, based on the Breusch-

Pagan's LM test by (Breusch and Pagan, The Lagrange multiplier test and its applications to model specification in econometrics 1980), our panel data is also cross sectional correlated. Therefore, the reported t statistics are corrected by the robust covariance matrix for both serial and cross sectional correlation. The method for robust covariance matrix is proposed by (Driscoll and Kraay 1998), and the small sample correction method is HC4 proposed by (Cribari-Neto 2004)[21].

After we get the link between the risk measures of portfolio without momentum effect and macroeconomic variables, we also test the link between macroeconomic variables and the risk measures of momentum portfolio. We regress the risk measures of WML portfolio (P10 minus P1) on macroeconomic variables, by using OLS (multiple linear regression). We select the macroeconomic variables for the ‘best fit model’ by using stepwise regression with object of minimize Akaike information criterion (AIC) proposed by (Akaike 1974). As mentioned before, the risk measures of WML portfolio is serial correlated by construction In order to correct to autocorrelation and heteroskedasticity, the reported t statistics on intercept and coefficient are corrected by robust covariance matrix with 12 months lag Newey West method proposed by (Newey and West 1987).

By comparing the results of previous two tests, we will not only be able to find the link between risk measures of momentum strategy and macroeconomic variables, but also able to find out whether such link is specific to momentum strategy. In another word, we will be able to find out whether the macroeconomic variables impact the risk measures of momentum strategy differently from its impact on a generally portfolio (not exposed to momentum effect).

[21] The choice of small sample correction method is arbitrary. We use HC4 because it will take the leverage point into account according to its inventor (Cribari-Neto 2004). We also compare the results with using original HC0 by (White 1980) as well as HC3 by (MacKinnon and White 1985), and the impact on the final result is very small and can be negligible.

Table 8 reports the panel regression result of ‘all variables model’ and ‘best fit model’ of the 4 scenarios we described at the start of the section. The response variables are the asymmetric beta ($\beta^- - \beta^+$) of P1 to P10. The Table 9 reports the multiple linear regression results of ‘all variables model’ and ‘best fit model’ with asymmetric beta ($\beta^- - \beta^+$) of WML portfolio as response variable of the 4 scenarios.

In general, by comparing the results from Table 8 and Table 9, we can see that the R square in Table 8 is lower than that in Table 9, which indicates that the explanatory power on the asymmetric beta $\beta^- - \beta^+$ of momentum portfolio WML is stronger than that on portfolio without momentum effect. In addition, the R square is higher for sub period than for whole period. There might be two possible reasons for this. Firstly, the 4 variables we add for sub period have additional explanatory power on asymmetric beta. Second, the macroeconomic drivers of the risk measures are not consistent throughout time. Another takeaway is that the R square is higher for contemporaneous test than for predictive test, which is opposite to the relationship between momentum return and risk measures. In another word, the macroeconomic variables have limited predictive power in explaining asymmetric beta.

For details, in Table 8 contemporaneous scenario (portfolio without momentum effect), inflation is the only macroeconomic variable significant in both whole period and sub period tests. Nevertheless, the sign of the coefficient is opposite, which indicates that the impact of these variables on asymmetric beta is time varying. Recession is significant for the whole period but not significant in the sub period, which also indicates that the effect is time varying. The positive sign of Recession coefficient within whole period shows that the asymmetric beta is higher when business cycle goes up. Log of VIX, TED and Log of oil price are all significant within sub period, the negative sign of coefficients shows that when volatility, credit spread, or oil price is high, the asymmetric beta gets lower.

The results in the Table 8 predictive scenario is entirely different compared to the contemporaneous test. DEF is significant within whole period with a negative sign. Thus, when default risk is higher, the asymmetric beta gets lower. Recession is significant within sub period but with a negative sign, which is the opposite than in our previous findings in contemporaneous whole period test. As mentioned, one explanation can be time varying impact of this variables. TERM is significant within sub period with a positive sign, meaning when the difference between long term interest rate and short term interest rate is high, the asymmetric beta is high.

When we look at the Table 9, in which we use same macroeconomic variables to explain the asymmetric beta of momentum portfolio WML, we find the results are quite different. The model fits better in terms of R square but with less significant variables. In contemporaneous test, Inflation and log of oil price are significant but with opposite sign for coefficients (both are positive in here) than in Table 8, which indicates that these two macroeconomic variables have opposite impact on the asymmetric beta ($\beta^{-} - \beta^{+}$) of momentum portfolio and portfolio without momentum effect. For the momentum portfolio, a high inflation and high oil price will contribute to high asymmetric beta.

In conclusion, there is indeed a correlation between macroeconomic variables and risk measure asymmetric beta ($\beta^{-} - \beta^{+}$) of our momentum portfolio: Firstly, in some scenario (e.g. contemporaneous sub period) we can get a high R square (i.e. 37%). In addition, the macroeconomic variables have a higher explanatory power to the asymmetric beta of momentum portfolio compared to a portfolio without momentum effect. However, the performance of individual variables in the different scenarios vary a lot and we cannot find a variable that is consistent across all scenarios. Considering that the contemporaneous test on momentum effect has the highest R square, we can say a high oil price and high inflation (both are high when economy is relatively good) will contribute to a high asymmetric beta at same period.

Table 10 and Table 11 report the results that we made the same test but on the risk measure Skewness. If we compare them with the Table 8 and Table 9, we will find that the models fit much better here with a higher R square in all the scenarios. Therefore, Skewness of portfolio, regardless of non-momentum or momentum, has a much stronger link to macroeconomic variables compared to asymmetric beta.

By comparing Table 10 and Table 11, we can find the same pattern as the comparison between Table 8 and Table 9: it is easier to observe the explanatory power of the macroeconomic variables on the Skewness of momentum portfolio WML than that on portfolio without momentum effect. Also, R square is higher for sub period than for whole period as well as higher for contemporaneous test than for predictive test.

For details, in Table 10 (portfolio without momentum effect) contemporaneous scenario, Recession is significant in whole period but not in sub period, and the negative sign indicates that when business cycle goes up, the Skewness goes down. Market Excess Return, DEF, Inflation, and TED is significant in sub period. The coefficients indicates that when market return or TED spread (Credit Risk) go up, the Skewness goes down and when the inflation and DEF (default risk) go up, the Skewness goes up.

In Table 10 predictive scenario, we still find that recession is significant with same positive sign within the whole period. In addition, Market Excess Return is significant in whole period with negative sign for coefficient (market goes up, the Skewness goes down). For the sub period, the inflation is still significant with the same sign. In addition, the log of VIX is also significant but with positive sign, which indicates that a high volatility will contribute to high Skewness.

If we look at Table 11 (portfolio with momentum effect), the models fit much better with a relative good R square in all scenarios. In the contemporaneous period, recession is significant in both whole and sub period. The positive sign indicates that the Skewness is higher when the business cycle goes up, which is the opposite as for the non-momentum effect portfolio. The inflation is significant within sub period but not within whole period, the negative sign indicates when inflation is high the Skewness is low.

In the contemporaneous period, Recession is still significant with same sign for both whole period and sub period. In the sub period, DEF, Inflation, TERM and TED are also significant. The coefficients indicates that when TERM spread (difference between long term and short term interest rate) goes up, the Skewness goes up. When TED spread (Credit Risk), inflation, or DEF (default risk) go up, the Skewness goes down.

In conclusion, we find a stronger link between macroeconomic variables and risk measure Skewness than asymmetric beta ($\beta^{-} - \beta^{+}$) of our momentum portfolio. The R square is quite satisfactory and can reach 44% in contemporaneous sub period scenario. Likewise, the macroeconomic variables has a higher explanatory power to the Skewness of momentum portfolio compared to a portfolio without momentum effect. We find some macroeconomic variables are significant in explaining the Skewness of momentum portfolio according to different scenario, but most importantly, we find the variable recession has a consistent and significant impact on the Skewness of momentum portfolio across all scenarios. That is to say that when the business cycle goes up, the Skewness goes up, and this correlation is time consistent.

This section shows several findings: First, the 2 keys risk measures we identified in the previous section for the momentum strategy, asymmetric beta ($\beta^{-} - \beta^{+}$) and Skewness, can be linked to macroeconomic factors. Second, there is a stronger link between macroeconomic factors and momentum portfolio than non-momentum portfolio. Third, the impact of macroeconomic factors on the risk measures are higher in same period (contemporaneous) than with 1 month lag (predictive). Fourth, the impact of macroeconomic factors are higher for Skewness than for asymmetric beta ($\beta^{-} - \beta^{+}$), and the R square for Skewness is quite high (44% and 37%) in contemporaneous sub period scenario. Sixth, for Skewness, the impact of variable recession is significant and time consistent, so we can conclude when the business cycle goes up, the Skewness goes up at both same period or with 1 month lag. For asymmetric beta ($\beta^- - \beta^+$), we are not able to find a variable that is so consistent over different scenarios, but if we only consider the scenario with highest R Square, we can say a high oil price and high inflation will contribute to a high asymmetric beta at same period.

8. Momentum Risk on other asset classes

By using U.S equity market as example, we have proved through section 5 to section 7 that momentum profit is largely due to its additional downside risk which can be measured by asymmetric beta ($\beta^- - \beta^+$) or Skewness. In this section, we will extend our research on 3 additional asset classes: International Equity Indices, Commodities, and Currency. For these three asset classes, the five portfolios which are sorted by momentum effect is taken from (Langlois 2013). The portfolios are daily excess return and rebalanced at monthly frequency. Section 4 of this paper gives additional information regarding the construction of the momentum portfolios of these three asset classes, and the complete description of the construction method can be find in the original paper by (Langlois 2013). For the market portfolio and risk free rate, we still use value weighted U.S equity return and one month Treasury bill return as proxy.

The momentum portfolio returns of International Equity Indices are available from 01/02/1974 to 30/04/2013, that of commodities are from 01/02/1970 to 30/04/2013, and that of Currencies are from 01/11/1984 to 30/09/2013. All returns of the 3 asset classes are excess returns on the risk free rate.

8.1 Momentum profits and non-time-varying risk measures – Other asset classes

We will start with the tests of Section 5 on the three additional asset classes. Table 12 reports the descriptive statistics of the momentum portfolios on the three asset classes. We can find that indeed the momentum effect exists in all the three asset classes but the magnitude is smaller than that of U.S equity. By longing the winner portfolio and shorting the loser portfolio, the International equity index can generate around 0.32% per month, Currencies can generate 0.18% per month, and commodity can generate 0.99% per month. This results is consistent with findings from various researches such as (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013) and (Langlois 2013) that momentum effect exists not just in the U.S equity market.

For the various risk measures, we can see Market Beta still do not show increasing trend from P1 to P5, and is at lowest level for WML, which are consistent with the results of test on U.S equity. Therefore, for these 3 asset classes, the momentum profit is not a compensation for market risk β. For the other risk measures, we also find similar patterns as in U.S equity. In general, for all the 3 asset classes, the relative upside beta ($\beta^{+} - \beta$) is decreasing from P1 to P5, the relative downside beta ($\beta^{-} - \beta$) and asymmetric beta ($\beta^{-} - \beta^{+}$) are increasing from P1 to P5, and Skewness is also decreasing from P1 to P5. All these results are similar as that in U.S Equity and may indicate the momentum profit is a compensation for downside risk in all the asset classes discussed. What need to be noticed is that the trend of risk measures are much less clear for currency, but this is actually consistent with the fact that the momentum effect itself is much less observable in Currency (only 0.18% profit per month).

The Table 13 reports the results of two types of regressions as before: Simple Linear Regression (both response and independent variables are non-time-varying) and

Fama-Macbeth Regression (time-varying response variable and non-time varying independent variable) from (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973). The results reported are quite different from that of U.S Equity. In general, the model are not fitted as good as that of U.S Equity, which may be due to the fact that only 5 observations are not stable enough for regression analysis. Therefore, the results are not as reliable as that of U.S Equity. We can also find that the most significant risk measures is different for different asset classes. For instance, by considering mainly the results of Fama-MacBeth Regression, we can see that volatility is the most significant risk measures for international equity indices with negative sign, which indicates that momentum portfolios actually have lower volatility. Volatility is also the most significant risk measures for currencies with positive sign, which indicates that momentum portfolios of currencies have higher volatility. The β^- is the most significant risk measures for commodities with positive sign, which indicates that for commodities, the momentum profits may be a compensation for high downside market risk. Both Skewness and asymmetric beta ($\beta^- - \beta^+$) are not significant on either type of regression for international equity indices, and are significant in at least one regression on currencies or commodities.

Table 14 reports the results of same regressions as in Table 13 but including Beta in each regression as proxy of controlling Market Risk. The results show that volatility is the most significant for both International Equity Indices and Currencies, and asymmetric beta ($\beta^- - \beta^+$) is the most significant for commodities. For the downside risk measures, Skewness is significant only in International Equity Indices, and asymmetric beta ($\beta^- - \beta^+$) is significant only in commodities. The results are quite different from that of Table 13. What need to be noticed is that compared to U.S equity, directly including Beta in regression as control variable is even less feasible here and the results are not as reliable as single regression. The reason is that for these 3 asset classes, we only have 5 observations. By including Beta in regression, we are using 2 independent variables to explain the 5 observations. In addition, as Beta is correlated with some other variables, directly including it in regression will worsen the multicollinearity problem, which can lead to extremely unreliable results in small sample regression.

In conclusion, this section shows that the momentum profits indeed exist in other asset classes, and the most significant risk measures under unconditional test (non-time varying risk measures) are volatility for international equity indices (negative correlation), volatility for currencies (positive correlation), and β^- for commodities (positive correlation). Skewness and asymmetric beta ($\beta^- - \beta^+$) are not significant for International Equity Indices but somewhat significant for currencies and commodities with same sign as that of U.S Equity. In general, the results are different from that of U.S Equity. The main reason could be either the risk driving the momentum profits are different for different asset classes or that since the three additional classes only have limited number of observation (5 quantile), the regression cannot generate stable and reliable results.

8.2 Momentum profits and time-varying risk measures – Other asset classes

We continue with conditional test in which we use time varying risk measures to explain time varying momentum returns as in Section 6 but on the 3 additional asset classes.

As mentioned in the Section 6, conditional test give us more reliable results as unconditional test may average out some important information between risk measures and momentum portfolio returns. Also, conditional test gives us additional information such as whether the risk measures drive the momentum return contemporaneously or predictively.

As in the Section 6, we make the same regression analysis (simple regression with time varying momentum portfolio returns on time varying risk measures) on the three additional asset classes with four different scenarios: Contemporaneous period, Forward period, Predictive period, and Predictive 1 year period.

Table 15 reports the regression results of International Equity Indices and Currencies and Table 16 reports the regression results of Commodities. We can find that the risk measures that are significant are quite different among different asset classes and are not consistent with the results of unconditional test.

From Table 15 we can see that for International Equity Indices, the variable Skewness is significant in 3 scenarios except Contemporaneous period. The sign of Skewness is negative in the Predictive period and Predictive 1 year period but positive in Forward period. We believe the positive sign in Forward period is a noisy result as it is not consistent with other test results such as unconditional test, and the negative sign in predictive period and predictive 1 year period is more economically meaningful and consistent with the results in U.S Equity. Therefore, based on the results of Predictive Period and Predictive 1 Year period, we can make the same conclusion as that of U.S Equity: the momentum profits of International Equity Indices maybe a compensation for its negative Skewness in previous period. In addition, the $Relative\ \beta^{+}$ is also significant in Predictive period with a negative premium as that of U.S equity. Asymmetric beta ($\beta^{-} - \beta^{+}$) is not significant in any scenario.

For Currencies, we can see β^{+} is significant in both Contemporaneous period and Forward period with negative premium. $Relative\ \beta^{-}$ is significant in Predictive 1 Year period with positive premium. Both Skewness and Asymmetric beta ($\beta^{-} - \beta^{+}$) are not significant in any scenario.

From Table 16 we can see that no risk measure, including Skewness and Asymmetric beta ($\beta^{-} - \beta^{+}$), is significant for commodities.

The Table 17 reports the additional regression analysis on the risk measures that we have identified as significant from Table 15 and Table 16. We control the variable beta by directly including it into the regression. However, as discussed before, the model do not give reliable result as we are using 2 explanatory variables to fit only 5 observations. The results in Table 17 can only be used as reference and do not make much statistical sense.

To conclude, firstly, we find that the results in conditional test is highly different from that in unconditional test. Especially, we find that some risk measures are significant in conditional test but not in unconditional test, which is quite unusual. We believe some of the significant variables should be just noisy results due to the small sample observations. Therefore, the results from other asset classes are much less reliable than that of U.S Equity and need to be interpreted with great cautions. Secondly, if we put aside small sample problem, we can see that the risk that drives the momentum profits seems to be not exactly the same for different asset classes. Same as U.S Equity, negative Skewness in previous period seems a major driver for the momentum profit in International Equity Indices (lower $Relative\ \beta^{+}$ in previous year seems also like a driver). For currencies, the lower β^{+} in Forward and Contemporaneous period and higher $Relative\ \beta^{-}$ in previous period seem to be the driver of momentum profit. We do not find any risk driver for momentum profits of commodities. Again, the results may be hard to interpret due to the noise caused by small sample and we cannot make firm conclusion as that of U.S Equity regarding the specific risks that drive momentum profits.

8.3 Regress momentum risk measures on macroeconomic variables – Other asset classes

In Section 8.3, we find out that the risk measures that drive the momentum profits of other asset classes seems not the same as that of U.S Equity. If we put aside the possibility of noisy results caused by small sample, we can see Skewness and $Relative\ \beta^{+}$ are significant risk measures for International Equity Indices in some scenarios, β^{+} and $Relative\ \beta^{-}$ are significant risk measures for currencies in some scenarios, and no risk measure is significant for commodities.

In this section, we will try to link the significant risk measures we identified in previous section of different asset classes to macroeconomic factors as we did in Section 7. We use the same method as before but we directly regress the risk measures of WML of different asset classes on the macroeconomic factors (we do not compare the results with panel regression in here). We use the same 4 scenarios as in Section 7 depending on the time lag between response variables and independent variables as well as data availability. The 4 scenarios are as following:
Scenario 1: contemporaneous test within whole period. Scenario 2: predictive test within whole period. Scenario 3: contemporaneous test within sub-period. Scenario 4: predictive test within sub-period.

The Table 18 reports the results of International Equity Indices and Table 19 reports the results of Currencies. We can see from the adjusted R^2 in the 2 tables that the model fits much worse compared to that of U.S equity. In general, the model of Sub period fits better than that of whole period and the model of contemporaneous period fits better than that of predictive period, which is the same trend as that of U.S Equity.

From the Table 18, which reports the results of International Equity Indices, we find that in general, the models fit better for $Relative\ \beta^{+}$ than for Skewness based on the adjusted R^2. For Skewness: Recession is significant in contemporaneous test within sub-period scenario with a negative sign. It indicates that Skewness is lower when business cycle goes up. Inflation is significant in predictive test within sub-period scenario with positive sign. It indicates that Skewness is higher when inflation is high. Both of this findings are opposite to those of U.S Equity. For $Relative\ \beta^{+}$: Recession is also significant with negative sign in both contemporaneous test within sub-period scenario and predictive test within sub-period scenario. It indicates that $Relative\ \beta^{+}$ is lower when business cycle goes up. Market Return is significant with negative sign in both predictive test within whole period scenario and predictive test within sub-period scenario. It indicates that $Relative\ \beta^{+}$ is lower when market return is higher. DEF is significant with positive sign in contemporaneous test within sub-period scenario. It indicates that when default risk is higher the $Relative\ \beta^{+}$ is higher.

The Table 19 reports the results of Currencies. For β^{+}: TED is significant with negative sign in predictive test within sub-period scenario. It indicates that when credit spread is higher, the β^{+} is smaller. For $Relative\ \beta^{-}$: Market Return is significant with negative sign in contemporaneous test within sub-period scenario. It indicates that when Market Return is higher, the $Relative\ \beta^{-}$ is smaller. The DEF is significant with negative sign in contemporaneous test within sub-period scenario. It indicates that when Default risk is higher, the $Relative\ \beta^{-}$ is smaller. TED is significant with negative sign in predictive test within sub-period scenario. It indicates that when credit spread is higher, the $Relative\ \beta^{-}$ is smaller.

In conclusion, we can indeed identify some links between the risk measures of momentum portfolio for other asset classes and the macroeconomic factors, but the results is more chaotic and less consistent compared to that of U.S Equity. We cannot find a common macroeconomic factor that contributes similarly to all the risk measures of all the asset classes discussed. For example, even though Recession is significant for both U.S Equity and International Equity Indices, but the sign the opposite, which indicates that the contribution is opposite. The results shows that not only the risk measures that drive the momentum profits for different asset classes may be different, but also the contribution of macroeconomic variables to the risk measures of the momentum profits of different asset classes may be different.

9. Conclusion

This paper contributes to the current risk based theories for the momentum strategy profits. We start with the momentum portfolios of basic asset class U.S Equity as it has the largest sample base. Through both unconditional and conditional test, we find that the momentum profit of U.S Equity is a just compensation for additional downside risks, which are measured by Asymmetric beta ($\beta^- - \beta^+$) of (Ang, Chen and Xing 2006) and Skewness, such strategy expose to. In addition, we find the momentum profits is a compensation for its downside risk takes in previous period not contemporaneous period, and therefore, we can actually predict the profit of momentum strategy based on its previous risk measures.

Taking U.S Equity as example, we also find a strong link between the major downside risk measures Skewness and Asymmetric beta ($\beta^- - \beta^+$) and macroeconomic factors. Such link is stronger in contemporaneous test than with lags. Based on the test, we can conclude that for Skewness, when the business cycle goes up, the Skewness goes up. For asymmetric beta ($\beta^- - \beta^+$), a high oil price and high inflation will contribute to a high asymmetric beta at same period.

We extend the same tests on the three additional asset classes: International Equity Indices, Currencies, and Commodities. We confirm that indeed the momentum profits also exist in the 3 additional asset classes, which is consistent with the findings by (Asness, Moskowitz and Pedersen, Value and momentum everywhere 2013), (Langlois 2013), and so on. However, the risk measures that drive such profits are quite different from those of U.S Equity (Skewness and $Relative\ \beta^+$ are the drivers for International Equitu Indices, and β^+ and $Relative\ \beta^-$ are the drivers for currencies). Due to the fact that for the three additional asset classes, the sample is relative small, we cannot conclude based on the results whether it is true that risk measures behind the momentum profit of different asset classes are different or the difference is just a noisy results caused by small sample problem. We also find some link between the risk measures of the three additional asset classes and macroeconomic factors, which is still quite different from the results of U.S Equity. Due to the same small sample problem, we are not able to make firm conclusion like we did for the U.S Equity about the specific macroeconomic factor that contribute to risk measures. However, based on the tests on the other asset classes, there is a high possibility that the risk measures and macroeconomic factors behind momentum profit for different asset classes are different.

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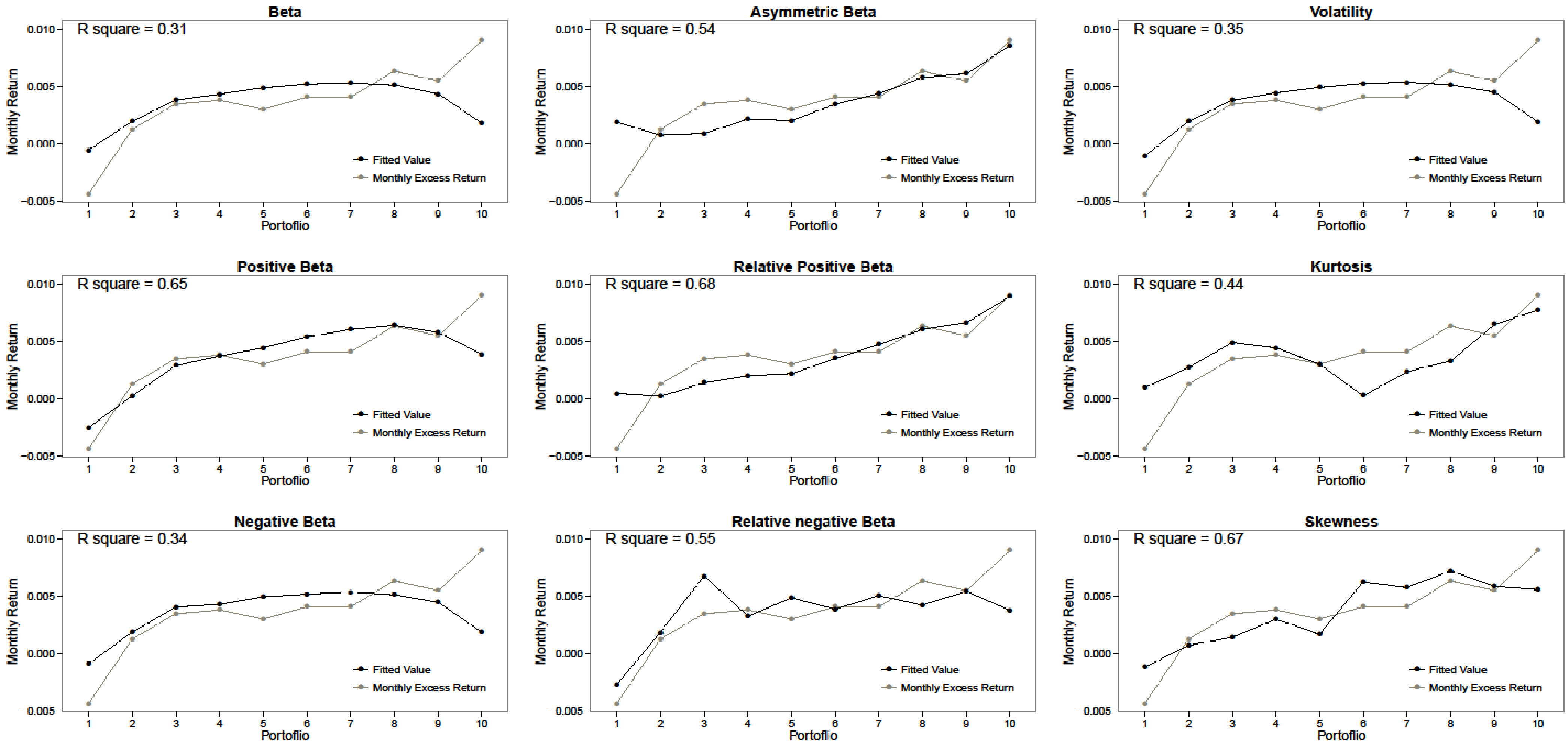
Table 1
Descriptive statistics for momentum portfolios

Portfolio	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	WML
Average Monthly Return	-0.44%	0.13%	0.35%	0.38%	0.30%	0.41%	0.41%	0.63%	0.55%	0.90%	1.07%
β	1.31	1.14	1.02	0.98	0.95	0.92	0.92	0.93	0.98	1.15	-0.16
β +	1.41	1.25	1.09	1.04	1.00	0.94	0.91	0.89	0.92	1.03	-0.37
β -	1.34	1.15	1.00	0.99	0.94	0.92	0.91	0.93	0.97	1.15	-0.19
Asymmetric β	-0.06	-0.09	-0.09	-0.06	-0.06	-0.02	0.00	0.04	0.05	0.12	0.18
Relative β +	0.10	0.11	0.07	0.06	0.05	0.02	-0.01	-0.05	-0.06	-0.12	-0.22
Relative β -	0.03	0.01	-0.02	0.00	-0.01	0.00	-0.01	0.00	-0.01	0.00	-0.03
Volatility	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Skewness	0.42	0.16	0.07	-0.15	0.03	-0.58	-0.52	-0.71	-0.53	-0.49	-1.17
Kurtosis	25.32	21.95	17.77	18.67	21.34	26.59	22.60	20.78	14.73	12.34	27.54

This table reports the descriptive statistics for 10 value weighted portfolios sorted by momentum, which is calculated from the daily excess return of momentum 10 portfolios provided by Kenneth R. French – Data Library for the period from 02 January 1964 to 31 December 2014. P10 represents the past winner portfolio and P1 represents the past loser portfolio. WML is calculated by P10 minus P1. The monthly excess return is compounded from daily excess return throughout the whole period and then scaled to monthly.
$\beta^+, \beta^-, Relative\ \beta^+, Relative\ \beta^-, asymmetric\ \beta\ (\beta^- - \beta^+)$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. β^+ measures the upside market risk and is calculated as $\beta_i^+ = \frac{cov(r_i^d, r_m^d | r_m^d > 0)}{var(r_m^d | r_m^d > 0)}$. β^- measures the downside market risk and is calculated as $\beta_i^- = \frac{cov(r_i^d, r_m^d | r_m^d < 0)}{var(r_m^d | r_m^d < 0)}$. $Relative\ \beta^+$ is calculated by $(\beta_i^+ - \beta_i)$, $Relative\ \beta^-$ is calculated by $(\beta_i^- - \beta_i)$, and $asymmetric\ \beta$ is calculated by $\beta_i^- - \beta_i^+$. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return: $\beta_i = \frac{cov(r_i^d, r_m^d)}{var(r_m^d)}$.

Figure 1: Simple linear regression on realized return with realized risk measures



This figures compare our realized returns with fitted returns from cross sectional regression with various risk measures on the period from 02 January 1964 to 31 December 2014. The dependent variable is the total realized return of portfolio P1 to P10 calculated from the whole period and scaled to monthly. The independent variables are the various risk measures of each portfolio calculated from the same period.

For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return

Table 2

Simple Linear Regression and Fama-MacBeth Regression

	Fama-MacBeth			Simple Linear Regression		
	Intercept	Risk Premium	Average R square	Intercept	Risk Premium	Average R square
β	0.0145	-0.0091	0.2678	0.0191	-0.0150	0.3064
	[2.88]	[-1.54]		[2.3]	[-1.88]	
β +	0.0185	-0.0127	0.3401	0.0215	-0.0171	0.6499
	[3.91]	[-2.39]		[4.58]	[-3.85]	
β -	0.0144	-0.0090	0.2715	0.0186	-0.0145	0.3386
	[3.11]	[-1.64]		[2.49]	[-2.02]	
Asymmetric β	0.0057	0.0343	0.3603	0.0042	0.0365	0.5369
	[2.87]	[3.07]		[5.14]	[3.05]	
Relative β +	0.0058	-0.0352	0.3812	0.0043	-0.0388	0.6842
	[2.91]	[-3.14]		[6.33]	[-4.16]	
Relative β -	0.0053	-0.1376	0.2440	0.0038	-0.1859	0.5463
	[2.6]	[-2.57]		[4.75]	[-3.1]	
Volatility	0.0125	-0.6426	0.2750	0.0153	-1.0218	0.3536
	[3.6]	[-1.68]		[2.7]	[-2.09]	
Skewness	0.0038	-0.0060	0.3369	0.0019	-0.0074	0.6656
	[1.61]	[-2.76]		[2.37]	[-3.99]	
Kurtosis	0.0152	-0.0005	0.1900	0.0142	-0.0005	0.4393
	[5.32]	[-4.06]		[3.29]	[-2.5]	

This table compares the results of two types of regressions. The first is simple linear regression with the contemporaneous cross sectional data of return and risk measures. We use the realized total return (scaled to monthly) of whole period from 02 January 1964 to 31 December 2014 of the portfolio P1 to P10 as dependent variable, and use the risk measures calculated from the same period as our independent variables.

The second is Fama-Macbeth Regression with the method from (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973). Instead of using the realized return of whole period, we calculate the monthly return by compounding daily return for each portfolio as our dependent variables. For the independent variables, we use the risk measures same as before, which is calculated from the whole period. We run the cross sectional regression on the return of each month with non-time varying risk measures to get intercept (alpha) and coefficient (premium) of each risk measures for each month. We perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix by (Newey and West 1987) to correct autocorrelation and heteroskedasticity.

For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return.

Table 3

Simple Linear Regression and Fama-MacBeth Regression (Controlled Beta)

	Fama-MacBeth				Simple Linear Regression			
	Intercept	Beta	Risk Premium	Avg adj R square	Intercept	Beta	Risk Premium	Avg adj R square
β +	0.0099	0.0293	-0.0333	0.5091	0.0143	0.0246	-0.0344	0.7507
	[2.16]	[2.68]	[-3.17]		[2.98]	[2.37]	[-4.25]	
β -	-0.0025	0.2014	-0.1938	0.1980	0.0010	0.2090	-0.2062	0.4215
	[-0.55]	[4.47]	[-4.42]		[0.08]	[1.81]	[-1.95]	
Asymmetric β	0.0129	-0.0069	0.0328	0.5018	0.0174	-0.0128	0.0337	0.6874
	[2.67]	[-1.23]	[3.06]		[3.31]	[-2.52]	[3.6]	
Relative β +	0.0099	-0.0040	-0.0333	0.5091	0.0143	-0.0098	-0.0344	0.7507
	[2.16]	[-0.75]	[-3.17]		[2.98]	[-2.1]	[-4.25]	
Relative β -	-0.0025	0.0076	-0.1938	0.1980	0.0010	0.0027	-0.2062	0.4215
	[-0.55]	[1.47]	[-4.42]		[0.08]	[0.24]	[-1.95]	
Volatility	-0.0663	0.2582	-17.0049	0.2704	-0.0675	0.2713	-18.2134	0.6832
	[-4.16]	[4.47]	[-4.38]		[-2.72]	[3.37]	[-3.56]	
Skewness	-0.0013	0.0047	-0.0071	0.4192	0.0029	-0.0009	-0.0072	0.5709
	[-0.24]	[0.83]	[-3.12]		[0.34]	[-0.12]	[-2.75]	
Kurtosis	0.0249	-0.0093	-0.0005	0.3048	0.0300	-0.0152	-0.0005	0.6856
	[3.71]	[-1.57]	[-4.05]		[4.94]	[-3.01]	[-3.59]	

This table compares the results of two types of regression. The first is simple linear regression with the contemporaneous cross sectional data of return and risk measures. We use the realized total return (scaled to monthly) of whole period from 02 January 1964 to 31 December 2014 of the portfolio P1 to P10 as dependent variable, and use the risk measures calculated from the same period as our independent variables. The second is Fama-Macbeth Regression with the method from (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973). Instead of using the realized return of whole period, we calculate the monthly return by compounding daily return for each portfolio as our dependent variables. For the independent variables, we use the risk measures same as before, which is calculated from the whole period. We run the cross sectional regression on the return of each month with non-time varying risk measures to get intercept (alpha) and coefficient (premium) of each risk measures for each month. We perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. For both regression, besides the risk measures we want to test, we also include β as controlled variable. For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. For controlled variable, the β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return.

Table 4

Cross Sectional Regression with time-varying risk measures (I)

	Contemporaneous Period			Forward Period		
	Intercept	Risk Premium	Average R square	Intercept	Risk Premium	Average R square
β	0.0022	0.0018	0.4114	0.0016	0.0038	0.3635
	[0.52]	[0.3]		[0.42]	[0.84]	
β +	0.0013	0.0028	0.3960	0.0012	0.0043	0.3450
	[0.35]	[0.54]		[0.29]	[0.93]	
β -	0.0039	-0.0001	0.3846	0.0072	-0.0019	0.3438
	[1.08]	[-0.02]		[2.37]	[-0.51]	
Asymmetric β	0.0037	0.0013	0.2404	0.0049	-0.0040	0.2374
	[1.01]	[0.3]		[2.45]	[-0.64]	
Relative β +	0.0039	-0.0018	0.2512	0.0051	0.0115	0.2220
	[1.1]	[-0.28]		[2.52]	[1.25]	
Relative β -	0.0037	0.0051	0.2538	0.0051	0.0030	0.2589
	[1.04]	[0.53]		[2.52]	[0.29]	
Volatility	0.0052	-0.0109	0.4035	0.0033	0.4740	0.3546
	[1.11]	[-0.02]		[0.99]	[1.17]	
Skewness	0.0030	-0.0038	0.2118	0.0043	-0.0021	0.2104
	[1.04]	[-1.96]		[1.97]	[-0.69]	
Kurtosis	0.0045	-0.0003	0.2212	0.0008	0.0011	0.2243
	[1.36]	[-0.35]		[0.15]	[0.85]	

This table reports the result of cross sectional regression for momentum portfolio P1 to P10 for each month t. We regress return of P1 to P10 by month on monthly time varying risk measures to get time series intercept (alpha) and coefficient (premium) of each risk measure monthly. Then we perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity.

In contemporaneous period, we use the risk measures calculated from t to t+11 to explain the portfolio return of same period from t to t+11. In forward period, we use the forward risk measures calculated from t to t+11 to explain the portfolio return of month t.

For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return.

Table 5
Cross Sectional Regression with time-varying risk measures (II)

	Predictive period			Predictive 1 year period		
	Intercept	Risk Premium	Average R square	Intercept	Risk Premium	Average R square
β	-0.0031	0.0081	0.3431	-0.0041	0.0077	0.3464
	[-0.69]	[1.78]		[-0.77]	[1.44]	
β +	-0.0057	0.0110	0.3308	-0.0052	0.0090	0.3312
	[-1.37]	[2.56]		[-1.29]	[2.25]	
β -	-0.0049	0.0098	0.3260	-0.0035	0.0069	0.3297
	[-1.39]	[2.66]		[-0.71]	[1.53]	
Asymmetric β	0.0050	0.0114	0.2321	0.0034	0.0077	0.2430
	[2.42]	[2.46]		[0.87]	[2.05]	
Relative β +	0.0050	-0.0188	0.2239	0.0034	-0.0027	0.2343
	[2.44]	[-1.83]		[0.88]	[-0.37]	
Relative β -	0.0049	0.0078	0.2363	0.0034	0.0098	0.2473
	[2.4]	[0.74]		[0.88]	[0.84]	
Volatility	0.0002	0.4477	0.3374	0.0002	0.4367	0.3342
	[0.05]	[0.88]		[0.04]	[0.72]	
Skewness	0.0039	-0.0083	0.2087	0.0026	-0.0077	0.2278
	[1.55]	[-3.12]		[0.66]	[-3.88]	
Kurtosis	0.0088	-0.0015	0.2018	0.0038	-0.0004	0.2281
	[1.58]	[-1.14]		[0.87]	[-0.46]	

This table reports the result of cross sectional regression for momentum portfolio P1 to P10 for each month t. We regress return of P1 to P10 by month on monthly time varying risk measures to get time series intercept (alpha) and coefficient (premium) of each risk measure monthly. Then we perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity.

In predictive period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12. In predictive 1 year period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12 to t+23 (scaled to monthly).

For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return.

Table 6

Cross Sectional Regression with time-varying risk measures - Controlled Beta

	Contemporaneous Period				Forward Period			
	Intercept	Beta	Risk Premium	Avg adj R square	Intercept	Beta	Risk Premium	Avg adj R square
Asymmetric β	0.0016	0.0024	-0.0059	0.4229	-0.0007	0.0061	-0.0084	0.3669
	[0.33]	[0.38]	[-1.55]		[-0.17]	[1.33]	[-1.58]	
Skewness	0.0012	0.0025	0.0003	0.4315	-0.0003	0.0058	0.0020	0.3521
	[0.24]	[0.38]	[0.17]		[-0.08]	[1.22]	[0.75]	
	Predictive period				**Predictive 1 year period**			
	Intercept	Beta	Risk Premium	Avg adj R square	Intercept	Beta	Risk Premium	Avg adj R square
Asymmetric β	-0.0030	0.0081	0.0024	0.3449	-0.0021	0.0058	0.0025	0.3394
	[-0.66]	[1.69]	[0.53]		[-0.5]	[1.33]	[0.56]	
Skewness	-0.0048	0.0088	-0.0034	0.3184	-0.0037	0.0056	-0.0047	0.3478
	[-0.99]	[1.79]	[-1.36]		[-0.71]	[1]	[-2.37]	

This table reports the result of cross sectional regression for momentum portfolio P1 to P10 for each month t. We regress return of P1 to P10 by month on monthly time varying risk measures as well as controlled variable β to get time series intercept (alpha) and coefficient (premium) of each risk measure monthly as well as controlled variable β. Then we perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity.

In contemporaneous period, we use the risk measures and controlled variable β calculated from t to t+11 to explain the portfolio return of same period from t to t+11. In forward period, we use the forward risk measures and controlled variable β calculated from t to t+11 to explain the portfolio return of month t. In predictive period scenario, we use past risk measures and controlled variable β calculated from t to t+11 to explain the future portfolio return of month t+12. In predictive 1 year period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12 to t+23 (scaled to monthly).

For the risk measures, $asymmetric\ \beta\ (\beta^- - \beta^+)$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. For controlled variable, the β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return.

Table 7
Correlation Matrix of Macroeconomic variables

Contemporaneous whole period: 1964/01 to 2014/12

	Recession	Market Return	DEF	Inflation	ADS
Recession	1.00	0.48	-0.50	-0.24	0.81
Market Return		1.00	-0.02	-0.21	0.30
DEF			1.00	0.12	-0.55
Inflation				1.00	-0.08
ADS					1.00

Predictive whole period: 1964/01 to 2014/12

	Recession	Market Return	DEF	Inflation	ADS
Recession	1.00	0.15	-0.40	-0.14	0.69
Market Return		1.00	0.05	0.00	0.07
DEF			1.00	0.04	-0.48
Inflation				1.00	-0.02
ADS					1.00

Contemporaneous sub-period: 1989/12 to 2014/12

	Recession	Market Return	DEF	Inflation	ADS	TERM	Log (VIX)	TED	Log (oil price)
Recession	1.00	0.61	-0.65	0.21	0.89	0.00	-0.56	-0.63	-0.16
Market Return		1.00	-0.36	0.11	0.60	0.07	-0.42	-0.43	-0.06
DEF			1.00	-0.43	-0.83	0.30	0.63	0.30	0.45
Inflation				1.00	0.28	-0.25	-0.33	0.00	-0.16
ADS					1.00	-0.11	-0.56	-0.47	-0.32
TERM						1.00	-0.03	-0.47	0.15
Log (VIX)							1.00	0.43	0.05
TED								1.00	-0.04
Log (oil price)									1.00

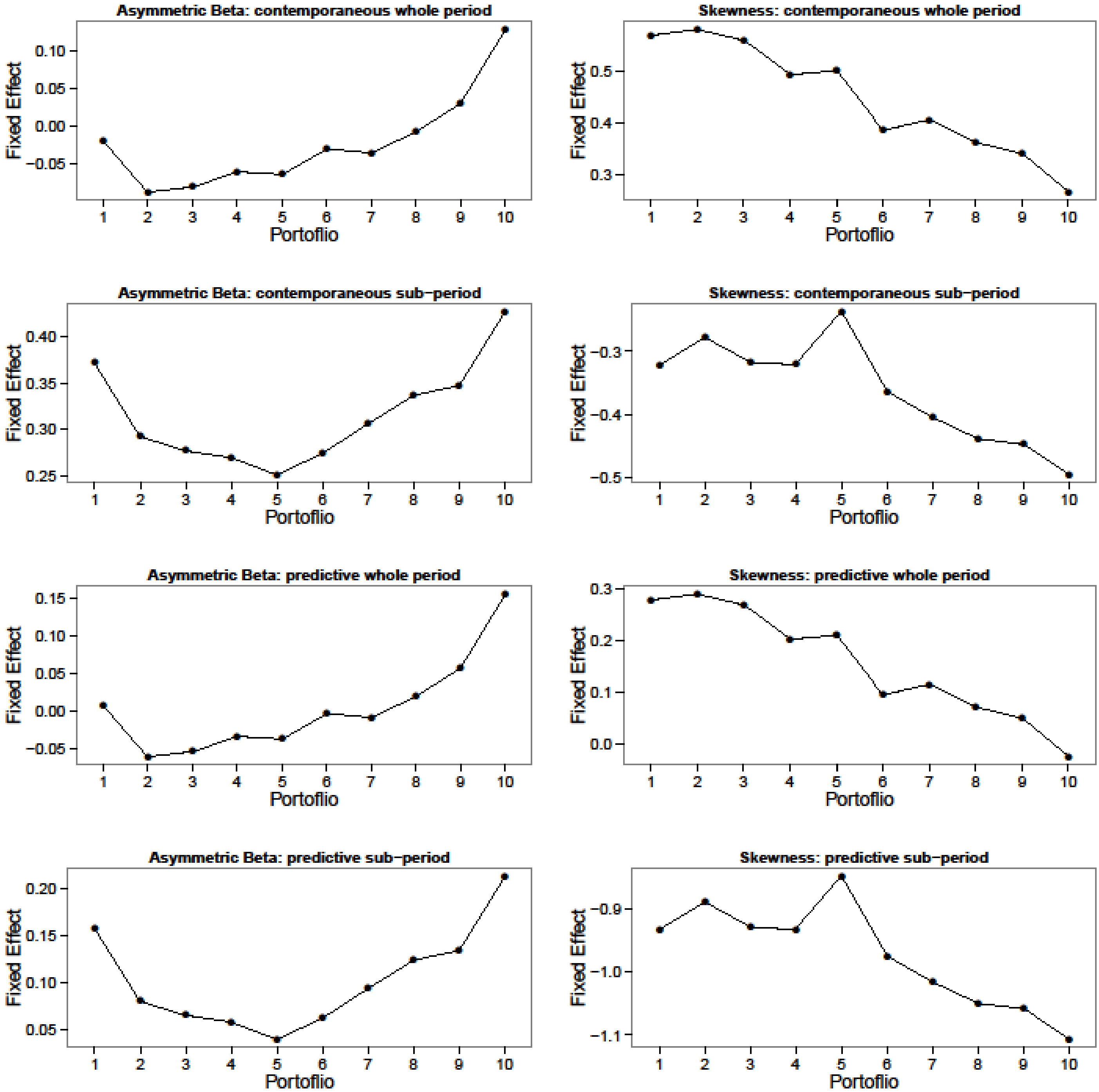
Predictive sub-period: 1989/12 to 2014/12

	Recession	Market Return	DEF	Inflation	ADS	TERM	Log (VIX)	TED	Log (oil price)
Recession	1.00	0.18	-0.54	0.07	0.75	-0.02	-0.45	-0.46	-0.14
Market Return		1.00	-0.09	0.17	0.18	0.03	-0.31	-0.22	-0.02
DEF			1.00	-0.18	-0.72	0.24	0.52	0.24	0.36
Inflation				1.00	0.10	-0.15	-0.19	-0.15	0.01
ADS					1.00	-0.07	-0.46	-0.40	-0.24
TERM						1.00	-0.02	-0.35	0.12
Log (VIX)							1.00	0.42	0.02
TED								1.00	-0.02
Log (oil price)									1.00

This table shows the correlation among the macroeconomic variables we selected. In contemporaneous whole period (1964/01 to 2014/12) and contemporaneous sub period (1989/12 to 2014/12), the macroeconomic variables is processed by taking monthly average from month t to t+11 as month t. So we actually test the correlation among macroeconomic variables with 12 month moving average. In predictive whole period (1964/01 to 2014/12) and predictive sub period (1989/12 to 2014/12), the macroeconomic variables at month t is the real monthly data of month t-1.

For VIX and Oil price at contemporaneous sub period (1989/12 to 2014/12), we calculate the average first and then take log of the value.

Figure 2: Plots of fixed effect from panel regression



This figure shows the fixed effect of our fixed effect panel regression when explain risk measures of Asymmetric Beta and Skewness. In contemporaneous whole period (1964/01 to 2014/12) and contemporaneous sub period (1989/12 to 2014/12), we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period (1964/01 to 2014/12) and predictive sub period (1989/12 to 2014/12), we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period (1989/12 to 2014/12), we calculate the average first and then take log of the value.

There are 4 macroeconomic variables in whole period as independent variables: Recession, DEF, Inflation and US stock market excess return. There are 4 additional macroeconomic variables in sub period as independent variables: Log of oil spot price, TERM, TED spread, Log of VIX

Risk measure $asymmetric\ (\beta^{-} - \beta^{+})$ is calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return.

Table 8
Panel Regression of Asymmetric Beta on Macroeconomic variables

	Contemporaneous within whole period: 1964/01-2014/12		Predictive within whole period: 1964/01-2014/12	
	All variables	Best Fit	All variables	Best Fit
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Recession	0.03	0.03	0.01	0.01
	[2.25]	[2.25]	[1.63]	[1.69]
Market Return	0.24	0.24	0.00	
	[0.99]	[0.99]	[0]	
DEF	-1.44	-1.44	-1.23	-1.23
	[-1.81]	[-1.81]	[-2.11]	[-2.11]
Inflation	4.40	4.40	1.05	1.05
	[2.93]	[2.93]	[1.75]	[1.76]
Adj. R square	0.01	0.01	0.00	0.00
f.stat	17.66	17.66	5.68	7.58

	Contemporaneous within sub-period: 1989/12-2014/12		Predictive within sub-period: 1989/12-2014/12	
	All variables	Best Fit	All variables	Best Fit
variable	Coefficient	Coefficient	Coefficient	Coefficient
Recession	-0.03		-0.03	-0.03
	[-1.21]		[-2.04]	[-2.11]
Market Return	0.27		-0.07	
	[0.81]		[-1.3]	
DEF	2.15	3.31	-1.67	-1.75
	[1.26]	[1.82]	[-1.63]	[-1.77]
Inflation	-14.39	-14.36	-0.64	
	[-3.12]	[-2.99]	[-0.84]	
TERM	0.11		1.15	1.19
	[0.31]		[3.64]	[3.68]
Log (VIX)	-0.14	-0.15	-0.04	-0.03
	[-3.24]	[-3.55]	[-1.25]	[-1.1]
TED	-0.05	-0.04	-0.02	-0.02
	[-2.46]	[-3.51]	[-1.47]	[-1.33]
Log (oil price)	-0.05	-0.05	-0.02	-0.01
	[-4.28]	[-4.53]	[-1.09]	[-1.06]
Adj. R square	0.04	0.04	0.02	0.02
f.stat	14.11	21.91	7.78	10.08

This table reports results of our fixed effect panel regression when explain risk measure Asymmetric Beta of P1 to P10. In contemporaneous whole period and contemporaneous sub period we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period and predictive sub period, we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period, we calculate the average first and then take log of the value. The variables in 'best fit model' is selected by using stepwise regression to minimize AIC proposed by (Akaike 1974) in OLS with portfolio P1 to P10 as factor variable.

Risk measure $asymmetric\ (\beta^{-} - \beta^{+})$ is calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return.

Table 9
Regression of Asymmetric Beta of WML factor on Macroeconomic variables

	Contemporaneous within whole period: 1964/01-2014/12		Predictive within whole period: 1964/01-2014/12	
	All variables	Best Fit	All variables	Best Fit
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	0.19	0.10	0.14	0.12
	[0.64]	[1.35]	[0.96]	[2.11]
Recession	-0.05		0.01	
	[-0.24]		[0.17]	
Market Return	-2.05	-2.51	-0.13	
	[-0.83]	[-1.06]	[-0.45]	
DEF	-4.61		-2.49	
	[-0.38]		[-0.29]	
Inflation	16.84	16.70	7.88	7.56
	[0.85]	[0.83]	[1.27]	[1.23]
Adj. R square	0.03	0.03	0.00	0.00
f.stat	5.89	10.90	1.36	3.96

	Contemporaneous within sub-period: 1989/12-2014/12		Predictive within sub-period: 1989/12-2014/12	
	All variables	Best Fit	All variables	Best Fit
variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	-0.12	-0.10	0.04	0.04
	[-0.16]	[-0.15]	[0.1]	[0.14]
Recession	-0.28	-0.29	0.03	
	[-0.7]	[-1.2]	[0.17]	
Market Return	-3.47	-3.47	-0.37	
	[-1.04]	[-1.05]	[-0.94]	
DEF	0.19		9.99	8.54
	[0.01]		[0.7]	[0.64]
Inflation	109.82	110.01	2.22	
	[1.93]	[1.96]	[0.26]	
TERM	-3.85	-4.11	-5.61	-5.67
	[-1.02]	[-1.55]	[-1.52]	[-1.52]
Log (VIX)	-0.31	-0.31	-0.40	-0.37
	[-0.76]	[-0.73]	[-1.26]	[-1.2]
TED	0.02		0.10	0.09
	[0.09]		[0.74]	[0.78]
Log (oil price)	0.43	0.43	0.30	0.30
	[2.04]	[2.35]	[1.17]	[1.19]
Adj. R square	0.36	0.37	0.14	0.15
f.stat	21.57	28.94	7.05	11.18

This table reports results of multiple linear regression when explain risk measure Asymmetric Beta of WML. In contemporaneous whole period and contemporaneous sub period we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period and predictive sub period, we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period, we calculate the average first and then take log of the value. The variables in 'best fit model' is selected by using stepwise regression to minimize AIC proposed by (Akaike 1974).

Risk measure $asymmetric\ (\beta^{-} - \beta^{+})$ is calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return.

Table 10
Panel Regression of Skewness on Macroeconomic variables

	Contemporaneous within whole period: 1964/01-2014/12		**Predictive within whole period: 1964/01-2014/12**	
	All variables	Best Fit	All variables	Best Fit
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Recession	-0.72	-0.74	-0.37	-0.38
	[-2.32]	[-3.93]	[-3.64]	[-5.37]
Market Return	4.69	4.92	-1.62	-1.60
	[0.85]	[1.1]	[-3.53]	[-3.34]
DEF	2.46		1.42	
	[0.17]		[0.17]	
Inflation	-0.61		8.54	8.50
	[-0.05]		[1.46]	[1.47]
Adj. R square	0.08	0.08	0.06	0.06
f.stat	125.19	249.85	102.28	136.20

	Contemporaneous within sub-period: 1989/12-2014/12		**Predictive within sub-period: 1989/12-2014/12**	
	All variables	Best Fit	All variables	Best Fit
variable	Coefficient	Coefficient	Coefficient	Coefficient
Recession	-0.09	-0.09	-0.07	-0.07
	[-0.56]	[-0.56]	[-0.8]	[-0.81]
Market Return	-5.98	-5.98	-0.78	-0.77
	[-2.62]	[-2.62]	[-1.78]	[-1.73]
DEF	54.43	54.43	8.92	8.25
	[3.29]	[3.29]	[0.79]	[0.75]
Inflation	105.65	105.65	20.80	20.68
	[3.25]	[3.25]	[3.02]	[2.97]
TERM	-6.10	-6.10	-2.46	-2.46
	[-1.88]	[-1.88]	[-1.14]	[-1.14]
Log (VIX)	0.14	0.14	0.66	0.66
	[0.39]	[0.39]	[2.63]	[2.56]
TED	-0.32	-0.32	0.04	0.04
	[-2.52]	[-2.52]	[0.53]	[0.54]
Log (oil price)	-0.17	-0.17	-0.02	
	[-1.75]	[-1.75]	[-0.21]	
Adj. R square	0.25	0.25	0.16	0.16
f.stat	122.90	122.90	69.52	79.37

This table reports results of our fixed effect panel regression when explain risk measure Skewness of P1 to P10. In contemporaneous whole period and contemporaneous sub period we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period and predictive sub period, we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period, we calculate the average first and then take log of the value. The variables in 'best fit model' is selected by using stepwise regression to minimize AIC proposed by (Akaike 1974) in OLS with portfolio P1 to P10 as factor variable.

Table 11
Regression of Skewness of WML factor on Macroeconomic variables

	Contemporaneous within whole period: 1964/01-2014/12		Predictive within whole period: 1964/01-2014/12	
	All variables	Best Fit	All variables	Best Fit
Variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	-0.81	-0.80	-0.43	-0.43
	[-2.07]	[-1.95]	[-2.92]	[-2.92]
Recession	0.81	0.80	0.39	0.39
	[3]	[2.95]	[2.79]	[2.79]
Market Return	-4.35	-4.43	0.68	0.68
	[-0.92]	[-0.93]	[1.34]	[1.34]
DEF	-18.84	-18.76	-17.74	-17.74
	[-0.83]	[-0.84]	[-1.73]	[-1.73]
Inflation	3.63		-12.62	-12.62
	[0.18]		[-1.55]	[-1.55]
Adj. R square	0.27	0.27	0.17	0.17
f.stat	57.07	76.11	31.34	31.34

	Contemporaneous within sub-period: 1989/12-2014/12		Predictive within sub-period: 1989/12-2014/12	
	All variables	Best Fit	All variables	Best Fit
variable	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	-0.27	-0.36	-0.54	-0.33
	[-0.31]	[-0.88]	[-1.1]	[-2.06]
Recession	0.81	0.80	0.28	0.28
	[3.63]	[4.01]	[2.49]	[2.36]
Market Return	-5.68	-5.65	0.49	
	[-1.13]	[-1.21]	[1.25]	
DEF	-18.75	-21.59	-24.79	-21.98
	[-0.66]	[-0.99]	[-2.2]	[-2.02]
Inflation	-136.05	-136.37	-18.91	-18.74
	[-1.67]	[-2.08]	[-2.65]	[-2.64]
TERM	-0.16		9.56	9.43
	[-0.04]		[2.5]	[2.4]
Log (VIX)	-0.03		0.20	
	[-0.07]		[0.67]	
TED	-0.17	-0.16	-0.18	-0.17
	[-0.92]	[-0.81]	[-2.22]	[-2.16]
Log (oil price)	-0.04		-0.01	
	[-0.19]		[-0.04]	
Adj. R square	0.43	0.44	0.35	0.35
f.stat	28.59	46.09	20.21	31.95

This table reports results of multiple linear regression when explain risk measure Skewness of WML. In contemporaneous whole period and contemporaneous sub period we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period and predictive sub period, we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period, we calculate the average first and then take log of the value. The variables in 'best fit model' is selected by using stepwise regression to minimize AIC proposed by (Akaike 1974) in OLS with portfolio P1 to P10 as factor variable.

Table 12
Descriptive statistics for momentum portfolios - Other Asset Classes

	International Equity Indices						**Currencies**						**Commodities**					
Portfolio	P1	P2	P3	P4	P5	WML	P1	P2	P3	P4	P5	WML	P1	P2	P3	P4	P5	WML
Average Monthly Return	-0.11%	0.26%	0.67%	0.69%	0.43%	0.32%	0.08%	0.28%	0.28%	0.28%	0.30%	0.18%	-0.31%	0.01%	0.40%	0.80%	0.95%	0.99%
β	0.41	0.49	0.56	0.48	0.44	0.03	0.05	0.05	0.03	0.03	0.02	-0.03	0.15	0.13	0.12	0.13	0.10	-0.05
β +	0.43	0.43	0.56	0.46	0.40	-0.03	0.08	0.07	0.02	0.03	0.01	-0.07	0.14	0.12	0.10	0.11	0.05	-0.09
β -	0.44	0.56	0.66	0.55	0.56	0.13	0.06	0.06	0.04	0.05	0.03	-0.03	0.18	0.18	0.21	0.20	0.20	0.02
Asymmetric β	0.01	0.13	0.10	0.09	0.17	0.16	-0.02	-0.01	0.02	0.02	0.02	0.04	0.05	0.06	0.10	0.08	0.15	0.10
Relative β +	0.02	-0.05	-0.01	-0.02	-0.04	-0.06	0.03	0.02	0.00	0.00	-0.01	-0.04	-0.01	-0.01	-0.02	-0.02	-0.05	-0.03
Relative β -	0.03	0.08	0.09	0.07	0.13	0.10	0.01	0.01	0.01	0.02	0.01	0.00	0.03	0.05	0.08	0.06	0.10	0.07
Volatility	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Skewness	0.09	-0.28	-0.31	-0.35	-1.05	-0.35	0.55	0.08	0.19	0.03	-0.23	-0.53	0.09	0.12	-0.03	0.00	-0.63	-0.36
Kurtosis	9.61	10.74	13.09	11.25	19.14	7.57	9.82	13.39	7.11	6.82	9.39	9.06	5.49	6.78	6.66	6.06	23.04	13.73

This table reports the descriptive statistics for 5 portfolios sorted by momentum on 3 asset classes provided by (Langlois 2013). The portfolios are daily returns and rebalanced every month. The momentum portfolio returns of International Equity Indices are available from 01/02/1974 to 30/04/2013, that of commodities are from 01/02/1970 to 30/04/2013, and that of Currencies are from 01/11/1984 to 30/09/2013. All returns of the 3 asset classes are excess returns on risk free rate. P5 represents the past winner portfolio and P1 represent the past loser portfolio. WML is calculated by P5 minus P1. We use value weighted U.S Equity returns and one month Treasury bill provided by Kenneth R. French – Data Library as proxy for market returns and risk free rates. The monthly excess return of each portfolio is compounded from daily excess return throughout the whole period and then scaled to monthly. $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. β^{+} measures the upside market risk and is calculated as $\beta_i^{+} = \frac{cov(r_i^d, r_m^d | r_m^d > 0)}{var(r_m^d | r_m^d > 0)}$. β^{-} measures the downside market risk and is calculated as $\beta_i^{-} = \frac{cov(r_i^d, r_m^d | r_m^d < 0)}{var(r_m^d | r_m^d < 0)}$. $Relative\ \beta^{+}$ is calculated by $(\beta_i^{+} - \beta_i)$, $Relative\ \beta^{-}$ is calculated by $(\beta_i^{-} - \beta_i)$, and $asymmetric\ \beta$ is calculated by $\beta_i^{-} - \beta_i^{+}$. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return: $\beta_i = \frac{cov(r_i^d, r_m^d)}{var(r_m^d)}$.

Table 13

Simple Linear Regression and Fama-MacBeth Regression - Other Asset Classes

	Fama-MacBeth								
	International Equity Indices			Currencies			Commodities		
	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2
β	-0.0109	0.0345	0.2383	0.0044	-0.0448	0.3615	0.0367	-0.2452	0.3259
	[-1.63]	[2.89]		[2.32]	[-1.4]		[3.1]	[-2.72]	
β +	-0.0056	0.0244	0.1947	0.0037	-0.0218	0.3768	0.0211	-0.1490	0.3400
	[-1.05]	[2.75]		[2.25]	[-1.45]		[3.35]	[-2.7]	
β -	-0.0111	0.0300	0.2753	0.0047	-0.0397	0.3471	-0.0727	0.4055	0.2644
	[-1.55]	[2.61]		[2.28]	[-1.3]		[-3.06]	[3.24]	
Asymmetric β	0.0028	0.0274	0.3176	0.0025	0.0386	0.3758	-0.0057	0.1276	0.3313
	[0.91]	[1.57]		[1.68]	[1.49]		[-1.25]	[2.91]	
Relative β +	0.0049	-0.0313	0.2695	0.0030	-0.0405	0.3830	-0.0018	-0.3318	0.3468
	[1.88]	[-0.99]		[2]	[-1.48]		[-0.46]	[-2.59]	
Relative β -	0.0014	0.0522	0.3256	0.0007	0.1588	0.2351	-0.0064	0.1812	0.3150
	[0.42]	[1.84]		[0.32]	[1.08]		[-1.41]	[2.99]	
Volatility	0.0426	-3.2728	0.2851	-0.0335	6.0994	0.2182	-0.0117	1.3953	0.3167
	[3.5]	[-3.05]		[-1.83]	[1.98]		[-0.99]	[1.56]	
Skewness	0.0042	-0.0035	0.3300	0.0032	-0.0029	0.3502	0.0043	-0.0146	0.3407
	[1.58]	[-1.52]		[2.1]	[-1.96]		[1.63]	[-2.46]	
Kurtosis	0.0015	0.0003	0.3112	0.0031	0.0000	0.2449	0.0006	0.0005	0.3379
	[0.39]	[1.32]		[1.44]	[-0.23]		[0.16]	[2.16]	
	Simple Linear Regression								
	International Equity Indices			Currencies			Commodities		
	Intercept	Risk Premium	R^2	Intercept	Risk Premium	R^2	Intercept	Risk Premium	R^2
β	-0.0151	0.0400	0.4967	0.0040	-0.0458	0.4420	0.0316	-0.2205	0.6229
	[-1.36]	[1.72]		[3.63]	[-1.54]		[2.5]	[-2.23]	
β +	-0.0092	0.0287	0.2883	0.0033	-0.0223	0.5259	0.0174	-0.1315	0.6465
	[-0.77]	[1.1]		[5.54]	[-1.82]		[2.87]	[-2.34]	
β -	-0.0147	0.0336	0.6452	0.0044	-0.0407	0.3422	-0.0715	0.3894	0.5321
	[-1.83]	[2.34]		[2.69]	[-1.25]		[-1.75]	[1.85]	
Asymmetric β	0.0010	0.0291	0.2677	0.0021	0.0393	0.5983	-0.0065	0.1147	0.7204
	[0.31]	[1.05]		[6.3]	[2.11]		[-1.65]	[2.78]	
Relative β +	0.0032	-0.0343	0.0817	0.0027	-0.0413	0.5769	-0.0027	-0.2861	0.5978
	[1.47]	[-0.52]		[7.96]	[-2.02]		[-0.78]	[-2.11]	
Relative β -	-0.0004	0.0548	0.3732	0.0003	0.1596	0.1984	-0.0074	0.1664	0.6973
	[-0.12]	[1.34]		[0.11]	[0.86]		[-1.65]	[2.63]	
Volatility	0.0462	-3.7363	0.7684	-0.0333	6.0060	0.4055	-0.0091	1.0327	0.1469
	[3.44]	[-3.15]		[-1.33]	[1.43]		[-0.51]	[0.72]	
Skewness	0.0025	-0.0035	0.1973	0.0028	-0.0029	0.7906	0.0026	-0.0125	0.5283
	[1.17]	[-0.86]		[11.35]	[-3.37]		[1.3]	[-1.83]	
Kurtosis	0.0001	0.0003	0.1179	0.0028	0.0000	0.0126	-0.0005	0.0004	0.3938
	[0.01]	[0.63]		[1.44]	[-0.2]		[-0.14]	[1.4]	

This table compares the results of two types of regression on 3 asset classes from (Langlois 2013). The momentum portfolio returns of International Equity Indices are available from 01/02/1974 to 30/04/2013, that of commodities are from 01/02/1970 to 30/04/2013, and that of Currencies are from 01/11/1984 to 30/09/2013. The first is simple linear regression with the contemporaneous cross sectional data of return and risk measures. We use the realized total return (scaled to monthly) of whole period of the portfolio P1 to P5 as dependent variable, and use the risk measures calculated from the same period as our independent variables. The second is Fama-Macbeth Regression with the method from (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973). Instead of using the realized return of whole period, we calculate the monthly return by compounding daily return for each portfolio as our dependent variables. For the independent variables, we use the risk measures same as before, which is calculated from the whole period. We run the cross sectional regression on the return of each month with non-time varying risk measures to get intercept (alpha) and coefficient (premium) of each risk measures for each month. We perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market and portfolio return.

Table 14
Simple Linear Regression and Fama-MacBeth Regression (Controlled Beta) - Other Asset Classes

	Fama-MacBeth											
	International Equity Indices				Currencies				Commodities			
	Intercept	Beta	Risk Premiu	Avg adj R^2	Intercept	Beta	Risk Premiu	Avg adj R^2	Intercept	Beta	Risk Premium	Avg adj R^2
β +	-0.0108	0.0573	-0.0240	-0.0085	0.0013	0.1379	-0.0824	0.1799	0.0145	0.1000	-0.2064	0.1725
	[-1.63]	[1.57]	[-0.79]		[0.48]	[0.85]	[-1.05]		[0.64]	[0.3]	[-0.97]	
β -	-0.0098	-0.0115	0.0376	0.1102	0.0026	-0.1683	0.1272	0.1727	-0.0036	-0.1864	0.1698	0.1057
	[-1.54]	[-0.38]	[1.35]		[1.2]	[-1.12]	[0.9]		[-0.1]	[-1.68]	[1.2]	
Asymmetric β	-0.0103	0.0291	0.0196	0.0727	0.0017	0.0207	0.0526	0.1808	-0.0515	0.2715	0.2559	0.0375
	[-1.59]	[2.81]	[1.17]		[0.66]	[0.34]	[1.01]		[-1.58]	[1.39]	[2.67]	
Relative β +	-0.0108	0.0333	-0.0240	-0.0085	0.0013	0.0555	-0.0824	0.1799	0.0145	-0.1063	-0.2064	0.1725
	[-1.63]	[2.96]	[-0.79]		[0.48]	[0.64]	[-1.05]		[0.64]	[-0.76]	[-0.97]	
Relative β -	-0.0098	0.0261	0.0376	0.1102	0.0026	-0.0411	0.1272	0.1727	-0.0036	-0.0166	0.1698	0.1057
	[-1.54]	[2.51]	[1.35]		[1.2]	[-1.33]	[0.9]		[-0.1]	[-0.07]	[1.2]	
Volatility	0.0541	-0.0096	-3.8867	-0.0656	-0.0370	-0.0513	7.0017	0.1740	0.0343	-0.2382	0.1221	0.2047
	[1.8]	[-0.48]	[-2.08]		[-1.99]	[-1.57]	[2.19]		[1.85]	[-2.69]	[0.14]	
Skewness	-0.0127	0.0353	-0.0037	0.1403	0.0032	-0.0018	-0.0028	0.1189	0.0255	-0.1612	-0.0058	0.1818
	[-1.75]	[2.9]	[-1.57]		[1.72]	[-0.05]	[-1.88]		[1.29]	[-1.12]	[-0.58]	
Kurtosis	-0.0156	0.0353	0.0003	0.1008	0.0036	-0.0614	0.0001	0.1118	0.0384	-0.2563	0.0000	0.2185
	[-1.83]	[2.89]	[1.39]		[1.62]	[-1.79]	[0.93]		[1.77]	[-1.84]	[-0.08]	

	Simple Linear Regression											
	International Equity Indices				Currencies				Commodities			
	Intercept	Beta	Risk Premiu	Adj R^2	Intercept	Beta	Risk Premiu	Adj R^2	Intercept	Beta	Risk Premium	Adj R^2
β +	-0.0151	0.0644	-0.0257	0.0847	0.0010	0.1371	-0.0825	0.2544	0.0181	-0.0105	-0.1255	0.2930
	[-1.16]	[1.05]	[-0.45]		[0.29]	[0.74]	[-1]		[0.45]	[-0.02]	[-0.37]	
β -	-0.0141	-0.0055	0.0372	0.2940	0.0022	-0.1694	0.1272	0.1304	-0.0151	-0.1524	0.1968	0.3986
	[-1.23]	[-0.1]	[0.92]		[0.82]	[-1.01]	[0.75]		[-0.23]	[-1.05]	[0.71]	
Asymmetric β	-0.0146	0.0346	0.0199	0.2245	0.0013	0.0197	0.0527	0.2223	-0.0473	0.2417	0.2289	0.5097
	[-1.21]	[1.33]	[0.77]		[0.42]	[0.26]	[0.93]		[-0.61]	[0.53]	[1.04]	
Relative β +	-0.0151	0.0387	-0.0257	0.0847	0.0010	0.0545	-0.0825	0.2544	0.0181	-0.1360	-0.1255	0.2930
	[-1.16]	[1.42]	[-0.45]		[0.29]	[0.52]	[-1]		[0.45]	[-0.52]	[-0.37]	
Relative β -	-0.0141	0.0317	0.0372	0.2940	0.0022	-0.0422	0.1272	0.1304	-0.0151	0.0445	0.1968	0.3986
	[-1.23]	[1.25]	[0.92]		[0.82]	[-1.3]	[0.75]		[-0.23]	[0.11]	[0.71]	
Volatility	0.0566	-0.0087	-4.2918	0.5496	-0.0369	-0.0523	6.9258	0.9446	0.0357	-0.2326	-0.2105	0.2542
	[1.22]	[-0.24]	[-1.57]		[-5.57]	[-6.4]	[6.19]		[1.13]	[-1.6]	[-0.15]	
Skewness	-0.0169	0.0408	-0.0037	0.4272	0.0029	-0.0032	-0.0028	0.5832	0.0279	-0.1928	-0.0019	0.2507
	[-1.63]	[1.9]	[-1.23]		[2.76]	[-0.1]	[-1.83]		[0.79]	[-0.72]	[-0.12]	
Kurtosis	-0.0197	0.0408	0.0003	0.2695	0.0033	-0.0621	0.0001	0.1057	0.0408	-0.2802	-0.0002	0.2749
	[-1.55]	[1.68]	[0.87]		[2.01]	[-1.55]	[0.7]		[1.14]	[-1.16]	[-0.28]	

This table compares the results of two types of regression on 3 asset classes from (Langlois 2013). The momentum portfolio returns of International Equity Indices are available from 01/02/1974 to 30/04/2013, that of commodities are from 01/02/1970 to 30/04/2013, and that of Currencies are from 01/11/1984 to 30/09/2013. The first is simple linear regression with the contemporaneous cross sectional data of return and risk measures. We use the realized total return (scaled to monthly) of whole period of the portfolio P1 to P5 as dependent variable, and use the risk measures calculated from the same period as our independent variables. The second is Fama-Macbeth Regression with the method from (Fama and MacBeth, Risk, Return, and Equilibrium: Empirical Tests 1973). Instead of using the realized return of whole period, we calculate the monthly return by compounding daily return for each portfolio as our dependent variables. For the independent variables, we use the risk measures same as before, which is calculated from the whole period. We run the cross sectional regression on the return of each month with non-time varying risk measures to get intercept (alpha) and coefficient (premium) of each risk measures for each month. We perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. For both regression, besides the risk measures we want to test, we also include β as controlled variable. For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess market & portfolio return.

Table 15

Cross Sectional Regression with time-varying risk measures - International Equity Indices and Currencies

	International Equity Indices											
	Contemporaneous Period			Forward Period			Predictive period			Predictive 1 year period		
	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2
β	0.0025	0.0052	0.2949	0.0048	0.0029	0.2567	0.0063	0.0010	0.3034	0.0052	0.0002	0.2803
	[0.81]	[1.34]		[1.07]	[0.45]		[1.77]	[0.18]		[1.35]	[0.04]	
β +	0.0045	0.0011	0.2572	0.0083	-0.0036	0.2628	0.0064	-0.0002	0.2855	0.0041	0.0017	0.2765
	[1.23]	[0.31]		[2.28]	[-0.86]		[1.9]	[-0.06]		[1]	[0.55]	
β -	0.0052	-0.0002	0.2815	0.0090	-0.0051	0.2529	0.0065	0.0007	0.2842	0.0057	-0.0008	0.2534
	[1.79]	[-0.07]		[2.04]	[-1]		[1.77]	[0.16]		[1.19]	[-0.22]	
Asymmetric β	0.0036	0.0027	0.2936	0.0054	-0.0043	0.2961	0.0040	0.0069	0.2730	0.0037	0.0060	0.2638
	[1.16]	[0.63]		[1.88]	[-0.62]		[1.49]	[0.99]		[1.07]	[1.79]	
Relative β +	0.0034	-0.0078	0.2755	0.0046	-0.0097	0.2951	0.0053	-0.0205	0.2912	0.0044	-0.0056	0.2762
	[1]	[-1.24]		[1.84]	[-0.89]		[1.97]	[-2.36]		[1.25]	[-0.85]	
Relative β -	0.0041	-0.0067	0.2840	0.0049	-0.0089	0.2855	0.0063	0.0162	0.2653	0.0040	0.0106	0.2679
	[1.69]	[-1.17]		[1.67]	[-0.85]		[2.45]	[1.76]		[1.14]	[1.56]	
Volatility	0.0109	-0.7189	0.3644	0.0073	-0.0196	0.3201	0.0113	-1.0821	0.3253	0.0120	-0.9871	0.3181
	[2.08]	[-1.31]		[1.04]	[-0.03]		[1.29]	[-1.16]		[2.29]	[-1.5]	
Skewness	0.0039	0.0006	0.3095	0.0052	0.0079	0.3142	0.0050	-0.0072	0.2858	0.0041	-0.0044	0.2976
	[1.12]	[0.27]		[1.91]	[2.34]		[1.76]	[-2.05]		[0.84]	[-2.14]	
Kurtosis	0.0032	0.0003	0.2469	0.0051	0.0001	0.2635	0.0046	0.0005	0.2612	0.0045	0.0001	0.2763
	[0.89]	[0.51]		[1.07]	[0.07]		[0.73]	[0.49]		[1.03]	[0.17]	

	Currencies											
	Contemporaneous Period			Forward Period			Predictive period			Predictive 1 year period		
	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2
β	0.0021	-0.0171	0.3557	0.0028	-0.0267	0.3060	0.0012	-0.0048	0.3147	0.0008	-0.0094	0.2880
	[1.54]	[-1.64]		[1.53]	[-1.83]		[0.71]	[-0.27]		[0.45]	[-0.84]	
β +	0.0025	-0.0109	0.3333	0.0032	-0.0327	0.3147	0.0016	0.0095	0.3094	0.0016	0.0014	0.2836
	[1.73]	[-1.96]		[1.81]	[-3.3]		[0.84]	[0.84]		[0.88]	[0.22]	
β -	0.0026	-0.0018	0.3049	0.0018	-0.0053	0.2979	0.0025	0.0038	0.3051	0.0011	0.0050	0.2722
	[1.78]	[-0.35]		[1.07]	[-0.5]		[1.77]	[0.38]		[0.62]	[1.11]	
Asymmetric β	0.0026	0.0063	0.3008	0.0042	0.0089	0.3143	0.0020	-0.0039	0.2851	0.0018	0.0038	0.3041
	[1.98]	[1.31]		[2.27]	[0.99]		[1.4]	[-0.66]		[1]	[0.91]	
Relative β +	0.0028	-0.0153	0.2762	0.0037	-0.0247	0.3148	0.0035	0.0086	0.2860	0.0023	0.0091	0.3259
	[1.71]	[-1.96]		[2.26]	[-1.53]		[2.41]	[0.54]		[1.33]	[1]	
Relative β -	0.0022	0.0065	0.2873	0.0023	0.0031	0.2993	0.0008	-0.0007	0.2605	0.0013	0.0210	0.2711
	[1.36]	[0.82]		[1.32]	[0.19]		[0.55]	[-0.04]		[0.8]	[2.22]	
Volatility	0.0008	0.1215	0.3453	-0.0014	0.7002	0.3615	0.0005	0.1164	0.3465	0.0008	0.3095	0.2980
	[0.42]	[0.24]		[-0.49]	[1.12]		[0.15]	[0.19]		[0.29]	[0.71]	
Skewness	0.0028	0.0008	0.3207	0.0024	0.0028	0.3275	0.0026	-0.0018	0.2851	0.0019	-0.0006	0.2764
	[1.26]	[0.62]		[1.54]	[1.49]		[1.47]	[-0.78]		[1.01]	[-0.52]	
Kurtosis	0.0028	0.0001	0.2879	0.0023	0.0002	0.3145	0.0078	-0.0010	0.2886	0.0009	0.0003	0.2926
	[1.07]	[0.14]		[0.71]	[0.31]		[2.35]	[-1.51]		[0.45]	[0.92]	

This table reports the result of cross sectional regression for momentum portfolio P1 to P5 for each month t. We regress return of P1 to P5 by month on monthly time varying risk measures to get time series intercept (alpha) and coefficient (premium) of each risk measure monthly. Then we perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. In contemporaneous period, we use the risk measures calculated from t to t+11 to explain the portfolio return of same period from t to t+11. In forward period, we use the forward risk measures calculated from t to t+11 to explain the portfolio return of month t. In predictive period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12. In predictive 1 year period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12 to t+23. For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess term. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess term.

Table 16

Cross Sectional Regression with time-varying risk measures - Commodities

	Commodities											
	Contemporaneous Period			Forward Period			Predictive period			Predictive 1 year period		
	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2	Intercept	Risk Premium	Avg R^2
β	0.0030	-0.0033	0.3147	0.0016	-0.0425	0.3092	0.0015	0.0441	0.2784	0.0019	0.0088	0.2657
	[0.67]	[-0.25]		[0.35]	[-0.98]		[0.43]	[1.34]		[0.69]	[0.85]	
β +	0.0042	-0.0086	0.2721	0.0064	-0.0232	0.3096	0.0012	0.0092	0.2711	0.0015	0.0088	0.2522
	[1.23]	[-0.81]		[1.75]	[-1.69]		[0.37]	[0.76]		[0.44]	[1.07]	
β -	0.0028	0.0119	0.3056	0.0048	0.0136	0.2911	0.0020	0.0134	0.2599	0.0028	-0.0039	0.2784
	[0.91]	[1.58]		[1.31]	[1.24]		[0.68]	[1.19]		[0.99]	[-0.69]	
Asymmetric β	0.0052	0.0080	0.2695	0.0068	0.0080	0.2833	0.0055	0.0096	0.2494	0.0048	-0.0010	0.2274
	[1.48]	[1.14]		[2.32]	[0.92]		[1.85]	[1.27]		[1.11]	[-0.21]	
Relative β +	0.0023	-0.0121	0.2644	0.0041	-0.0083	0.2913	0.0038	-0.0204	0.2680	0.0033	-0.0022	0.2323
	[0.65]	[-1.02]		[1.47]	[-0.48]		[1.3]	[-1.55]		[0.83]	[-0.32]	
Relative β -	0.0053	0.0000	0.3086	0.0055	0.0169	0.2950	0.0059	0.0097	0.2618	0.0050	-0.0085	0.2637
	[1.71]	[0]		[1.92]	[0.9]		[2.2]	[0.62]		[1.28]	[-0.88]	
Volatility	-0.0054	0.6705	0.3193	-0.0113	1.0547	0.3345	-0.0067	0.8610	0.3084	-0.0033	0.4818	0.2534
	[-0.76]	[1.11]		[-1.4]	[1.68]		[-1.14]	[1.84]		[-0.34]	[0.78]	
Skewness	0.0039	0.0000	0.3111	0.0053	0.0090	0.2685	0.0054	0.0046	0.2545	0.0040	-0.0068	0.2961
	[0.91]	[0]		[2]	[1.24]		[2.02]	[0.47]		[1.04]	[-1.19]	
Kurtosis	0.0100	-0.0011	0.2825	0.0106	0.0001	0.2810	0.0154	-0.0026	0.2602	0.0003	0.0009	0.2722
	[1.48]	[-0.56]		[0.89]	[0.03]		[2.07]	[-1.27]		[0.05]	[0.57]	

This table reports the result of cross sectional regression for momentum portfolio P1 to P5 for each month t. We regress return of P1 to P5 by month on monthly time varying risk measures to get time series intercept (alpha) and coefficient (premium) of each risk measure monthly. Then we perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. In contemporaneous period, we use the risk measures calculated from t to t+11 to explain the portfolio return of same period from t to t+11. In forward period, we use the forward risk measures calculated from t to t+11 to explain the portfolio return of month t. In predictive period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12. In predictive 1 year period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12 to t+23. For the risk measures, $\beta^{+}, \beta^{-}, Relative\ \beta^{+}, Relative\ \beta^{-}, asymmetric\ \beta\ (\beta^{-} - \beta^{+})$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return. The β is calculated from CAPM of (Sharpe 1964) and (Lintner 1965) but also on the excess term.

Table 17
Cross Sectional Regression with time-varying risk measures (Controlled Beta)
International Equity Indices and Currencies

International Equity Indices								
	Contemporaneous Period				Forward Period			
	Intercept	Beta	Risk Premium	Avg Adj. R^2	Intercept	Beta	Risk Premium	Avg Adj. R^2
Relative β +	0.0035	0.0016	-0.0088	0.1100	0.0089	-0.0048	-0.0139	0.0639
	[0.87]	[0.31]	[-1.25]		[1.86]	[-0.66]	[-0.93]	
Skewness	0.0041	0.0015	0.0038	0.1258	0.0079	-0.0027	0.0084	0.0595
	[1.34]	[0.39]	[1.48]		[1.71]	[-0.38]	[1.99]	
	Predictive period				Predictive 1 year period			
	Intercept	Beta	Risk Premium	Avg Adj. R^2	Intercept	Beta	Risk Premium	Avg Adj. R^2
Relative β +	0.0046	0.0042	-0.0276	0.1367	0.0052	0.0006	-0.0078	0.0681
	[1.22]	[0.57]	[-2.6]		[1.66]	[0.15]	[-1.05]	
Skewness	0.0093	-0.0093	-0.0064	0.1215	0.0064	-0.0031	-0.0047	0.0934
	[2.14]	[-1.25]	[-1.46]		[1.46]	[-0.71]	[-2.11]	
Currencies								
	Contemporaneous Period				Forward Period			
	Intercept	Beta	Risk Premium	Avg Adj. R^2	Intercept	Beta	Risk Premium	Avg Adj. R^2
Relative β -	0.0018	-0.0193	-0.0004	0.1931	0.0019	-0.0227	-0.0069	0.1103
	[1.37]	[-1.55]	[-0.05]		[0.92]	[-1.23]	[-0.35]	
β +	0.0032	-0.0238	0.0048	0.1730	0.0033	-0.0619	0.0068	0.1548
	[2.03]	[-1.74]	[0.48]		[1.31]	[-1.56]	[0.27]	
	Predictive period				Predictive 1 year period			
	Intercept	Beta	Risk Premium	Avg Adj. R^2	Intercept	Beta	Risk Premium	Avg Adj. R^2
Relative β -	-0.0001	-0.0102	0.0007	0.1148	0.0004	-0.0072	0.0226	0.0615
	[-0.07]	[-0.4]	[0.04]		[0.23]	[-0.59]	[2.05]	
β +	0.0009	-0.0017	0.0103	0.1138	0.0014	-0.0051	0.0052	0.1623
	[0.49]	[-0.06]	[0.52]		[0.79]	[-0.27]	[0.43]	

This table reports the result of cross sectional regression for momentum portfolio P1 to P5 for each month t. We regress return of P1 to P5 by month on monthly time varying risk measures as well as controlled variable β to get time series intercept (alpha) and coefficient (premium) of each risk measure monthly as well as controlled variable β. Then we perform t test on intercept and coefficient with 12 months lag Newey West covariance matrix proposed by (Newey and West 1987) to correct autocorrelation and heteroskedasticity. In contemporaneous period, we use the risk measures calculated from t to t+11 to explain the portfolio return of same period from t to t+11. In forward period, we use the forward risk measures calculated from t to t+11 to explain the portfolio return of month t. In predictive period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12. In predictive 1 year period scenario, we use past risk measures calculated from t to t+11 to explain the future portfolio return of month t+12 to t+23. For the risk measures, $\beta^{+}, Relative\ \beta^{+}, Relative\ \beta^{-}$ are calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return.

Table 18
Regression of risk measures of WML factor on Macroeconomic variables
International Equity Indices

	Skewness				**Relative β^+**			
	Contemporaneous within whole period: 1974/02-2013/04		**Predictive within whole period: 1974/02-2013/04**		**Contemporaneous within whole period: 1974/02-2013/04**		**Predictive within whole period: 1974/02-2013/04**	
	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit
Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	0.19	0.23	-0.07	-0.07	-0.03	-0.03	-0.12	-0.12
	[0.34]	[1.09]	[-0.22]	[-0.21]	[-0.16]	[-0.22]	[-1.41]	[-1.41]
Recession	-0.39	-0.41	-0.21	-0.21	-0.12	-0.11	-0.04	-0.04
	[-0.88]	[-1.32]	[-1.12]	[-1.13]	[-0.84]	[-1.07]	[-0.81]	[-0.81]
Market Return	10.04	10.17	-0.08		0.16		-0.38	-0.38
	[1.18]	[1.26]	[-0.13]		[0.08]		[-2.34]	[-2.34]
DEF	2.15		9.69	9.60	7.96	8.08	7.08	7.08
	[0.09]		[0.48]	[0.47]	[0.92]	[1.04]	[1.45]	[1.45]
Inflation	-37.03	-36.80	-14.24	-14.29	-15.69	-15.67	-3.89	-3.89
	[-1.6]	[-1.55]	[-1.08]	[-1.09]	[-1.49]	[-1.49]	[-0.85]	[-0.85]
Adj. R^2	0.07	0.07	0.03	0.04	0.10	0.10	0.05	0.05
f.stat	9.76	13.01	4.98	6.65	13.20	17.62	7.03	7.03

	Contemporaneous within sub-period: 1989/12-2013/04		**Predictive within sub-period: 1989/12-2013/04**		**Contemporaneous within sub-period: 1989/12-2013/04**		**Predictive within sub-period: 1989/12-2013/04**	
	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit
variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	-0.15	0.34	-0.51	-0.10	0.19	0.01	-0.07	-0.16
	[-0.11]	[2.23]	[-0.59]	[-0.43]	[0.39]	[0.11]	[-0.26]	[-1.1]
Recession	-0.56	-0.60	-0.22	-0.23	-0.26	-0.24	-0.08	-0.10
	[-1.43]	[-2.79]	[-1.02]	[-1.09]	[-2.81]	[-2.79]	[-1.92]	[-3.04]
Market Return	7.27	7.00	0.60		0.38		-0.52	-0.42
	[1.64]	[1.52]	[1.07]		[0.3]		[-1.94]	[-2.21]
DEF	-9.83		-5.99		19.91	18.47	4.53	
	[-0.34]		[-0.36]		[2.18]	[2.04]	[0.9]	
Inflation	18.09		19.30	20.25	38.37	42.95	3.99	
	[0.34]		[1.45]	[2.28]	[1.92]	[1.9]	[0.78]	
TERM	2.42		1.19		-4.78	-4.58	-2.10	-2.36
	[0.22]		[0.21]		[-1.49]	[-1.41]	[-0.8]	[-1.02]
Log (VIX)	0.16		0.18		-0.13		-0.13	
	[0.14]		[0.36]		[-0.42]		[-0.72]	
TED	0.11		0.21	0.19	-0.14	-0.14	0.05	
	[0.35]		[1.46]	[1.83]	[-1.75]	[-1.7]	[0.79]	
Log (oil price)	0.13		0.13		0.01		0.12	0.14
	[0.28]		[0.42]		[0.07]		[1.34]	[1.49]
Adj. R^2	0.08	0.09	0.09	0.10	0.22	0.23	0.13	0.13
f.stat	3.82	14.02	4.43	10.73	10.69	16.76	5.88	10.61

This table reports results of multiple linear regression when explain risk measures of WML of International Equity Indices portfolio. In contemporaneous within whole period and contemporaneous within sub period we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period and predictive sub period, we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period, we calculate the average first and then take log of the value. The variables in 'best fit model' is selected by using stepwise regression to minimize AIC proposed (Akaike 1974).

Risk measure $Relative\ \beta^+$ is calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return.

Table 19
Regression of risk measures of WML factor on Macroeconomic variables
Currencies

	β^+				Relative β^-			
	Contemporaneous within whole period: 1984/11-2013/09		**Predictive within whole period: 1984/11-2013/09**		**Contemporaneous within whole period: 1984/11-2013/09**		**Predictive within whole period: 1984/11-2013/09**	
	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit
Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	-0.16	-0.17	-0.18	-0.17	0.07	0.07	0.02	0.00
	[-0.81]	[-1.09]	[-1.57]	[-1.43]	[0.4]	[0.4]	[0.21]	[-0.05]
Recession	-0.01		0.10	0.11	0.06	0.06	0.02	0.03
	[-0.09]		[1.85]	[1.81]	[0.69]	[0.69]	[0.52]	[0.73]
Market Return	1.54	1.44	0.17		-1.93	-1.93	0.12	
	[0.61]	[0.55]	[1.37]		[-1.92]	[-1.92]	[0.83]	
DEF	6.69	7.03	4.14	3.89	-6.61	-6.61	-1.11	
	[0.48]	[0.52]	[0.5]	[0.41]	[-0.86]	[-0.86]	[-0.26]	
Inflation	23.96	23.78	3.19		-9.89	-9.89	-0.12	
	[0.94]	[0.98]	[0.8]		[-0.78]	[-0.78]	[-0.05]	
Adj. R^2	0.04	0.04	0.04	0.04	0.09	0.09	0.00	0.01
f.stat	4.46	5.94	4.55	7.76	9.11	9.11	1.26	3.46

	Contemporaneous within sub-period: 1989/12-2013/09		**Predictive within sub-period: 1989/12-2013/09**		**Contemporaneous within sub-period: 1989/12-2013/09**		**Predictive within sub-period: 1989/12-2013/09**	
	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit	All variables	Best Fit
variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
Intercept	-0.49	-0.54	-0.14	-0.22	-0.06	-0.06	0.01	0.02
	[-0.97]	[-1.37]	[-0.53]	[-1.17]	[-0.14]	[-0.27]	[0.02]	[0.08]
Recession	-0.04		0.05	0.06	-0.05		0.00	
	[-0.27]		[1.13]	[1.24]	[-0.62]		[0.05]	
Market Return	0.84		0.18		-2.05	-2.33	0.11	
	[0.39]		[0.72]		[-2.26]	[-2.84]	[0.64]	
DEF	-10.88	-10.85	0.19		-17.32	-13.01	-0.65	
	[-0.89]	[-0.75]	[0.04]		[-2.32]	[-3.11]	[-0.19]	
Inflation	26.89	27.69	-2.31		-3.16		-1.62	
	[0.8]	[0.78]	[-0.56]		[-0.29]		[-0.71]	
TERM	-0.54		-3.40	-3.34	1.56	1.36	-1.00	-1.00
	[-0.18]		[-1.42]	[-1.37]	[0.67]	[0.65]	[-0.6]	[-0.57]
Log (VIX)	0.13	0.13	-0.06		0.21	0.19	0.12	0.10
	[0.33]	[0.37]	[-0.29]		[0.96]	[1.13]	[0.71]	[0.65]
TED	0.05	0.07	-0.06	-0.06	-0.09	-0.08	-0.09	-0.09
	[0.4]	[0.8]	[-2.11]	[-2.07]	[-1.95]	[-1.41]	[-2.12]	[-2.11]
Log (oil price)	0.22	0.22	0.14	0.14	0.04		-0.04	-0.04
	[1.61]	[1.53]	[1.27]	[1.3]	[0.46]		[-0.51]	[-0.61]
Adj. R^2	0.19	0.19	0.16	0.17	0.20	0.20	0.06	0.07
f.stat	9.01	14.08	7.71	14.84	9.39	14.34	3.25	6.34

This table reports results of multiple linear regression when explain risk measures of WML of Currencies portfolio. In contemporaneous within whole period and contemporaneous within sub period we use the macroeconomic variables of monthly average from month t to t+11 to explain the risk measures calculated from t to t+11. In predictive whole period and predictive sub period, we use the macroeconomic variables of month t-1 to explain the risk measures calculated from t to t+11. For log of VIX and log of Oil price at contemporaneous sub period, we calculate the average first and then take log of the value. The variables in 'best fit model' is selected by using stepwise regression to minimize AIC proposed (Akaike 1974).

Risk measure β^+ and $Relative\ \beta^-$ is calculated with method proposed by (Ang, Chen and Xing 2006) but on excess market and portfolio return.