Evidence for Currency Factor Premiums in G10 and Emerging Markets

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MSc Financial Economics

August, 2022

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Abstract

This paper examines the presence of well documented currency factors in developed and emerging markets. This paper also examines the performance of newer factors such as equity differential, output gap and variations to the Betting-Against-Beta (BAB) factors using the G10 and emerging market currencies. I find evidence that these well documented factors which perform well in the G10 currency markets, emerging currency markets and continue to perform better than the rest when both the G10 and emerging currencies are used together. I also find evidence for the newer factors in the G10 currency market. However, these newer factors do not perform as well in the emerging currency market and when both sets of currency pairs are included together in the investment universe.

JEL Classification: G10, G15, G40

Keywords: Factor investing, Currencies, Emerging Markets

Contents

1. Introduction

The Forex market is the largest, most liquid market in the world which by trading volume exceeds the global equities market almost 25 times[1]. Besides the currencies being traded by central banks and managers who hedge their positions, the features of the Forex market such as low transaction costs and no short selling constraints, attracts professional investors who generate profits from implementing various systematic currency investment strategies.

The literature of factor investing has only very recently extended to include the currency asset class. Since the oldest and most prominent Carry factor, there have been many studies in the recent years to explore the existence of other factor premiums in the currency markets. Literature shows that most of the factors that generate high returns in equity and bond markets also perform well in the currency markets. However the studies till now only explore individual factors and majority of these studies do not include the emerging market currencies.

In this paper, I study well documented global factors and more recently documented factor premiums in developed and emerging currency markets. This paper, for the first part, follows the methodology by Baltussen et al., (2020) who study the six major global factor premiums (value, momentum, trend, carry, return seasonality, and betting against beta) over a large sample across five asset classes in an extended time period of 217 years. The factors are constructed as defined in their original documentation.

In the previous literature when these factors are constructed using emerging market currencies, there tends to be an increase the performance of factor investment strategies. But these emerging currencies are not attractive to investors and are excluded out due to higher volatility, less developed political environments and financial systems and limited availability of historic data. In recent years the highly globalized markets provide these currencies with more stable prospects.

Li.D(2021) shows that there is an economic benefit in diversifying a forex portfolio between developed and developing markets. However, this is also associated with a higher annualized volatility and a larger negative skew which is an indication for potential crash risk. In this paper, I aim to examine the presence of currency factor premiums in both the

1. The FX market has a daily trading volume of $6.6 trillion according to Bank for International Settlements (‘Foreign Exchange turnover in April 2019’)

markets (G10 and Emerging) and also study if constructing these factors with emerging market currencies (and together with G10 currencies) tend to increase the performance of these factors. I will also additionally analyze the downside risk that is associated with the inclusion of emerging currency pairs.

I find that among the 'classic' well recorded factors in factor investing literature, momentum, Trend and carry factors perform significantly better than the other factors (return seasonality, betting-against-beta and value) when constructed using G10 currency pairs and these factors and yield a much higher and significant Sharpe ratios when the emerging market currencies are included in the investment universe.

The paper also looks at the performance of new currency factors recorded in recent literature. When compared to the 'classic' factors, the newer factors perform relatively better when constructed using the G10 currencies than when using the emerging market currencies. The paper also looks at variations to the betting -against -beta factor which substitutes the composite currency index for a global equity index (Global equity BAB) and a beta factor which takes positions in currency pairs based on the performance of a country's equity index relative to the global equity index (Equity Index Beta). These two factors also perform better when using the G10 currency pairs than using only the emerging currencies and using both currencies.

Out of all the 'classic' factors in both G10 and emerging currencies universe, the downside risk does not explain the factor premium except for Momentum and Value factor where the downside risk can be used to predict almost all the alpha generated. Among the newer factors, there is a considerable difference between the downside and regular betas (often in a negative direction). A general pattern that is noticeable is that for these factors, the kurtosis (extreme outliers) of the return distribution, also doubles when including the emerging market currencies indicating more extreme highs and lows in factor returns.

The paper will be structured as follows. In Section 2, I will be reviewing the relevant literature in currency factor premiums and strategies. In Section 3 and 4, I will be discussing the data and methodology followed for the construction of the various factors. I will report and discuss the results of the currency factor strategies in Section 5 and Section 6 concludes.

2. Literature Review

In this section, I will provide descriptions of some of the widely recorded factors that I will be implementing using the developed and emerging market currencies. Though most of the factors were first recorded in other asset classes (such as equity) these factor investing strategies have been extended and proved to generate returns even in currency markets in recent literature.

2.1 Value

The value factor in currencies looks at the difference in real and nominal exchange rates. Abuaf and Jorion (1990) show that the shocks to the Real Exchange Rate (RER) slowly cancel out over time. They show the fundamental differences in the behavior of real and nominal exchange rates was due to the interactions between price levels and exchange rates. Their results indicate that the price levels therefore play an important role in the long-term stability in real exchange rates.

Menkhoff et al., (2015) find a positive correlation between interest differentials and RER and show that this is driven by persistent differences in country characteristics. They argue that only after controlling for these macroeconomic fundamentals does the RER have predictive power of currency excess returns. The RER reverts to its fundamental value which drives these excess returns in the long run which is distinct from the carry component which is driven by buying (selling) high (low) interest rates.

They also show that though constructing the RER changes mitigate the persistent country characteristics, adjusting for macroeconomic fundamentals improves forecast power and it strongly predicts both currency excess returns and exchange rate changes. Barroso and Santa-Clara (2015) however show momentum and value reversal[2] help optimize currency portfolios better than real exchange rate.

Baltussen, Swinkels and Vliet (2020) use an equally weighted measure of absolute and relative purchasing power parity (PPP)[3,4] and ignore the more defined value measures like productivity and macro fundamentals due to historical data constraints. Doing so

2. Value reversal as the cumulative real currency depreciation in the previous 5 years (the cumulative deviation from the purchasing power parity instead of cumulative return)

3. The relative PPP is the 5-year reversal of the spot rate corrected for inflation.

4. The data for absolute PPP was only available on a yearly frequency.

produced very low Sharpe ratios in the currency value strategies.

2.2 Carry

Carry trade is one of the most prominent currency speculation strategies which is built on the uncovered interest rate parity puzzle. Lustig et al., (2011) contribute a crucial risk-based explanation for carry trade returns by documenting the common factor in exchange rates sorted by interest rates. They identify a level factor which is the average excess return on all foreign currency portfolios, also called the dollar risk factor. They also identify a second slope factor which decreases monotonically from high to low interest rate currency portfolios, which they label carry trade risk factor HML_{FX}. The dollar risk factor captures the country-specific risk, and the slope factor measures an exposure to global risk. They also show that the loadings on this slope factor have a strong explanatory power for the average returns on currency portfolios (carry trade risk premium).

Using an alternate definition of carry, Koijen et al., (2016) study the carry factor on different asset classes. They define carry as an asset's futures return assuming the prices remain the same and the return of an asset is its carry plus an expected price appreciation. They show that the returns to carry strategies across assets cannot be explained by other known global return factors such as momentum, time series momentum and value.

2.3 Volatility

Following Lustig et al., (2011), Menkhoff et al., (2012) show that the global FX volatility is a key driver of risk premia in the cross section of carry trade returns. The authors employ two risk factors to price the cross section of carry trade returns. Like Lustig et al., (2011) they use the dollar risk factor but instead of the slope factor (HML_{FX}) factor they study the innovations in global FX volatility which is a proxy for unexpected changes in the FX market volatility. They argue that the excess returns to carry trade are indeed a compensation for time-varying risk. They show that the sensitivity of excess returns to global FX volatility can explain the returns to currency portfolios.

While both of these risk-based explanations account for variations in the interest rate sorted portfolio, Rafferty (2012) introduces a global currency skewness risk factor, related to the literature focusing on downside and crash risk as explanations for currency returns.

Rafferty (2012) focuses on the exposure to an aggregate measure of skewness which is crucial in pricing the cross section of carry trade, momentum, and value portfolios.

Another interesting factor related to volatility, skewness and risk was introduced by Lee and Wang (2016) who propose a jump modified carry trade strategy which has a higher return than carry trade. They base the strategy on the cross-sectional differences in the sensitivity of individual exchange rates to jumps (extreme discontinuous changes). The strategy involves going long on currencies which react more negatively to jumps than the funding currencies.

Ang et al., (2006) study the volatility factor at the firm level for stocks. They show that the firms which are highly sensitive to innovations in aggregate volatility have low average returns and stocks with high idiosyncratic volatility have lower average returns. While Blitz, Pang and van Vliet (2012) show the volatility effect (the relation between risk and return) in emerging equity markets is negative and this effect is more pronounced when they use volatility instead of beta to measure risk.

2.4 Momentum

The cross sectional momentum (henceforth referred to as momentum) factor in the stock market was first documented by Jegadeesh and Titman in 1993. Okunev and White (1993) study the momentum strategy in currency markets. They show that the profitability of the momentum-based strategies hold for currencies and its performance is not due to a time-varying risk but is derived from the underlying autocorrelation of the currency returns.

Following Burnside et al. (2011) who find little evidence that the profitability of momentum strategies stem from the compensation for the risk they bear, Menkhoff et al. (2012) empirically study the momentum strategy in FX markets and find evidence for under and subsequent over reaction in the long horizon momentum returns. They show that the excess returns from momentum strategies in currency markets is as high as documented in stock markets.

2.5 Trend

The time series momentum (henceforth referred to as trend) was first documented in currencies and other asset classes such as equity index, commodities and bond futures by Moskowitz, Ooi and Pedersen (2011). They show that even though there is a relation between

time series and cross section momentum, the strategies are distinct, and it is the positive auto-covariance between the securities' monthly excess returns that drives these strategies.

However a recent paper by Zhang (2020) dissects the currency cross section and time series momentum and argues that these strategies have a common source which are systematic returns. He shows that it actually originates from factor (carry and dollar) momentum which are systematic returns. He proposes a factor momentum strategy (FMOM) which they show to have higher Sharpe ratios than both, cross section momentum (MOM) and time series momentum (TSM).

2.6 Return Seasonality

Keloharju et al. (2016) document a return seasonality strategy which involves selecting stocks based on their historical same-calendar-month returns. They argue that the disconnect between seasonality in individual stock returns is because no factor by itself is responsible for the seasonal patterns but the seasonality aggregates across the various factor premiums. They show that return seasonality is persistent across assets and is often large.

There is no evidence in prior literature of the profitability of return seasonality factor strategy in the currency asset class. Tse (2017) studies the return seasonality in foreign exchange markets using currency futures and shows that all G10 currency futures yield negative returns in January (this effect is more prominent for countries' tax year ending in December). He argues that currency portfolios sorted based on their same calendar month return following Keloharju et al (2016) does not produce any excess returns like in the stock portfolios.

2.7 Betting-against Beta

The Betting-Against-Beta (BAB) factor strategy which goes long leveraged low-beta assets and shorts high beta assets was documented by Frazzini and Pedersen (2010) who show a significant positive risk adjusted return. They empirically show that portfolios of high-beta assets have lower alphas and Sharpe ratios than portfolios of low-beta assets. They also report weak evidence for BAB in currencies. Baltussen et al. (2020) also find the BAB effect outside equity markets to be weak.

Marx and Velikov (2018) argue that the non-standard construction of BAB by Frazzini and Pedersen contributes significantly to the strategy's remarkable performance, and this reflects biases in their betas. They argue that the BAB which follows a standard

construction does not provide strong evidence for the profitability of the equity strategies. This paper follows the factor definitions as in the original literature, in this case, by Frazzini and Pedersen and also explored different definitions of beta (Global equity BAB and Equity Beta)

These global factors that have so far been reviewed have historically produced returns that are consistent across literature. In one study by Bartram et al. (2018) who examine the cross section of currency excess return predictors (11 factors for 76 countries), find that Risk-adjusted profits decrease substantially after the publication of the underlying academic research which suggests mispricing and inefficiencies in the market that is ultimately traded away.

2.8 Output Gap

Apart from the Global factors covered by Baltussen et al(2020) , there have been numerous other currency factors recorded in recent literature. Colacito et al. (2019) propose a 'business cycle factor' based on the strong link between currency excess returns and the strength of the business cycle. They find that currency excess returns are higher for strong economies (peak position in the business cycle). They sort portfolios on relative output gaps which generates a GAP premium.

They find that given the negative relationship between the output gap of a currency *i* and its correlation with the output gap of the base currency, it follows that countries with low(high) output gaps have safe (risky) currencies. The output gap factor takes advantage of this negative relationship since the factor premium depends on the expected appreciation of the currency which in turn results in a positive premium.

2.9 Equity Differential

Burnside (2012) attempts at a unified risk-based explanation for returns in the equity and currency markets. They show that conventional stock market-based models of risk do not explain the returns to the carry trade and currency fluctuation-based factors do not explain the returns to the stock market. However, they do find that the demand from cross-border equity has predictive power over currency returns.

Turkington and Yazdani (2020) show that the differential in trailing equity market performance across countries strongly predicts the cross section of currency returns. They

also state that the anticipation of country fundamentals may also play a role in the return predictability.

Though there exists a relation between the equity market volatility, shocks, downside risk and the currency market, this has not been explored much in the prior literature, especially in emerging markets.

2.10 Term spread

Ang and Chen in 2010 showed that term spread between long-term and short-term is a predictor of foreign exchange returns independent of carry. They show that the currencies tend to depreciate if the term spread is steep. This can be exploited to build portfolio strategies with high Sharpe ratios which have relatively low correlations with carry strategies. They argue that this factor predicts returns up to 12 months and also show that the returns from this strategy are robust to controlling for other currency risk factors.

2.11 Other Beta Factors

Ang et al. (2006) find that stocks with high sensitivities to innovations in volatility have low average returns therefore stocks with high idiosyncratic volatility have low average returns. Following this, Victoria Atanasov and Thomas Nitschka, authors of the 2015 study "Foreign Currency Returns and Systematic Risks" found a strong relation between currencies' average returns and their sensitivities to cash-flow shocks in equity markets. I exploit this relationship between the currency returns and the equity markets of a country.

One variation to Betting-against-Beta uses the global equity index as a proxy for the market. Here I call it the Global equity BAB. For the global BAB factor, the proxy for 'market' is the index of equally weighted currencies. On the other hand the BAB factor with the global equity index of all countries in our dataset including USA, captures a more accurate beta measure of a currency with respect to movements in the equity market.

Another volatility related factor constructed in this paper looks at the volatility of the individual country's equity index volatility instead of the currency's volatility relative to the global equity index volatility and takes positions in the respective currency (with the USD base) .

There is a gap in prior literature when it comes to extending these strategies to emerging markets. This paper contributes to the existing literature by studying these well documented factors strategies in currencies of emerging markets. This paper also extends to a

few newer factors and their performance in the emerging markets while also examining the downside risks, volatility and skewness, kurtosis which are factors to be taken into account when in comparison with the G10 currencies.

I have summarized the literature reviewed in this section in a concise way in the table below. The table shows the sample period that was considered for each of these papers. It also shows their findings relevant to my paper and the factors I construct along with the asset class and currencies that were used.

At the end of the table, I introduce two new factors which are variations to the betting against beta factor that I will later construct and examine its performance in three different investment universes.

Factor	**Paper**	**Main Findings**	**Sample Period**	**Asset class**
Value	Abuaf and Jorion (1990)	- Shocks to the Real Exchange Rate (RER) slowly cancel out over time. - Fundamental differences in the behavior of real and nominal exchange rates is due interactions between price levels and exchange rates. - Price levels play an important role in the long-term stability in real exchange rates	1900-1990	G10 Currencies
	Menkhoff et al., (2015)	- Positive correlation between interest differentials and RER. - Driven by persistent differences in country characteristics. - Controlling for macroeconomic fundamentals makes the RER have predictive power of currency excess returns. - RER reverts to its fundamental value which drives these excess returns in the long run	1976-2014	G10+EM Currencies
	Barroso and Santa-Clara (2015)	- (On the contrary) Momentum and value reversal help optimize currency portfolios better than real exchange rate.	1927-2011	Equity & Currencies
	Baltussen, Swinkels and Vliet (2020)	- Currency value strategies have low Sharpe ratios historically	1972-2012	G10 Currencies
Momentum	Jegadeesh and Titman in 1993	- First documented the cross sectional momentum factor in the stock market.	1965-1989	Equity

	Okunev and White (1993)	- Profitability of the momentum-based strategies hold for currencies and its performance is not due to a time-varying risk. - Return generated is from the underlying autocorrelation of the currency returns	1980-2000	G10 Currencies
	Burnside et al. (2011)	- Little evidence that the profitability of momentum strategies stem from the compensation for the risk they bear	1976-2010	G10 + EM: 20 currency pairs
	Menkhoff et al. (2012)	- Evidence for under and subsequent over reaction in the long horizon momentum returns. - Excess returns from momentum strategies in currency markets is as high as documented in stock markets.	1983-2009	G10+ EM
Trend	Moskowitz, Ooi and Pedersen (2011)	- There is a relation between time series and cross section momentum but these strategies are inherently distinct	1965-2009	G10 currencies : 12 pairs
	Zhang (2020)	- Argues that these Momentum and Trend have a common source which are systematic(factor) returns.	1983-2020	G10+EM : 48 currencies
Carry	Lustig et al., (2011)	- Identification of a second slope factor which decreases monotonically from high to low interest rate currency portfolios, which they label carry trade risk factor HML_{FX}	1983-2008	G10 + EM : 37 currencies
	Koijen et al., (2016)	- Returns to carry strategies across assets cannot be explained by other known global return factors such as momentum, time series momentum and value.	1988-2012	All Asset classes including G10 currencies
Return Season-ality	Keloharju et al. (2016)	- Documents a return seasonality strategy in which stocks are selected based on their historical same-calendar-month returns.	1963-2011	Equity
	Tse (2017)	- Currency portfolios sorted based on their same calendar month return following Keloharju et al (2016) does not produce any excess returns like in the stock portfolios.	1973−2015	G10 Currencies
BAB	Frazzini and Pedersen (2010)	- Documentation of a Betting-Against-Beta (BAB) factor strategy which goes long leveraged low-beta assets and shorts high beta assets.	1984-2012	All Asset classes
	Baltussen et al. (2020)	- BAB effect outside equity markets is found to be weak.	1972-2012	G10 currencies

	Marx and Velikov (2018)	- Non-standard construction of BAB by Frazzini and Pedersen contributes significantly to the strategy's remarkable performance, and this reflects biases in their betas. - BAB which follows a standard construction does not provide strong evidence for the profitability of the equity strategies	1968-2012	US Equity
Output Gap	Colacito et al. (2019)	- Colacito et al. (2019) propose a 'business cycle factor' based on the strong link between currency excess returns and the strength of the business cycle. - Sorting portfolios on relative output gaps generates a GAP premium	1983-2016	G10+EM : 27 countries
Equity Differential	Burnside (2012)	- Attempts a unified risk-based explanation for returns in the equity and currency markets. - Demand from cross-border equity has predictive power over currency returns.	1976-2010	G10, 20 pairs
	Turkington and Yazdani (2020)	- Differential in trailing equity market performance across countries strongly predicts the cross section of currency returns. - Anticipation of country fundamentals may also play a role in the return predictability.	1990--2017	G10 : 45 currency pairs
Term Spread	Ang and Chen in 2010	- Term spread between long-term and short-term is a predictor of foreign exchange returns independent of carry. - Currencies tend to depreciate if the term spread is steep.	1975-2009	G10: 23 currencies
Global equity BAB	Ang et al. (2006)	- Stocks with high sensitivities to innovations in volatility have low average returns therefore stocks with high idiosyncratic volatility have low average returns	1967-2001	Equity
Equity Beta	Atanasov, Nitschka,(2015)	- Strong relation between currencies' average returns and their sensitivities to cash-flow shocks in equity markets	1983-2010	G10+EM: 37 currencies
Beta Factors	Menkhoff et al., (2012)	- Global FX volatility is a key driver of risk premia in the cross section of carry trade returns	1983-2009	G10+EM : 48 currencies
	Ang et al., (2006)	- Firms which are highly sensitive to innovations in aggregate volatility have low average returns and stocks with high idiosyncratic volatility have lower average returns	1986-2000	Equity

	Rafferty (2012)	- Introduces a global currency skewness risk factor based on using downside and crash risk as explanations for currency returns	1976-2011	G10+EM : 37 currencies
	Blitz, Pang and van Vliet (2012	- Volatility effect (the relation between risk and return) in emerging equity markets is negative. - Effect is more pronounced when they use volatility instead of beta to measure risk.	1988-2010	Equity

This paper contributes to the related literature by examining the existence of all these factors in three investment universes (G10 , Emerging Markets and both together) and comparing their performance. This paper also introduces two new factors:

Factor	**Description**	**Sample period**	**Assets**
Global Equity- BAB	- Builds on the BAB factor and the relationship between currency and equity markets. - Currency positions are taken on the signal which measures the beta of a currency pair relative to the global equity index.	1990-2022	G10 , EM and G10+EM
Equity Beta	- This factor builds a signal based on the movement of a country's equity index relative to the world equity index. - This can give us a new measure for the volatility in the currency markets based on the conditions of a country's equity market	1996-2022	G10 , EM and G10+EM

3. Data

This paper in the first part uses an investment universe consisting of only G10 currency pairs and then extends to include emerging market currency pairs. The currency pairs all have a common base currency which is the US dollar (following Baltussen et al, 2020). The G10 (developed markets) currency pairs in our sample are AUD , CAD, CHF , EUR, GBP, JPY, NOK , NZD , SEK and USD (all against USD) . Before 1999 (when the EUR started circulation) I use the currency pairs BEF, DEM, ESP, FRF, ITL, and NL (all with USD base).

For the emerging market currencies , this paper follows Alvero and Eterovic (2022) and uses those currency pairs that are defined as emerging markets by MSCI and that are not pegged to the USD. The authors also chose those currencies whose one-month currency forward contracts are tradable internationally. Additionally they exclude those markets that are considered frontier by MSCI, FTSE, S&P and Russell. The emerging currency pairs therefore included in this paper are ARS, CNY, IDR, INR, KRW, MYR, PHP, SGD, THB, TWD, CZK, HUF, ILS, PLN, RON, RUB, TRY, ZAR, BRL, CLP, COP, MXN, PEN (all against the USD)

It is important to note that not all factors are constructed using all the emerging market currency pairs mentioned above. This is because few of the definitions require Emerging market data which was not available (equity index , short/long term interest rates, production index etc.) To avoid significant data gaps, certain emerging market currency pairs were dropped from the factor strategy construction. The currency returns (spot returns and forward returns) used for each factor along with its annualized mean and standard volatility is provided in table[1].

INSERT TABLE 1 HERE

The spot and forward rates (1 month) are from Bloomberg. The whole sample of the dataset begins from January 1972 and extends till June 2022. The forward returns were available only from the year 1990 for the G10 currencies and from the year 2000 for the Emerging Market currencies. Therefore the currency returns calculated as the change in spot rates. The forward returns however are used only for the Carry factor which begins from the year 1990.

For the Value factor construction, I use CPI data (monthly frequency) obtained from OECD (Organization for Economic Co-operation and Development) . For the Equity differential factor, the individual country's equity index is obtained from WRDS (Wharton Research Data Services – Monthly World Indices) . The one-month interbank deposit rates (LIBOR), three month government bill rate, 5- year government bond rates and 10-year government bond rates are from the Global Financial Data (GFD) which were used to construct the Term Spread factor.

4. Methodology

The first part of the paper replicates and extends the global factors to 2022 closely following the methodology in Baltussen et al, (2020). The paper then expands the investment universe to include emerging market currencies. The paper then looks at new factors, such as the equity differential factor, Term spread, output gap and two variations of the Betting against beta factor.

4.1 Factor definitions

Below I will define and describe the definitions followed for the factors constructed in this paper.

Value Factor

This factor builds on the idea similar to purchasing power parity, the law of one price, where in the absence of trading costs a basket of goods must have the same price in different countries. A rise(fall) in the purchasing power leads to the strengthening(weaking) of the currency. I take the 5 year change because the PPP is said to hold in the long run (Abuaf and Jorian, 1990)

The value of a currency is typically measured as either the absolute or the relative purchasing power parity in previous literature. While Baltussen et al(2020) equally weight the absolute and relative PPP as a signal of the value factor, I use only the relative PPP[3]. The relative purchasing power parity follows Asness, Moskowitz and Pedersen(2013) , who use a negative of the 5-year change in purchasing power parity.

The relative PPP is hence calculated as follows:

> *log [average spot exchange rate 4.5 to 5.5 years prior / spot exchange rate today] – log [(change in CPI of foreign in 4.5 years / change in CPI of US in 4.5 years) – (change in CPI of foreign in 5.5 years /change in CPI of US in 5.5 years)]*

Momentum Factor

This factor is based on the evidence from numerous prior literature that the 'winner' assets that historically perform well and the 'loser' assets which historically perform worse will continue to do so in the future. This momentum can be exploited to predict future returns.

The cross section momentum follows Menkhoff et al., 2012 who construct the momentum signal as the currency return over the past 12 months skipping the most recent month to account for any short term reversals .

This paper also constructs a 6- month momentum factor, skipping the most recent week. I also check for the 12 month momentum factor's performance when we skip one week instead of the 1 month which is usually followed in the prior literature. The results for this are not included in this paper since the optimum performance for the momentum currency factor was when the 12 minus 1 month construction was followed.

Time Series Momentum

There has been an extensive record of an asset's past returns having a strong predictability of its future returns. Unlike the cross sectional momentum, the time series momentum is directional in nature.

The time series momentum factor is constructed by going long the currencies which have a positive (>0) currency return and short the currencies which have a negative currency return (<0) in the past 12 months. This definition follows the definition of Moskowitz et al(2012) who first documents the time series momentum across all asset classes.

Similar to cross section momentum, the trend factor also skips the most recent month to be free from the effects of any short term reversals or spurious autocorrelations.

Carry Factor

The carry factor exploits the difference between high yielding currencies and low yielding currencies. This factor invests in currencies with high yield while funding with a currency which has a relatively low yield.

The carry factor signal construction uses the short term yield differential based on forward rates. A currency's carry is defined as the difference between the spot and forward rate at time *t* , divided by the forward rate at time *t*. The spot and forward rates are measured as the number of local units per unit of USD. The carry signal of a currency constructed can be denoted as:

$$C_{i,t} = \frac{S_{i,t} - F_{i,t}}{F_{i,t}}$$

Return Seasonality

This factor exploits the seasonality patterns recorded in the returns of an asset to help predict the returns of that asset in a particular month.

The return seasonality factor is constructed based on the currency return in a certain month over the period of the prior 20 years. The current month's return can be calculated using a univariate regression of month t's return on month t-k returns with k ranging from 1 to 240 months (20 years)

Betting- Against- Beta

The beta factor (similar to the volatility factor) builds on the historical evidence that the high beta assets have relatively lower returns than the low beta assets. This paper exploits this risk return relationship and invests in currencies with a low beta measure and funding in high beta currencies.

The Betting against Beta factor follows the definition of Beta by Frazzini and Pedersen, where the beta of a given currency over a given time period is the estimated volatility of the local currency divided by the estimated volatility of the portfolio of the whole currency basket (in this case, the portfolio of all the currencies included in the dataset) which is then multiplied by the correlation between the two. The beta measure can be given by:

$$\beta_i^{ts} = \rho \frac{\sigma_i}{\sigma_m}$$

This paper extends the Betting Against Beta factor to try a different market proxy. I use the world equity index volatility instead of the volatility of the composite of currencies in the dataset used. This factor is called the Global BAB factor in this paper. The second variation of the beta factor is calculated by looking at the individual country's equity volatility relative to the global equity index volatility. I call this factor the Equity Beta factor.

I used a minimum of 6 months (120 trading days) of non- missing data to calculate the estimated volatilities and a minimum of 3 years(750 trading days) of non-missing data for calculating the correlations.

The beta factors go long the low beta currencies and shorts the currencies with the high beta estimates. This paper implements the Betting-Against-Beta factor strategies in two ways, one uses the High-minus-Low method in which the return on the strategy is the

difference between the two portfolios which takes long and short positions based on the beta estimates. The second strategy uses a weighting scheme used by Koijen et al(2017) and Asness et al (2010) where positions are taken equal to the rank minus the cross sectional average.

Term Spread

Boudoukh, Richardson and Whitelaw (2006) show that exchange rates can be predicted using term structure variables to forecast exchange rates. In this paper , factor construction follows Ang and Chen(2010) who take long (high) and short (low) positions based on term spread levels . The term spread is defined as the difference between long and short rate.

The short term interest rates are the One-month interbank deposit rates (LIBOR) rates or the country's three month government bill rate if the LIBOR rate wasn't available. The long term interest rates are the 10- year(or 5-Year if this wasn't available) government bond rates. The strategy goes long the currencies of the countries with the largest spread and short the ones with the shorter spread (difference)

Output Gap

Colacito et al(2019) find that macroeconomic variables (such as output gap) have a strong currency exchange rate predictability. They show that buying currencies of strong economies and selling currencies of weak economies generate returns in the cross section of economies. The Output gap factor definition follows Colacito et al(2019), where the output gap is defined as the logarithm of the difference between actual (y_i) and 'potential' ($\bar{y}_i$) output:

$$gap_i = y_i - \bar{y}_i$$

A country's potential output is not directly observable and must therefore be estimated. I use the Hamilton method for linear projection to derive the potential output at time *t*. In this method $y_{i,t}$ is the log value of the industrial production for a country *i* available at time *t*. This is regressed on their corresponding values from two years earlier and includes 12 lags. I use the Industrial production index for each country as the proxy for their actual output (y).

$$y_{i,t} = \sum_{s=0}^{11} \beta_{i,s} y_{i,t-24-s} + \varepsilon_{i,t}$$

Equity Differential Factor

Turkington and Yazdani(2020) find that countries with strong equity returns in the previous 12 months see an appreciation in exchange rates. This factor thus exploits this relationship and forms portfolios sorted on historic equity index returns outperform those formed on traditional carry, trend, and valuation factors.

This factor takes currency positions based on the differential in trailing 12-month equity index total returns as of the end of the previous month for each pair (omitting the most recent month). This is then used to record the subsequent month's performance of the factor portfolio.

4.2 Portfolio Construction

The signals for each factor constructed as described in the previous section are then ranked according to its definition (ascending or descending). Next, positions are taken equal to the rank minus the cross sectional average as followed by Asness et al (2010) and Koijen et al (2017). This weighting scheme ensures that the sum of the long and short positions equals 1 and -1 respectively.

The weights of each currency pair in a portfolio is therefore given by :

$$w_{j,t+1} = c_t \left(\text{rank}(x_{j,t}) - \sum_{j=1}^{N_t} \text{rank}(x_{j,t})/N_t \right)$$

This paper follows a standard cross sectional method of portfolio construction for all the factors except the BAB factor and its variations which use a low (beta) minus high (beta) method as well as the time series momentum (Trend) which is directional and the signals are not ranked.

The high minus low method calculates the returns as the difference between low beta currencies (long positions) and high beta currencies (short positions). Time series momentum assigns the weight 1/N to the currency in the portfolio if the past signal (past return) is positive and -1/N if negative, where N is the number of currencies at time t.

The rebalancing frequency across all factors is monthly and all the factor returns are scaled at the 10% (target) ex post , in-sample 3-year (36 month) volatility. This follows the volatility scaling method given by Harvey et al (2018). The factor returns calculated are monthly returns. The paper primarily reports the Sharpe ratios to see the profitability of these factor strategies.

4 Results

4.1 Factors Performance of G10 Currencies

INSERT TABLE 2 HERE

Table [2] shows us the performance of the 'classic' that are well recorded across various asset markets in recent literature. Similar to Baltussen et al(2020), the results show that out of the global returns factors constructed using G10 currency pairs, momentum (0.40), trend (0.46) and carry (0.58) have significant Sharpe ratios higher than the other factors, Value, Return seasonality and Betting-Against -Beta. The table also shows the appraisal ratios of these factor portfolios. The appraisal ratios as shown above are similar to the Sharpe ratios and the factors Momentum, Return Seasonality and Carry like also have high appraisal ratios compared to the other well recorded factors when using the currency asset class.

In the appendix, table [8] shows a high correlation between the two factors, Trend and Momentum. And since the trend factor produces a higher Sharpe ratio than momentum , there is a cause for concern that the trend will dominate momentum in the long run. Baltussen et al(2020) control for static effects (trend factor on average tends to be long on factors with positive return) and show that this dominance of trend factor disappears.

Panel A of Table[3] shows the Sharpe ratios (and appraisal ratios) of the currency factors that are recorded in more recent literature and the variations to the beta factor. The methodology used closely follows the original literature where it was first recorded. Using the G10 currencies, the equity differential factor and term spread factor produce very low Sharpe ratios compared to the rest of the new factors. The Output gap (0.29) , global equity BAB (0.33) and the Equity Index Beta (0.39) factors perform relatively better and produce significant Sharpe ratios. It is important to note that not all G10 currency pairs were used for the construction of the newer factors due to the unavailability of macroeconomic data (production index for output gap factor) and equity index data (beta factors).

Out of these new factors, the most promising is the Equity Index beta which takes positions in the currency market based on the performance of a certain country's equity market relative to the global equity index. Exploiting the movement in currencies(volatility) based on the movements (volatility) in the equity market produces a significant alpha and appraisal ratio. This measure of the currency beta performs better than the beta definition followed by Frazzini and Pedersen.

4.2 Factor Performance of Emerging Market Currency Universe

Panel B in table [2] shows the Sharpe and appraisal ratios of the 'classic' well recorded factors when the investment universe contains just the emerging market currencies. The results indicate evidence for a strong presence of all classic factors when the universe included only the emerging market currencies. The factor which performs the best is Time Series Momentum (Trend) with a the highest Sharpe Ratio of (1.33), which also has a high statistical significance. The performance of emerging currency pairs is much better and higher than just the G10 currencies. This is higher performance is also reflected in the appraisal ratios as shown in panel B of Table[2]. The betting against beta factor (0.27) using the weighting scheme used by Koijen et al (2017) shows the least strength in Sharpe ratio compared to the rest but is still significant at the 1% level.

These factor premiums generated however have a much high kurtosis than compared to the G10 currency universe as expected. These returns have similar market betas as the G10 currency universe but almost double the average annualized returns as shown in panel B in Table[2]

There however is no evidence for the set of new currency factors that have been recorded in recent literature in the emerging currencies universe. Panel C in table[2] shows that the Global Equity BAB shows a relatively higher Sharpe ratio but is statistically insignificant. The other factors all produce negative Sharpe ratio close to zero indicating the absence of these factor premiums in the emerging markets. The equity beta factor also generates a negative Sharpe ratio (factor reversal effect) in the emerging market universe. These results are in line with the findings of a similar paper on volatility by Blitz et al.,(2013) who find that the risk return relationship in emerging (in this case equity) market is flat or even negative.

INSERT TABLE 3 HERE

4.3 Factor Performance of G10 and Emerging Market Currency Universe

Panel C of Table[2] shows the Sharpe and appraisal ratios of the 'classic' when the universe is extended to include G10 currencies along with emerging market currencies. The Sharpe ratios of momentum (0.90) , trend (0.92) and carry (0.85) factors almost double from the G10 universe when the dataset includes emerging currency pairs also having a high statistical significance. The other factors, Value (0.34) , return seasonality (0.41) and the betting against beta factor (0.48) using the weighting scheme used by Koijen et al (2017) produce higher Sharpe ratios when the emerging currencies are included with the G10 currencies as shown previously.

The betting against beta factor which uses a high (low beta currencies) minus low (high beta currencies) portfolio construction does not produce any significant alpha or Sharpe ratio in the G10 universe and in the universe which has both currencies but does well when only emerging market currencies are used. This indicates that the BAB factor in G10 currencies brings down the performance of the emerging market currencies. Apart from this factor and the Trend factor, including both currency pairs, produces higher Sharpe ratios for the rest of the 'classic' factors.

The set of new currency factors that have been recorded in recent literature do not tend to perform better once the emerging currency pairs are included along with G10 currencies in the dataset. The equity differential (0.10) and term spread factor (0.14) continue to yield low, insignificant Sharpe ratios while the other factors, output gap (0.05) , global equity BAB (0.24) and equity index beta factor (0.20) portfolios have a lower a performance when including emerging market currencies.

The betting against beta (and its variations- beta factors in general) have a higher performance when the portfolios are constructed using the weighting scheme used by Koijen et al(2017) . The same factors generate lower Sharpe ratios when the High-minus-Low method was used to construct the portfolios.

INSERT FIGURE 1 HERE

Therefore an overview of performance of all three currency universes across the various factors can be seen in figure [1]. There is no strong significant evidence for the factors Term spread, Equity Differential and Output Gap in all three investment universes.

Overall, we see that the 'classic' factors outperform the newer factors and inclusion of emerging markets can significantly improve the returns of these factor strategies.

These classic factors also are not highly correlated with one another (with an exception for momentum and Trend) as seen in Table[9] in the appendix . The term spread factor like in the paper by Ang and Chen can be seen to have low correlation with the carry factor for which evidence is found in [9]. Overall any correlations greater than or lower than $\pm$ 0.1 except between the factor returns of Momentum, Trend, Return seasonality factor and the two BAB factors which differ in the method of portfolio construction is not observed in all three invest universes.

The next step will be to construct an optimum multi factor model using the strongest factors for which this paper can be a good starting point.

4.4 Downside Risk Analysis

It is important when looking at the performance of factor strategies in emerging markets, to also look at the risk and volatility associated with it. To assess the downside risk, I construct the downside betas for the factor strategies along with the downside CAPM alpha. The difference in the regular beta and the downside beta is compared between the G10 currencies and the Emerging currencies. For this analysis the factor returns that are below one standard deviation from the mean return are considered. The beta and alpha is then calculated for these returns and called the 'downside' beta alpha.

INSERT TABLE 4 HERE

INSERT TABLE 6 HERE

In the investment universe which uses only the G10 currencies, there is not a big difference ($\pm$0.1) between the downside beta and the regular beta for all the 'classic' factors. But the newer factors, Term spread, Equity Beta and the Equity differential have downside betas which differs by a large margin with the regular beta. The factors Term spread and Equity differential especially carry a high alpha for their downside betas (risk) which better predict its strategy returns.

Similar large difference of the term spread factor betas is also observed for the emerging market currencies universe. However, the beta is more negative (moves in the opposite direction of the benchmark) indicating a reversal effect in downside return distribution. The

value factor downside beta varies a lot to its regular beta and explains almost all the alpha generated by the strategy. Similarly, the output gap factor also sees a huge difference between the two beta values.

INSERT TABLE 5 HERE

When we consider the downside risk for the investment universe of only emerging market currencies as seen in table [5] currencies we see that the factors Value, Term Spread, Output Gap and Equity Differential have high differences between the market beta and the downside betas which also carry high downside alpha (significant at 1% for the term spread factor) . These factors despite having a higher crash risk and extreme downside volatilities, do not produce high returns in the emerging markets. The returns of other factors which are relatively higher are not completely attributable to the compensation for downside risk in the emerging market currency universe.

Another important feature of the factor strategy returns is the difference in kurtosis and skewness between the three investment universes. There is not much difference between the skewness levels of the returns from the two datasets. In table[7] we see that the kurtosis (width of the tail ends of the distribution based on outlier values) doubles for the factors value, momentum, return seasonality and BAB (with the weighting scheme by Koijen et al in 2017) when we include the emerging market currencies and remains similar for the rest of the factors.

INSERT TABLE 7 HERE

In the universe with G10 and EM currencies together however, the increase in the volatility (prevalence of extreme outliers in the return distribution) combined with the increase in downside beta for Value and Momentum factors might indicate that the high returns are associated with the compensation for a volatile emerging currency market.

5 Conclusion

There is a gap in the exiting factor investing literature when it comes to uniformly examining factor premiums in the emerging markets, especially in the currency asset class. The results of this paper indicates the presence of factor premiums in employing strategies using emerging market currencies.

The factors whose existence has been widely recorded in literature, such as, Carry, Momentum and Trend , Return Seasonality, Betting-against-Beta produce the high Sharpe ratios in all the investment universes and is higher when the universe includes emerging market currencies. There is strong indication for diversification benefits of using the these emerging market currencies. However, one must be cautious in implementing newer factors using the emerging market currencies. Since these markets are not efficient enough, there is a lot of risk associated with betting against any anomaly than compared to G10 currencies.

The newer factors such as output gap, equity differential, term spread and variations to the BAB which use the global equity index data do not show improved performance in the emerging market universes. This may be because the strength of the signals which use macroeconomic data or the equity index data does not have predictive power over the emerging market currencies as it does over the G10 currencies. The less efficient and stable emerging markets will benefit from employing factor signals that have been built over past returns or changes in nominal rates. When economic factors are instead used to construct signals in emerging markets, they do not have as good a predictive power as they do in the developed markets. This however can be an avenue for further research as to why there is a difference in the performance of these newer factors.

The next step would ideally be constructing multifactor currency portfolios. The portfolios including emerging markets currencies with optimal currency factor timing or tilting strategy, by using some factors as diversifiers to mitigate the downside risks that comes with momentum and value has the potential to generate returns better than the individual factors and an equally weighted benchmark. The paper by Lohre et al. (2019) shows that employing these sophisticated portfolio formation strategies improves the performance. Thus this thesis has many directions in which the results can be used to construct optimal portfolios which exploit the 'classic' factor returns generated from emerging market currencies and the newer currency factor returns using the G10 currencies.

6 Acknowledgements

A Master thesis comes with its own set of challenges and completing it successfully would have not been possible without the support I was grateful to receive from the people around me.

Foremost, I would like to express heartfelt gratitude to my thesis supervisor, Dr. Guido Baltussen who kindled my interest in behavioral and factor investing during his seminar classes and encouraging me to take up this topic for my thesis. I would like to thank him for his guidance, feedback and comments which helped improve the quality of my Thesis.

I would like to thank my Internship supervisor at Robeco, Lodewijk van der Linden, for his invaluable support and guidance. His practical views and comments help make sure my work was relevant in academics and in practice. I would also like to thank Fabio Martinetti for his inputs and technical help with the programming.

Last, but definitely not least, I want to thank my parents who gave me the opportunity to explore my interests and follow my path halfway across the world. Nothing would be possible without their unconditional support.

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8 Appendix

8.1 Tables

Table 1 : Descriptive Statistics: The table summarizes the currency returns included in the Dataset. return series used in the paper's sample. It shows the annualized mean ('Mean') and the annualized volatility ('SD') for each currency pair used for factor construction in this paper. Panel A shows the mean and standard deviation (in %) of the spot returns and Panel B for the Forward returns (used for the Carry Factor)

Panel A: Spot Returns

Pairs	SD	Mean	Pairs	STD	Mean
GBPUSD	9.39%	-0.09%	CZKUSD	11.47%	0.04%
JPYUSD	10.02%	0.11%	HUFUSD	13.58%	-0.14%
CHFUSD	11.36%	0.17%	ILSUSD	13.79%	-0.87%
CADUSD	6.49%	-0.03%	PLNUSD	12.57%	-0.20%
AUDUSD	10.87%	-0.07%	RONUSD	10.61%	-0.31%
NZDUSD	11.68%	-0.08%	RUBUSD	22.41%	-0.87%
SEKUSD	10.62%	-0.09%	TRYUSD	41.30%	-1.77%
NOKUSD	10.76%	-0.05%	ZARUSD	15.58%	-0.43%
EURUSD	9.45%	-0.03%	BRLUSD	19.09%	-1.89%
ARSUSD	15.65%	-0.96%	CLPUSD	17.37%	-0.46%
CNYUSD	8.27%	-0.22%	COPUSD	10.90%	-0.36%
IDRUSD	19.82%	-0.40%	MXNUSD	30.91%	-0.89%
INRUSD	7.30%	-0.28%	PENUSD	5.51%	-0.22%
KRWUSD	11.15%	-0.09%	BEFUSD	9.34%	0.02%
MYRUSD	7.06%	-0.05%	DEMUSD	9.93%	0.07%
PHPUSD	9.13%	-0.14%	ESPUSD	12.87%	-0.11%
SGDUSD	5.35%	0.05%	FRFUSD	10.08%	-0.06%
THBUSD	8.42%	-0.08%	ITLUSD	14.35%	-0.02%
TWDUSD	4.27%	0.04%	NLGUSD	9.78%	0.05%

Panel B: Forward Returns

Pairs	SD	Mean	Pairs	SD	Mean
AUDUSD	2,13%	-0,01%	MYRUSD	31,37%	1,56%
CADUSD	1,60%	-0,01%	NOKUSD	2,16%	0,02%
CHFUSD	1,88%	-0,04%	NZDUSD	2,23%	-0,02%
COPUSD	34,13%	-0,09%	PHPUSD	43,68%	-0,27%
CZKUSD	39,52%	-0,91%	PLNUSD	28,63%	0,40%
EURUSD	1,68%	0,00%	RONUSD	40,56%	-0,94%
GBPUSD	3.78%	0,02%	RUBUSD	21.77%	-0.52%
HUFUSD	27,91%	-0,08%	SEKUSD	2,00%	0,01%
ILSUSD	39,07%	-0,51%	SGDUSD	4.85%	0.02%
JPYUSD	1,62%	0,02%	THBUSD	6.23%	-0.02%
KRWUSD	8.55%	-0.03%	TRYUSD	12,81%	-0,33%
MXNUSD	7,87%	-0,01%	ZARUSD	5,31%	-0,06%

Table 2 :Performance results of the 'Classic' Currency Factors: The tables shows us the annualized Sharpe ratios and appraisal ratios of the new factors constructed in the three currency universes, Panel A: shows us the performance when only G10 currencies are used, Panel B: only Emerging Market currencies and Panel C: both G10 and Emerging Market currencies. The Sharpe ratio ("SR") calculates the excess currency return per unit of risk. The appraisal ratio ("AR") is calculated as the Jensen's alpha(annualized) divided by the residual volatility. The table shows the annualized Average return of the factor premiums(in %) along with the Market beta (in basis points). Numbers in parentheses indicate t-values. Asterisks are used to indicate significance at a 10% (*), 5% (**) or 1% (***) level. The table also shows the start date, end date and the number of currency pairs of the dataset used.

Factor	SR	AR	Average Return	Market Beta	Start	End	# Pairs
Panel A: G10 Currency Universe							
Value	0.07(0.45)	0.08(0.54)	0.7%	-0.04	May'1972	May 2022	14
Momentum	0.40***(2.76)	0.32**(2.23)	0.7%	0.00	Jan'1972	May 2022	16
Return Seasonality	0.22(1.45)	0.21(1.39)	2.6%	0.02	Jan'1972	May 2022	16
Trend	0.46***(3.12)	0.46***(3.11)	4.6%	0.00	Jan'1972	May 2022	15
Carry	0.58***(2.90)	0.60***(3.00)	5.7%	0.12	Jan'1990	June 2022	9
BAB(HML)	0.12(0.86)	0.13(0.90)	0.7%	0.00	Jan'1972	May 2022	15
BAB(KW)	0.04(0.29)	0.03(0.22)	0.1%	0.00	Jan'1972	June 2022	15
Panel B: EM Currency Universe							
Value	0.31**(2.07)	0.28(0.38)	3.5%	-2.77	Jan'1972	May 2022	16
Momentum	0.89***(6.10)	0.51***(3.56)	6.4%	0.00	Jan'1972	May 2022	23
Return Seasonality	0.31**(1.69)	0.30**(1.97)	3.3%	0.00	Jan'1972	May 2022	23
Trend	1.33***(9.12)	1.21***(8.99)	16.4%	0.01	Jan'1972	May 2022	23
Carry	0.72***(2.94)	0.73***(2.97)	7.8%	-0.01	Jan'2000	May 2022	15
BAB(HML)	0.88***(6.19)	0.85***(5.95)	18.1%	0.05	Jan'1972	May 2022	23
BAB(KW)	0.27*(1.91)	0.27*(1.88)	1.9%	0.00	Jan'1972	May 2022	23
Panel C: G10+ EM Currency Universe							
Value	0.34**(2.28)	0.55(0.77)	3.8%	-3.77	Jan'1972	May 2022	29
Momentum	0.90***(6.14)	0.87***(6.13)	2.4%	2.68	Jan'1972	May 2022	38
Return Seasonality	0.41***(2.76)	0.441***(2.77)	4.6%	0.01	Jan'1972	May 2022	38
Trend	0.92***(6.29)	0.92***(6.30)	9.7%	0.00	Jan'1972	May 2022	38
Carry	0.85***(3.46)	0.85***(3.45)	9.1%	0.02	Jan'2000	May 2022	24
BAB(HML)	0.06(0.43)	0.05(0.43)	1.4%	0.01	Jan'1972	May 2022	38
BAB(KW)	0.48***(3.44)	0.49***(3.47)	1.2%	0.00	Jan'1972	May 2022	38

Table 3 :Performance results of the New Currency Factors: The tables shows us the annualized Sharpe ratios and appraisal ratios of the new factors constructed in the three currency universes, Panel A: shows us the performance when only G10 currencies are used, Panel B: only Emerging Market currencies and Panel C: both G10 and Emerging Market currencies. The Sharpe ratio ("SR") calculates the excess currency return per unit of risk. The appraisal ratio ("AR") is calculated as the Jensen's alpha(annualized) divided by the residual volatility. The table shows the annualized Average return of the factor premiums(in %) along with the Market beta (in basis points). Numbers in parentheses indicate t-values. Asterisks are used to indicate significance at a 10% (*), 5% (**) or 1% (***) level. The table also shows the start date, end date and the number of currency pairs of the dataset used.

Factor	SR	AR	Average Return	Market beta	Start	End	# Pairs
Panel A: G10 Currency Universe							
Equity Differential	0.08(0.45)	0.09(0.46)	0.8%	-0.39	Jan' 1990	June 2022	9
Term Spread	0.02(0.15)	0.04(0.30)	0.2%	-2.81	Jan' 1972	Dec' 2021	13
Output Gap	0.29**(2.00)	0.29**(1.98)	2.8%	0.01	Jan' 1972	May 2022	8
BAB(Global Equity)	0.33*(1.73)	0.37*(1.92)	3.7%	4.25	Jan' 1990	May 2022	9
Equity Index Beta	0.39**(2.20)	0.39**(2.19)	0.5%	0.00	Mar' 1996	May 2022	9
Panel B: EM Currency Universe							
Equity Differential	-0.07(-0.36)	0.04(0.20)	-0.7%	1.30	Jan'1990	June 2022	16
Term Spread	-0.05(-0.37)	-0.07(-0.49)	-0.6%	-0.22	Jan'1972	July 2022	15
Output Gap	-0.08(-0.49)	-0.16(-0.89)	-0.9%	-0.81	Feb' 1972	Mar' 2022	10
BAB(Global Equity)	0.33(1.59)	0.04(1.18)	0.7%	-0.01	Jan'1990	May 2022	15
Equity Index Beta	-0.11(-0.56)	-0.25(-1.30)	-0.2%	-0.00	Mar' 1996	May 2022	15
Panel C: G10+EM Currency Universe							
Equity Differential	0.10(0.53)	0.13(0.69)	1.0%	0.53	Jan' 1990	June 2022	24
Term Spread	0.14(0.96)	0.10(0.67)	1.5%	-0.56	Jan' 1972	July 2022	21
Output Gap	0.05(0.36)	0.05(0.34)	0.5%	-0.03	Feb' 1972	Mar' 2022	18
BAB(Global Equity)	0.32*(1.82)	0.11(0.61)	0.4%	0.00	Jan'1990	May 2022	24
Equity Index Beta	0.20(1.02)	0.04(0.21)	0.0%	-0.01	Mar' 1996	May 2022	24

Table 4: Downside risk of G10 currency factors: The table shows the downside beta and downside alpha which is used to analyze the downside risk. The regular beta is reported as (β) and downside beta (β -). Similarly the regular alpha as (α) , and the downside alpha as (α-). The market is an equally weighted index of all currencies in the dataset used in the paper. The downside beta is calculated using a (-1) standard deviation as the threshold (beta of the returns of the factor below one standard deviation). All the values reported are in basis points. Asterisks are used to indicate significance at a 10% (*), 5% (**) or 1% (***) level.

Factor	β^-	**β**	$\beta^- - \beta$	α^-	**t-stat**	**α**	**t-stat**
Value	-0.02	-0.04	0.02	0.04	0.90	0.00	0.54
Momentum	0.01	0.00	0.01	0.02*	1.77	0.01**	2.23
Trend	0.02	0.00	0.02	0.04	1.16	0.13***	3.12
Return Seasonality	0.01	0.02	-0.01	0.03	1.06	0.01	1.39
Carry	0.05	0.12	-0.07	0.12**	2.48	0.02***	3.00
BAB (HML)	-0.02	0.00	-0.02	-0.04**	-1.98	0.00	0.90
BAB (KW)	-0.01	0.00	-0.01	-0.01**	-2.16	0.00	0.22
Term spread	-0.18	-2.81	2.63	3.38	0.62	0.13	0.30
Output Gap	0.02	0.01	0.01	0.06	1.46	0.01**	1.98
Global Equity BAB	-0.04	0.05	-0.09	-0.01	-0.98	0.00	0.64
Equity Beta	-1.47	0.00	-1.47	0.00	0.52	0.01**	2.2
Equity Differential	1	-0.39	1.39	2.14	0.47	0.25	0.46

Table 5: Downside risk of EM currency factors: The table shows the downside beta and downside alpha which is used to analyze the downside risk. The regular beta is reported as (β) and downside beta (β -). Similarly the regular alpha as (α) , and the downside alpha as (α-). The market is an equally weighted index of all currencies in the dataset used in the paper. The downside beta is calculated using a (-1) standard deviation as the threshold (beta of the returns of the factor below one standard deviation). All the values reported are in basis points. Asterisks are used to indicate significance at a 10% (*), 5% (**) or 1% (***) level.

Factor	**β -**	**β**	**β - - β**	**α-**	**t-stat**	**α**	**t-stat**
Value	0.64	-2.77	3.41	7.89	1.63	0.19	0.375
Momentum	0.01	0.00	0.01	0.01*	1.69	0.01	3.56
Trend	0.00	0.01	-0.01	0.04	0.89	0.05***	8.99
Return Seasonality	0.00	0.00	0.00	0.01	0.21	0.01**	1.97
Carry	-0.02	-0.01	-0.01	0.01	0.20	0.02	2.97
BAB (HML)	0.02	0.05	-0.03	0.08	0.94	0.05***	5.95
BAB (KW)	0.00	0.00	0.00	0.00	-0.03	0.01*	1.88
Term spread	-3.49	-0.22	-3.27	-11.29*	-1.93	-0.24	-0.49
Output Gap	-2.85	-0.81	-2.04	-6.40	-1.10	-0.48	-0.89
Global Equity BAB	-0.00	-0.01	0.01	0.00	0.21	0.00	0.18
Equity Beta	-0.01	-0.00	-0.01	0.01	0.36	-0.00	-1.30
Equity Differential	2.23	1.30	0.93	2.16	0.43	0.11	0.20

Table 6: Downside risk of G10 and EM currency factors: The table shows the downside beta and downside alpha which is used to analyze the downside risk. The regular beta is reported as (β) and downside beta (β -). Similarly the regular alpha as (α) , and the downside alpha as (α-). The market is an equally weighted index of all currencies in the dataset used in the paper. The downside beta is calculated using a (-1) standard deviation as the threshold (beta of the returns of the factor below one standard deviation). All the values reported are in basis points. Asterisks are used to indicate significance at a 10% (*), 5% (**) or 1% (***) level.

Factor	**β -**	**β**	**β - - β**	**α-**	**t-stat**	**α**	**t-stat**
Value	-1.29	-3.77	2.48	3.20	0.78	0.36	0.77
Momentum	0.01	2.68	-2.67	0.02*	1.82	0.01***	6.14
Trend	0.00	0.01	-0.01	0.01	0.28	0.03***	6.30
Return Seasonality	0.00	0.01	-0.01	0.01	0.30	0.01***	2.76
Carry	-0.03	0.02	-0.05	-0.08**	-1.87	0.03***	3.46
BAB (HML)	-0.03	0.00	-0.03	-0.10	-1.55	0.01	0.43
BAB (KW)	0.00	0.00	0.00	0.01	1.33	0.01***	3.47
Term spread	-2.92	-0.56	-2.36	-3.58	-0.70	0.32	0.67
Output Gap	-1.10	-0.03	-1.07	-2.65	-0.52	0.15	0.33
Global Equity BAB	-0.01	0.00	-0.01	-0.01	-0.98	0.01	0.61
Equity Beta	-0.02	-0.01	-0.01	-0.03**	-2.21	0.01	0.21
Equity Differential	0.65	0.53	0.12	1.80	0.41	0.38	0.69

Table 7: Skewness and Kurtosis of Factor Returns : The table shows the skewness and the kurtosis of the factor returns in all three investment universes, the G10 currencies, Emerging Market currencies and the factor returns of the universe which uses both G10 and emerging currency pairs. Skewness measures the symmetry of the returns distribution, while kurtosis determines how fat or thin the tails of the distribution are.

Factor	Skewness (G10)	Kurtosis (G10)	Skewness (EM)	Kurtosis (EM)	Skewness (G10+EM)	Kurtosis (G10+EM)
Value	0.54	4.47	0.22	10.69	1.07	9.30
Momentum	-0.11	4.21	-3.05	14.49	-0.42	9.24
Return Seasonality	0.13	3.14	1.37	10.44	1.18	9.69
Trend	-0.21	3.02	0.40	5.88	-0.09	3.86
Carry	-0.78	4.11	0.50	4.47	0.55	4.22
BAB HML	0.23	4.36	1.11	7.69	0.26	5.08
BAB KW	0.29	4.67	3.12	14.26	0.55	11.25
Output Gap	0.13	5.00	0.07	5.62	0.13	5.76
ED	-0.09	4.76	-0.06	4.30	0.21	5.15
Global equity BAB	0.34	8.72	0.03	4.95	0.18	8.96
Equity beta	-0.17	6.10	0.06	13.12	0.06	6.81
Term spread	-0.30	3.77	0.11	6.13	0.19	5.26

Table 8 : Correlation Matrix : The tables shows the correlation matrix of the factor strategy returns generated by three investment universes. Panel A shows us the correlation matric of the factor returns from the G10 currency universe, Panel B is the Emerging Market currency universe and Panel C shows the correlation of factor returns when the investment universe uses both the G10 and Emerging Market Currencies.

Panel A: G10 Universe

	Value	*Momentum*	*RS*	*Trend*	*Carry*	*BAB HML*	*BAB KW*	*Output gap*	*ED*	*Term Spread*	*GE*	*Equity Beta*
Value	1,00	0,02	-0,03	0,02	0,02	0,04	0,11	0,07	-0,01	0,01	-0,02	0,04
Momentum	0,02	1,00	0,02	0,81	-0,01	0,02	0,11	0,01	-0,02	0,03	0,09	-0,02
RS	-0,03	0,02	1,00	0,07	-0,09	-0,06	0,00	0,04	-0,07	-0,09	0,09	0,00
Trend	0,02	0,81	0,07	1,00	-0,02	0,01	0,05	-0,01	-0,01	0,08	0,07	0,00
Carry	0,02	-0,01	-0,09	-0,02	1,00	-0,02	-0,02	-0,07	-0,05	-0,08	0,00	0,04
BAB HML	0,04	0,02	-0,06	0,01	-0,02	1,00	0,33	0,00	0,01	-0,05	0,00	0,07
BAB KW	0,11	0,11	0,00	0,05	-0,02	0,33	1,00	0,07	0,04	0,02	-0,06	0,05
Output gap	0,07	0,01	0,04	-0,01	-0,07	0,00	0,07	1,00	0,15	0,05	0,00	0,02
ED	-0,01	-0,02	-0,07	-0,01	-0,05	0,01	0,04	0,15	1,00	0,00	0,00	0,01
Term Spread	0,01	0,03	-0,09	0,08	-0,08	-0,05	0,02	0,05	0,00	1,00	-0,03	0,02
GE	-0,02	0,09	0,09	0,07	0,00	0,00	-0,06	0,00	0,00	-0,03	1,00	0,05
Equity Beta	0,04	-0,02	0,00	0,00	0,04	0,07	0,05	0,02	0,01	0,02	0,05	1,00

Panel B: EM Universe

	Value	*Momentum*	*RS*	*Trend*	*Carry*	*BAB HML*	*BAB KW*	*Output gap*	*ED*	*Term Spread*	*GE*	*Equity Beta*
Value	1,00	-0,03	-0,01	-0,03	-0,07	-0,03	0,03	0,03	-0,02	-0,01	-0,03	0,00
Momentum	-0,03	1	0,22	0,41	0,12	0,38	0,29	0,01	0,00	-0,01	0,27	0,24
RS	-0,01	0,22	1,00	0,16	0,05	0,35	0,22	0,02	-0,01	-0,03	0,13	0,11
Trend	-0,03	0,41	0,16	1,00	0,07	0,26	0,21	0,01	-0,04	-0,02	0,23	0,09
Carry	-0,07	0,12	0,05	0,07	1,00	0,03	0,01	-0,11	0,05	0,00	0,02	0,02
BAB HML	-0,03	0,38	0,35	0,26	0,03	1,00	0,20	0,03	-0,02	0,03	0,14	0,14
BAB KW	0,03	0,29	0,22	0,21	0,01	0,20	1,00	-0,02	-0,03	0,01	0,26	0,20
Output gap	0,03	0,01	0,02	0,01	-0,11	0,03	-0,02	1,00	-0,03	0,01	-0,11	-0,02
ED	-0,02	0,00	-0,01	-0,04	0,05	-0,02	-0,03	-0,03	1,00	-0,02	-0,02	-0,01
Term Spread	-0,01	-0,01	-0,03	-0,02	0,00	0,03	0,01	0,01	-0,02	1,00	0,03	0,00
GE	-0,03	0,27	0,13	0,23	0,02	0,14	0,26	-0,11	-0,02	0,03	1,00	0,36
Equity Beta	0,00	0,24	0,11	0,09	0,02	0,14	0,20	-0,02	-0,01	0,00	0,36	1,00

Panel C: G10 and EM Universe

	Value	*Momentum*	*RS*	*Trend*	*Carry*	*BAB HML*	*BAB KW*	*Output Gap*	*ED*	*Term Spread*	*GE*	*Equity Beta*
Value	1,00	-0,06	-0,05	-0,05	0,04	0,10	-0,06	-0,01	-0,01	0,00	0,02	-0,12
Momentum	-0,06	1,00	0,23	0,70	0,04	-0,19	0,24	-0,02	0,05	0,01	0,04	0,06
Ret Season	-0,05	0,23	1,00	0,16	0,03	-0,13	0,22	-0,08	0,01	0,00	0,03	-0,05
Trend	-0,05	0,70	0,16	1,00	-0,01	-0,09	0,21	0,07	0,01	0,03	0,04	0,06
Carry	0,04	0,04	0,03	-0,01	1,00	0,08	-0,05	0,05	0,03	0,10	-0,21	-0,08
BAB HML	0,10	-0,19	-0,13	-0,09	0,08	1,00	-0,51	0,04	-0,03	-0,03	-0,04	-0,05
BAB KW	-0,06	0,24	0,22	0,21	-0,05	-0,51	1,00	-0,01	-0,03	0,05	0,04	0,02
Output Gap	-0,01	-0,02	-0,08	0,07	0,05	0,04	-0,01	1,00	-0,09	0,00	0,00	0,02
ED	-0,01	0,05	0,01	0,01	0,03	-0,03	-0,03	-0,09	1,00	-0,06	0,01	-0,12
Term Spread	0,00	0,01	0,00	0,03	0,10	-0,03	0,05	0,00	-0,06	1,00	-0,01	0,01
GE	-0,12	0,06	-0,05	0,06	-0,08	-0,05	0,02	0,02	-0,12	0,01	0,02	1,00
Equity Beta	0,02	0,04	0,03	0,04	-0,21	-0,04	0,04	0,00	0,01	-0,01	1,00	0,02

8.2 Figures

Figure 1: Annualized Sharpe ratios of G10, Emerging Market and both G10 + EM currencies: The figures shows the annualized Sharpe ratios of all the factors constructed in this paper on the horizontal axis and their performance (Sharpe Ratio) on the vertical axis for all three universes side-by-side.

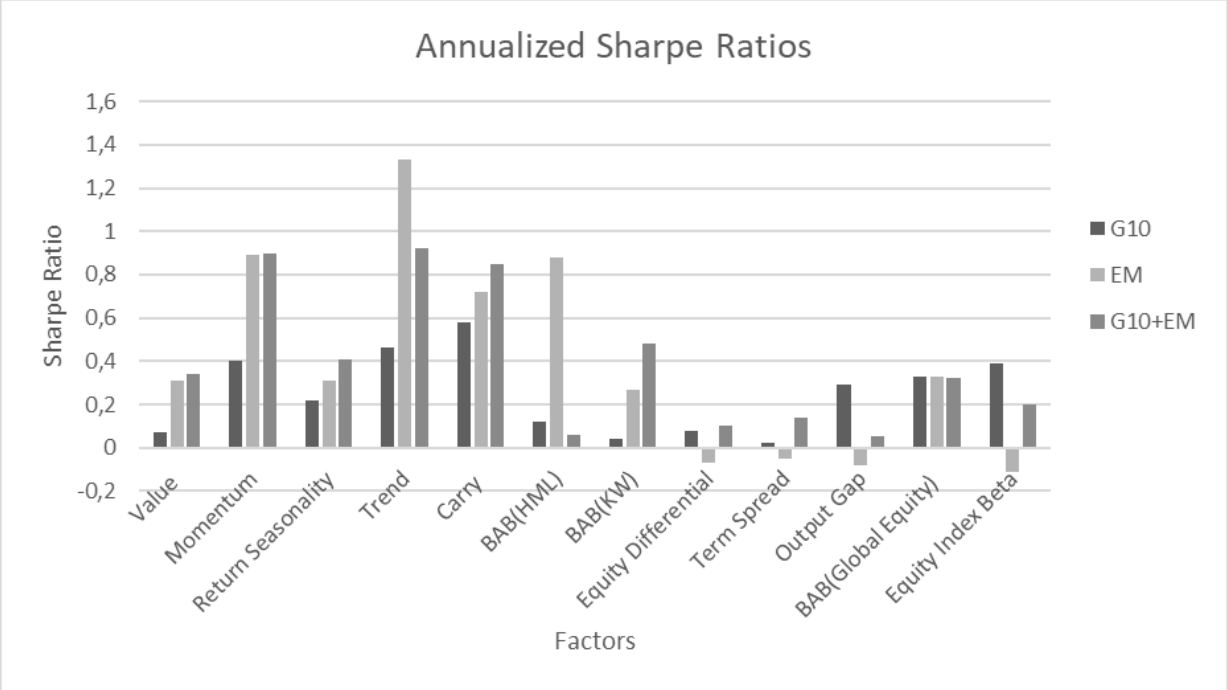
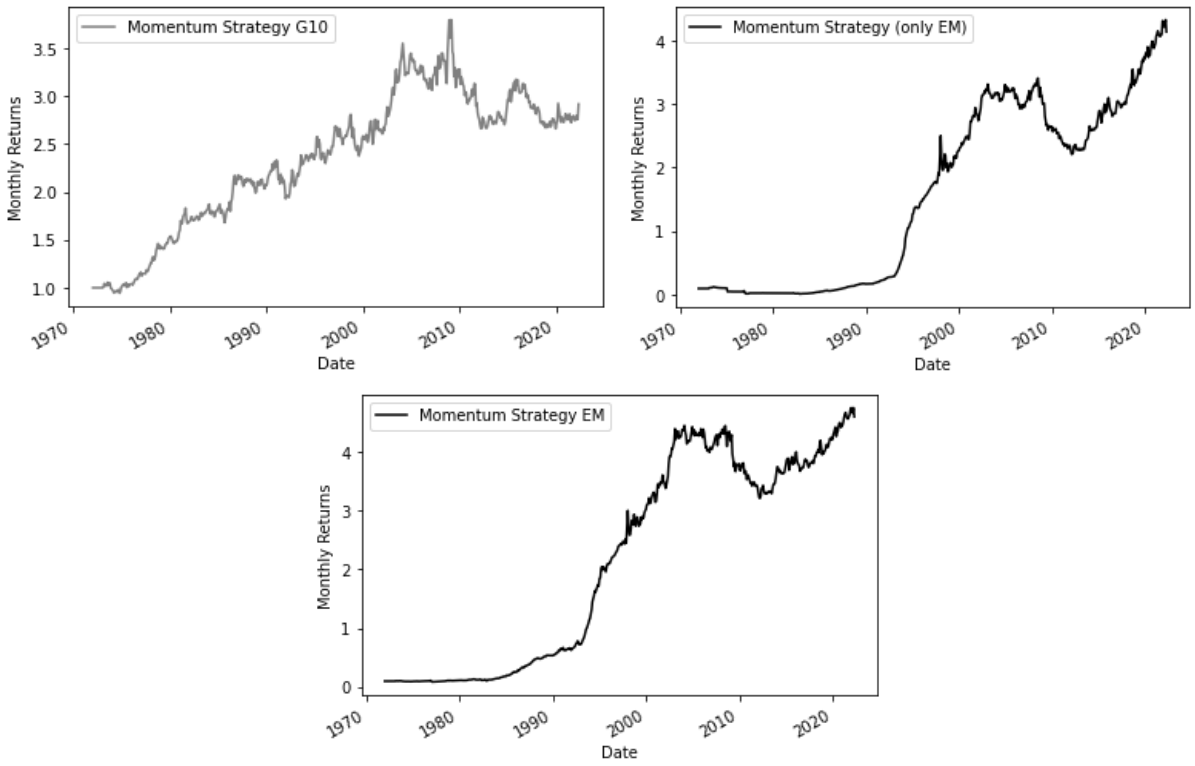
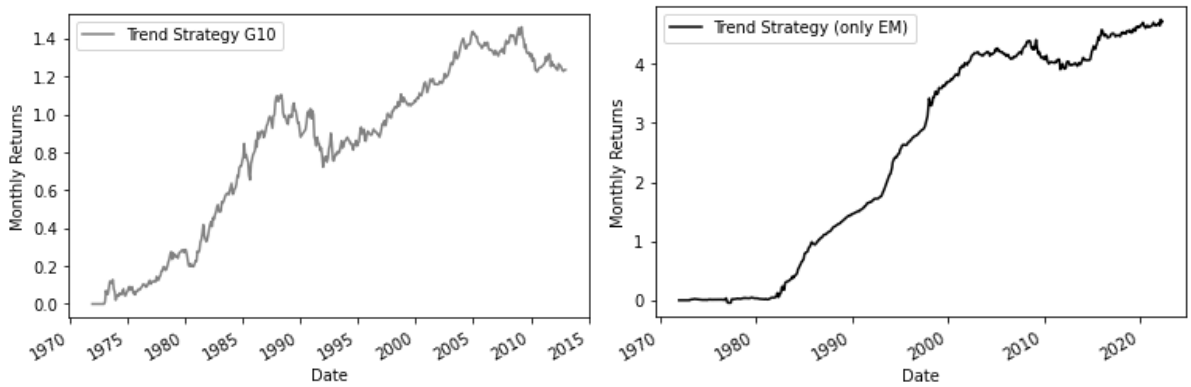
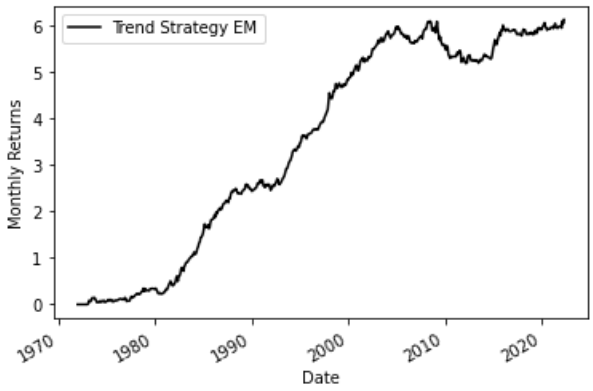


Figure 2: Cumulative Factor Return graphs: The figures below show the cumulative returns of the factors constructed. The cumulative factor returns of the strategies that use the dataset containing only G10 currencies is on the left (grey) and the returns of the strategy which uses only emerging currencies is on the right (black) and the cumulative returns of the universe with both G10 and Emerging market currencies is below in between (black)

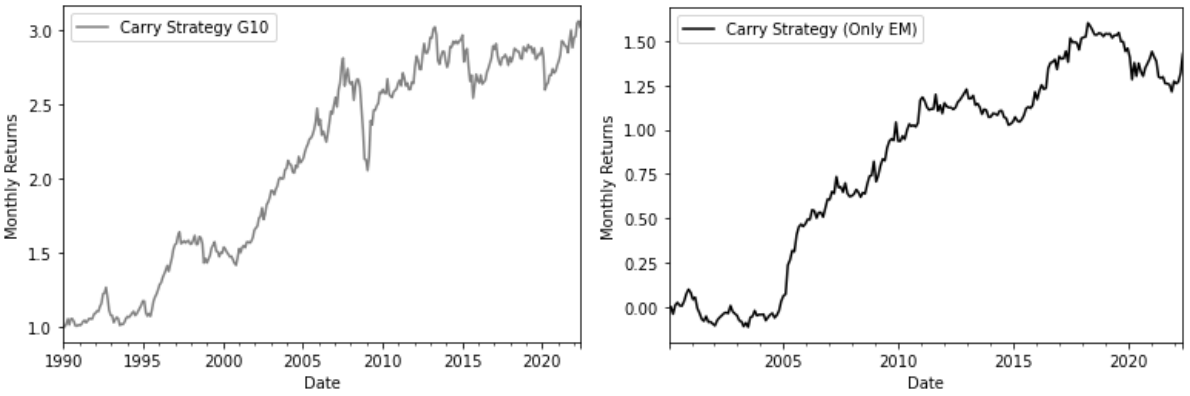


Momentum




Trend Strategy EM
Monthly Returns
Date
0
1
2
3
4
5
6
1970
1980
1990
2000
2010
2020

Trend


Carry Strategy G10
Monthly Returns
Date
1.0
1.5
2.0
2.5
3.0
1990
1995
2000
2005
2010
2015
2020
Carry Strategy (Only EM)
Monthly Returns
Date
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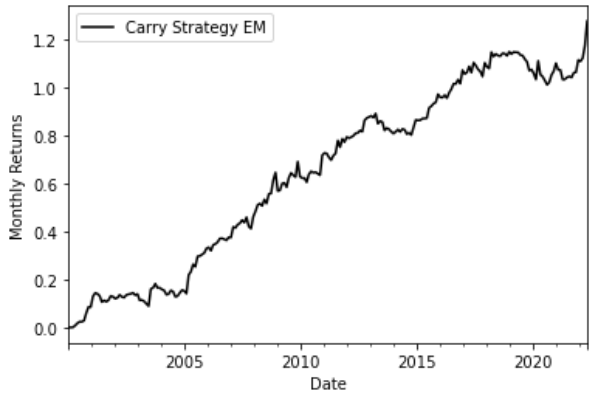
1.25
1.50
2005
2010
2015
2020


Carry Strategy EM
Monthly Returns
Date
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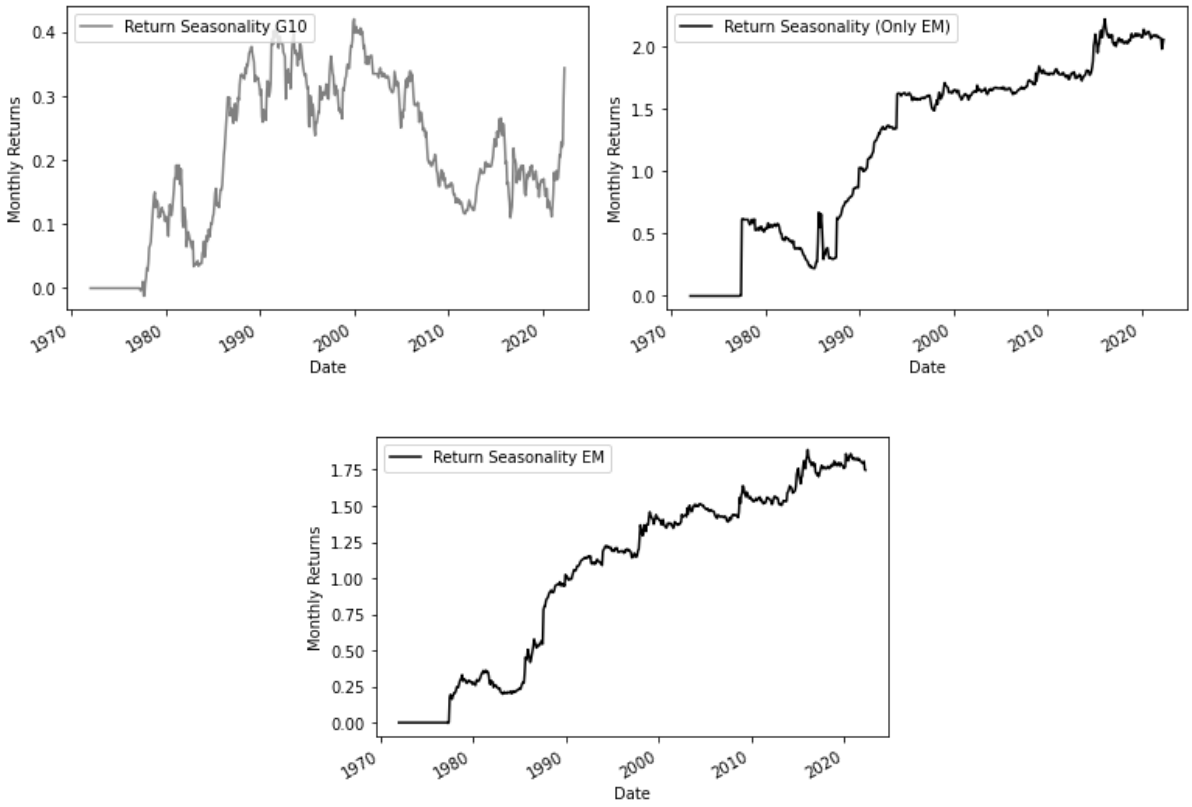
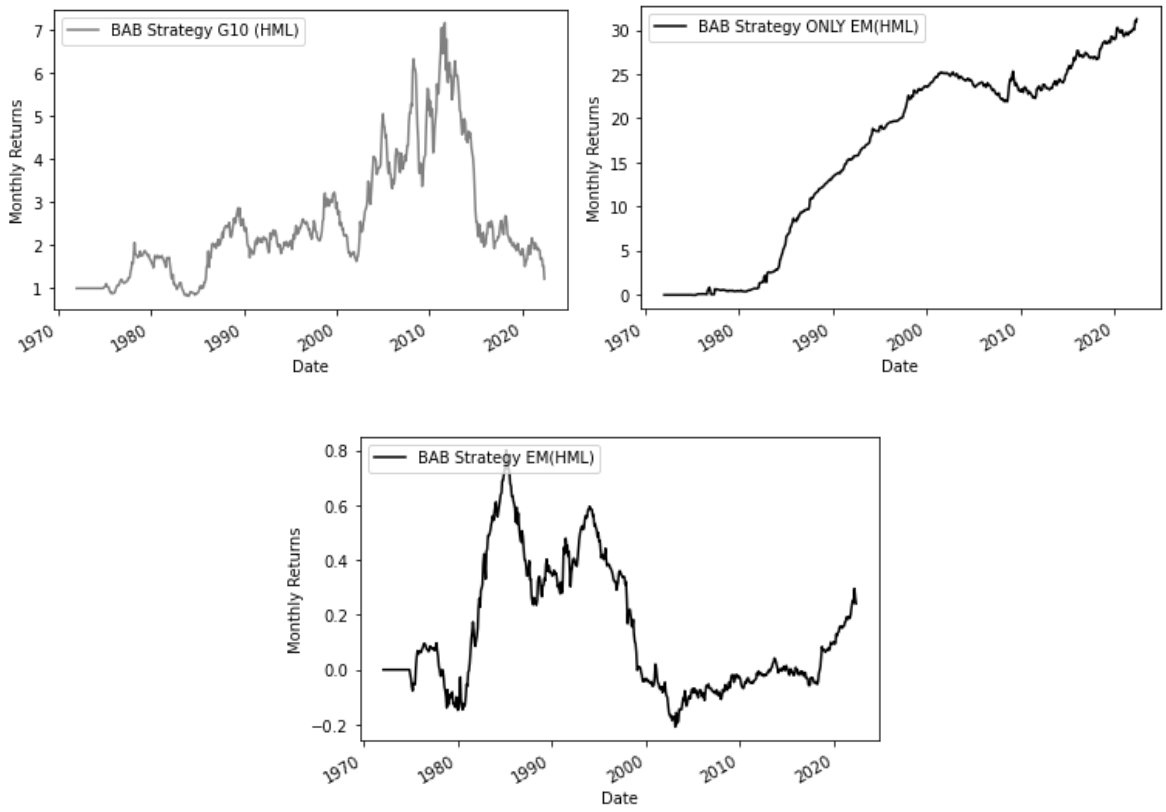
0.2
0.4
0.6
0.8
1.0
1.2
2005
2010
2015
2020

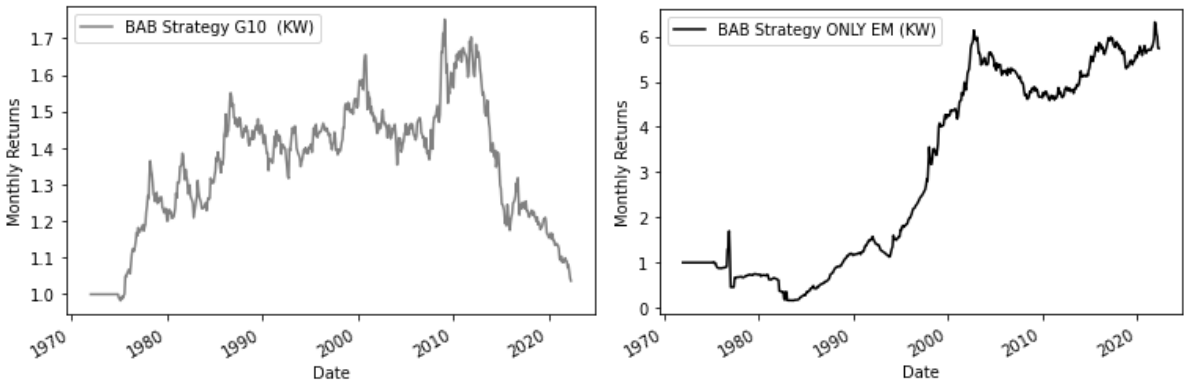
Carry

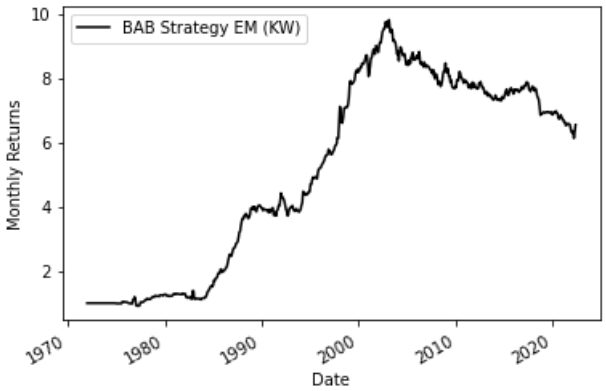


Return Seasonality

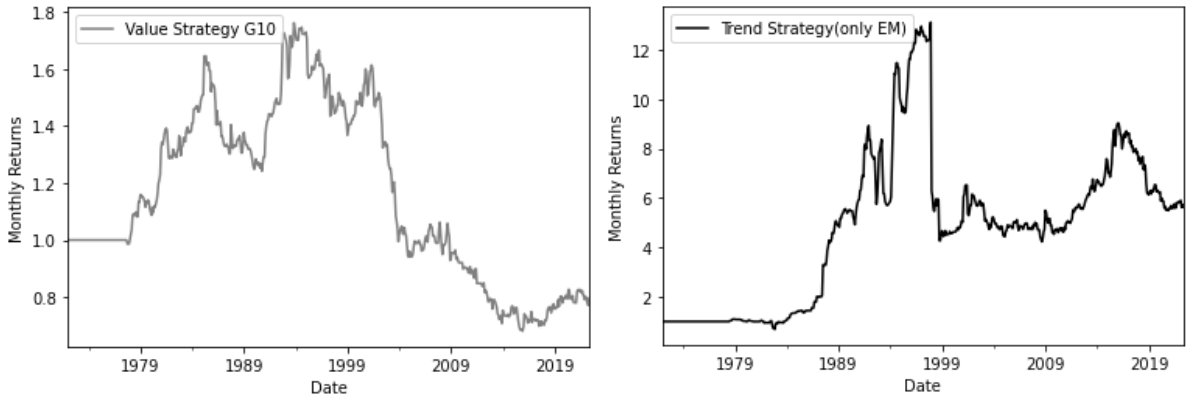


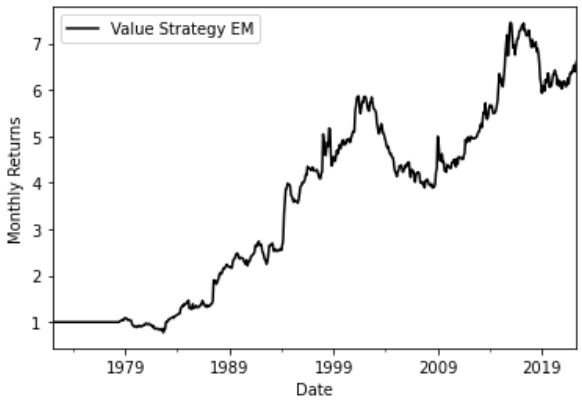
Betting-Against-Beta (High minus Low)



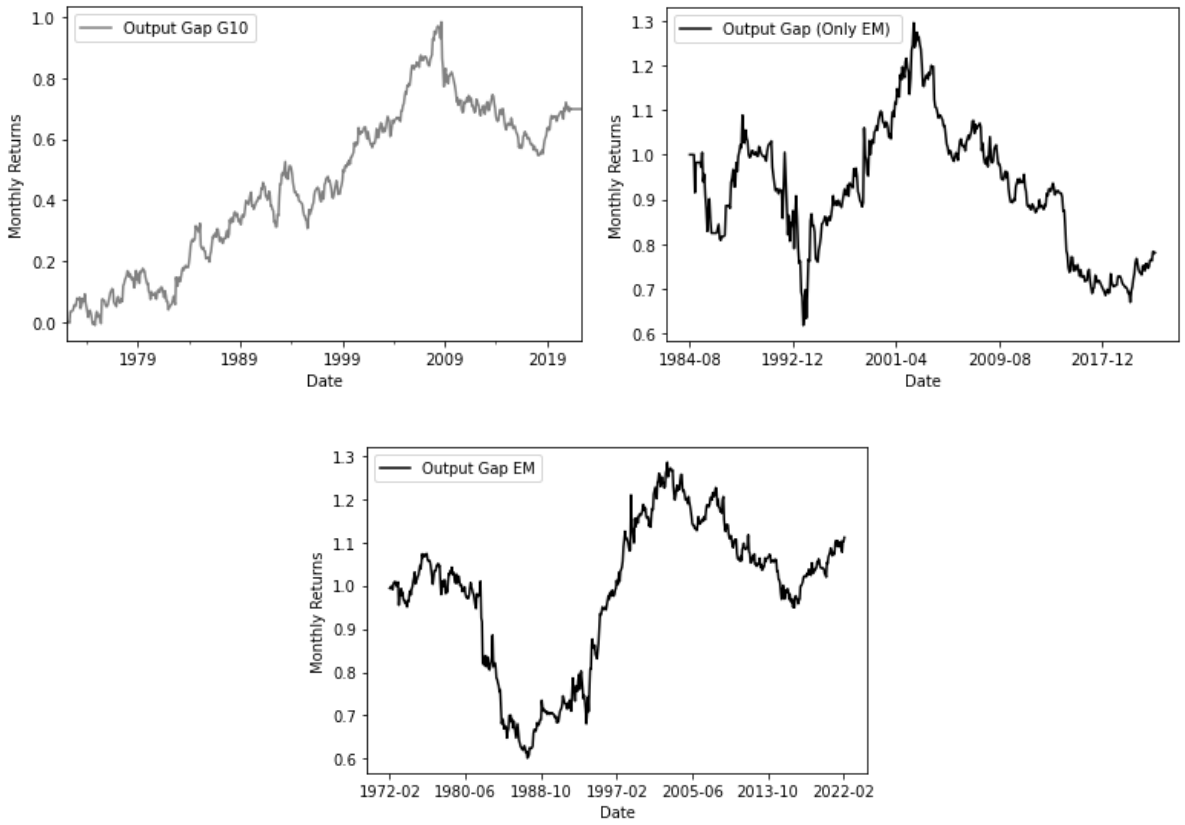


BAB -Koijen et al(2017) weighting scheme

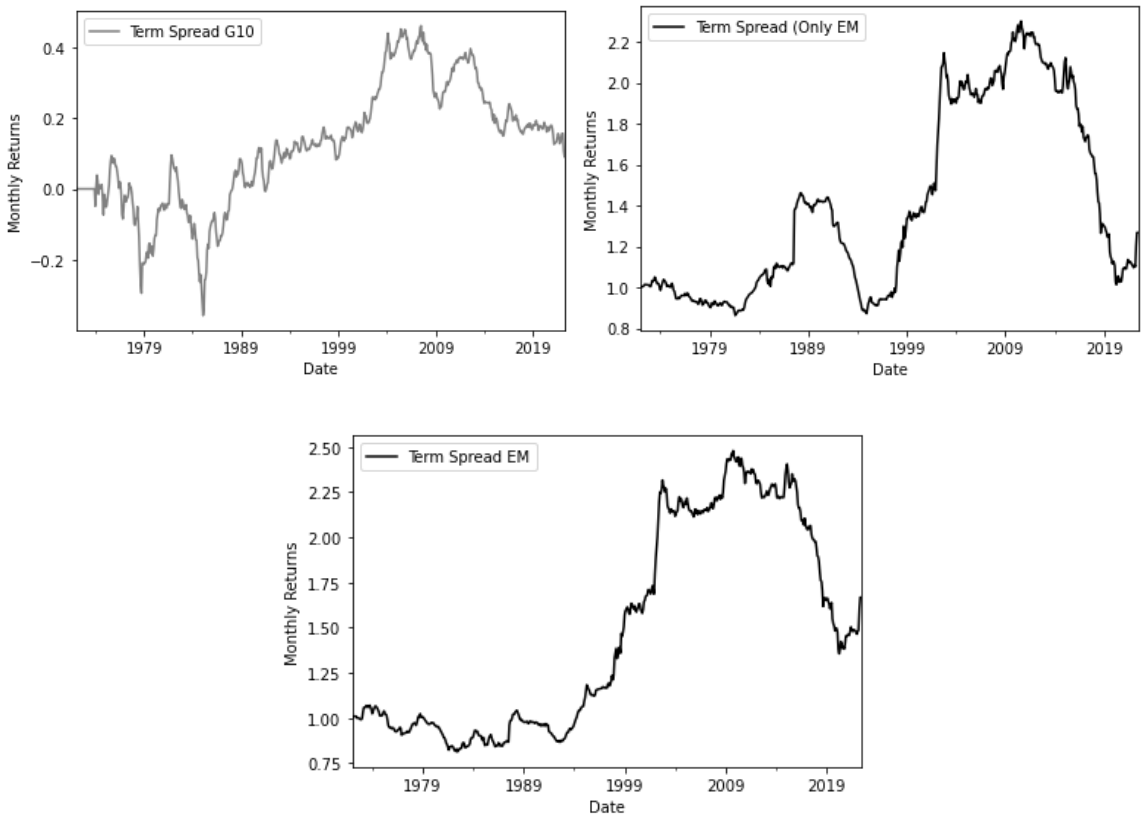




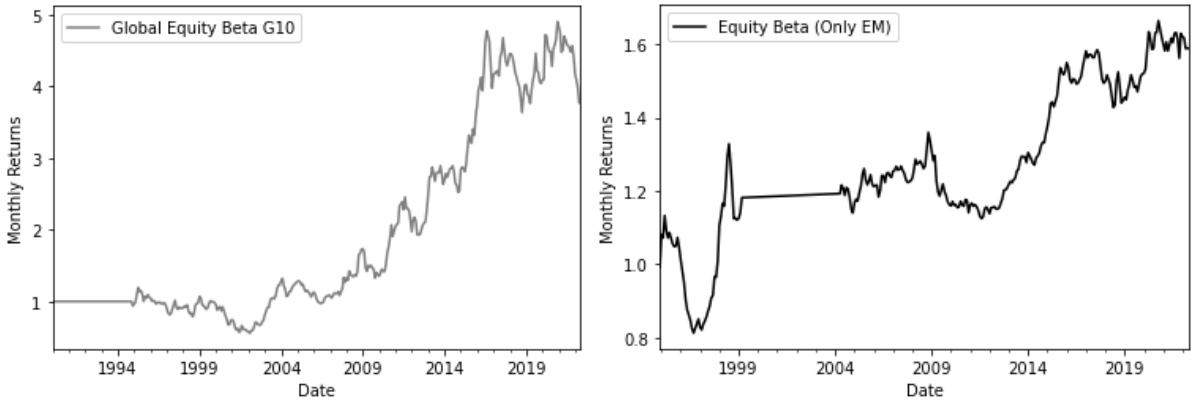
Value

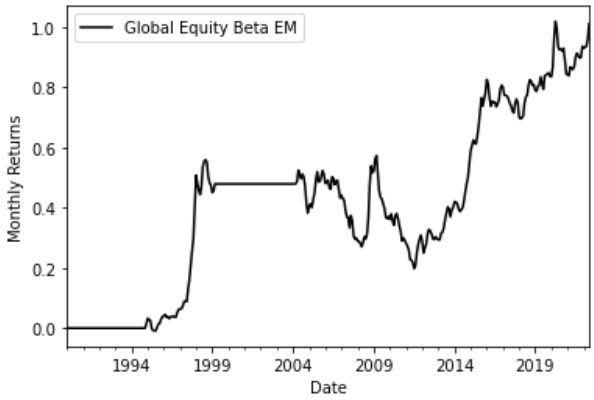


Output Gap

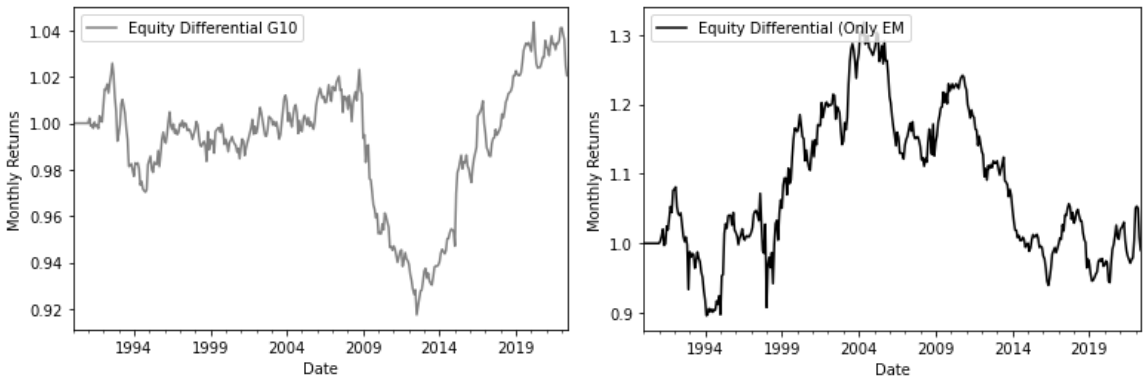


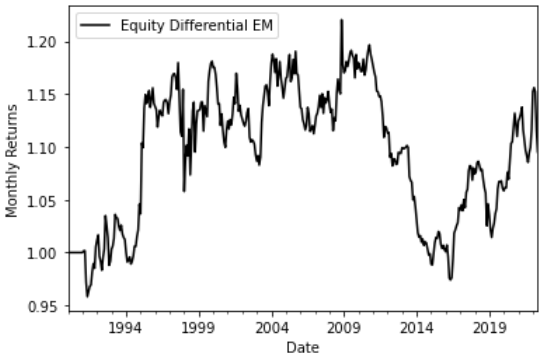
Term Spread





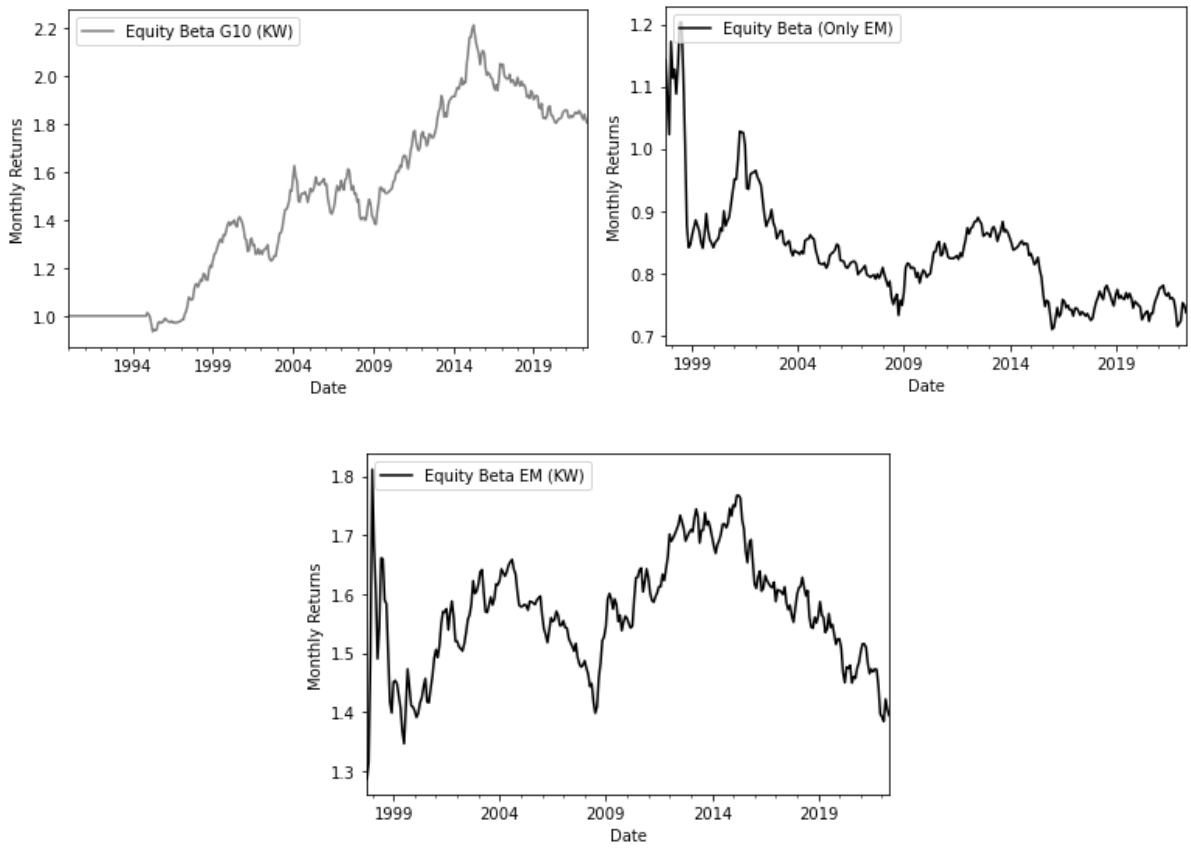
Global Equity BAB[4]





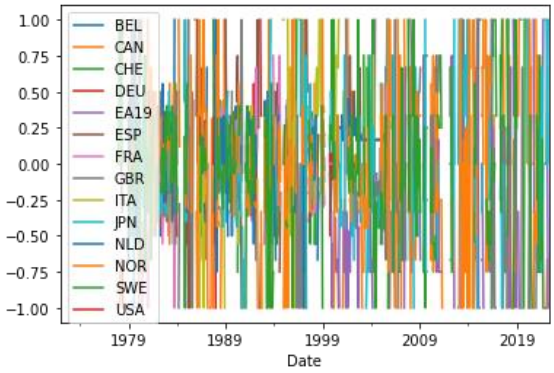
Equity Differential

4. There was a gap in the dataset for global equity indices between the years 2000-20003 when including the emerging market currencies for the Global equity BAB

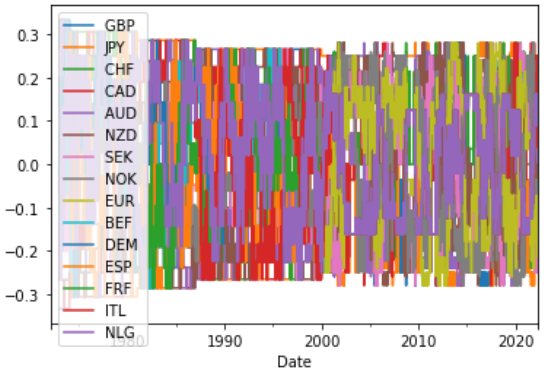

Equity Beta G10 (KW)
Monthly Returns
Date
Equity Beta (Only EM)
Monthly Returns
Date
Equity Beta EM (KW)
Monthly Returns
Date

Equity Beta

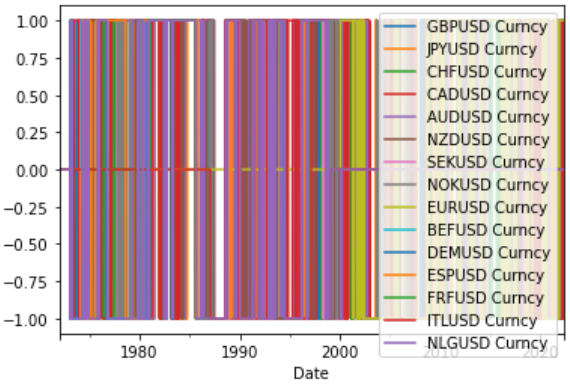
Figure 3:Positions of all G10 Currency pairs per factor over time: The figures below show the position (long or short) of every G10 currency leg per factor. The factor Trend takes positions based on a signal which is directional. The Betting-Against Beta using a High-minus -Low method (BAB HML) takes positions only if the currency falls in the highest or lowest portfolio.



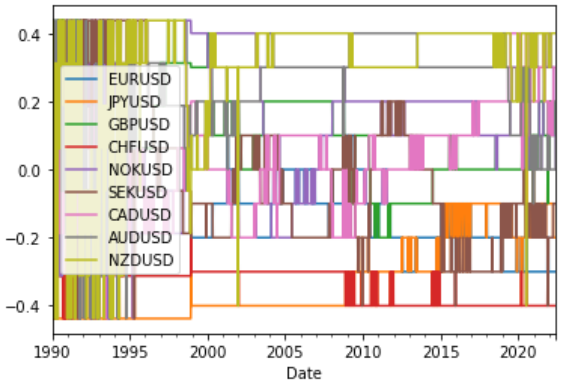
Value



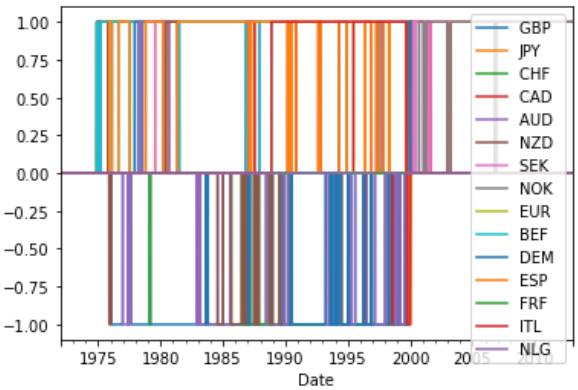
Momentum



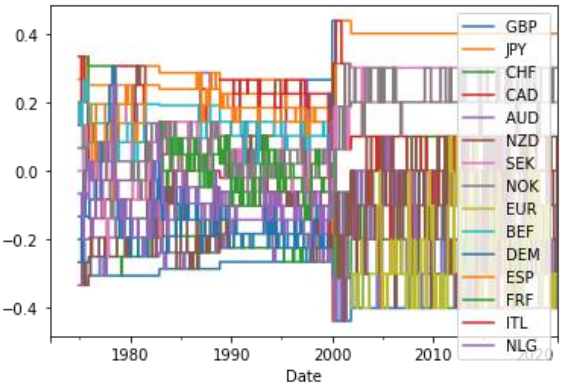
Trend



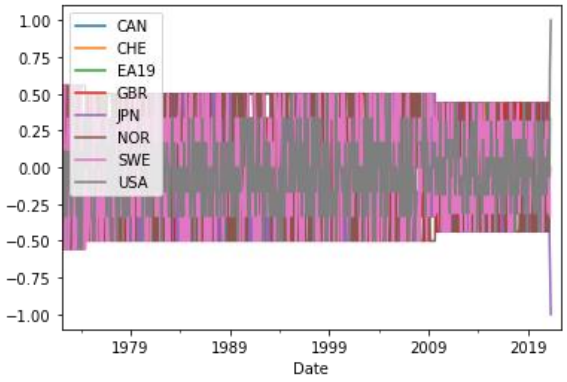
Carry



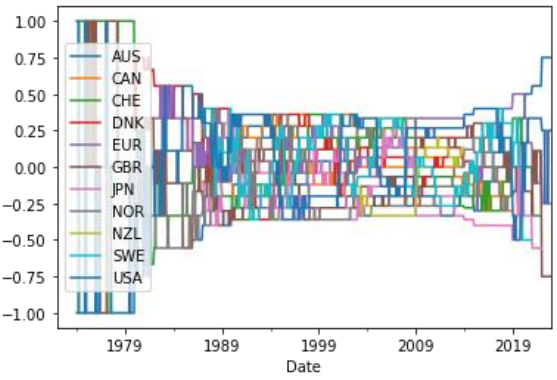
BAB (HML)



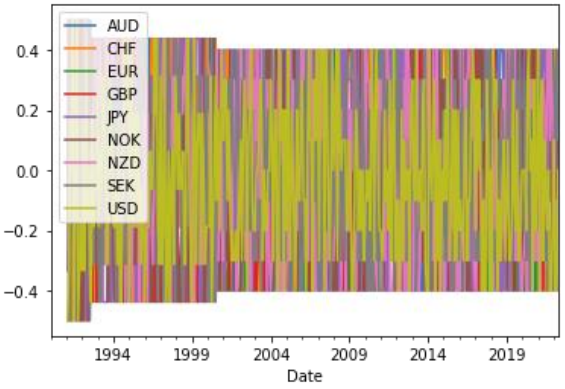
BAB (KW)



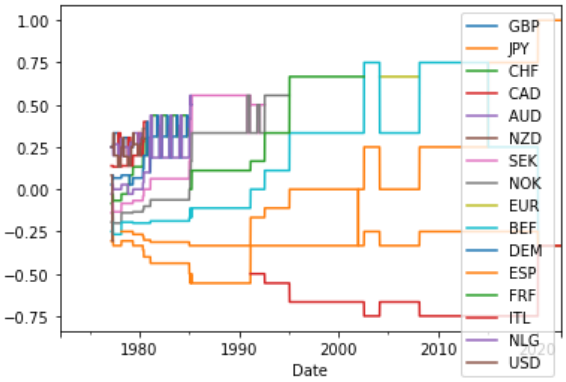
Output gap



Term spread

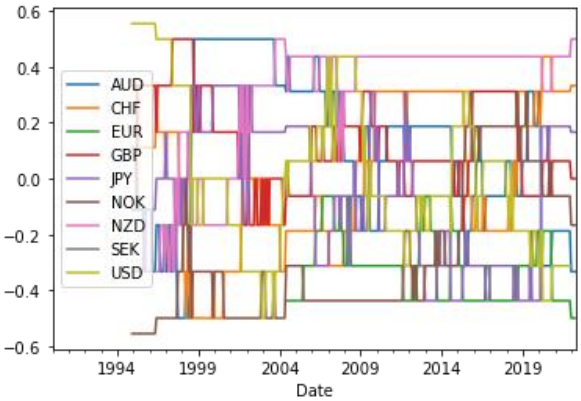


Equity Differential

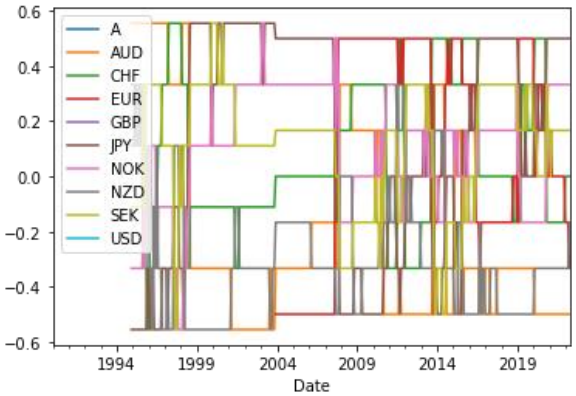


Return Seasonality

:

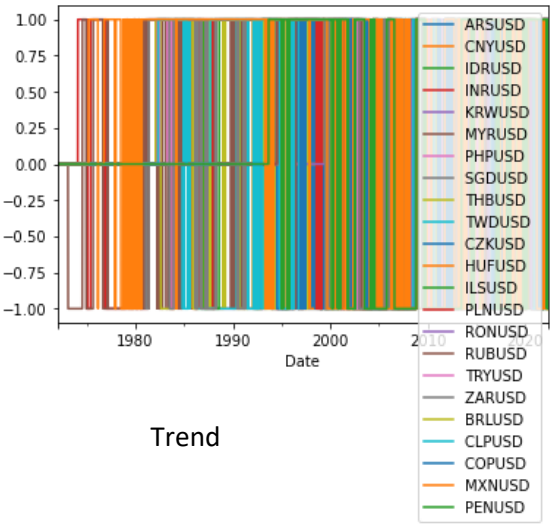


Equity Beta

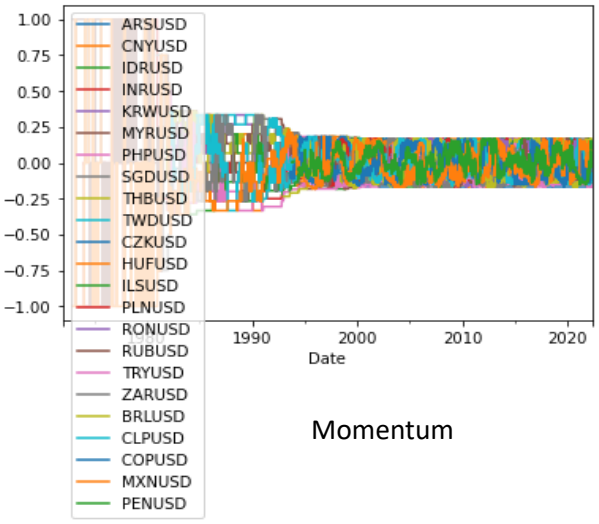


Global Equity BAB

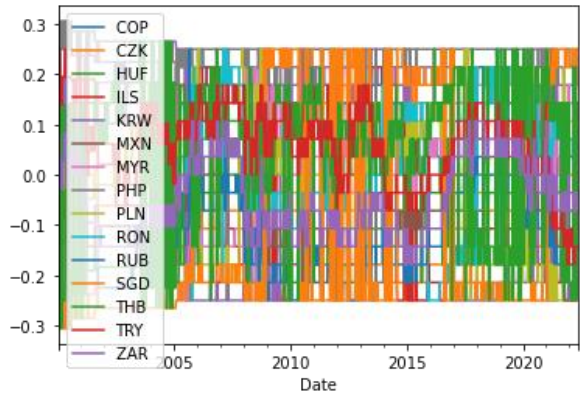
Figure 4:Positions of only Emerging Market Currency pairs per factor over time: The figures below show the position (long or short) of all Emerging Market currencies per factor. The factor Trend takes positions based on a signal which is directional. The Betting-Against Beta using a High-minus -Low method (BAB HML) takes positions only if the currency falls in the highest or lowest portfolio.



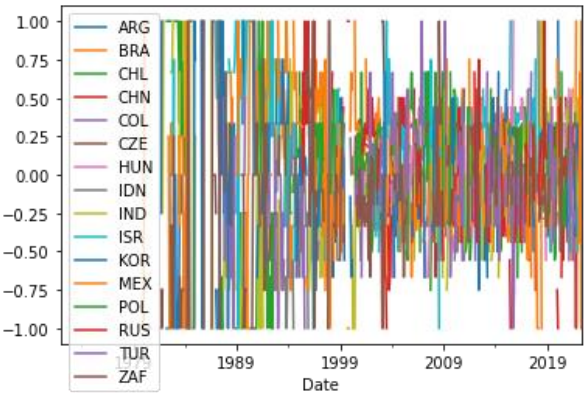
Trend



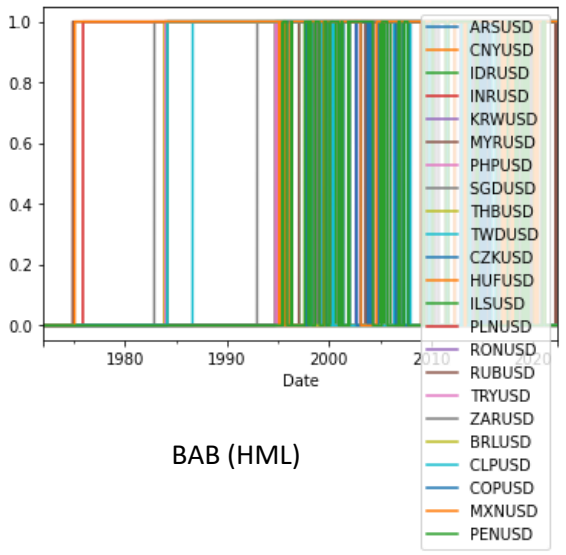
Momentum



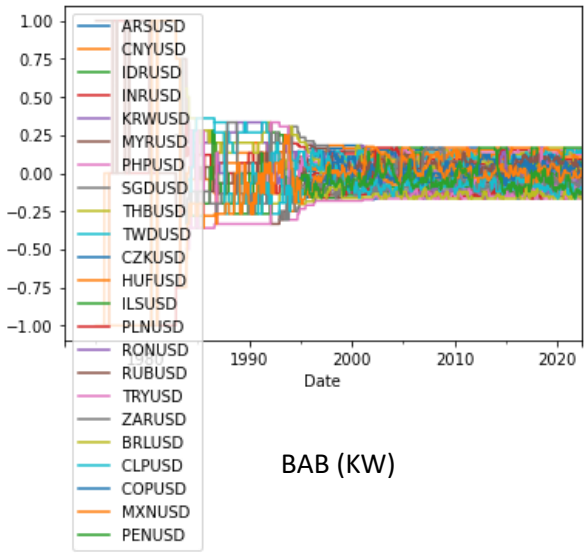
Value



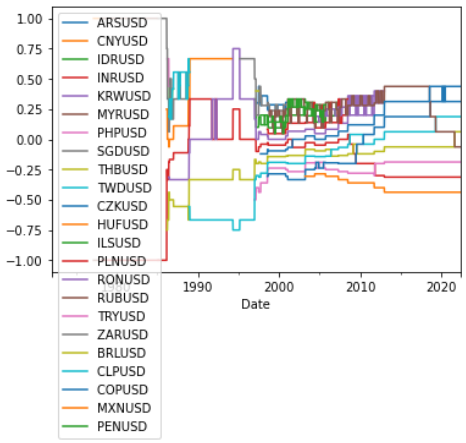
Carry



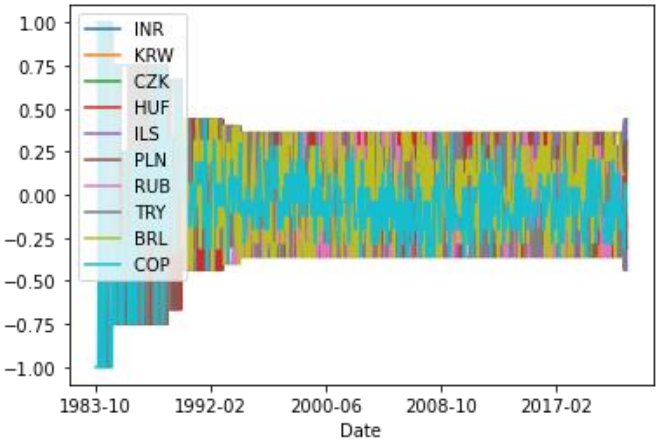
BAB (HML)



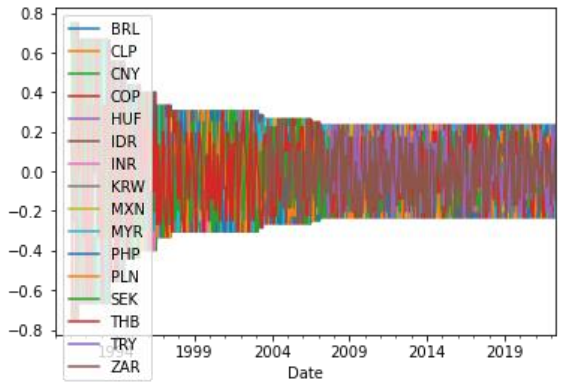
BAB (KW)



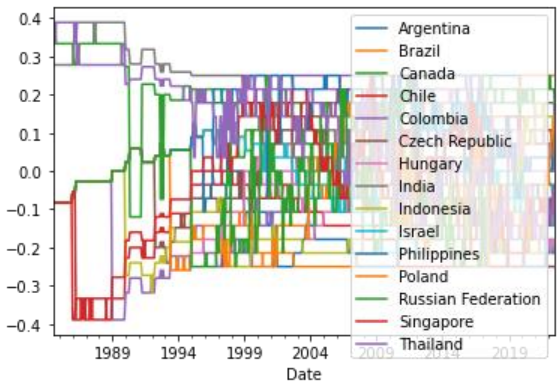
Return Seasonality



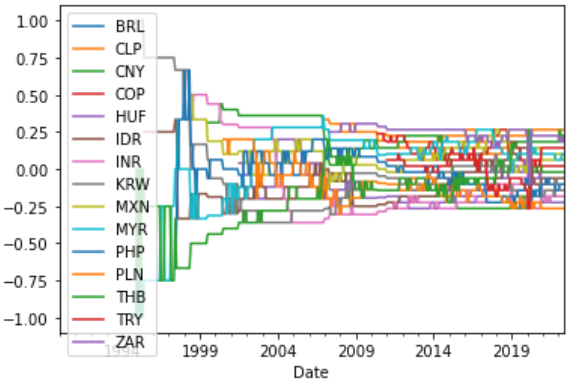
Output gap



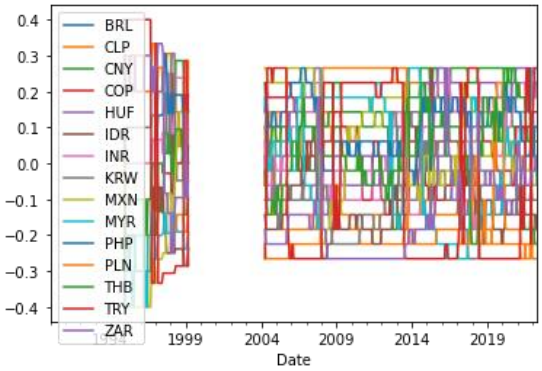
ED



Term spread :



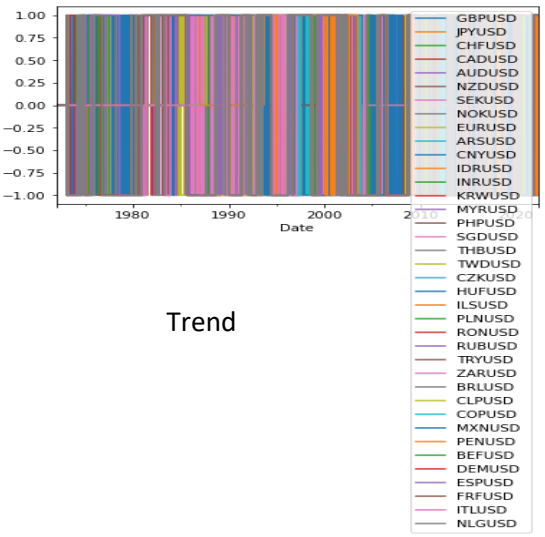
Equity Beta



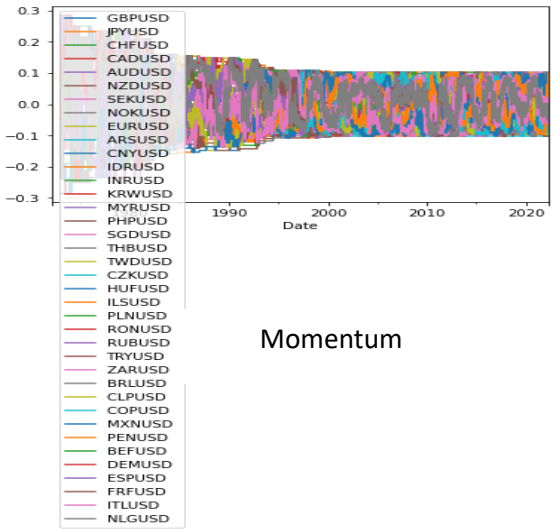
Global Equity BAB[5]

5. There was a gap in the dataset for global equity indices between the years 2000-20003 for the emerging market countries for Global Equity BAB

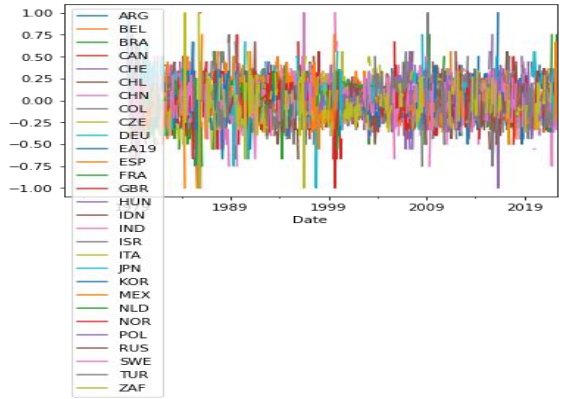
Figure 5:Positions of the G10 currencies together with Emerging Market currencies per factor over time: The figures below show the position (long or short) of all G10 currencies along with Emerging Market currencies per factor. The factor Trend takes positions based on a signal which is directional. The Betting-Against Beta using a High-minus -Low method (BAB HML) takes positions only if the currency falls in the highest or lowest portfolio.



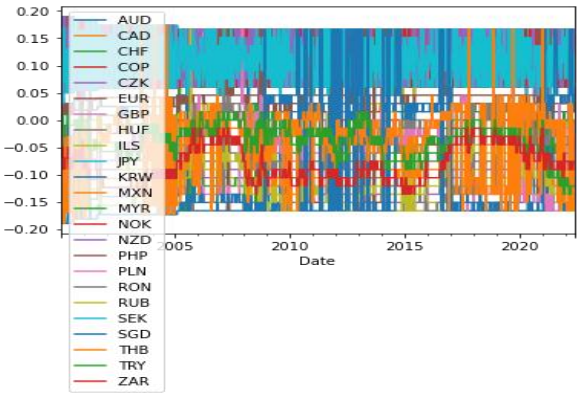
Trend



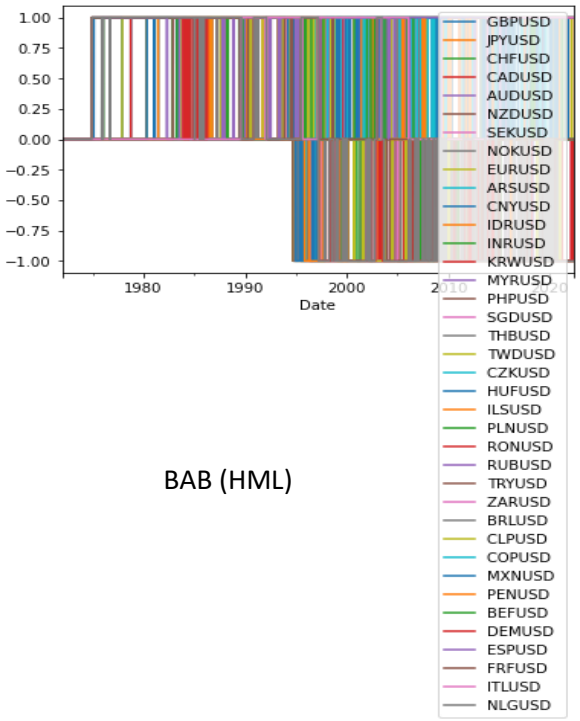
Momentum



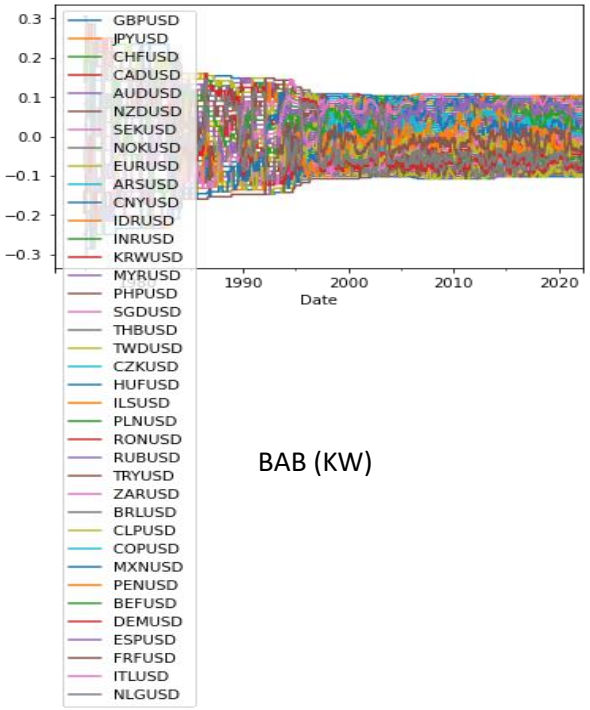
Value



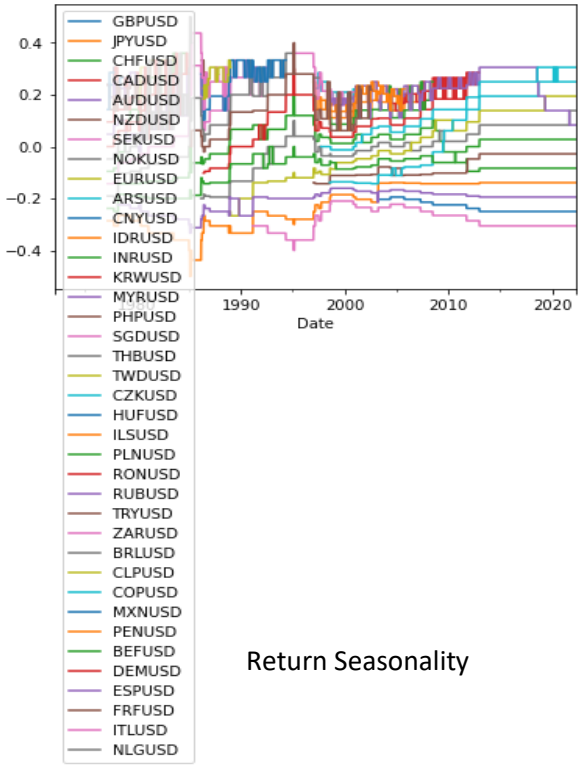
Carry



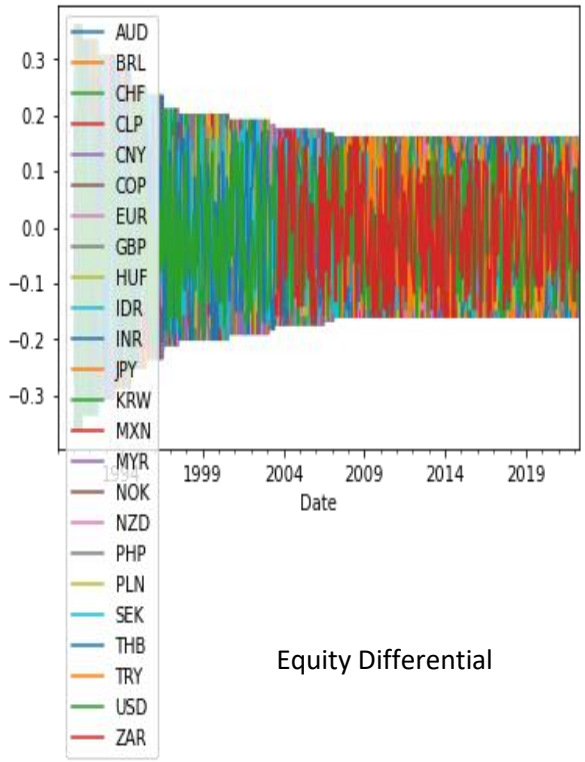
BAB (HML)



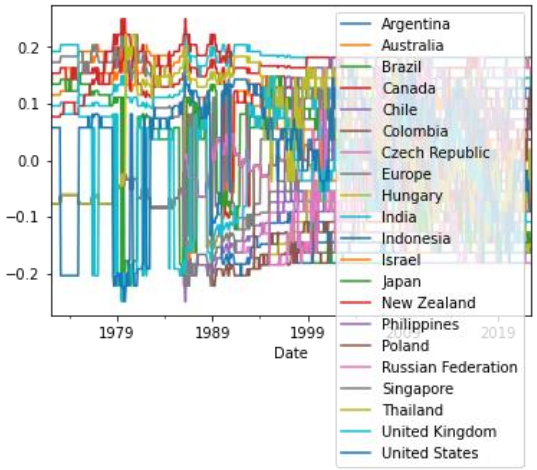
BAB (KW)



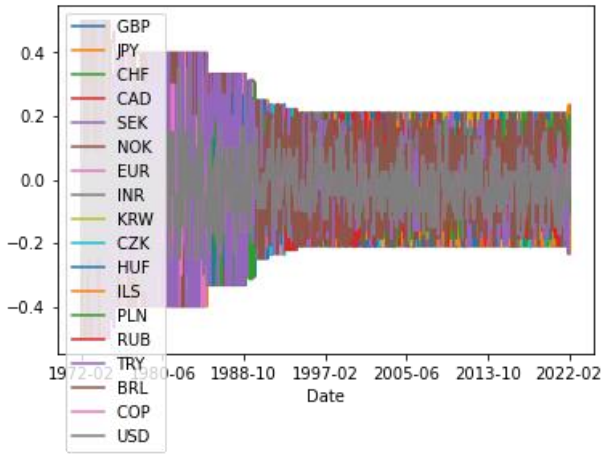
Return Seasonality



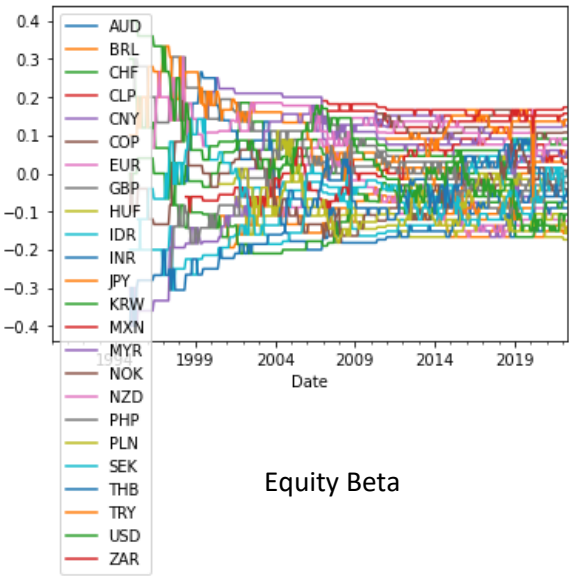
Equity Differential



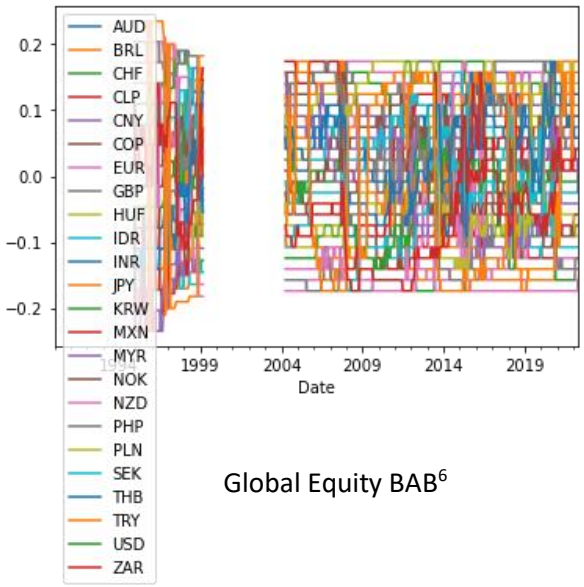
Term spread



Output gap :



Equity Beta



Global Equity BAB[6]

6. There was a gap in the dataset for global equity indices between the years 2000-20003 when including the emerging market currencies for the Global equity BAB