Characteristic-based factors and exposure to macroeconomic risks

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Abstract

This paper investigates the ability of characteristic-based factor models to capture and account for macroeconomic risk. We study how benchmark factor models (e.g., Fama and French, 2015; Carhart, 1997; Hou et al., 2021) relate to a factor model based on macroeconomic fundamentals. In particular, in the macroeconomic model, we consider five factors: changes in growth expectation, unexpected inflation, changes in the aggregate survival probability, changes in the average level and the slope of the term structure, and changes in the currency exchange rate. The findings in this paper could potentially explain the reasons behind the varying performance of characteristic-based factor models over time, specifically in the context of regime changes.

Keywords: Asset pricing; Fama and French model; Macroeconomic factors; Momentum; q-factor model; and Regime switching

1 Introduction

In recent years, researchers have proposed new factor models (e.g., Fama and French, 2018, 2015; Hou et al., 2021). However, the performance of characteristic-based factors has shown significant variation over time. Following the financial crises of 2007-2009, the returns of the factors from the Fama and French (FF) model have remained stagnant, despite the increasing equity market returns (see Figure 1). This puzzling phenomenon has motivated some papers to understand the underlying causes. For instance, Herskovic et al. (2023) attribute the divergent performance between the equity market premium and the size and value premium to fluctuations in micro and macro uncertainty. In our study, we take a different approach. Previous research has explored the relationship between the FF factors and the risk derived from macroeconomic fundamentals (e.g., Aretz et al., 2010; Hahn and Lee, 2006; Petkova, 2006; Vassalou and Xing, 2004; Vassalou, 2003; Liew and Vassalou, 2000). By examining this relationship and analyzing its changes over time, we aim to shed light on the time-varying performance of the FF model. Specifically, our objective is to ascertain whether the observed change in performance is derived from a regime shift, indicating an altered relationship between characteristic factors and macroeconomic risks.

Our study focuses on examining the benchmark FF model from the perspective of a macroeconomic factor model. To accomplish this, we use the comprehensive macroeconomic factor (MF) model proposed by Aretz et al. (2010). First, I investigate the univariate correlations between the factors derived from both models. Furthermore, we explore how characteristics relate to macroeconomic risk by estimating the exposure of one-way sorted portfolios, based on characteristics, to each of the macroeconomic factors.

By exploring the relationship in different subsamples, we can identify and document any changes in the relationship between the FF model and the macroeconomic factor model. We seek to understand whether the varying performance of the characteristic factors can be attributed to a regime shift that occurred after the financial crisis.

The rest of the paper is organized as follows. In Section 2, we review the literature. In Section 3, we explain the empirical methodology and describe the data. In Section 4, we show and comment on the results. In Section 5, we outline the plan for future drafts.

2 Prior literature

Working in progress...

3 Research Design

This section is divided into two subsection. In Subsection 3.1, we describe the methodology used to study the relationship between benchmark factor model and risk captured by macroeconomic risk. In Subsection 3.2, we describe the source of the data.

3.1 Methodology

We consider the Fama and French five-factor model (Fama and French, 2015) along with the momentum factor (Carhart, 1997) as the benchmark firm-characteristic model. The time-series regression of the FF six-factor model can be defined as follows:

$$R^i_{t-1,t} = \beta^i_0 + \beta^i_1 RM_{t-1,t} + \beta^i_2 SMB_{t-1,t} + \beta^i_3 HML_{t-1,t} + \beta^i_4 RMW_{t-1,t} + \beta^i_5 CMA_{t-1,t} + \beta^i_6 MOM_{t-1,t} + \varepsilon^i_{t-1,t} \tag{1}$$

The term $R^i_{t-1,t}$ represents the excess return for portfolio i. $RM_{t-1,t}$ indicates the excess return on a value-weighted stock market index. $SMB_{t-1,t}$ represents the return of a portfolio that takes a long position in small market capitalization stocks and a short position in big market capitalization stocks. $HML_{t-1,t}$ indicates the return of a portfolio that takes a long position in high book-to-market (BM) ratio stocks and a short position in low BM ratio stocks. $RMW_{t-1,t}$ represents the return of a portfolio that takes a long position in stocks with robust operating profitability and a short position in stocks with weak operating profitability. $CMA_{t-1,t}$ indicates the return of a portfolio that takes a long position in conservative investment stocks and a short position in aggressive investment stocks. Lastly, $WML_{t-1,t}$ represents the return of a portfolio that takes a long position in winner stocks and a short position in loser stocks. Except for $R^i_{t-1,t}$, which represents the excess return for a specific portfolio, the remaining factors ($RM_{t-1,t}$, $SMB_{t-1,t}$, $HML_{t-1,t}$, $RMW_{t-1,t}$, $CMA_{t-1,t}$, $WML_{t-1,t}$) are firm-level characteristics that are used to explain the excess returns.

To examine the relationship between the firm characteristic factors and macroeconomic risks, we investigate how they align with a factor model comprised of macroeconomic fundamentals. In this context, we refer to the comprehensive model proposed by Aretz et al. (2010). This macroeconomic factor model encompasses six factors: (i) changes in one-year ahead industrial production growth expectations, (ii) unexpected inflation, (iii) changes in the aggregate survival probability, (iv) changes in the average level of the term structure, (v) changes in the slope of the term structure, and (vi) changes in a multilateral US dollar exchange rate. The time-series regression of the MF model can be defined as follows:

$$R^i_{t-1,t} = \beta^i_0 + \beta^i_1 MYP_{t,t+12} + \beta^i_2 UI_{t-1,t} + \beta^i_3 DSV_{t-1,t} + \beta^i_4 ATS_{t-1,t} + \beta^i_5 STS_{t-1,t} + \beta^i_6 FX_{t-1,t} + \varepsilon^i_{t-1,t} \tag{2}$$

To compute the change in one-year ahead of industrial production growth expectation ($MYP_{t,t+12}$), we employ the mimicking portfolio approach, similar to Vassalou (2003) and Aretz et al. (2010). Firstly, we regress the logarithmic change in industrial production over the next year on a set of base asset excess returns and lagged control variables. At time t, the variable $MYP_{t,t+12}$ is calculated as the fitted value of the base asset. In constructing the mimicking portfolio, we are careful not to include factors from the benchmark model to avoid introducing mechanical correlations between the two models. To compute the unexpected inflation ($UI_{t-1,t}$), we adopt the approach outlined by Fama and Gibbons (1984). We first compute the inflation as the logarithmic change in the natural logarithm of the Consumer Price Index. Then, we estimate changes in inflation as a first-order moving average. Unexpected inflation is determined by taking the difference between the actual change in inflation and the estimated change. The aggregate survival probability ($DSV_{t-1,t}$) is computed using Merton's (1974) option pricing model, as described in Vassalou and Xing (2004). The change in the average level of the term structure ($ATS_{t-1,t}$) is obtained by computing the change in the mean of the 3-month Treasury bill yield and the 10-year Treasury bond yield. The change in the term structure slope ($STS_{t-1,t}$) is derived from the change in the difference between the 10-year Treasury bond yield and the 3-month Treasury bill yield. The change in a multilateral US dollar exchange rate ($FX_{t-1,t}$) is determined using the change in a US composite exchange rate index.

To analyze the relationship between these characteristics and exposure to macroeconomic risks, we begin with univariate analysis. We compute the correlations between the factors from the (FF) and MF models. Next, we use the one-way sorted deciles characteristic portfolios from the benchmark models. For each portfolio, we estimate the risk exposure to the macroeconomic factors. Significant estimates indicate a relationship between the characteristic-based factor and the macroeconomic fundamental factors. Differences in risk exposure across portfolios provide insight into how the characteristic-based factor relates to macroeconomic fundamentals. We then conduct regressions of each characteristic factor on the macroeconomic factors. A significant coefficient suggests that the macroeconomic factor and characteristic factor capture common information.

We correct the standard errors of the analysis induced by the generated macroeconomic factor (MYP). Specifically, we stack the moment condition of the first-stage mimicking portfolio regression onto those of the time-series asset pricing model and we estimate the parameters through the Generalized Method of Moments (GMM), following the methodology detailed in Vassalou (2003).

To examine regime changes, we repeat the analysis for three subsamples: the full sample period (1975-2021), the sample period before November 2007, and the sample period after December 2007.

3.2 Data description

Regarding the FF model, the portfolios and the factors data, as well as the risk-free rate, are sourced from Kenneth French's website. The dividend yield on the S&P 500 index was obtained from Robert Shiller's website. Maria Vassalou's website has data regarding the changes in the survival probability have public data only until 1999. I extended the data to the period from 2000 to 2008 [1]. The yield data for 3-month US government Treasury bills, 10-year Treasury bonds, Aaa/Baa-rated corporate bond portfolios, and the exchange rate between the US dollar and a broad trade-weighted composite currency index are sourced from the Federal Reserve Bank's website. Return data on US bond return data are from the CRSP US treasury Database. Gold return data are from Goldhub website. Seasonally-adjusted level of the US industrial production index and the consumer price index from DataStream. All the variables we used are based on a monthly frequency and cover the sample period from January 1975 to December 2021.

4 Preliminary Results

Table 1 shows the results of the OLS regression used to find the base asset weights of the mimicking portfolio for MYP. We run the regression for three sample periods. The adjusted R squared is high for the subsamples, but it decreases when we consider the full sample. This indicates that the coefficients have varied throughout the sample.

[1] The Pearsons' correlation between the monthly DSV series obtained from Maria Vassalou's website and ours is 0.645

Table 2 shows the summary statistics of the macroeconomic factors. In the second subsample (December 2007 - December 2021), we have a higher standard deviation for MYP and UI with a higher mean. Instead, the standard deviation for DSV, ATS, STS, and FX is smaller compared to the first subsample (January 1975 - November 2007) in Panel B.

Table 3 shows the correlations between the factors from the FF and the MF model.

Figure 2 shows which macroeconomic factors have an impact on the one-way sorted characteristic portfolios. In line with the findings in Aretz et al. (2010), in the first part of the sample (January 1975 - November 2007), MYP, DSV, and STS are significant for the portfolios sorted on BM, Size, and Momentum. A similar conclusion can be derived from the portfolio sorted on Profitability and Investment. In the second part of the sample (December 2007 - December 2021), we see a significant change in the macroeconomic exposure of the portfolios. The change in expectation MYP remains significant, but there is no clear pattern on how it correlates with the characteristics since the estimated betas are similar across the portfolios. DSV and STS still show a clear pattern across the portfolios but are only significant for a portion of them. The factors UI and ATS seem to have a more important role compared to the past.

Table 4 reports the estimation outcome of characteristic factors on the macroeconomic fundamentals. The results seem to be more or less in line with the results from the one-way sorted portfolios. In the first subsample (Panel B), MYP is significant in explaining RM, the BM factor, the Profitability factor, and the Investment factor. DSV has a significant loading on RM and Size factor. ATS significantly correlates with the Size factor. STS is significant in explaining all the FF factors except for Profitability. FX has a significant influence on the BM factor. In the second subsample (Panel C), MYP is only significant in explaining the RM and the Size factor. UI can explain the BM and Investment factors. DSV is significant in explaining BM, Size, Profitability, and Momentum. ATS can still significantly explain Size, but it also has a significant loading on Profitability and Momentum. Unlike the first subsample, STS has a significant loading on Size, Profitability, and Momentum. Finally, FX loads positively on RM.

5 Future Plan

An additional characteristic-based model worth exploring is the q-theory factor model (Hou et al., 2015, 2021). We could investigate how each factor - profitability, investment, and expected investment growth - relates to macroeconomic factors. This would be a valuable contribution, as the q-theory model is more theory-based.

As a robustness test, we could use an alternative measure of the macroeconomic fundamental factors. As a proxy of growth expectation, we could use survey data (eg. revisions of Greenbook forecasts or Survey of Professional Forecasters, see Duffee, 2023). As an alternative to unexpected inflation, we could compute unexpected inflation as the difference between the actual inflation and the forecasts of inflation from the Livingston surveys. An alternative to the aggregate survival probability is the default spread, which is defined as the spread between yield to maturity on a Baa corporate bond index and 10-year Treasury constant maturity rate.

Moreover, an important step would be the estimation of the risk premia associated with the MF model. By assessing variations in the risk premia across various subsamples, we can provide evidence supporting the existence of regime changes.

References

Aretz, K., S. M. Bartram, and P. F. Pope (2010). Macroeconomic risks and characteristic-based factor models. *Journal of Banking & Finance 34*(6), 1383–1399.

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal of finance 52*(1), 57–82.

Duffee, G. R. (2023). Macroeconomic news in asset pricing and reality. *The Journal of Finance 78*(3), 1499–1543.

Fama, E. F. and K. R. French (2015). A five-factor asset pricing model. *Journal of financial economics 116*(1), 1–22.

Fama, E. F. and K. R. French (2018). Choosing factors. *Journal of financial economics 128*(2), 234–252.

Fama, E. F. and M. R. Gibbons (1984). A comparison of inflation forecasts. *Journal of monetary Economics 13*(3), 327–348.

Hahn, J. and H. Lee (2006). Yield spreads as alternative risk factors for size and book-to-market. *Journal of Financial and Quantitative Analysis 41*(2), 245–269.

Herskovic, B., T. Kind, and H. Kung (2023). Micro uncertainty and asset prices. *Journal of Financial Economics 149*(1), 27–51.

Hou, K., H. Mo, C. Xue, and L. Zhang (2021). An augmented q-factor model with expected growth. *Review of Finance 25*(1), 1–41.

Hou, K., C. Xue, and L. Zhang (2015). Digesting anomalies: An investment approach. *The Review of Financial Studies 28*(3), 650–705.

Liew, J. and M. Vassalou (2000). Can book-to-market, size and momentum be risk factors that predict economic growth? *Journal of Financial Economics 57*(2), 221–245.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. *The Journal of finance 29*(2), 449–470.

Petkova, R. (2006). Do the fama–french factors proxy for innovations in predictive variables? *The Journal of Finance 61*(2), 581–612.

Vassalou, M. (2003). News related to future gdp growth as a risk factor in equity returns. *Journal of financial economics 68*(1), 47–73.

Vassalou, M. and Y. Xing (2004). Default risk in equity returns. *The journal of finance 59*(2), 831–868.

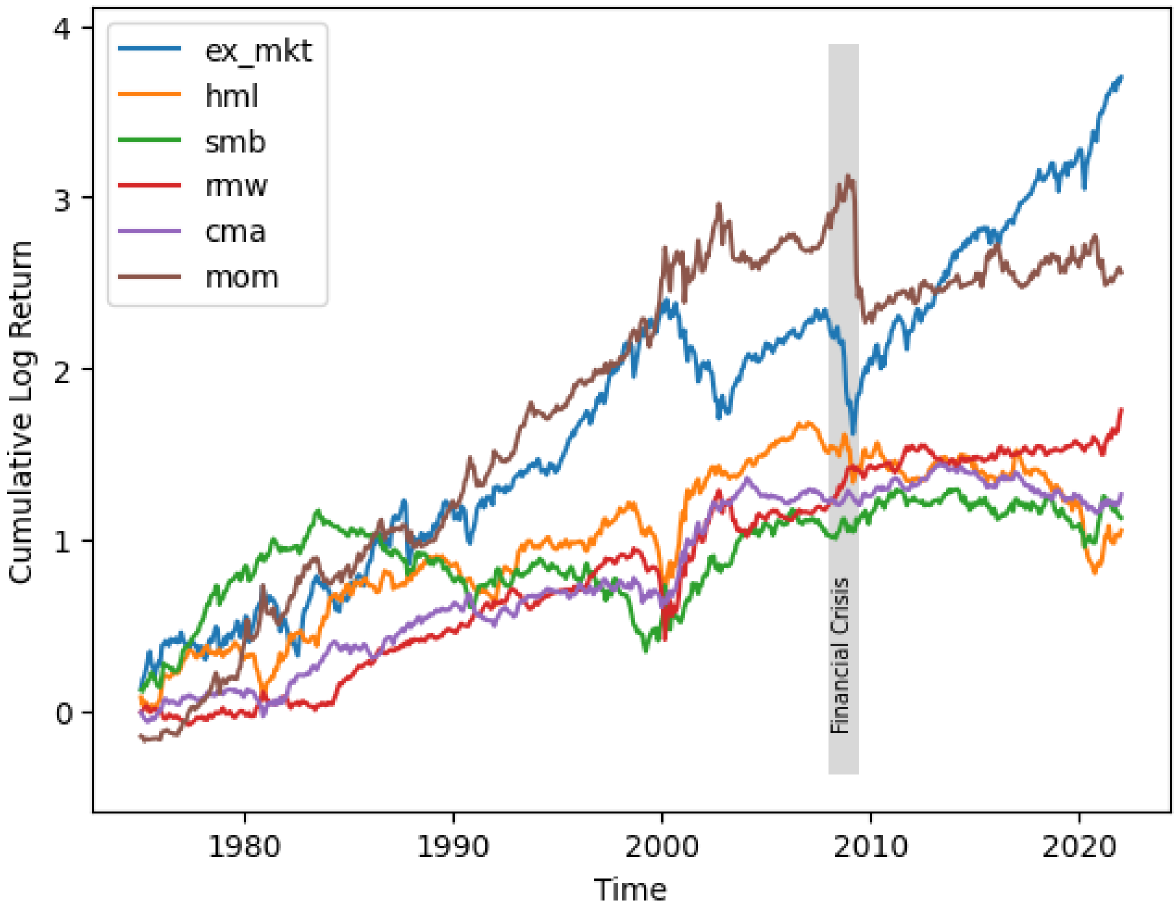


Figure 1: This figure shows the cumulative log return of the five factors in the FF five-factor model along with the momentum factor.

Figure 2: Panel A: January 1975 - December 2021 (full sample)

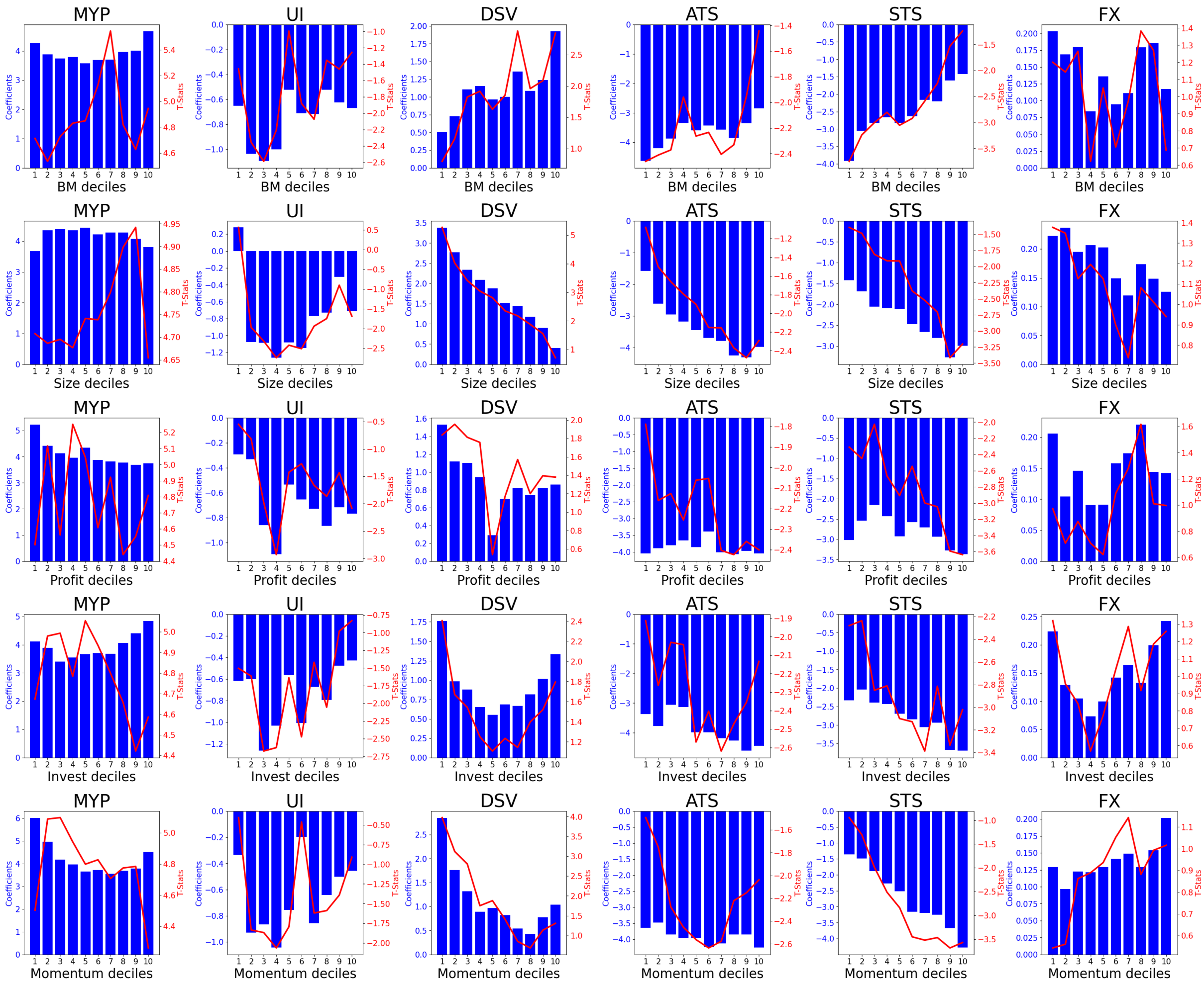


Figure 2: Panel B: January 1975 - November 2007 (first subsample)

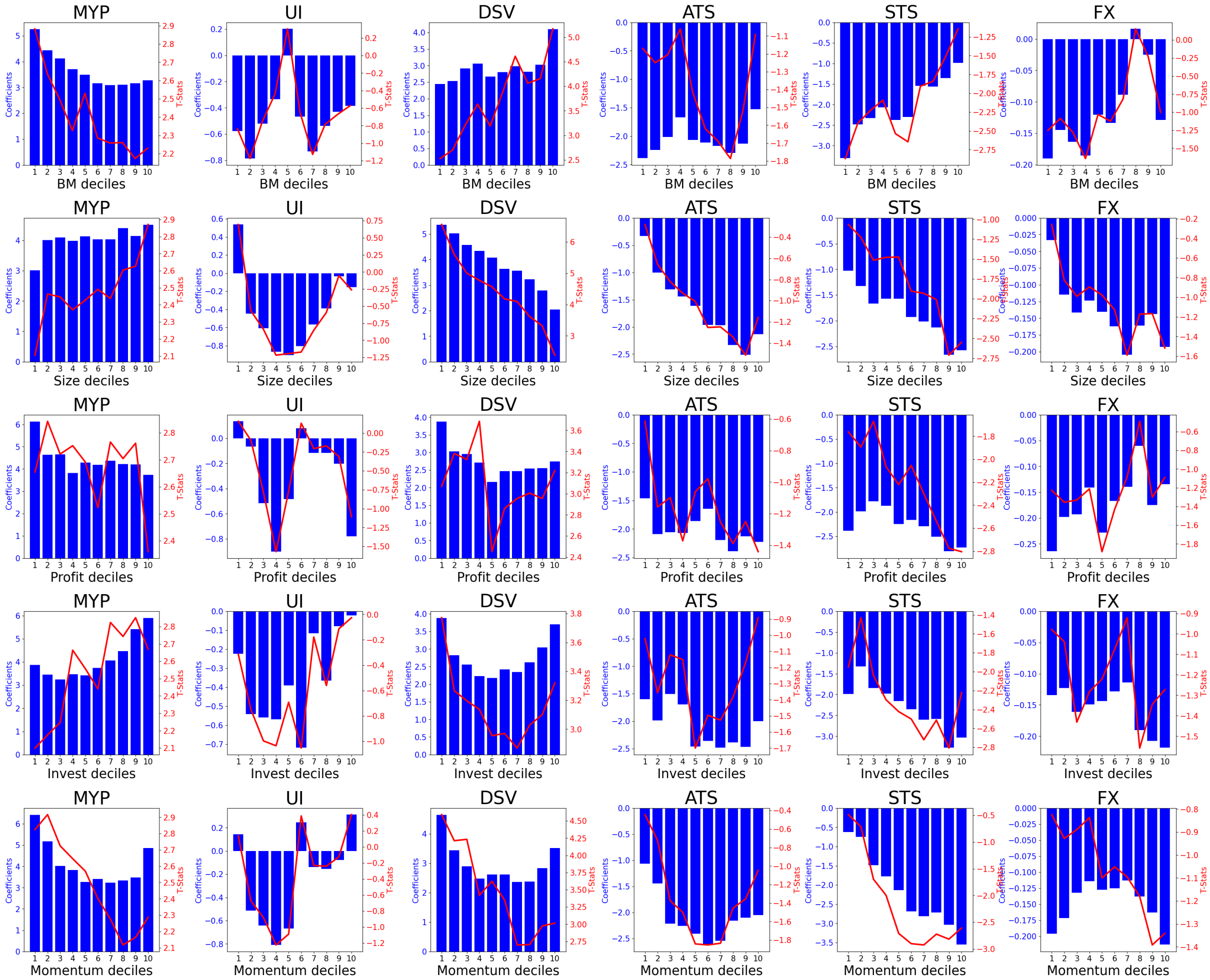
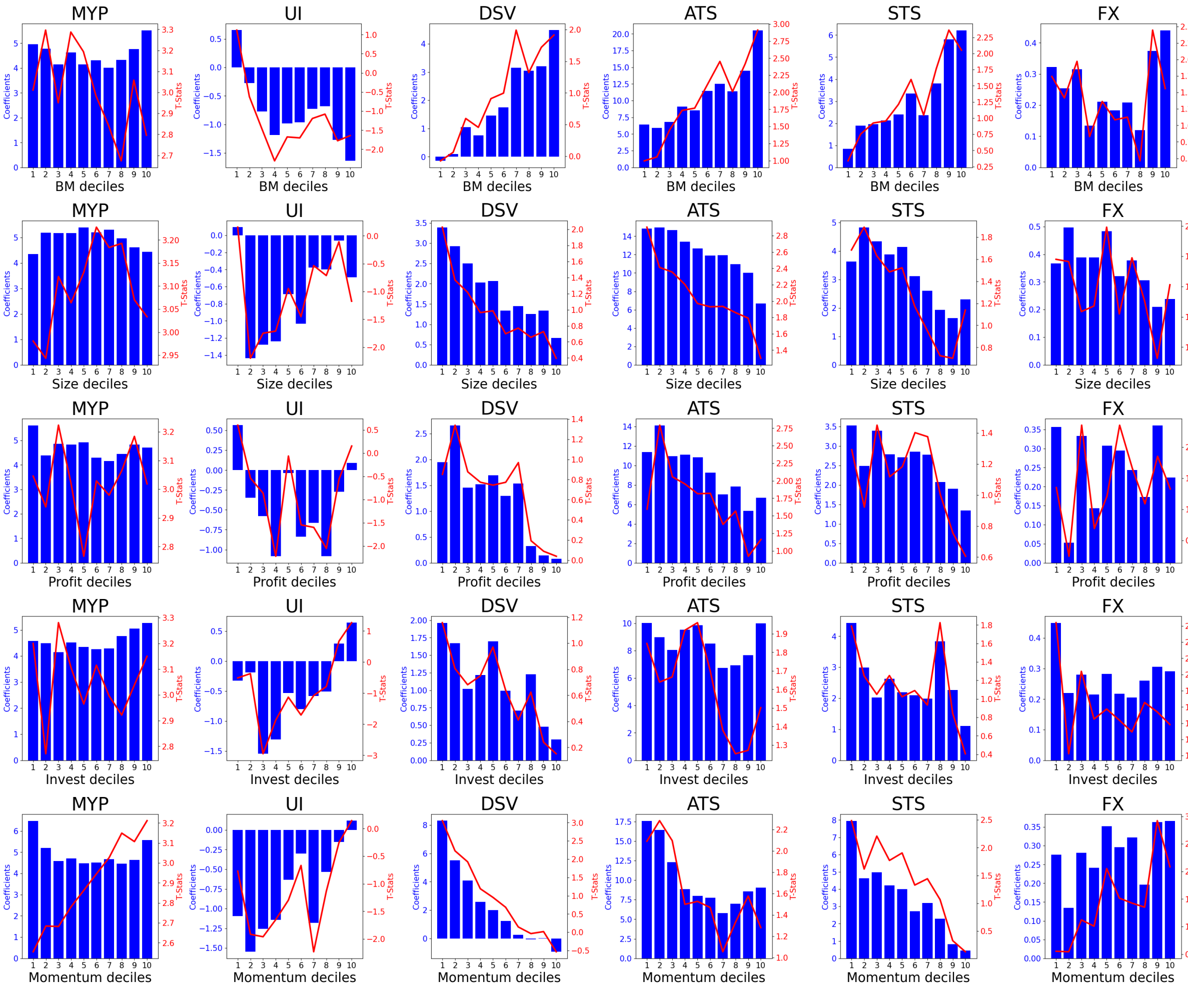


Figure 2: Panel C: December 2007 - December 2021 (second subsample)



This figure shows the macroeconomic risk exposure estimates of the one-way sorted firm characteristic deciles on the macroeconomic fundamentals and their statistics. The macroeconomic fundamentals are changes in industrial production growth expectations (MYP), unexpected inflation (UI), changes in the aggregate survival probability (DSV), changes in the average level and the slope of the term structure of risk-free interest rate yields (ATS and STS, respectively), and changes in the exchange rate between the US dollar and a trade-weighted composite currency (FX). The blue bars are the estimated risk exposures, while the red lines are the t-statistics. The first row shows the outcomes related to the one-way sorted book-to-market deciles, the second those related to the one-way sorted size deciles, the third those related to the one-way sorted momentum deciles, the fourth those related to the one-way sorted operating profitability deciles, the fifth those related to one-way sorted investment deciles, and the sixth those related to one-way sorted accruals deciles. The figures use monthly data (Panel A) from January 1975 to December 2021, (Panel B) from January 1975 to April 2008, and (Panel C) from May 2008 to December 2021.

Table 1: Estimation of the mimicking portfolio for industrial production growth

	jan1975-dec2021	jan1975-nov2007	dec2007-dec2021
Market portfolio ex. return ($RM_{t-1,t}$)	0.176***	0.064	0.180***
	(3.958)	(1.398)	(3.006)
10-year gov. bond ex. return$_{t-1,t}$	-0.336**	-0.264**	0.050
	(-2.360)	(-2.265)	(0.189)
5-year gov. bond ex. return$_{t-1,t}$	0.253	0.321*	0.080
	(1.145)	(1.688)	(0.157)
Gold ex. returns$_{t-1,t}$	0.015	-0.048**	0.058
	(0.518)	(-1.980)	(1.432)
Slope dummy mkt ex. return (87)	-0.128***	-0.095**	
	(-2.870)	(-2.022)	
Slope dummy mkt ex. return (96-02)	-0.012	0.085	
	(-0.168)	(1.311)	
Slope dummy mkt ex. return (07-09)	0.278**		-0.000
	(2.249)		(-0.003)
Intercept	-0.010	0.031**	-0.077
	(-0.666)	(2.338)	(-0.876)
Risk-free rate of return	0.562	-12.887***	-54.985***
	(0.223)	(-5.094)	(-4.654)
10-year minus 3-month gov. bond yield$_{t-1}$	1.062**	-0.386	-1.641*
	(2.335)	(-0.903)	(-1.660)
1-year minus 3-month gov. bond yield$_{t-1}$	1.416*	1.295**	6.476
	(1.676)	(1.987)	(1.487)
Baa minus Aaa corporate bond yield$_{t-1}$	-0.874	1.068	1.106
	(-0.834)	(1.054)	(0.624)
Dividend yield$_{t-1}$	0.591	1.855***	4.500
	(0.808)	(3.504)	(1.127)
Industrial production growth$_{t-13,t-1}$	0.154*	0.079	0.181
	(1.772)	(0.959)	(1.444)
Inflation$_{t-13,t-1}$	-0.297	-0.429**	-0.102
	(-1.138)	(-2.079)	(-0.173)
Market portfolio ex. return ($RM_{t-13,t-1}$)	0.085***	0.095***	0.186**
	(3.760)	(5.659)	(2.342)
1-month lagged base asset returns	Yes	Yes	Yes
Obs	564	395	169
Adj. R^2	0.279	0.475	0.591
F-stat	5.314	10.161	24.507

This table shows the outcomes from OLS estimations of the log change in industrial production over the next year onto a set of base asset excess returns and lagged control variable realizations. The base assets consist of the market portfolio, 10-year treasury bond return, 5-year treasury bond return, and gold. To allow for time-variation in the market portfolio weight, the regression includes two market portfolio slope dummies for the period from April 1987 to April 1988 (the one year surrounding the October 1987 stock market crash), the period from January 1996 to December 2002 (the Internet bubble period), and the period from December 2007 to May 2009 (the Financial crises). All base asset returns are in excess of the risk-free rate of return, and thus weights do not need to sum up to unity. The regressions control for the expected level of returns by including a set of lagged control variables, containing the risk-free rate, the yield spread between long-term and short-term government bonds, the yield spread between one-year and short-term government bonds, the yield spread between Baa-rated and Aaa-rated corporate bonds and the dividend yield on the S&P 500. Controls include industrial production growth, inflation, and excess market returns over the last year. Since realized industrial production growth has an overlap with its lagged value of eleven months, the variances have the Newey and West (1987) correction with $l = 11$. The table presents the result for three sample periods: i) from January 1975 to December 2021, ii) from January 1975 to November 2007, and iii) from December 2007 to December 2021.

Table 2: Summary statistics

Panel A: January 1975 - December 2021 (full sample)								
	N	Mean ($\times 10^3$)	Median ($\times 10^3$)	Std. dev. ($\times 10^3$)	Skew	Kurt	Min. ($\times 10^3$)	Max. ($\times 10^3$)
MYP	564	0.869	1.391	9.991	-1.185	8.385	53.421	-68.452
UI	564	-0.037	-0.109	3.166	-0.765	4.101	9.222	-21.147
DSV	564	0.274	0.300	6.267	0.490	13.293	52.100	-35.000
ATS	564	-0.114	-0.025	3.499	-1.160	14.170	18.000	-28.650
STS	564	0.020	-0.300	3.832	0.797	5.731	21.300	-15.100
FX	564	-0.196	0.437	18.352	0.108	2.155	92.430	-65.885

Panel B: January 1975 - November 2007 (first subsample)								
	N	Mean ($\times 10^3$)	Median ($\times 10^3$)	Std. dev. ($\times 10^3$)	Skew	Kurt	Min. ($\times 10^3$)	Max. ($\times 10^3$)
MYP	395	0.528	0.349	5.207	-0.371	2.144	16.894	-21.966
UI	395	-0.105	-0.143	2.822	-0.270	1.295	9.222	-11.771
DSV	395	0.353	0.323	6.764	0.597	13.195	52.100	-35.000
ATS	395	-0.094	-0.100	4.038	-1.039	10.779	18.000	-28.650
STS	395	0.014	-0.300	4.263	0.786	4.913	21.300	-15.100
FX	395	-0.735	-0.290	19.069	-0.054	1.322	72.889	-65.885

Panel C: December 2007 - December 2021 (second subsample)								
	N	Mean ($\times 10^3$)	Median ($\times 10^3$)	Std. dev. ($\times 10^3$)	Skew	Kurt	Min. ($\times 10^3$)	Max. ($\times 10^3$)
MYP	169	2.378	1.822	8.847	-0.632	3.390	28.310	-41.739
UI	169	0.119	-0.031	3.857	-1.238	5.260	8.008	-21.147
DSV	169	0.090	0.072	4.929	-0.341	5.476	19.396	-22.189
ATS	169	-0.162	0.050	1.672	-1.808	7.631	3.750	-8.700
STS	169	0.034	-0.100	2.569	0.486	1.837	10.000	-7.800
FX	169	1.063	1.013	16.540	0.770	5.178	92.430	-47.970

This table provides summary statistics on the analysis variables. The sample periods extend (Panel A) from January 1975 to December 2021, (Panel B) from January 1975 to November 2007, and (Panel C) from December 2007 to December 2021.

Table 3: Correlations

Panel A: January 1975 - December 2021 (full sample)

	RM	HML	SMB	RMW	CMA	MOM	MYP	UI	DSV	ATS	STS	FX
RM	1.00	-0.19	0.26	-0.24	-0.36	-0.15	0.83	-0.04	0.55	-0.06	-0.01	-0.17
HML	-0.19	1.00	-0.01	0.19	0.65	-0.25	-0.05	0.04	-0.01	0.00	0.13	-0.01
SMB	0.26	-0.01	1.00	-0.40	-0.04	-0.02	0.30	-0.02	0.40	0.11	0.10	0.00
RMW	-0.24	0.19	-0.40	1.00	0.10	0.08	-0.28	-0.07	-0.15	-0.04	-0.11	0.07
CMA	-0.36	0.65	-0.04	0.10	1.00	-0.03	-0.24	-0.02	-0.15	0.02	0.11	0.04
MOM	-0.15	-0.25	-0.02	0.08	-0.03	1.00	-0.27	-0.01	-0.23	-0.00	-0.21	0.07
MYP	0.83	-0.05	0.30	-0.28	-0.24	-0.27	1.00	0.10	0.49	0.19	0.16	-0.20
UI	-0.04	0.04	-0.02	-0.07	-0.02	-0.01	0.10	1.00	-0.07	0.14	0.07	-0.06
DSV	0.55	-0.01	0.40	-0.15	-0.15	-0.23	0.49	-0.07	1.00	-0.03	0.01	-0.12
ATS	-0.06	0.00	0.11	-0.04	0.02	-0.00	0.19	0.14	-0.03	1.00	-0.31	0.21
STS	-0.01	0.13	0.10	-0.11	0.11	-0.21	0.16	0.07	0.01	-0.31	1.00	-0.09
FX	-0.17	-0.01	0.00	0.07	0.04	0.07	-0.20	-0.06	-0.12	0.21	-0.09	1.00

Panel B: January 1975 - November 2007 (first subsample)

	RM	HML	SMB	RMW	CMA	MOM	MYP	UI	DSV	ATS	STS	FX
RM	1.00	-0.41	0.21	-0.26	-0.45	-0.01	0.60	-0.16	0.57	-0.15	-0.04	-0.06
HML	-0.41	1.00	-0.17	0.28	0.71	-0.15	-0.31	0.05	-0.11	-0.05	0.11	0.04
SMB	0.21	-0.17	1.00	-0.41	-0.08	0.10	0.09	-0.07	0.45	0.08	0.08	0.03
RMW	-0.26	0.28	-0.41	1.00	0.10	0.08	-0.31	-0.04	-0.14	-0.02	-0.11	0.05
CMA	-0.45	0.71	-0.08	0.10	1.00	-0.01	-0.36	0.05	-0.20	0.03	0.10	0.02
MOM	-0.01	-0.15	0.10	0.08	-0.01	1.00	-0.19	0.03	-0.15	0.03	-0.22	0.00
MYP	0.60	-0.31	0.09	-0.31	-0.36	-0.19	1.00	-0.11	0.30	-0.03	0.19	0.10
UI	-0.16	0.05	-0.07	-0.04	0.05	0.03	-0.11	1.00	-0.13	0.13	0.03	0.01
DSV	0.57	-0.11	0.45	-0.14	-0.20	-0.15	0.30	-0.13	1.00	-0.02	0.04	-0.03
ATS	-0.15	-0.05	0.08	-0.02	0.03	0.03	-0.03	0.13	-0.02	1.00	-0.37	0.25
STS	-0.04	0.11	0.08	-0.11	0.10	-0.22	0.19	0.03	0.04	-0.37	1.00	-0.12
FX	-0.06	0.04	0.03	0.05	0.02	0.00	0.10	0.01	-0.03	0.25	-0.12	1.00

Panel C: December 2007 - December 2021 (second subsample)

	RM	HML	SMB	RMW	CMA	MOM	MYP	UI	DSV	ATS	STS	FX
RM	1.00	0.27	0.40	-0.21	-0.11	-0.40	0.89	0.17	0.53	0.41	0.07	-0.47
HML	0.27	1.00	0.38	-0.05	0.50	-0.46	0.13	0.03	0.29	0.27	0.26	-0.11
SMB	0.40	0.38	1.00	-0.36	0.11	-0.31	0.27	0.06	0.24	0.33	0.19	-0.08
RMW	-0.21	-0.05	-0.36	1.00	0.08	0.08	-0.12	-0.16	-0.19	-0.18	-0.11	0.12
CMA	-0.11	0.50	0.11	0.08	1.00	-0.08	-0.13	-0.16	0.03	-0.05	0.18	0.09
MOM	-0.40	-0.46	-0.31	0.08	-0.08	1.00	-0.33	-0.07	-0.50	-0.17	-0.21	0.26
MYP	0.89	0.13	0.27	-0.12	-0.13	-0.33	1.00	0.12	0.59	0.11	-0.14	-0.60
UI	0.17	0.03	0.06	-0.16	-0.16	-0.07	0.12	1.00	0.09	0.30	0.17	-0.22
DSV	0.53	0.29	0.24	-0.19	0.03	-0.50	0.59	0.09	1.00	-0.12	-0.10	-0.46
ATS	0.41	0.27	0.33	-0.18	-0.05	-0.17	0.11	0.30	-0.12	1.00	0.29	0.02
STS	0.07	0.26	0.19	-0.11	0.18	-0.21	-0.14	0.17	-0.10	0.29	1.00	0.03
FX	-0.47	-0.11	-0.08	0.12	0.09	0.26	-0.60	-0.22	-0.46	0.02	0.03	1.00

This table shows the correlation matrix between the factors of the FF six-factor model (market excess return, BM, size, profitability, investment, and momentum) and the MF model (industrial production growth expectation, unexpected inflation, changes in aggregate survival probability, change in the average level and the slope of the term structure of the risk-free rate, and changes in the exchange rate). The sample periods extend (Panel A) from January 1975 to December 2021, (Panel B) from January 1975 to April 2008, and (Panel C) from May 2008 to December 2021.

Table 4: Macroeconomic risk exposures

Panel A: January 1975 - December 2021 (full sample)							
	Constant	MYP	UI	DSV	ATS	STS	FX
RM	-0.00	3.98***	-0.68*	0.88	-3.91**	-2.96***	0.14
	(-0.01)	(4.70)	(-1.67)	(1.50)	(-2.27)	(-3.08)	(0.95)
HML	-0.00	-0.38	0.31	0.29	0.75	1.33***	-0.05
	(-0.53)	(-1.07)	(0.93)	(0.94)	(1.39)	(3.14)	(-0.66)
SMB	-0.00	0.26	-0.27	1.77***	1.18***	0.90**	0.07
	(-1.44)	(1.20)	(-1.12)	(6.21)	(2.61)	(2.52)	(1.04)
RMW	0.00	-0.57**	-0.31	-0.08	-0.01	-0.47	0.00
	(0.31)	(-2.18)	(-0.92)	(-0.41)	(-0.03)	(-1.51)	(0.08)
CMA	-0.00	-0.59***	-0.11	0.01	0.89**	0.98***	-0.05
	(-0.51)	(-2.64)	(-0.50)	(0.04)	(2.49)	(3.30)	(-1.03)
WML	0.00*	-0.66	0.19	-1.05**	-0.54	-2.31***	0.03
	(1.88)	(-1.36)	(0.40)	(-2.35)	(-0.77)	(-3.70)	(0.35)

Panel B: January 1975 - November 2007 (first subsample)							
	Constant	MYP	UI	DSV	ATS	STS	FX
RM	-0.00	4.40***	-0.22	2.71***	-2.04	-2.47**	-0.20
	(-0.75)	(2.75)	(-0.37)	(3.11)	(-1.16)	(-2.45)	(-1.59)
HML	0.00	-2.01***	0.07	0.03	-0.11	1.15**	0.14*
	(0.27)	(-2.59)	(0.14)	(0.08)	(-0.13)	(2.30)	(1.78)
SMB	-0.00	-0.50	-0.33	2.19***	1.02**	0.87**	0.05
	(-1.64)	(-1.20)	(-0.91)	(7.86)	(2.03)	(2.37)	(0.71)
RMW	-0.00	-1.42*	-0.61	-0.15	-0.36	-0.43	0.10
	(-0.46)	(-1.94)	(-1.10)	(-0.63)	(-0.59)	(-1.28)	(1.26)
CMA	-0.00	-1.50**	-0.11	-0.22	0.46	0.95***	0.05
	(-0.43)	(-2.48)	(-0.32)	(-1.21)	(0.80)	(2.72)	(0.75)
WML	0.00**	-0.96	0.27	-0.57	-0.59	-2.20***	-0.02
	(2.29)	(-0.91)	(0.44)	(-1.16)	(-0.83)	(-3.19)	(-0.18)

Panel C: December 2007 - December 2021 (second subsample)							
	Constant	MYP	UI	DSV	ATS	STS	FX
RM	-0.00	4.64***	-0.44	1.01	8.35	2.33	0.27*
	(-0.35)	(3.07)	(-1.00)	(0.58)	(1.55)	(1.06)	(1.74)
HML	-0.00	-0.41	-1.02**	2.69***	5.82	2.73	-0.05
	(-0.33)	(-1.16)	(-2.25)	(5.27)	(1.34)	(1.42)	(-0.30)
SMB	-0.00	0.60*	-0.52	1.28***	5.03***	1.62**	0.19
	(-0.23)	(1.86)	(-1.26)	(2.64)	(2.66)	(2.13)	(1.24)
RMW	0.00*	0.11	-0.36	-0.80*	-1.85*	-0.53	0.05
	(1.73)	(0.31)	(-0.91)	(-1.79)	(-1.93)	(-0.91)	(0.52)
CMA	0.00	-0.30	-0.76***	0.62	-0.07	1.29***	0.03
	(0.38)	(-1.00)	(-3.46)	(1.54)	(-0.07)	(2.69)	(0.34)
WML	-0.00	-0.05	1.04	-5.17***	-5.34*	-4.34**	0.11
	(-0.31)	(-0.10)	(1.53)	(-4.94)	(-1.68)	(-2.04)	(0.46)

In this table, we show the outcomes from OLS estimations of characteristic portfolio returns onto macroeconomic fundamental realizations. The table shows the estimates and significance levels from the time-series regressions using the factor RM, HML, SMB, RMW, CMA, and WML as dependent variables. The numbers in square parentheses are t-statistics. In the one-step GMM approach, we stack the moment conditions of the mimicking portfolio onto the moment conditions of the asset pricing model. All estimation procedures correct for heteroscedasticity and autocorrelation by using the Newey and West (1987) correction with $l = 12$. The sample periods extend (Panel A) from January 1975 to December 2021, (Panel B) from January 1975 to November 2007, and (Panel C) from December 2007 to December 2021.