Decomposing Basis-Momentum in Currency Market

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Abstract

We conduct an in-depth analysis on basis-momentum in the foreign exchange market and investigate its relationship with the prevalent currency market anomalies. We find that basis-momentum strategies generate significant excess returns and Sharpe ratios with formation periods of 1, 3, 6, 9 and 12 months. The abnormal returns of basis-momentum are not fully explained by the closed related currency carry and momentum factors. We further decompose the basis-momentum signal into four components and find that carry and momentum contribute most to the return of basis-momentum, whereas the lagged spot rate change contributes the least. By adding basis-momentum to the existing currency pricing models, however, the goodness-of-fit of pooled panel regressions has only marginal improvement.

Keywords: Basis-momentum, Currency market factors, Carry trades, Currency momentum

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1. Introduction

As one of the world's largest financial markets,[1] the foreign exchange (FX) market is highly liquid, efficient, and featured low transaction costs. Currency exchange rate is perhaps one of the most important indicators of an economy's relative level of strength. There is a large number of studies utilising country characteristics and macroeconomic fundamentals to explain currency excess returns, see, e.g., country size (Hassan, 2013), term spread (Ang and Chen, 2010), global imbalance (Corte et al., 2016), and business cycles (Colacito et al., 2020), among others. In recent years, however, a growing body of literature shows that the cross-section of currency excess returns can be largely explained by various trading strategies based on market anomalies such as currency momentum, see, e.g., Okunev and White (2003), Menkhoff et al. (2012a); carry, see, e.g., Lustig et al. (2011), Menkhoff et al. (2012b); value, see, e.g. Asness et al. (2013), Menkhoff et al. (2017); and economic momentum, see, e.g., Dahlquist and Hasseltoft (2020), among others. Despite all these findings, it is still unclear whether the existing factors are adequate in explaining currency market returns, and researchers are working on further extending the literature.

In this study, we provide an in-depth analysis on the basis-momentum (henceforth, BM) effect proposed by (Boons and Prado, 2019) in currency markets. BM was initially documented in commodity futures markets, which is defined as the difference in momentum returns between first- and second- nearby contracts and can be decomposed into average curvature and changes in the slope of the futures curve.[2] Boons and Prado (2019) conclude that curvature contributes the most to predicting commodity returns and is distinct from the existing basis and momentum factors. Both currency and

[1] Bank for International Settlements (BIS) reports that the FX markets trading volume has reached $6.6 trillion per day in April 2019, which is the highest among all the financial markets.

[2] The predictability of the slope of the futures curve are extensively studied by the financial literature in the foreign exchange, see, e.g., Ang and Chen (2010), commodity futures, see, e.g., Nikitopoulos et al. (2017), Paschke et al. (2020) and Bianchi et al. (2020), and equity indices, see, e.g.,Zaremba et al. (2021).

commodity can be traded via pre-defined forward or futures contracts with different maturities. While it is difficult for investors to trade commodity spot contracts as it involves purchase, payment and delivery, trading in currency spot markets is more accessible. Therefore, the nearest basis strategy in currency market becomes sorting the difference between one-month forward and spot rate, which is analogous to the well-known carry trade. These similarities and differences motivate us to examine the BM effect in currency market and its relationship with existing currency anomalies.

Our results suggest that the currency BM strategies generate statistically significant excess returns and Sharpe ratios with formation periods of 1,3,6,9, and 12 months after considering transaction costs. Among them, the BM strategy with a three-month formation period yields the highest monthly returns at 0.72% (*t*-statistic = 4.35) and Sharpe ratios at 1.12. One of the major advantages of the BM strategy over the benchmark strategies, i.e. carry and momentum, is its lower volatility and hence, leading to higher Sharpe ratios.

Since the BM signal is formed based on a combination of the term structure of forward curve and momentum. It is natural to ask the question: Is BM a distinct factor in currency market or it can be fully explained by the existing carry and momentum factors? We show that the currency BM signal can be decomposed into four components, namely carry, momentum, change in spot rate and a cumulative difference between two- and one-month forward exchange rates. The change in spot rate is known as the spot rate momentum according to Menkhoff et al. (2012b), whereas the difference between two- and one-month forward exchange rates is defined as basis-two.[3] While carry and momentum are well documented in the currency market, spot rate momentum and basis-two are not extensively studied. Results of the decomposition suggest that

[3] Likewise, in currency market, the difference between one-month forward rate and spot rate is defined as basis-one.

carry and momentum contribute the most to the BM returns and spot rate momentum and basis-two contribute relatively less but are still statistically significant. However, spot rate momentum and the basis-two components do improvement the volatility and Sharpe ratios suggesting that these two components play important roles in risk management. In contrast with the carry factor, the basis-two component is a negative slope predictor which provides a hedging benefit to the BM portfolio. Moreover, the returns of the BM strategies with formation periods of 1, 3 and 6 months cannot be fully explained by the carry and momentum factors, indicating that abnormal returns are still significant.

Next, we examine whether BM can add value in explaining the cross-section of currency market returns. We run a series of pooled panel regressions by including and excluding BM factor based on those established currency market predictors, namely, carry, momentum and value. We show that the BM factor keeps significant only if the carry factor in not included in the tests after controlling time series heteroskedasticity using Newey-West standard errors (Newey and West, 1987).the inclusion of the BM factor canonly increase the of the pooled panel regressions to a limited extend compared to the models based on the same setting without the BM factor. Controlling the economic momentum related factors of Dahlquist and Hasseltoft (2020), we find the similar story that the adjusted R^2 is barely changed. Moreover, we find that the coefficient of the BM factor becomes insignificant with the inclusion of the economic momentum strategy. It is also the case with other factors including momentum, carry and economic momentum itself.

Overall, the main contribution of this study is twofold. First, we decompose the BM returns into four components, namely carry, momentum, spot rate momentum and basis-two. This allows us to examine which components contribute more to the return of BM. Results suggests that the BM factor is highly related to carry and momentum factors. Second, we justify the statistical and economic significance of BM strategies in currency market and the ability of it in generating abnormal returns. However, adding the BM strategy into the existing currency factor pool results in a similar model goodness-of-fit compared to models without BM. Therefore, we do not suggest the BM factor can contribute to additional explanatory power based on the existing setting of currency pricing models.

The remainder of the paper is organised as follows: Section 2 describes our sample data and the methods to construct currency portfolios. Section 3 reports the performance of BM strategies compared to two of its main baseline strategies. A decomposition of the BM signal is introduced in Section 4 to allow examine the major components of BM. In Section 5, we examine whether the BM adds value in explaining the cross-section of currency returns. Finally, we conclude and propose possible future research in Section 6.

2. Data and portfolio construction

2.1. Data

Following Menkhoff et al. (2012a), we collect the monthly spot, one-month and two-month exchange rates in the form of foreign currency against one U.S. dollar from November 1983 to December 2020. The data is sourced from Barclays Bank PLC (BBI) and WM Refinitiv (WMR) which is available from Datastream.[4] Our entire sample covers currencies from 48 countries and regions: Australia, Austria, Belgium, Brazil,

[4] We additional add Belgian franc from 1990 to 1996 and obtained from HSBC through Datastream. We use the USD exchange rate against the Irish pound (IEP) and Pound sterling (GBP) in source of BBI, and the USD against Euro, IEP, New Zealand (NZD), and GBP in source of WMR, as they provide the longest data history, others we use forward exchange rate against the USD.

Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Euro Area, Finland, France, Germany, Greece, Hong Kong, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Kuwait, Malaysia, Mexico, Netherlands, New Zealand, Norway, Philippines, Poland, Portugal, Russia, Saudi Arabia, Singapore, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Ukraine, and the United Kingdom.

Apart from the abovementioned spot and forward rate, we use some macroeconomic fundamental data in order to construct our benchmark strategies. First, to build the currency value strategy, we collect the Consumer Price Index (CPI) of the 48 countries and regions plus that of the U.S. from the International Monetary Fund (IMF) via Bloomberg, except for Taiwan, which is directly retrieved from Bloomberg due to data availability. Second, for economic momentum, we collect the data for economic activity via industrial production, retail, and retail sale indices, and for inflation momentum via consumer prices, and producer prices indices. The above data is collected from the statistical database of the Organisation for Economic Co-operation and Development (OECD).

Next, we move on to measure the currency excess returns following the existing FX literature, e.g., Lustig and Verdelhan (2007), Menkhoff et al. (2012a). Specifically, we consider the interest rate differentials between domestic and foreign economies when calculating currency excess returns, so the monthly excess returns of holding currency k in month $t+1$ month equal:

$$rx_{k,t+1} = i_{k,t} - i_t^* - \Delta s_{k,t+1} \approx f_{k,t}^1 - s_{k,t+1}, \quad (1)$$

where $s_{k,t+1}$ and $f_{k,t}^1$ represents spot exchange and one-month forward exchange rates of currency k in logs, i refers to the foreign exchange rate, and i^* represents the domestic exchange rate. As noted by Menkhoff et al. (2012a), if the covered interest rate differential holds, the forward discount is equivalent to the interest rate differential: $f_{k,t}^{1} - s_{k,t} \approx i_{k,t} - i_{t}^{*}$. Thus, the monthly excess return of currency k approximately equals the interest rate differential minus the change in the spot rate. Similarly, the excess return of the holding one-month forward of currency k in month $t+1$ is on the difference between lagged two-month and one-month forward exchange rate: $rx_{k,t+1}^{f^{1}} = f_{k,t}^{2} - f_{k,t+1}^{1}$, where $f_{k,t}^{2}$ refers to the two-month forward exchange rate in logs.

Table 1 presents the summary statistics for each currency including the average return, maximum return, minimum return, standard deviation, and sample period. This table suggests that there is a large variation in the mean excess returns and their standard deviation across currencies. The excess return of the spot Indonesia Rupiah reports the highest mean at 1.16%, whereas Finland Markka exhibits the lowest mean at (-0.59%). For the one-month forward exchange rate excess returns, Slovakia Koruna has the highest mean excess returns at 1.11%, whereas the lowest mean is still observed in Finland Markka at (-0.58%). The standard deviation also varies across currencies with spot excess return values ranging from 0.1% (Saudi Riyal) to 8.03% (Indonesian Rupiah). Currency return and risk characteristics are similar for both spot and one-month forward rates. We conclude that, compared to emerging economies, most developed economies report relatively lower standard deviations in the excess returns of both spot exchange rates and one-month forward rates.

Table 1

Summary statistics of all currencies.

This table reports the mean returns, maximum returns, minimum returns and standard deviations (in percentage) of the monthly excess returns of the spot and the one-month forward exchange rates for the 48 currencies. In month t, the excess return of the spot rate is the difference between lagged one-month forward rate and spot rate, $rx_t^s = f_{t-1}^1 - s_t$, whereas the excess return of the one-month forward rate is the difference between the lagged two-month forward rate and one-month forward rate, $rx_t^f = f_{t-1}^2 - f_t^1$. Fourteen countries entered the Eurozone and exited from the local currency markets with ten of which ended in December 1998 and others afterwards. Ukraine exited the forwards market in the middle of 2015, therefore, its one-month and two-month forward rates are unavailable after July 2015. The sample period is from November 1983 to December 2020.

Countries and regions	Excess return of the spot				Excess return of the one-month forward				Sample	
	Mean (%)	Max (%)	Min (%)	Std (%)	Mean (%)	Max (%)	Min (%)	Std (%)	Start	End
Australia	0.21	9.18	-17.78	3.42	0.20	9.15	-17.77	3.41	Jan-1985	Dec-2020
Austria	-0.50	5.20	-6.31	2.76	-0.50	5.18	-6.31	2.76	Jan-1997	Dec-1998
Belgium	0.34	8.18	-10.78	3.36	0.31	8.20	-10.83	3.32	Dec-1983	Dec-1998
Brazil	0.38	12.64	-15.87	4.57	0.35	12.54	-15.82	4.60	Apr-2004	Dec-2020
Bulgaria	-0.02	9.45	-10.45	2.75	-0.01	9.39	-10.62	2.76	Apr-2004	Dec-2020

Countries and regions	Excess return of the spot				Excess return of the one-month forward				Sample	
	Mean (%)	Max (%)	Min (%)	Std (%)	Mean (%)	Max (%)	Min (%)	Std (%)	Start	End
Canada	0.05	8.07	-13.59	2.15	0.06	8.07	-13.72	2.16	Jan-1985	Dec-2020
Croatia	0.05	7.72	-10.90	2.85	0.08	7.77	-11.30	2.87	Apr-2004	Dec-2020
Cyprus	0.40	4.15	-4.69	2.02	0.40	4.10	-4.64	2.01	Apr-2004	Dec-2007
Czech Rep.	0.13	9.73	-12.23	3.49	0.12	9.71	-12.22	3.51	Jan-1997	Dec-2020
Denmark	0.18	9.38	-10.86	3.00	0.17	9.19	-10.83	3.00	Jan-1985	Dec-2020
Egypt	0.98	18.81	-48.90	4.33	0.64	14.10	-42.07	3.60	Apr-2004	Dec-2020

(Continued)

Table 1 – *Continued*

Countries and regions	Excess return of the spot				Excess return of the one-month forward				Sample	
	Mean (%)	Max (%)	Min (%)	Std (%)	Mean (%)	Max (%)	Min (%)	Std (%)	Start	End
Euro area	-0.03	9.15	-10.56	2.79	-0.03	9.03	-10.70	2.78	Feb-1999	Dec-2020
Finland	-0.59	5.16	-5.98	2.80	-0.58	5.14	-5.98	2.80	Jan-1997	Dec-1998
France	0.33	7.99	-10.64	3.25	0.34	7.84	-10.67	3.24	Dec-1983	Dec-1998

Germany	0.19	7.95	-10.95	3.39	0.19	7.98	-10.99	3.38	Dec-1983	Dec-1998
Greece	-0.40	7.49	-9.73	3.13	-0.41	7.51	-9.51	3.13	Jan-1997	Dec-2000
Hong Kong	-0.02	1.18	-1.07	0.19	-0.01	1.51	-1.13	0.22	Dec-1983	Dec-2020
Hungary	0.20	11.35	-19.17	3.86	0.19	11.28	-19.29	3.87	Nov-1997	Dec-2020
Iceland	0.14	16.67	-23.09	4.16	0.13	16.35	-22.49	4.13	Apr-2004	Dec-2020
India	0.13	7.81	-7.45	2.05	0.12	7.64	-7.53	2.05	Nov-1997	Dec-2020
Indonesia	1.16	38.78	-63.94	8.03	0.12	39.19	-65.21	6.87	Jan-1997	Dec-2020
Ireland	0.14	5.11	-6.20	2.27	0.14	5.09	-6.19	2.26	Nov-1993	Dec-1998
Israel	0.17	6.32	-7.27	2.27	0.16	6.23	-7.29	2.27	Apr-2004	Dec-2020
Italy	0.31	7.96	-13.61	3.26	0.34	8.19	-11.74	3.19	Apr-1984	Dec-1998
Japan	-0.02	15.10	-10.90	3.12	-0.01	15.11	-10.67	3.12	Dec-1983	Dec-2020
Kuwait	0.04	3.48	-4.37	0.65	0.04	3.50	-4.36	0.66	Jan-1997	Dec-2020
Malaysia	0.20	13.02	-31.31	4.53	0.34	13.16	-10.59	2.20	Jan-1985	Dec-2020
Mexico	0.25	7.84	-16.49	3.21	0.25	7.84	-16.49	3.26	Jan-1997	Dec-2020
Netherlands	0.20	7.79	-11.47	3.39	0.21	7.84	-11.54	3.37	Dec-1983	Dec-1998
New Zealand	0.41	13.28	-13.71	3.57	0.39	13.25	-13.70	3.57	Jan-1985	Dec-2020
Norway	0.17	7.65	-12.80	3.24	0.16	7.67	-12.85	3.24	Jan-1985	Dec-2020

(Continued)

Table 1 – *Continued*

Countries and regions	Excess return of the spot				Excess return of the one-month forward				Sample	
	Mean (%)	Max (%)	Min (%)	Std (%)	Mean (%)	Max (%)	Min (%)	Std (%)	Start	End
Philippines	0.10	8.95	-12.36	2.28	0.10	8.89	-12.79	2.31	Jan-1997	Dec-2020
Poland	0.22	9.69	-15.63	3.94	0.21	9.67	-15.60	3.95	Mar-2002	Dec-2020
Portugal	-0.44	5.06	-5.51	2.62	-0.44	5.03	-5.53	2.62	Jan-1997	Dec-1998
Russia	0.05	14.28	-17.86	4.25	0.01	14.19	-19.05	4.34	Apr-2004	Dec-2020
Saudi Arabia	0.01	0.67	-1.22	0.10	0.01	0.88	-1.14	0.11	Jan-1997	Dec-2020
Singapore	0.03	5.99	-8.07	1.57	0.03	6.25	-8.08	1.58	Jan-1985	Dec-2020
Slovakia	1.11	9.93	-10.90	3.36	1.11	9.83	-11.12	3.36	Mar-2002	Dec-2008
Slovenia	0.22	4.52	-4.29	2.17	0.23	4.55	-4.29	2.18	Apr-2004	Dec-2006
South Africa	0.06	14.43	-19.34	4.44	-0.01	14.45	-21.63	4.57	Dec-1983	Dec-2020
South Korea	0.15	14.49	-13.46	3.12	0.14	14.30	-12.93	3.09	Mar-2002	Dec-2020
Spain	-0.41	5.19	-6.23	2.71	-0.41	5.17	-6.22	2.71	Jan-1997	Dec-1998
Sweden	0.10	9.13	-15.51	3.20	0.10	9.10	-15.61	3.19	Jan-1985	Dec-2020
Switzerland	0.04	13.00	-11.98	3.24	0.05	12.88	-12.01	3.24	Dec-1983	Dec-2020

Taiwan	-0.09	6.00	-7.82	1.53	-0.10	6.00	-7.82	1.60	Jan-1997	Dec-2020
Thailand	0.10	21.04	-19.68	3.00	0.07	21.28	-19.01	3.02	Jan-1997	Dec-2020
Ukraine	0.16	11.30	-22.46	3.97	0.36	13.99	-23.16	4.30	Apr-2004	Sep-2010
the UK	0.10	13.86	-12.66	2.91	0.09	13.20	-12.61	2.91	Dec-1983	Dec-2020

2.2. Portfolio construction

This section describes how we construct currency portfolios used in our empirical analysis. First, we follow Boons and Prado (2019) and build the currency Basis-Momentum (BM) portfolios. Next, to explore the relationship between BM and other currency anomalies, we further build four prominent currency market factors as the benchmark strategies, namely carry, momentum, value and economic momentum strategies.

2.2.1 Basis-momentum portfolio in the FX markets

In line with Boons and Prado (2019), for a given currency in month t, we define the basis (B_t) as the difference between the one-month forward rate and spot rate; momentum (M_t) as J month cumulative excess return, and BM_t as the difference in momentum between first- and second-nearby contracts in the currency market as follow:

$$B_t = f_t^1 - s_t, \tag{2}$$

$$M_t = \sum_{s=t-J+1}^{t} (f_{t-1}^1 - s_t), \tag{3}$$

$$\begin{aligned} BM_t &= \sum_{s=t-J+1}^{t} (f_{t-1}^1 - s_t) - \sum_{s=t-J+1}^{t} (f_{t-1}^2 - f_t^1) \\ &= \sum_{s=t-J+1}^{t} (f_t^1 - s_t) - \sum_{s=t-J}^{t-1} (f_t^2 - f_t^1), \end{aligned} \tag{4}$$

where s_t, f_t^1 and f_t^2 represent the logarithm of spot, one-month forward and two-month forward exchange rates of currency k, respectively.[5] J denotes the formation period which takes values of 1, 3, 6, 9, and 12 months. Next, we follow Boons and Prado (2019) and define basis-one as $b_t^1 = f_t^1 - s_t$ and basis-two as $b_t^2 = f_t^2 - f_t^1$. Equation (4) thus can be converted to $\sum_{s=t-J+1}^{t}(b_t^1) - \sum_{s=t-J}^{t-1}(b_t^2)$.

To construct the BM portfolio, at the end of each month, we sort the 48 currencies into five portfolios based on their period returns over the past $J = \{1, 3, 6, 9, 12\}$ months.[6] Portfolio one contains the highest-ranked signals (called "winner"), and portfolio two consists of the lowest-ranked signals (called "loser"). Therefore, the winner-minus-loser (WML) series represents the returns of a long-short zero net investment BM strategy.

2.2.2. Benchmark strategies

The most direct benchmarks related to the BM are the currency basis and momentum factors. As is defined in the last sub-section, basis-one is the difference between one-month forward rate and spot rate, and basis-two is the difference between two- and one-month forward rates. Therefore, a basis-one strategy with a formation period of one month is equivalent to a currency carry strategy, which is long high-interest rate currencies and short low-interest rate currencies.[7] This indicates that higher interest rate currencies tend to be stronger and lower interest rate currencies tend to be weaker. Following Menkhoff et al. (2012a), we approximate carry as the forward discount, $f_t^1 - s_t$, which is equivalent to interest rate differential when covered interest parity holds closely in the data at the frequency used in our paper (Akram et al., 2008).

[5] We measure the exchange rates as the U.S. dollar per unit of foreign currency, which is consistent with Menkhoff et al. (2012a).
[6] Each portfolio contains 48 currencies, and we sort the dataset into quintiles which is consistent with Menkhoff et al. (2012a). We also provide the results of sorting currencies into quartiles and tertiles and report them in Appendix C.
[7] Carry trade is also effective in other asset classes as justified by Koijen et al. (2018).

Our second benchmark, the currency momentum factor, is long currencies with high past excess returns and short those with low past excess returns. As shown in Equation (3), the momentum signals are calculated as the cumulative difference between one-month forward rates and spot rates. To better explain BM anomaly, similar to Menkhoff et al. (2012b), we further consider the momentum strategies based on the spot rate change $s_t - s_{t-J+1}$ (sport rate momentum). The spot rate momentum is one of the four components when decomposing the BM signals discussed in Section 4.

Furthermore, we construct the currency value portfolio according to Asness et al. (2013) and Menkhoff et al. (2017). We measure currency value based on the real exchange rate (RER) as follows

$$RER_t = s_t * \frac{c_t}{c_{f,t}}, \tag{5}$$

where s_t is the spot rate, $c_{f,t}$ is the foreign inflation in month t, and c_t is the domestic inflation in month t. $\frac{c_{f,t}}{c_t}$ is also known as the Purchasing Power Parity (PPP) (Rogoff, 1996, Taylor and Taylor, 2004). The currency value is computed as the log difference in the real exchange rates over the past 60-month (5 years). Currencies with low RER against the U.S. dollar have higher returns as the strategy is long the low-value currencies and short the high-value currencies. Therefore, in line with Asness et al. (2013) and Menkhoff et al. (2017), currency value (V_t) is calculated as:

$$V_t = \log\left(\frac{spot_t * c_t}{c_{f,t}}\right) - \log\left(\frac{spot_{t-60} * c_{t-60}}{c_{f,t-60}}\right), \tag{6}$$

where the $spot_{t-60}$ is the average spot exchange rate from 4.5 to 5.5 years ago. For the inflation rates, we adopt the Consumer Purchase Index (CPI), where the c_t denotes the domestic CPI index, $c_{f,t}$ denotes the foreign CPI index, and c_{t-60} represents the CPI 60 months ago.

Finally, our last benchmark strategy refers to the recently documented economic momentum of Dahlquist and Hasseltoft (2020). The economic momentum signals reflect the trends in two fundamental indices, i.e. economic activities and inflation changes.[8] In line with Dahlquist and Hasseltoft (2020), we adopt the log growth rate to measure the trends in the fundamental indices, $z_{c,i,l,t} = ln(X_{c,i,t}) - ln(X_{c,i,t-l})$, where $X_{c,i,t-l}$ represents the given index i at time t with the formation period l of currency c. The formation period ranges from one to 60 months.

At the end of each month, currencies are sorted by the trend, $z_{c,i,l,t}$, in descending orders, depending on various indices and formation periods. We then build a 50/50 portfolio for each index and for each formation period, where we have 120 different sub-portfolios in total. The aggregated economic momentum return series is measured as the weighted average of all these sub-portfolio returns. Since the volatilities vary across sub-portfolios, we weight each sub-portfolio by the inverse of its related volatility and scale the weights to ensure that they sum to one. The realised volatility is estimated by the exponentially weighted moving average volatility of strategy returns based on daily spot returns, using a RiskMetrics lambda of 0.94.

2.2.3 Transaction costs and net excess returns

Existing literature concludes that transaction costs are crucial to the profitability of currency strategies, and find that the transaction costs reduce profits considerably

[8] The economic momentum index is constructed through an equal-weighted average of growth rates in industrial production, retail sales, and the inverse of unemployment. Similarly, the inflation index is constructed as an equal-weighted average of growth rates in consumer and producer price indices. For more details, please see Dahlquist and Hasseltoft (2020).

(Korajczyk and Sadka, 2004, Menkhoff et al., 2012a). Menkhoff et al. (2012b) also conclude that momentum returns are much lower in currency market when applying the full spread. Following Menkhoff et al. (2012a), we compute the excess returns based on adjusted bid-ask spreads. The net return enters a portfolio at time t and exits the portfolio at the end of the month for the long and short positions as $rx_{t+1}^{l} = f_t^{1,b} - s_{t+1}^{a}$ and $rx_{t+1}^{s} = -f_t^{1,a} + s_{t+1}^{b}$. The net excess return for currency enters a portfolio but stays in the portfolio at the end of the month for the long and short position as: $rx_{t+a}^{l} = f_t^{1,b} - s_{t+1}$ and $rx_{t+1}^{s} = -f_t^{1,a} + s_{t+1}$. A currency has an excess return that exits a portfolio at the month of t but already was in the current portfolio the month before $(t-1)$ for the long and short position as: $rx_{t+1}^{l} = f_t^{1} - s_{t+1}^{a}$ and $rx_{t+1}^{s} = -f_t^{1} + s_{t+1}^{b}$, where a and b superscripts denote the ask and bid quotes. We assume that investors take a new position in each available currency in the first month of our sample period (November 1983) and mute all positions in the last month (December 2020).

To adjust for the bid-ask spreads (transaction costs), we follow Menkhoff et al. (2012a) and Menkhoff et al. (2012b) and calculate the net excess returns when investigating dynamic currency portfolios (e.g., carry, basis-momentum, momentum and value). The net return for a currency that enters a portfolio at time t and exits at the end of the month is computed as $rx_{t+1}^{l} = f_t^{1,b} - s_{t+1}^{a}$ for a long position and $rx_{t+1}^{s} = -f_t^{1,a} + s_{t+1}^{b}$ for a short position, where the upper scripts, $a(b)$, refers to the ask (bid) quote. A currency selected by a portfolio and further stays in the portfolio at the end of the month produces a net excess return $rx_{t+a}^{l} = f_t^{1,b} - s_{t+1}$ and $rx_{t+1}^{s} = -f_t^{1,a} + s_{t+1}$, for the long and short positions, respectively. On the other hand, a currency that exits the portfolio at month t but already was in the current portfolio the month before $(t-1)$ has a net excess return of $rx_{t+1}^{l} = f_t^{1} - s_{t+1}^{a}$ and $rx_{t+1}^{s} = -f_t^{1} + s_{t+1}^{b}$, for the long and short positions, respectively. We assume that investors take a new position in each available currency in the first month of our sample period (November 1983) and close all positions in the last month (December 2020).

3. Currency BM Strategies

In this section, we present the performance of the BM strategies based on our currency sample. **Table 2** summarises the average monthly excess returns and Sharpe ratios of the winner, loser, and winner-minus-loser (WML) portfolio of the BM strategies with formation period, $J = \{1, 3, 6, 9, 12\}$ months. We find that, across all the formation periods, the BM strategies generate positive excess returns that are statistically significant at the 1% level. The Sharpe ratios of BM strategies range from 0.92 to 1.12 which are higher than the benchmarks (momentum and basis-one). Across all the formation periods, the BM strategy with a three-month formation period (BM-3) yields the highest monthly return of 0.72% (t-statistic = 4.35) and Sharpe ratio of 1.12. BM returns reduce with the increase of formation periods from one- to nine-month and slightly rise with the 12-month formation period. Overall, our results suggest that the BM strategies work in the FX markets and the BM-3 strategy performs best across various formation periods, which is consistent with Boons and Prado (2019).

In the last two columns of **Table 2**, we can see that the benchmark factors, momentum and basis-one, also perform well with their returns being significantly different from zero at the 1% level. However, the BM strategy still beats both benchmarks in terms of Sharpe ratio when formation periods are between 3 and 12 months. The best performing momentum strategy is the one with the one-month formation period, which reports an average monthly return of 0.68% (t-statistic = 4.48). The highest mean return of basis-one also appears in the one-month formation period strategy (0.83%) which outperforms the BM-3. As is mentioned before, the basis-one strategy with a one-month formation period is equivalent to the currency carry strategy. Therefore, for the rest of the paper, when the momentum and basis-one strategies are adopted as benchmarks, we use one month as their formation period.

Besides sorting currencies into quintiles, we also present the analogous results of sorting currencies into quartiles and tertiles based on the same sample in Appendix A. The results of sorting the currencies into quintiles are similar to the main results reported in **Table 2** with both supporting that the BM-3 strategy performs best across five formation periods. However, when sorting the currencies into tertiles, the BM-3 yield an average monthly return of 0.44% (*t*-statistic = 4.20), which is slightly below the best performing BM-12 strategy at 0.45% (*t*-statistic = 3.38). Despite all these minor differences, our main findings remain the same disregarding the choice of sub-portfolio size.

Next, we compare the cumulative performance of the best performing BM strategy (BM-3) with benchmark strategies over the entire investment horizon, from May 1989 to December 2020.[9] We plot the cumulative return of the winner, loser and winner-minus-loser (WML) portfolios of BM-3 in Panel A of **Fig. 1** with an initial investment of $1. We see that the profitability of its WML series is sourced from both the long and short ends. The cumulative returns increase steadily since the late 1990s with very small drawdowns over time.

Panel B of **Fig. 1** compares the cumulative return of BM-3 with benchmark currency strategies including carry and momentum (with one month formation period). We find that the cumulative returns of the BM-3, carry, and momentum strategies are all positive but the BM3 provides a more steady return path than the other two. $1 invested in BM-3, carry, and momentum strategies in May 1989 end up with values of $14.06, $19.22, and $13.93, respectively, in December 2020. The momentum strategy shows a clear downward trend after the 2008 global financial crisis which seems consistent with the momentum crashes literature of Barroso and Santa-Clara (2015) and Daniel and

[9] We skip the first 66 observations as the value strategy generates the first signal in the 67th month.

Moskowitz (2016).[10] During the global financial crisis and afterwards period from January 2007 to December 2010, the maximum drawdown of BM-3, carry, and momentum strategies decreased by 8.16%, 14.74%, and 11.90%, respectively. The BM-3 strategy is least affected by the financial crisis and growing persistently over the sample period while carry suffers most. Over the entire sample period from May 1989 to December 2020, the maximum drawdown of BM-3 (13.63%), is lower than those of carry and momentum (14.96 and 31.45%). This further supports that the BM-3 strategy is superior as it provides lower volatility and a smaller drawdown.

Table 2

Currency portfolios sorted on Basis-Momentum.

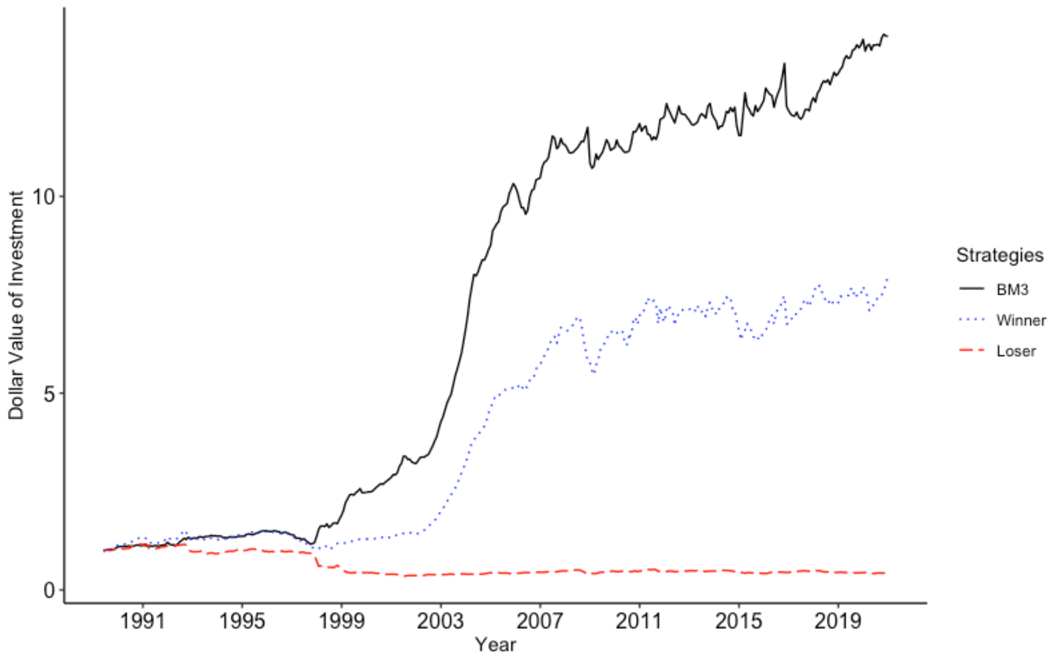
This table reports the average monthly return in percentage and Sharpe ratios of the winner, loser, and winner-minus-loser for BM strategies. J denotes 1, 3, 6, 9 and 12 months formation periods, and t-statistics are reported in parentheses based on Newey-West standard errors. We use momentum and basis-one as benchmarks. The 48 currencies are sorted into quintiles and each quintile portfolio is equally weighted. The sample period ranges from November 1983 to December 2020.

		BM			Momentum	Basis-one
j		Winner	Loser	WML	WML	WML
1	Avg.ret.	0.50	-0.11	0.59	0.68	0.83
	(t)	(3.28)	(-0.61)	(4.82)	(4.48)	(4.13)
	Sharpe	0.76	-0.16	0.97	0.88	1.12
3	Avg.ret.	0.58	-0.18	0.72	0.64	0.73
	(t)	(3.47)	(-1.10)	(4.35)	(3.84)	(3.49)
	Sharpe	0.82	-0.24	1.12	0.81	0.96
6	Avg.ret.	0.49	-0.12	0.59	0.63	0.71
	(t)	(2.79)	(-0.80)	(3.71)	(3.82)	(3.30)

[10] The crash risks in the foreign exchange markets is much smaller than those in other asset classes, but still result in significant drawdown after the financial crisis (Fan et al., 2018, Fan et al., 2020).

	Sharpe	0.65	-0.19	0.98	0.76	0.90
9	Avg.ret.	0.52	-0.08	0.58	0.65	0.67
	(t)	(2.95)	(-0.54)	(3.28)	(3.90)	(3.31)
	Sharpe	0.69	-0.12	0.92	0.76	0.86
12	Avg.ret.	0.52	-0.10	0.61	0.48	0.68
	(t)	(2.96)	(-0.78)	(3.23)	(2.83)	(3.37)
	Sharpe	0.68	-0.16	0.92	0.58	0.87

Panel A: Cumulative excess returns of BM-3 strategy



Panel B: BM-3 and benchmark strategies

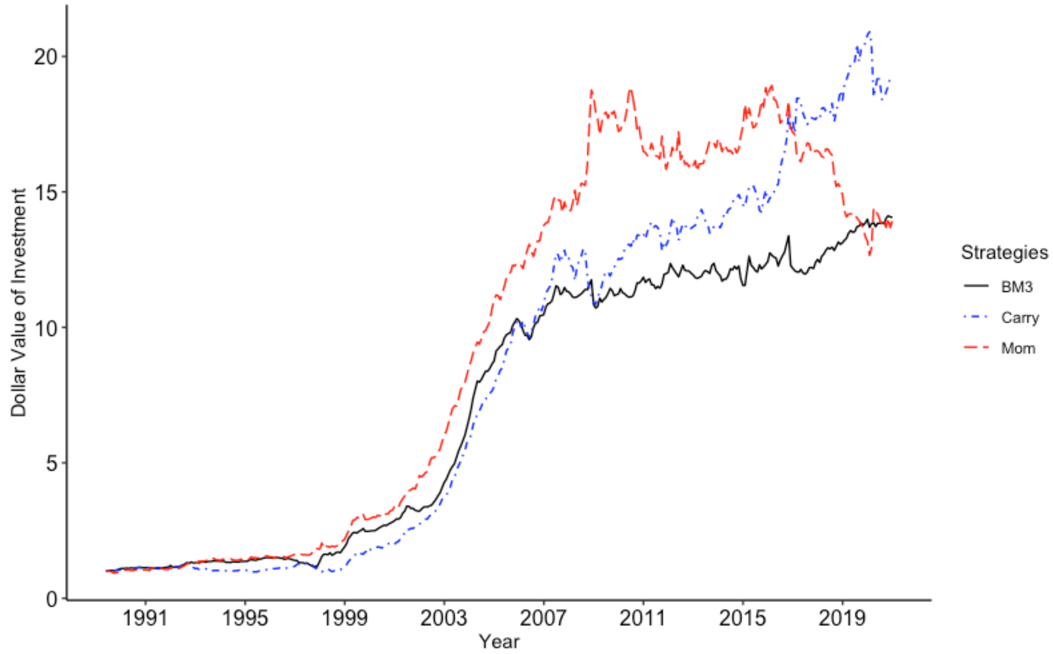


Fig. 1. Panel A: Cumulative excess return of the BM-3 strategy. The figure shows the cumulative excess returns of winner, loser and winner minus loser of BM strategies with a three-month formation period. The solid black line refers to the winner minus loser, and the dotted blue and the dashed red lines represent the winner and the loser portfolios. Panel B: BM-3 and benchmark strategies. This figure illustrates the cumulative excess return of BM-3 and two benchmark strategies, i.e. carry and momentum. The colour and symbol schemes are BM-3 (solid black line), carry (dotted blue line) and momentum (dashed red line). Portfolio returns are calculated using an equal-weighted scheme and strategies are rebalanced at the end of each month. The entire sample period is from November 1983 to December 2020, but the cumulative returns plot starts from May 1989 due to the formation period of the strategy.

Over the entire sample period, the database is dramatically affected by the introduction of the Euro and the 2007-2008 global financial crisis. To investigate how these two economic shocks affect the BM strategy, we divided the entire time horizon into three sub-periods. The first sub-period is from December 1985 to December 1998, the second one is from January 1999 to December 2010, and the last sub-period spans January 2011 to December 2020.[11] Same as before, we use momentum and basis-one as benchmarks.

In **Table 3**, we present the sub-period analysis of the BM-3 strategy based on the same sorting methods defined in **Table 2**. Panel A reports the results of the periods between 1985 and 1998. The BM-3 and momentum strategies produce positive monthly returns of,0.61% (t-statistics=2.30) and 0.63% (t-statistics=2.18) respectively, which are statistically significant at the 5% level. In contrast, the basis-one strategy yields an insignificant return at 0.25% (t-statistics=0.80). Consequently, we conclude that the BM and momentum effects are strong before Euro is introduced, whereas the basis-one or carry effect is weak in general. After the launch of the Euro, results in Panel B suggest that the BM-3 strategy still yields statistically significant sub-period performance at 1.21% (t-statistics=4.19). Meanwhile, the benchmark strategies, basis-one and momentum, also generate higher profits over the second sub-period than the first sub-period. The improved profitability after 1999 is not unique to the BM strategy, but is applicable to all the FX market factors with increased monthly average returns. According to Chinn and Frankel (2007) and Antonakakis (2012), the launch of the Euro provides an alternative reserve option to the FX market participants (especially the central banks) to the U.S dollar, which can reduce the exchange risks in the Eurozone and facilitate global transactions. Therefore, an intuitive explanation of the improvements in performance in Panel B is that the entire FX market booms after the introduction of Euro due to the lower market risks.

[11] We determined the sub-periods according to the following reasons. First, Hau et al. (2002) demonstrate that the Euro acts differently from the German Mark, leading to a reconstruction of the FX markets. Second, the financial crisis dramatically shocks the exchange rates as discussed by previous literature, e.g., Melvin and Taylor (2009) and Bénétrix et al. (2015). In addition, we treat the 2009-2010 Eurozone sovereign debt crisis as the extension of the global financial crisis, which is in line with the existing currency literature, e.g., Bekiros and Marcellino (2013).

Finally, Panel C of **Table 3** shows that the BM-3 strategy exhibits relatively low positive returns from January 2011 to December 2020, but is still statistically significant with the *t*-statistics of 1.68. By contrast, the momentum strategy reports a negative monthly return at -0.25%, which is consistent with the finding of Daniel and Moskowitz (2016) that the momentum profits suffer from crash risks after panic periods. The returns of basis-one also largely decrease during sub-period three. According to McLean and Pontiff (2016) and Hou et al. (2020), the post-publication effect can be one possible explanation for the lower performance of the BM strategy and the insignificant returns of the benchmark portfolios. Many academic papers that uncover currency market anomalies were published around 2011, e.g., Lustig and Verdelhan (2007), Darvas (2009), Lustig et al. (2011), Christiansen et al. (2011) and Spronk et al. (2013), and this leads to decreasing strategy performance.

Table 3

Sub-period analysis of BM-3 strategy.

This table reports the average monthly returns in percentage and Sharpe ratios of the winner, loser, and winner-minus-loser (WML) for BM-3 strategies. The entire sample period is divided into three subperiods as shown in Panel A, B, and C. We use momentum and basis-one with one-month formation periods as benchmarks. The *t*-statistics reported in parentheses are calculated based on Newey-West standard errors.

	BM-3			Momentum	Basis-one
	Winner	Loser	WML	WML	WML
Panel A: Dec 1985 - Dec 1998					
Avg.ret.	0.27	-0.40	0.61	0.63	0.25
(t)	(1.15)	(-1.16)	(2.30)	(2.18)	(0.80)
Sharpe	0.35	-0.44	0.81	0.69	0.31

Panel B: Jan 1999 - Dec 2010					
Avg.ret.	1.31	0.08	1.21	1.29	1.41
(t)	(3.45)	(0.36)	(4.19)	(5.77)	(4.40)
Sharpe	2.02	0.14	2.11	1.83	1.96
Panel C: Jan 2011 - Dec 2020					
Avg.ret.	0.17	0.01	0.16	-0.25	0.34
(t)	(0.56)	(-0.36)	(1.68)	(-1.04)	(1.62)
Sharpe	0.27	0.01	0.35	-0.42	0.55

4. A Decomposition Model of Basis-Momentum

The signal construction of the BM factor implies that it might be highly related to the existing currency market anomalies such as momentum and carry (basis-one with one month formation period). To further investigate this relationship, we propose a decomposition model of BM signal to find out which component contributes most to the formation of the BM factor. According to the definition of BM suggested by Boons and Prado (2019), we decompose BM as follows:

$$BM_t = \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) - \sum_{s=t-J+1}^{t} (f_{s-1}^2 - f_s^1), \tag{7}$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) + (f_t^1 - s_t) + (s_t - s_{t-J+1}) - [\sum_{s=t-J}^{t-1} (f_s^2 - f_s^1) + f_{t-J}^1 - s_{t-J+1}],$$

where $\sum_{s=t-J+1}^{t}(f_{s-1}^1 - s_s)$ represents the momentum based on excess return over J month formation period, $mom_{t-J+1,t}$; $(f_t^1 - s_t)$ is the carry component, $carry_t$; $(s_t - s_{t-J+1})$ refers to the period return of spot rate, known as the spot rate momentum as in Menkhoff et al. (2012b), $mom_{t-J+1,t}^{\text{spot rate}}$; $(f_s^2 - f_s^1)$ is the basis-two component, b_s^2. Thus, the above formula can be converted to:

$$BM_t = mom_{t-J+1,t} + carry_t + mom_{t-J+1,t}^{spot\,rate} - \sum_{s=t-J}^{t-1}(b_s^2) - rx_{t-J+1}, \qquad (8)$$

$$= mom_{t-J+2,t} + carry_t + mom_{t-J+1,t}^{spot\,rate} - \sum_{s=t-J}^{t-1}(b_s^2),$$

where rx_{t-J+1} refers to the excess return in month $t-J+1$. As suggested by the above equation, the BM signal can be decomposed into four components, namely momentum, carry, spot rate momentum, and a lagged basis-two term.[12] Remarkably, the decomposition allows us to examine the relationship between BM strategy and the existing prevalent currency factors, but those components that are specific to the BM factor, i.e. spot rate momentum and basis-two.[13] Moreover, our decomposition enables us to answer a very important question: are the existing currency factors, carry and momentum, subsume the BM factor? If not, then we are confident to conjecture that the BM is a distinct factor in currency market.

In **Table 4,** we examine the strategies performance of the four BM components individually (Panel A) and collectively (Panel B). As shown in Panel A of Table 4, the carry and momentum with different specifications report large positive excess returns and Sharpe ratios, whereas spot rate momentum and the negative basis-two components exhibit negative and statistically significant profits, indicating both components are negative currency market predictors. Our results of the spot rate momentum is similar to Menkhoff et al. (2012b), suggesting a positive return contribution to a currency strategy when using exchange rate against the USD. Direction of the basis-two predictability is the same as the carry (basis-one), meaning that the trend of the forward curve is generally unchanged.

[12] Details of derivations of the decomposition is available in Appendix B.
[13] Note that, the momentum here converts to $t-J+2$ month formation period which excludes the farthest month.

Although neither of the spot rate momentum and basis-two components contributes to the profitability of BM, they jointly work with the carry and momentum factors to alleviate the risks of the portfolio. Panel B of Table 4 illustrates the performance of several portfolios based on two to four components of our decomposition model to investigate their joint predictability. Compared to the $carry_t + mom_{t-J+2,t}$ based strategy, the $carry_t + mom_{t-J+2,t}$+$mom_{t-J+1,t}^{spot\ rate}$ portfolios yield lower volatility and result in higher Sharpe ratios across the four different formation periods. Moreover, after adding the$-\sum_{s=t-J}^{t-1}(b_s^2)$ component, the volatility is further reduced from 0.77-0.79 to 0.61-0.66. Overall, the Sharpe ratios of the strategies based on all the four components (0.92-1.12) are much higher than those portfolios based on carry and momentum only (0.67-0.94). The results shows that the spot rate momentum component can reduce the risks of the portfolio based on both $carry_t\ and\ mom_{t-J+2,t}$ components.

Table 4

Sorted currencies on decomposing components.

This table reports the average monthly performance of the winner-minus-loser (WML) for individual decomposed components and combinations of multiple components strategy. The carry and basis-two components use the 1, 3, 6, 9 and 12 months formation periods, while momentum and spot rate momentum use the 2, 5, 8 and 11 months formation periods. *t*-statistics are reported in parentheses based on Newey-West standard errors. 48 currencies are sorted into quintiles and each quintile portfolio is equally weighted. The sample period ranges from November 1983 to December 2020.

Panel A: Individual BM component						
J		1	3	6	9	12
$carry_t$	Avg.ret. (%)	0.83				
	(t)	(4.13)				
	Sharpe	1.12				
$mom_{t-J+2,t}$	Avg.ret. (%)		0.67	0.56	0.65	0.55
	(t)		(4.66)	(3.43)	(3.83)	(3.23)
	Sharpe		0.84	0.68	0.77	0.65
$mom_{t-J+1,t}^{spot\ rate}$	Avg.ret. (%)	-0.39	-0.35	-0.22	-0.40	-0.43
	(t)	(-3.22)	(-2.85)	(-1.78)	(-2.86)	(-3.23)
	Sharpe	-0.53	-0.46	-0.28	-0.50	-0.56
$-\sum_{s=t-J}^{t-1}(b_s^2)$	Avg.ret. (%)	-0.82	-0.74	-0.72	-0.70	-0.70
	(t)	(-4.01)	(-3.52)	(-3.49)	(-3.61)	(-3.71)
	Sharpe	-1.07	-0.94	-0.90	-0.87	-0.88

Panel B: Combinations of BM components					
J		3	6	9	12
$carry_t + mom_{t-J+2,t}$	Avg.ret. (%)	0.76	0.62	0.67	0.57
	(t)	(4.97)	(3.78)	(3.93)	(3.33)
	Volatility	0.80	0.83	0.85	0.85
	Sharpe	0.94	0.75	0.79	0.67
$carry_t + mom_{t-J+2,t} + mom_{t-J+1,t}^{spot\ rate}$	Avg.ret. (%)	0.73	0.71	0.67	0.68
	(t)	(3.49)	(3.30)	(3.31)	(3.37)
	Volatility	0.77	0.78	0.79	0.77
	Sharpe	0.96	0.90	0.86	0.87
$carry_t + mom_{t-J+2,t} + mom_{t-J+1,t}^{spot\ rate} - \sum_{s=t-J}^{t-1}(b_s^2)$	Avg.ret. (%)	0.72	0.59	0.58	0.61
	(t)	(4.35)	(3.71)	(3.28)	(3.23)
	Volatility	0.64	0.61	0.63	0.66
	Sharpe	1.12	0.98	0.92	0.92

Table 5 presents the results of the BM returns explained by its components as in Equation (9). We regress the returns of BM-3 strategy on the strategy returns generated by the four decomposition components' signals. We find that all the coefficients of the four components are statistically significant, but the momentum and carry factors show much stronger predictability on the BM returns. The *t*-statistics linked to the alphas are significantly different from zero at the 1% level across all models, that is, BM returns are not entirely subsumed by the above decomposition components. On the other hand, the BM strategy is highly related to the market factors, momentum and carry, and it explains the part returns in the currency markets. Models (1) and （2） show the coefficient estimates of the momentum and carry are both highly significant at 0.26% (*t*-statistic = 7.09) and 0.28% (*t*-statistic = 7.06), respectively. The adjusted R^2 of momentum and carry 10.57% and 10.48%, which is reported quite a similar explaining power to the BM returns. Moreover, in Models (3) and （4）, the negative coefficients of -0.07% (*t* -statistic = -1.81) for spot rate momentum, and -0.07 (*t* -statistic = -1.70) for basis-two, indicating that both components are negatively correlated with BM returns. This is not surprising as is justified in Table 4, both strategies generate negative profitabilities. Finally, basis-two reports lowest adjusted R^2 of 0.45%, it has the least effectiveness in explaining the BM returns.

In factors combination models, we see that the explanatory power rises when successively adding different combinations across the abovementioned components. The momentum and carry components make the greatest contribution in explaining the BM returns, where the adjusted R^2 is 21.15%. The Models (6) and (7) report the adjusted R^2 at 28.82% and 25.19% when we add the spot rate momentum and basis-two component, respectively. The explanatory power of BM still improves slightly when successively adding the spot rate momentum and basis-two components but the magnitude is marginal. Finally, Model (8) subsumes all characteristic jointly and report the strongest explanatory for BM returns at 32.32%, which is the highest across all the candidate models. Hence, we conclude that each component from our decomposition has effects to explain the returns of BM, but the momentum and carry contribute the most.

Table 5

Returns of BM explained by its components.

This table analyses how the four components suggested by the decomposition model in Equation (9) explain BM returns. Model (1) to Model (4) regress the BM-3 returns on the returns of momentum, carry, spot rate momentum, and basis-two strategies as independent variables with the same formation periods, respectively. Model (5) to Model (8) run similar regressions but employ multiple combinations of the abovementioned four variables as regressors. The Newey-West *t*-statistics are reported in parentheses. Portfolios are rebalanced monthly, and the sample period is from November 1983 to December 2020.

Model	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
α (%)	0.55	0.50	0.70	0.68	0.32	0.32	0.37	0.37
	(5.16)	(4.60)	(6.34)	(6.00)	(3.08)	(3.24)	(3.65)	(3.80)
λ_{mom}	0.26				0.26	0.71	0.20	0.63
	(7.09)				(7.57)	(9.64)	(5.57)	(8.66)
λ_{carry}		0.28			0.28	0.16	0.54	0.40
		(7.06)			(7.54)	(3.99)	(8.35)	(6.25)
$\lambda_{spot\ rate\ mom}$			-0.07			0.53		0.51
			(-1.81)			(6.76)		(6.69)
$\lambda_{-b_t^2}$				-0.07			0.30	0.28
				(-1.70)			(4.83)	(4.74)
$Adj.R^2$(%)	10.57	10.48	0.54	0.45	21.15	28.82	25.19	32.32

4.1 Do existing currency market factors explain BM?

The currency momentum and carry factors are widely investigated in the FX market literature.[14] To understand the existing factors, momentum and carry of the explanatory power to BM returns, we run spanning tests to assess whether the factors discussed above are related to BM returns. Panel A employs BM returns as the dependent variable, whereas Panel B and C use momentum and carry returns as the dependent variables, respectively. We report the results of spanning tests in formation period $J = \{1, 3, 6, 9, 12\}$ months.

In Panel A of **Table 6**, the alphas are statistics significantly in models using one, three and six-month formation periods, indicating that BM strategies are not subsumed by momentum and carry factors. By contrast, the *t*-statistics decreased to 1.27 and 1.32 and become insignificant for the 9 and 12-month formation period. Our results suggest that momentum and carry are associated with the return of BM, whereas momentum has lower coefficients than the carry factor.

Panel B and C of **Table 6** examines whether momentum and carry are subsumed by the other two factors. We find that the *t*-statistics of momentum alphas are at least statistically significant at the 5% level across all formation periods, while the t-statistics of carry alphas are all at the 1% level, being the strongest among the three factors. Overall, we conclude that none of BM, momentum and carry can be fully explained by each other. The results confirmed that BM is an independent factor in currency markets. In addition, we report the results of spanning tests by sorting currencies into quartiles and tertiles in Appendix C. We find that the results are qualitatively similar to the results in **Table 6**.

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[14] In related work, see, e.g., Okunev and White (2003) investigate whether currency momentum is profitable, Menkhoff et al. (2012a) examine the risk-return properties of carry trade, Menkhoff et al. (2012b) conduct a comprehensive cross-section analyse for momentum, and Burnside et al. (2011) jointly examine the carry and momentum effects.

Table 6

Spanning tests of BM, momentum and carry.

This table presents the results of spanning tests for the monthly returns of BM (Panel A), momentum (Panel B), and carry (Panel C) as the dependent variable, respectively. The rows report coefficient, Newey-West t-statistics (in parentheses) and adjusted R^2. Each column presents results with different formation periods, $J = \{1, 3, 6, 9, 12\}$ months. The sample period ranges from November 1983 to December 2020.

f	1	3	6	9	12
Panel A: BM as dependent variable					
α (%)	0.27	0.35	0.19	0.12	0.12
	(2.61)	(3.39)	(2.11)	(1.27)	(1.32)
Momentum	0.19	0.25	0.10	0.04	0.06
	(5.33)	(7.10)	(3.38)	(1.46)	(2.01)
Carry	0.24	0.27	0.41	0.52	0.55
	(6.46)	(7.25)	(12.18)	(15.49)	(15.98)
$Adj. R^2$ (%)	13.96	19.99	28.99	37.33	40.29
Panel B: Momentum as dependent variable					
α (%)	0.56	0.36	0.44	0.55	0.30
	(4.11)	(2.61)	(3.04)	(3.55)	(2.09)
BM	0.34	0.44	0.26	0.12	0.16
	(5.33)	(7.10)	(3.38)	(1.46)	(2.01)
Carry	-0.08	-0.09	0.01	0.02	0.09
	(-1.60)	(-1.71)	(0.19)	(0.30)	(1.33)
$Adj. R^2$ (%)	5.94	10.49	3.42	0.59	3.15
Panel C: Carry as dependent variable					
α (%)	0.64	0.55	0.42	0.42	0.38
	(4.96)	(4.37)	(3.64)	(3.98)	(3.71)
BM	0.38	0.41	0.65	0.71	0.70
	(6.46)	(7.25)	(12.18)	(15.49)	(15.98)
Momentum	-0.07	-0.08	0.01	0.01	0.05

	(-1.60)	(-1.71)	(0.19)	(0.30)	(1.33)
$Adj.R^2$ (%)	8.65	10.90	27.03	37.01	39.96

5. BM and the cross-section of currency excess return

In this section, we examine whether the BM factor adds any value in explaining the cross-sectional variation of currency expected returns based on the prevalent currency factors including carry, momentum, value and economic momentum. We run a series of pooled panel regressions to test the relationship between the currency excess returns and the BM factor by controlling for existing currency factors from the literature.[15] The main objective is to examine which factors play the most important roles in predicting currency excess returns. Another motivation here is to investigate the model predictability with and without the BM factor. Our results suggest that the BM factor undoubtedly contributes to the model explanatory power by increasing the goodness-of-fit significantly.

Table 7 presents the results of pooled regressions using currency excess returns as the dependent variable. As shown in Models (1), (2), (4) and (6), we run single factor pooled regressions by employing independent variables including BM, carry, momentum, and value, respectively. We then add the BM factor to each of these single factor models except for Model (1) and report the results in Models (3), (5) and (7). Finally, Models (8) and (9) report the results of multi-factor pooled regressions by controlling all the abovementioned benchmark factors with and without the BM factor.

[15] Apart from the carry and momentum factors, we add two other currency factors, value (Asness et al., 2013) and economic momentum (Dahlquist and Hasseltoft, 2020) in our empirical analysis in this section.

Results of Model (1) in **Table 7** suggest that the beta coefficient of BM as the single regressor is significantly positive at the 1% level, with the alpha being statistically insignificant and the adjusted R^2 being 39.4%. Beta coefficients of BM are also statistically significant at least at the 1% level when it is added to the single factor models as shown in Models (5) and (7), but become insignificant when carry is included as shown in Model (3). Interestingly, adding the BM factor to the carry factor model results in only a marginal increase in the adjusted R^2, from 40.7% to 40.8%, while adding the BM factor to the momentum factor model increases the adjusted R^2 from 36.2% to 40% as shown in Model (5). Comparing Models (6) and (7), the the inclusion of BM leads an increase in adjusted R^2 from 36.5% to 42.7%. Finally, in Model (8), the benchmark factors, carry, momentum and value already explain a large proportion of currency return variation with an adjusted R^2 of 43.9%. The results in Model (9) suggest that the inclusion of the BM factor has no improvement on the adjusted R^2 indicating that BM has marginal contribution in explaining the currency excess returns based on the existing currency factor models.

Table 7

Using the BM and benchmark factors to predict currency returns

This table reports the results of - pooled panel regressions using currency excess returns as the dependent variables. We employ BM strategy returns and other currency market factors, namely carry, momentum and value as independent variables. The first model contains BM. Column (2) to Column (7) presents the results of pooled regressions with and without the BM factor, controlling for a single existing currency factor. Column (8) and Column (9) perform the same analysis but keep all three control variables, i.e. carry, momentum and value. We report the coefficients of alpha, carry, momentum, value, and BM in percentage. The Newey-West *t*-statistics (in parentheses), number of observations, and the adjusted R^2 are also reported. The sample period spans December

1985 to December 2020. `*', `**', `***' represent that the t-values are statistically significant at 10%, 5% and 1% level.

	Currency returns								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Intercept	0.022***	0.020**	0.020**	0.022**	0.022**	-0.049***	-0.047***	-0.046***	-0.046***
	(3.64)	(2.42)	(2.40)	(2.52)	(2.53)	(-6.78)	(-6.98)	(-7.02)	(-7.02)
BM	0.265***		0.024		0.238***		0.262***		0.031
	(31.30)		(0.37)		(19.87)		(16.07)		(0.43)
Carry		0.777***	0.722***					0.743***	0.669**
		(7.24)	(2.83)					(6.64)	(2.39)
Mom				0.172**	0.085**			0.031	0.031
				(2.30)	(2.55)			(1.43)	(1.45)
Value						0.005	-0.003	-0.005**	-0.005**
						(0.77)	(-1.15)	(-2.14)	(-2.18)
Number of currencies	48	48	48	48	48	44	44	44	44
$Adj.R^2$	0.394	0.407	0.408	0.362	0.400	0.365	0.427	0.439	0.439

Dahlquist and Hasseltoft (2020) introduce economic momentum as a new currency market predictor as it generates significant abnormal returns that cannot be explained by existing market factors. The economic momentum strategies include economic activity momentum (Econ-mom), inflation momentum (Inf-mom) and trend combo. A trend combo strategy is an aggregation of 120 sub-strategies that combines economic and inflation activity. To examine the relationship between BM and the economic momentum, we continue to run pooled panel regressions as in **Table 7** by adding the above three strategy returns. Other known market factors including carry, momentum and value remain the same as control variables. Due to data availability, we follow

Dahlquist and Hasseltoft (2020) and use a subsample consisting of 33 currencies to economic momentum related portfolios.[16]

Table 8 presents the results of pooled panel regressions of BM by including inflation momentum (Inf-mom), economic activity momentum (Econ-mom) and trend combo strategies. Models (1), (3) and (5) are the tests without the BM factor, whereas Models (2), (4) and (6) are the ones controlling the BM factor. First, we observe that the economic momentum effect as represented by the trend combo strategy is statistically insignificant. This is because one of the components, Inf-mom, is somehow similar to the value factor as both reflect long-term economic growth. Second, in line with our findings in Table 7, we find that the BM factor does not contribute to the explanatory power of thesecurrency pooled regressions. Models that include BM factors show similarly adjusted R^2 compared to the models without BM factors. For example, the adjusted R^2 of Model (6), aggregating all the prevalent factors to the pooled panel regression including BM, carry, momentum, value and economic momentum, is only 0.1% higher than that of Model (5). These results are consistent with those in Table 7, suggesting that the BM factor may not add value to the current set of currency anomalies.

Table 8

Using the BM and benchmark factors to predict currency returns

[16] The subsample countries and regions are Australia, Austria, Belgium, Brazil, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Switzerland and the United Kingdom.

This table presents the results of pooled panel regressions of BM by including economic activity momentum (Econ-mom), inflation momentum (Inf-mom) and trend combo (Dahlquist and Hasseltoft, 2020). The dependent variables are currency excess returns, and the control variables are the return series of carry, momentum, value and economic momentum. Columns (1), (3) and (5) represent models only include the benchmarks. Columns (2), (4) and (6) report results by adding the BM to the previous models. The Newey-West *t*-statistics (in parentheses), the number of observations, and the adjusted R^2 are also reported. The sample period spans December 1985 to October 2020. `*', `**', `***' represent that the t-values are statistically significant at 10%, 5% and 1% level.

	Currency returns					
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.051***	-0.050***	-0.051***	-0.050***	-0.051***	-0.050***
	(-9.86)	(-9.55)	(-10.12)	(-9.76)	(-10.14)	(-9.76)
BM		-0.502		-0.503		-0.508
		(-1.61)		(-1.63)		(-1.64)
Carry	0.496	0.768	0.532	0.819	0.539	0.823
	(0.87)	(1.56)	(0.87)	(1.58)	(0.88)	(1.59)
Mom	0.021	0.020	0.018	0.018	0.019	0.018
	(0.85)	(0.84)	(0.70)	(0.70)	(0.71)	(0.71)
Value	-0.008***	-0.009***	-0.008**	-0.008***	-0.007**	-0.008***
	(-3.23)	(-3.55)	(-2.73)	(-2.99)	(-2.71)	(-2.98)
Inf-mom	-0.000	-0.000				
	(-0.24)	(-0.46)				
Econ-mom			0.006*	0.006*		
			(1.96)	(1.84)		
Trend combo					0.000	-0.000
					(0.22)	(-0.11)
Number of currencies	29	29	29	29	29	29
$Adj. R^2$	0.497	0.498	0.504	0.505	0.500	0.501

6. Conclusion

In this study, we extend the basis-momentum effect proposed by Boons and Prado (2019) to the currency market and examine its possibility of being a new currency risk factor. Based on the extensively used dataset of Menkhoff et al. (2012a), our findings justify the effectiveness of BM both statistically and economically, and that the BM-3 strategy is the optimal setup. Moreover, we innovatively decompose the BM signals into four components to explore the primary driver of the BM returns. This novel decomposition model aims to build a linkage between BM and the existing currency market risk factors, i.e. carry, momentum, spot rate momentum and basis-two components. We find that the carry and momentum factors are highly related to BM, whereas the remaining two components contribute relatively less in explaining the variation of BM returns. Our findings have implications for understanding the BM strategies in currency market for both academics and practitioners.

Our study also contributes to factor investing in currency market for practitioners, which suggests that the BM factor should be considered as an effective investment approach. First, the risk exposure of the BM factor is not fully captured by the existing carry and momentum factors. Second, the BM strategy benefit from a hedging effect as it contains a negative basis-two component, and hence exhibiting lower volatility and higher Sharpe ratio than the carry trade strategy. Future research can be focused on digging deeper into the basis-two strategy and its relationship with the more commonly used basis-one.

Appendix A. Currency portfolios sorted on BM

This section reports the results of sorting currencies into quartiles (**Table A1**) and tertiles (**Table A2**) on BM strategies. We report the average monthly return of winner, loser and WML portfolios for BM in the $J = \{1, 3, 6, 9, 12\}$ months formation period. We employ momentum and basis-one strategies as benchmarks.

The results in **Table A1** suggest that all the average WML returns of the BM strategies are economically and statistically significant, and so do both benchmarks: momentum and basis-one. The results are very similar to those of sorting currencies into quintiles as shown in **Table 2** in the main body of the paper. The BM strategy with three months formation period has the highest monthly return at 0.59% (t-statistic = 4.51) and Sharpe ratio of 1.05. By contrast, the best momentum and basis-one strategies are the ones with one month formation period. The results of sorting currencies into tertiles reported in **Table A2** suggest the consistent finding as in **Table A1**, where all the BM returns are significant. Therefore, our findings in the main body are robust to the way we construct winner and loser portfolios.

Table A1

Currency portfolios sorted on BM.

This table reports the average monthly return in percentage and Sharpe ratios of the winner, loser, and winner-minus-loser for BM strategies. J denotes the 1, 3, 6, 9 and 12 months formation periods, and t-statistics are reported in parentheses based on Newey-West standard errors. We use momentum and basis-one as benchmarks. We sort currencies into quartiles and form equally weighted portfolios in each quartile. The sample period is November 1983 to December 2020.

		BM			Momentum	Basis-one
f		Winner	Loser	WML	WML	WML
1	Avg.ret.	0.43	-0.07	0.48	0.59	0.69
	(t)	(3.32)	(-0.36)	(4.57)	(4.67)	(4.14)
	Sharpe	0.67	-0.11	0.87	0.82	1.03
3	Avg.ret.	0.48	-0.13	0.59	0.55	0.64
	(t)	(3.33)	(-0.92)	(4.51)	(3.78)	(3.65)
	Sharpe	0.72	-0.19	1.05	0.76	0.91
6	Avg.ret.	0.45	-0.10	0.54	0.55	0.60
	(t)	(2.94)	(-0.64)	(4.19)	(3.79)	(3.43)
	Sharpe	0.64	-0.16	0.99	0.75	0.86
9	Avg.ret.	0.47	-0.07	0.52	0.55	0.57
	(t)	(3.08)	(-0.45)	(3.67)	(3.65)	(3.33)
	Sharpe	0.66	-0.11	0.94	0.71	0.80
12	Avg.ret.	0.42	-0.10	0.51	0.39	0.58
	(t)	(2.78)	(-0.80)	(3.29)	(2.73)	(3.46)
	Sharpe	0.59	-0.16	0.89	0.53	0.85

Table A2

Currency portfolios sorted on BM.

This table reports the average monthly return in percentage and Sharpe ratios of the winner, loser, and winner-minus-loser for BM strategies. J denotes the 1, 3, 6, 9,12 months formation periods, and t-statistics are reported in parentheses based on Newey -West standard errors. We use momentum and basis-one as benchmarks. We sort currencies into tertiles and form equally weighted portfolios in each tertile. The sample period is November 1983 to December 2020.

		BM			Momentum	Basis-one
f		Winner	Loser	WML	WML	W WML
1	Avg.ret.	0.38	-0.08	0.44	0.50	0.55
	(t)	(3.13)	(-0.38)	(5.17)	(4.34)	(4.04)
	Sharpe	0.61	-0.12	1.00	0.79	0.97
3	Avg.ret.	0.38	-0.07	0.44	0.46	0.51
	(t)	(3.00)	(-0.58)	(4.20)	(3.95)	(3.64)
	Sharpe	0.61	-0.11	0.96	0.73	0.89
6	Avg.ret.	0.39	-0.03	0.42	0.39	0.48
	(t)	(2.87)	(-0.19)	(4.06)	(3.37)	(3.40)
	Sharpe	0.60	-0.06	0.95	0.61	0.85
9	Avg.ret.	0.38	-0.07	0.44	0.40	0.46
	(t)	(2.71)	(-0.52)	(3.70)	(3.11)	(3.40)
	Sharpe	0.58	-0.11	0.95	0.60	0.81
12	Avg.ret.	0.38	-0.08	0.45	0.31	0.45
	(t)	(2.65)	(-0.65)	(3.38)	(2.56)	(3.40)
	Sharpe	0.57	-0.13	0.93	0.49	0.81

Appendix B. Decomposition of BM

According to Boons and Prado (2019), we define BM in currency markets as formula (B1), as follows:

$$BM_t = \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) - \sum_{s=t-J+1}^{t} (f_{s-1}^2 - f_s^1) \qquad (B1)$$

We intend to decompose the BM into serval components of various existing currency market factors including carry, momentum and spot rate momentum. The first term in Equation B1, $\sum_{s=t-J+1}^{t}(f_{s-1}^1 - s_s)$, refers to the currency momentum of Menkhoff et al. (2012b), but excludes the farthest month of the formation period. Next, to achieve the carry component, we start from the second term of Equation B1, $\sum_{s=t-J+1}^{t}(f_{s-1}^2 - f_s^1)$, as follow:

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) - \sum_{s=t-J+1}^{t} (f_{s-1}^2 - f_s^1 + s_s - s_s)$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) - \sum_{s=t-J+1}^{t} (f_{s-1}^2 - s_s) + \sum_{s=t-J+1}^{t} (f_s^1 - s_s)$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) - \sum_{s=t-J+1}^{t} (f_{s-1}^2 - s_s) + (f_s^1 - s_s) + \sum_{s=t-J+1}^{t-1} (f_s^1 - s_s)$$

Here, $f_s^1 - s_s$ represents the currency carry. We keep the carry and momentum terms and further decompose the remaining terms to explore the spot rate momentum, as follows:

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) + (f_s^1 - s_s) + \sum_{s=t-J+1}^{t-1} (f_s^1 - s_s) - [\sum_{s=t-J+1}^{t-1} (f_{s-1}^2 - s_s) + f_{s-1}^2 - s_s]$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) + (f_s^1 - s_s) + \sum_{s=t-J+1}^{t-1} (f_s^1 - s_s) - [\sum_{s=t-J+1}^{t-1} (f_{s-1}^2 - f_s^1)$$

$$+ \sum_{s=t-J+1}^{t-1} (f_s^1 - s_s) + f_{s-1}^2 - s_s]$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) + (f_s^1 - s_s) - [\sum_{s=t-J+1}^{t-1} (f_s^2 - f_s^1) + f_{s-J}^2 - f_{s-J}^1 + f_{s-J}^1 - s_s]$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) + (f_s^1 - s_s) - [\sum_{s=t-J}^{t-1} (f_s^2 - f_s^1) + f_{s-J}^1 - s_{s-J+1}$$

$$+ s_{s-j+1} - s_s]$$

$$= \sum_{s=t-J+1}^{t} (f_{s-1}^1 - s_s) + (f_s^1 - s_s) + (s_s - s_{s-J+1}) - [\sum_{s=t-J}^{t-1} (f_s^2 - f_s^1) + f_{s-J}^1$$

$$- s_{s-J+1}]$$

$$= \sum_{s=t-J+2}^{t} (f_{s-1}^1 - s_s) + (f_s^1 - s_s) + (s_s - s_{s-J+1}) - \sum_{s=t-J}^{t-1} (f_s^2 - f_s^1)$$

where $s_s - s_{s-J+1}$ represents the spot rate momentum, which also excludes the farthest month and has the same formation period as the momentum component, $\sum_{s=t-J+1}^{t}(f_{s-1}^1 - s_s)$. Consequently, we successfully extract the momentum, spot rate change, and carry from the decomposition model of the BM factor. The remaining terms, $\sum_{s=t-J}^{t-1}(f_s^2 - f_s^1)$ refers to the information specific to the BM.

Appendix C. Spanning tests

This section reports the spanning tests of sorting currencies into quartiles (Table C1) and tertiles (Table C2). The alphas of BM are statistics significantly at the 10% level in 1, 3, 6 and 9 months formation periods when sorting currencies into quartiles, and are all statistically significant across all five formation periods for tertile portfolios. Such results confirm our conclusion in the main context that BM return cannot be explained by existing prevalent factors, momentum and carry, and the BM is a novel factor in currency market.

Table C1

Spanning tests of BM, momentum and carry.

This table shows the results of spanning tests for the BM, momentum and carry. The rows report coefficient, t-statistics (in parentheses), and adjusted R^2, and columns present J = 1, 3, 6, 9, 12 months formation periods. Panel A reports BM as the dependent variable; Panel B reports momentum as the dependent variable; Panel C reports carry as the dependent variable. The sample period is November 1983 to December 2020, and we use monthly frequency data.

f	1	3	6	9	12
Panel A: BM as Dependent Variable					
α (%)	0.23	0.33	0.22	0.15	0.13
	(2.45)	(3.53)	(2.62)	(1.85)	(1.59)
Momentum	0.16	0.19	0.11	0.06	0.08
	(4.66)	(5.60)	(3.70)	(2.23)	(2.63)
Carry	0.23	0.25	0.38	0.47	0.50
	(6.26)	(6.79)	(11.30)	(14.48)	(14.85)
$Adj.R^2$ (%)	12.10	15.94	26.71	34.75	37.57
Panel B: Momentum as Dependent Variable					
α (%)	0.52	0.33	0.37	0.44	0.23
	(4.08)	(2.55)	(2.88)	(3.21)	(1.77)

BM	0.31	0.37	0.28	0.19	0.21
	(4.66)	(5.60)	(3.70)	(2.23)	(2.63)
Carry	-0.09	-0.05	0.01	0.00	0.08
	(-1.72)	(-0.88)	(0.21)	(-0.05)	(1.14)
$Adj.R^2$ (%)	4.53	6.77	4.01	1.29	3.94
Panel C: Carry as Dependent Variable					
α (%)	0.55	0.46	0.33	0.33	0.32
	(4.70)	(3.95)	(3.10)	(3.43)	(3.37)
BM	0.37	0.39	0.63	0.71	0.70
	(6.26)	(6.79)	(11.30)	(14.48)	(14.85)
Momentum	-0.08	-0.04	0.01	0.00	0.04
	(-1.72)	(-0.88)	(0.21)	(-0.05)	(1.14)
$Adj.R^2$ (%)	8.18	9.75	24.27	33.96	36.70

Table C2

Spanning tests of BM, momentum and carry.

This table shows the results of spanning tests for the BM, momentum and carry. The rows report coefficient, t-statistics (in parentheses), and adjusted R^2, and columns present J = 1, 3, 6, 9, 12 months formation periods. Panel A reports BM as the dependent variable; Panel B reports momentum as the dependent variable; Panel C reports carry as the dependent variable. The sample period is November 1983 to December 2020, and we use monthly frequency data.

f	1	3	6	9	12
Panel A: BM as Dependent Variable					
α (%)	0.24	0.22	0.18	0.15	0.14
	(3.13)	(3.02)	(2.80)	(2.23)	(2.16)
Momentum	0.11	0.18	0.07	0.06	0.08
	(3.33)	(5.62)	(2.44)	(2.15)	(2.67)

Carry	0.26	0.28	0.40	0.49	0.51
	(7.14)	(7.80)	(12.24)	(15.18)	(15.05)
$Adj. R^2$ (%)	12.54	19.05	28.69	37.38	38.54
Panel B: Momentum as Dependent Variable					
α (%)	0.43	0.27	0.26	0.28	0.16
	(3.77)	(2.50)	(2.33)	(2.37)	(1.46)
BM	0.24	0.39	0.20	0.19	0.21
	(3.33)	(5.62)	(2.44)	(2.15)	(2.67)
Carry	-0.06	-0.03	0.09	0.05	0.10
	(-1.08)	(-0.46)	(1.33)	(0.75)	(1.44)
$Adj. R^2$ (%)	2.12	7.22	3.16	2.22	4.75
Panel C: Carry as Dependent Variable					
α (%)	0.38	0.33	0.22	0.22	0.21
	(3.99)	(3.59)	(2.62)	(2.75)	(2.73)
BM	0.41	0.45	0.67	0.73	0.71
	(7.14)	(7.80)	(12.24)	(15.18)	(15.05)
Momentum	-0.04	-0.02	0.05	0.03	0.05
	(-1.08)	(-0.46)	(1.33)	(0.75)	(1.44)
$Adj. R^2$ (%)	10.47	12.94	27.97	36.76	37.78

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