The long-run risk premium in the ICAPM: International evidence

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Abstract

This study investigates whether long-run conditional covariance risk is linked to expected returns in the Intertemporal CAPM framework. We observe that the long-run value risk is positively associated with the expected returns on the global portfolios excluding the US. We also find that the long-run momentum risk is negatively related to the expected returns. In contrast, the long-run market risk is not associated with them, due to the low covariance variation across portfolios. Finally, we uncover that the long-run value premiums were strong for the global and European portfolios before the COVID-19 pandemic.

Keywords: ICAPM, long-run risk, value anomalies, factor models, COVID-19, DCC-MIDAS
JEL codes: G12, G15

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1.Introduction

One of the key research questions in asset pricing is whether there exists a positive risk-return relationship. In an Intertemporal Capital Asset Pricing Model (ICAPM), an expected return on a portfolio (stock) is dependent upon its covariance with the market portfolio, and its covariance with state variables which capture an investment opportunity set (Merton, 1973, 1980). The previous studies found mixed results for risk-return trade-offs.[1] This study explores the relationship between long-run covariance risk with the market portfolio and expected returns in the international stock market context. Furthermore, we investigate the covariance risk with size, value, momentum, profitability and investment (Fama and French, 1992, 1993, 2015; Carhart, 1997). These risk factors influence the stochastic investment opportunity set, and investors require additional risk premium holding assets which with unfavourable shifts of the investment opportunity set. We focus upon long-run risk that is directly linked to business cycles and intertemporal consumption smoothing (e.g., Bansal and Yaron, 2004; Adrian and Rosenberg, 2008; Ortu et al., 2013; Campbell et al., 2018).

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[1] For instance, some studies report a positive risk-return relationship, which is consistent with the finance theory (e.g., French et al., 1987; Scruggs, 1998; Ghysels et al., 2006; Guo and Whitelaw, 2006). The other studies present empirical evidence that the trade-off is weak (e.g., Campbell, 1987; Glosten et al., 1993; Ang, et al., 2006). Maio (2013) uncovers that the positive risk-return relationship is sensitive to state variables. Wang et al. (2017) employ individual stocks and find that the trade-off is associated with the firm's state.

One of the reasons for not finding a positive risk-return relationship in the literature is that it does not take into account time-varying covariance risk.[2] For instance, Bali et al. (2016) find that time-varying conditional market risk is positively related to expected returns, which is not observed in unconditional models. We employ a conditional covariance approach in order to estimate time-varying covariance risk (Bali, 2008; Bali and Engle, 2010). Another advantage of this approach is that it allows us to keep time-series estimation while maintaining cross-sectional consistency.[3] Adopting time-varying models for a single asset return causes a lack of statistical power, for instance, Lewellen and Nagel (2006) deploy a conditional approach in a time series context, while they conclude that it does not lead to smaller pricing errors. To overcome this problem, we extract information from cross-sectional variation. We employ 25 portfolios sorted by size and book-to-market (Size-B/M), and size and momentum (Size-Mom) in our main results, allowing us to avoid a free parameter problem that leads a spurious fit. A small number of test portfolios induces the problem that risk factor structures and characteristic sorted test portfolios have common variations, see, Daniel and Titman (1997, 2012) and Lewellen et al. (2010).

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[2] Whitelaw (2000) and Guo et al. (2013) also investigate time-varying risk-return trade-offs.

[3] Maio and Santa-Clara (2012) highlight that we need to explore the ICAPM in both time-series and cross-sectional contexts.

The first contribution of this study is that we extend the time-series and cross-sectional consistent ICAPM framework to long-run risk and evaluate whether a long-run conditional covariance risk is a determinant for risk premiums.[4] We estimate the long-run conditional covariance risk by adopting a dynamic conditional correlation and mixed-data sampling approach (DCC-MIDAS) proposed by Colacito et al. (2011). This approach allows us to employ a rich data set and decompose long-run and short-run correlation components.[5] This decomposition is important because long-run and short-run volatilities entail different information. For instance, Adrian and Rosenberg (2008) reveal that long-run risk is linked to business cycles, while short-run risk is associated with financial constraints. Chen et al. (2018) show that long-run downside risk is more important than short-run downside risk for advanced stock markets. The long-run component of idiosyncratic volatility is related to lower future returns, see Liu (2021). Our novelty relative to Lewellen and Nagel (2006) and Bali and Engle (2010) is that we focus on the long-run conditional covariances, not conventional conditional covariances.

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[4] Barroso and Maio (2019) investigate risk-return trade-offs for several risk factors, while they use a single regression.

[5] It has been used for ICAPM (Ghysels, et al., 2005); volatility prediction (Ghysels et al., 2006; Engle et al., 2013); stock markets in the Euro currency zone (Connor and Suurlaht, 2013); conditional skewness (Ghysels et al., 2016); stock-bond correlation (Asgharian et al., 2016); and industry betas (Baele and Londono, 2013).

The long-run conditional covariances are linked to business cycles and a relationship between risk premiums and business cycles is a fundamental question of asset pricing models (e.g., Ferson and Harvey 1991; Cochrane, 1996; Ludvigson and Ng, 2007; Cooper and Priestley, 2009). Our study is also different from Chen et al. (2018) who focus upon time-series relationships since we explore both time-series and cross-sectional relationships.

The second contribution of this study is that we focus upon international portfolios. Although most studies investigate the U.S. markets and estimate the ICAPM, several cross-sectional investment strategies are applicable to international stock markets and there are common risks across them (e.g., Asness et al., 2013; Frazzini, and Pedersen, 2014; Koijen et al., 2018; Cooper, et al., 2020). Motivated by these findings, we explore risk-return relationships in international stock markets and positive relationships are observed for world and regional portfolios. We employ regional portfolios proposed by Fama and French (2012, 2017). These portfolios are advantageous since they cover not only large firms, but also small firms, and provide cross-sectional heterogeneities. The previous literature finds that the world stock market is partially segmented and regional portfolios are suitable for asset pricing tests (Bekaert and Harvey, 1995; Bali and Cakici, 2010; Bekaert et al., 2011; Hou et al., 2011; Karolyi and Wu, 2018).

Our third contribution is that we explore the relationship between COVID-19 and risk premiums on a four-factor model (Fama and French, 1993; Carhart, 1997) and a five-factor model (Fama and French, 2015). COVID-19 has affected financial markets and economic activities and increased stock market volatility, which was not observed for the past pandemic (e.g., Baker et al. 2020; Gormsen and Koijen, 2020; Ramelli and Wagner, 2020). Investors changed their risk-averseness after the stock market crash triggered by COVID-19, see Giglio et al. (2021). Risk premiums vary over time through changes in economic states, as shown by Petkova and Zhang (2005) and the pandemic may have effects on them. The pandemic impacts are heterogeneous across countries, and hence it is worthwhile to adopt international test portfolios.[6] These points have not been explored by the previous studies such as Lewellen and Nagel (2006) and Bali and Engle (2010). Considering the impact of the pandemic, we need to assess how it is associated with asset pricing models and risk premiums.

To preview our results, we find that the long-run conditional covariance of portfolio returns with the value factor is positively associated with the expected returns on portfolios for the World ex US portfolio, which suggests that an upward shift in the

[6] Ramelli and Wagner (2020) report that stocks which have high exposure to trade with China underperformed in the beginning of the pandemic.

value factor is favourable. In contrast, the long-run conditional covariance with the market return is not linked to the expected returns. The dispersion of long-run covariances is not sufficient in explaining the expected returns on the test portfolios. Moreover, the long-run value premiums are strong for the World and European portfolios before the pandemic and the economic downturn induced by COVID-19 reduces the value premiums. Zhang (2005) proposes a model that dividends of value firms covary with economic downturns, since value firms are burdened with more unproductive real capital than growth firms. This mechanism leads to an increase in the value premium during economic recessions (Fama and French, 1995; Petkova and Zhang, 2005). The COVID-19 pandemic impact on industries is different from a normal economic downturn due to the pandemic lockdown, and hence long-run value premiums become weak. This is associated with the recent finding of Arnott et al. (2021) who report that the importance of intangible assets weakens traditional value strategies. The pandemic lockdown amplifies this mechanism. Our results are robust after controlling for global macroeconomic variables and policy uncertainty.

The rest of paper is organized as follows: Section 2 describes estimation methodologies, Section 3 explains the data sets used in this study, Section 4 presents the main empirical results, Section 5 conducts robustness tests and Section 6 provides the conclusion.

2. Estimation methodology

2.1. *The intertemporal relation between expected return and risk*

This subsection describes the ICAPM. Let μ_{t+1} be the $n \times 1$ vector of conditional mean portfolio returns r_{t+1} at time $t+1$, $r_{f,t+1}$ be the $n \times 1$ vector of risk-free rate, and x_{t+1} be the $1 \times k$ vector of state variables. The conditional mean excess returns on portfolios at time *t*+1, $\mu_{t+1} - r_{f,t+1}$ are determined by the expected conditional covariance between the portfolio return r_{t+1} and the market return $r_{mkt,t+1}$, where $\mu_{t+1} = E_t(r_{t+1})$, and by the expected conditional covariance between the portfolio return r_{t+1} and the state variables x_{t+1} that shift investment opportunity sets (Merton, 1973). The conditional mean excess returns are denoted as:

$$\mu_{t+1} - r_{f,t+1} = C + A \cdot Cov_t(r_{t+1}, r_{mkt,t+1}) + Cov_t(r_{t+1}, x_{t+1}) \cdot S \qquad (1)$$

where the estimated parameters, *A* is the scalar, and *C* and *S* are the $k \times 1$ vectors. *A* indicates the average relative risk-aversion of an investor. The ICAPM implies that all elements of the intercept vector *C* should be zero. The important point of Equation (1) is that the portfolios are estimated simultaneously by the system of equations, and hence the parameters *A* and *S* should have the same values across all portfolios. Following Bali and Engle (2010), we implement a seemingly unrelated regression (SUR) and estimate

Equation (1).

2.2. *DCC-MIDAS*

This section describes estimation steps for a DCC-MIDAS model. We follow Engle et al. (2013) and consider a GARCH-MIDAS process in the first step. Let a portfolio return on day *i* at month *t*, $r_{i,t}$ be denoted as:

$$r_{i,t}=\mu+\sqrt{\tau_{i,t}g_{i,t}}\xi_{i,t} \quad \xi_{i,t}\big|\Phi_{i-1,t}\sim N(0,1) \tag{2}$$

where $\mu=E_{i-1,t}(r_{i,t})$, $\tau_{i,t}$ is the long-run component, $g_{i,t}$ is the short-run component, $\xi_{i,t}$ is the standardised residual, and $\Phi_{i-1,t}$ is the information set up to day i-1. The short-run component $g_{i,t}$ follows a GARCH (1,1) process and is described:

$$g_{i,t}=(1-\alpha-\beta)+\alpha\frac{(r_{i,t-1}-\mu)^2}{\tau_{i,t}}+\beta g_{i,t-1} \tag{3}$$

where α and β are the estimated parameters. The long-run component $\tau_{i,t}$ has a MIDAS component and is given by a weighted sum of *K* lags of realised variance (RV) over a long horizon:

$$\tau_{i,t}=\bar{\tau}_i+\theta_i\sum_{L=1}^{K}\varphi_k(w)RV_{i,t-L} \tag{4}$$

where $\bar{\tau}_i$ and θ_i are the estimated parameters, $\varphi_k(w)$ represents the weighting scheme and we employ Beta weights as in Colacito et al. (2011). $RV_{i,t-L}$ is the realised variance and calculated by the daily squared returns as:

$$RV_{i,t}=\sum_{i=1}^{N}r_{i,t}^2 \tag{5}$$

where N represents the number of the daily observations within a month and we select 22 as the monthly aggregation.

Next, we obtain a conditional correlation using a DCC-MIDAS model proposed by Colacito et al. (2011). The short-run conditional correlation between asset returns p and q, $q_{p,q,t}$ is modelled by the long-run conditional correlation, the standardised residuals for p and q and the lagged short-run conditional correlation, and denoted as:

$$q_{p,q,t} = (1-a-b)\bar{\rho}_{p,q,t} + a\xi_{p,t-1}\xi_{q,t-1} + bq_{p,q,t-1} \tag{6}$$

where a and b are the estimated parameters and $\bar{\rho}_{p,q,t}$ is the long-run conditional correlation component written as:

$$\bar{\rho}_{p,q,t} = \sum_{L=1}^{Kc} \varphi_{kc}(w_c) c_{p,q,t-L} \tag{7}$$

where $\varphi_{kc}(w_c)$ represents the weighting scheme as in Equation (4)[7] and $c_{p,q,t-L}$ denotes the cross-products of the standardized residuals given by:

$$c_{p,q,t} = \frac{\sum_{k=t-N}^{t} \xi_{p,k}\xi_{q,k}}{\sqrt{\sum_{k=t-N}^{t} \xi_{p,k}^2}\sqrt{\sum_{k=t-N}^{t} \xi_{q,k}^2}} \tag{8}$$

Then, we calculate the long-run conditional covariance using the long-run conditional correlation and the long-run components of volatility:

$$lcov_{p,q,t} = \sqrt{\tau_{p,t}}\sqrt{\tau_{q,t}}\,\bar{\rho}_{p,q,t}. \tag{9}$$

[7] Following Colacito et al. (2011), we set the number of the GARCH process K as 36 and that of the DCC process Kc as 144.

The long-run components of volatility $\tau_{p,t}$ and $\tau_{q,t}$ are estimated in the first step by the univariate GARCH-MIDAS model and the long-run conditional correlation $\bar{\rho}_{p,q,t}$ is obtained in the second step by the DCC-MIDAS model. We use the long-run covariances in Equation (1) and estimate parameters for the long-run covariance risk. We focus on long-run risk that is directly linked to business cycles and intertemporal consumption smoothing as reported by Adrian and Rosenberg (2008) and Campbell et al. (2018). Moreover, the short-run covariance risk has many jumps that are not appropriate to capture business cycles, See Figures A3-A8.

3. Data

3.1. *Portfolios*

Our main data are returns on world and regional stock portfolios. We consider World portfolios, which represent 23 developed countries and US portfolios. We also focus upon the following five regional portfolios: (i) World excluding US, (ii) Europe (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the U.K.), (iii) Japan, (vi) Asia Pacific (Australia, New Zealand, Hong Kong, and Singapore) and (v) US. These regional regions are proposed by Fama and French (2012, 2017) and these regional portfolios have sufficient diversification, which is important to evaluate asset pricing models.[8] We add the World excluding US portfolios into our test assets, because the U.S. market has the largest market and a significant impact on the other regions (Rapach et al., 2013).[9] Therefore the World and World ex US portfolios have different variation.

Following Bali (2008) and Maio and Santa-Clara (2012), we employ 25 portfolios sorted by size and book-to-market (Size-B/M), and size and momentum (Size-Mom). All returns are calculated using the U.S. dollars and the U.S. one-month Treasury-Bill yield is used as the risk-free rate. The data sets are downloaded from Kenneth French's website. We employ daily data to estimate the DCC-MIDAS and use monthly data to test the ICAPM. The sample is between July 2, 1990 and June 30, 2020 and we select the end of the month data to construct the monthly data.

3.2 *Risk factors*

We consider the CAPM, the four-factor model (Fama and French, 1992, 1993; Carhart 1997) and the five-factor model (Fama and French, 2015) for global and regional portfolios. Fama and French (2012) use the four-factor model and Fama and French

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[8] Karolyi and Wu (2018) present the empirical evidence that international markets are partially segmented.

[9] This is the reason we employ the US portfolios, while Fama and French (2012, 2017) adopt the North American portfolios.

(2017) employ the five-factor model, and conduct cross-sectional asset pricing tests. We follow these studies and the excess return on the market portfolio (MKT) is calculated as the region's value weighted market portfolio minus the U.S. one-month Treasury-Bill. The four-factor model has MKT, size (SMB), value (HML) and momentum (UMD) factors and the five-factor model has MKT, SMB, HML, profitability (RMW) and investment (CMA) factors. These data are obtained from Kenneth French's website.

4. Empirical Results

This section presents empirical results. First, we estimate the ICAPM without other risk factors. Second, we employ the four-factor model and evaluate whether long-run covariances with the risk factors predict expected returns. Third, we repeat the same estimation without the COVID-19 pandemic period. Finally, we explore average returns on the test portfolios excluding the pandemic period.

4.1. *CAPM*

We begin with the CAPM and report parameter estimates for long-run conditional covariances between excess returns on the market and the 25 Size-B/M and Size-Mom portfolios. The long-run covariance estimate (*A*) indicates the risk-return relationship for the portfolios and is the common slope coefficient for the 25 test portfolios. Panel A of Table 1 presents that A is positive and statistically significant at the 5% level for the Size-Mom portfolios in World, US, World ex US and Asia-Pacific, which suggests that long-run risk is positively associated with the expected returns on the portfolios. In contrast, most results are insignificant for the Size-B/M portfolios.

To see an economic impact, we follow Bali and Engle (2010) and implement the following transformation of Equation (1) for a portfolio i:

$$E[r_i]=C_i+A\cdot \sigma_{mkt}^2 \frac{\sigma_{i,mkt}}{\sigma_{mkt}^2} = C_i+(A\cdot\sigma_{mkt}^2)\cdot\beta_i \quad (10)$$

where σ_{mkt}^2 is the long-run variance of the market portfolio, $\sigma_{i,mkt}$ is the long-run covariance between the portfolio i and the market excess returns, and β_i is the market beta for the portfolio i. The cross-term $A\cdot\sigma_{mkt}^2$ is interpreted as an expected long-run market risk premium. In Panel B of Table 1, we calculate monthly standard deviation and then estimate the annualised long-run market risk premium. The results for the Size-Mom portfolios range from 0.62% to 2.62%. These magnitudes are economically reasonable, since the total market risk premium estimated by Bali and Engle (2010) ranges from 4.10% to 8.37%. The long-run risk premium is a portion of the total market risk premium. Interestingly, the MKT factor is successful in explaining expected returns for Size-Mom, which contrasts with the results of Fama and French (1996) and Maio and Santa-Clara

(2012). The divergence comes from the estimation methodologies and constraints adopted by our analysis.

In summary, the long-run conditional covariances of portfolio returns with MKT is partially successful in predicting the Size-Mom portfolios but not the Size-B/M portfolios.

4.2. *Four-factor model*

Having found the mixed results of the CAPM, we employ the four-factor model (Fama and French, 1993; Carhart, 1997) that includes the market (MKT), size (SMB), value (HML) and momentum (UMD) factors. We estimate long-run conditional covariance of a portfolio return with the factor return using the DCC-MIDAS model for each portfolio, and then run the following SUR regression:

$$\mu_{t+1} - r_{f,t+1} = C + A \cdot Cov_t(r_{t+1}, r_{mkt,t+1}) + S_1 \cdot Cov_t(r_{t+1}, r_{smb,t+1}) + S_2 \cdot Cov_t(r_{t+1}, r_{hml,t+1}) + S_3 \cdot Cov_t(r_{t+1}, r_{umd,t+1}). \quad (11)$$

where S_1, S_2 and S_3 are the common slope coefficients for all 25 test portfolios.

Panels A and C in Table 2 show that World ex US display that the covariances of portfolio returns with HML (S_2) are positively related to the expected returns for both test portfolios. This suggests that an upward shift in the HML factor is linked to a favourable shift in the investment opportunity set. Investors invest less in the portfolio when the HML factor rises, since the portfolio does not work as a hedge against the HML risk. The long-run risk premium ranges from 0.37% to 0.68%, which is relatively smaller than the market risk premium reported by Bali and Engle (2010).

The covariances of portfolio returns with UMD (S_3) are negatively associated with the expected returns in World ex US, which implies that an upward shift in the UMD factor is unfavourable in the investment opportunity set, which is opposite to the result of HML. An increase in the correlation between UMD and the portfolio return leads to an increase in intertemporal hedge demands for investors. The momentum factor has negative exposures to the market and value risks, which is in line with the results of Barroso and Santa-Clara (2015) and Daniel and Moskowitz (2016). Bali and Engle (2010) report that the impact of the UMD factor depends upon the US portfolios at a daily frequency, while the signs of the parameter estimates depend upon test portfolios. Our results uncover that there is a strong negative relationship for the different regional portfolios at a longer frequency.

In contrast to the HML and UMD results, we do not see the consistent result for the MKT factor for all regions. This relates to the long-run covariances with MKT are less variation compared with those with HML and UMD. Figure 1 displays the estimated long-run covariances with MKT for the World ex US portfolios. We select six out of the 25 portfolios for each panel and the figures reveal that there are two peaks: global financial crisis and COVID-19 crisis. Figure 2 shows long-run covariances with HML and we see that there exist heterogeneities across the portfolios within the test portfolio groups. In contrast, the covariances with MKT have time-variations while most portfolios comove in Figure 1. These heterogeneous time variations for the covariances with HML induce the statistically significant relationship with the expected return on portfolios. Figure A1 and A2 provide long-run covariances with SMB and UMD and confirm our conclusion, since the covariances with UMD contain more heterogeneous time variations than those with SMB.[10]

The recent pandemic provides a different pattern compared with the global financial crisis, as presented in Figure 2. Most covariances increased greatly during the global financial crisis in 2008, except the big-low B/M and the two high Mom portfolios, while we do not observe these patterns during the pandemic. For instance, the covariance of small-high B/M moves the opposite direction during the two crises.

[10] We compare the long-run and the short-run covariances in Figures A3-A8 and confirm that the long-run covariances are more stable and suitable for a pricing model at a low frequency.

4.3. *Four factor model before the COVID-19 outbreak*

Given the strong impacts of the COVID-19 pandemic, we repeat the same estimation but exclude the pandemic period. Thus, the data period covers from August 1993 to December 2019.[11] Panels A and C of Table 3 presents the empirical evidence that expected returns on portfolios and covariances with HML are positively linked for the World, World ex US and European portfolios. We only see the value premium for the World ex US portfolios in the previous results, which suggests that the pandemic impacts the value premium for the World and European portfolios. The weak relationship between covariances with HML and expected returns for the US portfolios is also observed by the literature, see, for example, Arnott et al. (2021) and Blitz and Hanauer (2021). Arnott et al. (2021) describe that the traditional value factor construction process does not fit for the economy that has a high proportion of intangible investments.

We also observe that the estimates for the covariance with UMD in Panels A and C of Table 3 are negative and statistically significant at the 5% level for World and World ex US. The hedge demand of the momentum becomes stronger before the pandemic. There is debate whether momentum anomalies generated by business cycles, see, for example, Chordia and Shivakumar (2002) and Griffin et al. (2003). Johnson (2002), Liu

[11] The first confirmed case of COVID-19 was observed in European countries at the end of January 2020.

and Zhang (2008), and Misirli (2018) address that when firm's expected growth is high, the stock return is more sensitive to a change in the expected growth. Li (2017) proposes the theoretical model that past winner firms tend to have greater investment plans and more exposures to shocks of investment goods. The COVID-19 pandemic impacts the expected growth and investment plans, and hence the standard momentum mechanism does not function.

Panels B and D in Table 3 show that the long-run risk premiums on UMD have greater impacts than those on HML in terms of the absolute values. Furthermore, we explore whether excluding the COVID-19 period affects the long-run covariance estimates. Figures A9 and A10 illustrate that we obtain almost the same results without the pandemic period.

In summary, we confirm that the positive links between expected returns and covariances with HML and the negative links between expected returns and covariances with UMD are strong excluding the pandemic period.

4.4. *Value anomalies during the COVID-19 pandemic*

Why are the value anomalies not observed during the pandemic period? One possible explanation is that the pandemic differs from normal economic recessions and a mechanism that generates the value premium does not function. Normally, the value premium varies over time and the risk increases in bad economic states since high B/M stocks are more distressed (Fama and French, 1995; Petkova and Zhang, 2005). Zhang (2005) proposes a model that dividends of value firms covary with economic downturns, since the value firms are burdened with more unproductive real capital than the growth firms. Real capital is irreversible and it is difficult for the value firms to adjust capital during economic recessions, which causes the value firms are riskier and generates the value premium.[12] However, the economic downturn triggered by COVID-19 is different from normal recessions and it has heterogeneous impacts on the firms. Consumers are forced to stay home and some firms receive benefits and the other firms suffer a huge loss from this behaviour (Donthu and Gustafsson, 2021). These heterogeneous impacts do not allow investors to evaluate the firms using the conventional manner. The value factor does not function when intangible assets such as patent and intellectual property play a substantial role, see, Arnott et al. (2021). The COVID-19 related restriction amplifies this pattern since some firms without physical economic activities increase their profits.

Table 4 presents excess returns for the World portfolios during the global

[12] Cooper (2006) also uses a costly investment assumption and develops a real option model that generates the value premium.

financial and the pandemic periods.[13] We note that all portfolios generate negative returns during the global financial crisis. In contrast, some portfolios produce positive returns while the others do negative returns during the pandemic period, which indicates that the pandemic has more heterogeneous impacts on firms than the global financial crisis.

5. Robustness

This section conducts the following robustness tests: (i) five-factor model, (ii) five-factor model excluding the pandemic period, (iii) different test portfolios, (iv) controlling for macroeconomic variables and (v) controlling for economic uncertainty effects.

5.1. *Five factor model*

We employ the five-factor model proposed by Fama and French (2015, 2017) and repeat the same estimation. The model includes the market (MKT), size (SMB), value (HML), profitability (RMW) and investment (CMA) factors. The SUR regression is described as:

$$\mu_{t+1} - r_{f,t+1} = A \cdot Cov_t(r_{t+1}, r_{mkt,t+1}) + S_1 \cdot Cov_t(r_{t+1}, r_{smb,t+1}) + S_2 \cdot Cov_t(r_{t+1}, r_{hml,t+1}) + S_3 \cdot Cov_t(r_{t+1}, r_{rmw,t+1}) \quad (12)$$

[13] The results for World ex US and European portfolios are provided in Online Appendix.

$$+S_4 \cdot Cov_t(r_{t+1}, r_{cma,t+1})$$

where S_4 is the common slope coefficient for all 25 test portfolios.

Panels A and C of Table 5 provide the empirical results for the five factor models and we note that the coefficients on covariances with HML is positive and statistically significant at the 5% level for the World ex US portfolios, which is consistent with the results of the four-factor model. Moreover, Panels B and D of Table 5 reports that the long-run risk premium has a similar magnitude to that of the four-factor model. Another notable point is that the conditional covariances of portfolio returns with the CMA factor have positive predictive power for one-month ahead returns on the US portfolios. This is related to the finding reported by Barroso and Maio (2019) who adopt a different estimation strategy and reveal that CMA is positively related to the market risk. This indicates that an upward movement in the CMA factor has a positive shift in the investment opportunity set for the US portfolios. Fama and French (2015) and Hou et al. (2015) report that investment factors capture value anomalies and HML is redundant. Our findings in the US portfolios are in line with their results.

5.2. *Five-factor model before the COVID-19 outbreak*

Having found the COVID-19 effects in the previous section, we estimate the five-factor model excluding the pandemic period. Panels A and C in Table 6 show that the common slope coefficient on HML (S_2) is positive and statistically significant at least at the 10% level for both test portfolios in World, World ex US and Europe. This is consistent with the four factor model results in Table 3 and we confirm that upward movements in the HML factor are favourable in World and Europe during a normal time. Another important point is that the common slope coefficient on CMA (S_4) for the US results are highly statistically significant for both test portfolios, which implies that the effects of CMA are irrelevant to the pandemic.

In summary, we observe that the long-run conditional covariances of portfolio returns with HML are positively linked to the expected returns in World and Europe, and those with CMA are more important for the US portfolios.

5.3. *Adopting different test portfolios*

We employ different test portfolios and estimate four and five factor models. Cross-sectional asset pricing models are sensitive to sorting rules, see for instance, Griffin et al. (2003), Liu and Zhang (2008), and Lewellen et al. (2010). We adopt 25 size and operating profitability, and size and investment portfolios.

We summarise all results in Table 7. The single circle indicates that three out of the four parameter estimates (Size-B/M, Size-Mom, Size-OP, Size-Inv) are statistically significant at least at the 10% level and the double circle indicates that all parameter estimates are statistically significant at least at the 10% level. The grey area means that the parameter estimates are negatively linked to the expected returns. The covariances with HML are positively associated with the expected returns for the World and European portfolios before the pandemic, as reported by Panels A and B of Table 7. Those with UMD are negatively related to the expected returns for the World, World ex US and Asia-Pacific portfolios, as shown by Panel A. Importantly, Panel B indicates that the US results are different and the covariances with CMA are driving forces for the expected returns.

5.4. *Controlling for macroeconomic effects*

Macroeconomic environments are associated with systematic risk and affect an investment opportunity set. Following Bali (2008) and Bali and Engle (2010), we include macroeconomic variables in our SUR regression. We consider the following three macroeconomic variables.

The first variable is the growth rate of industrial production (IP_t) as in Chen et al. (1986) and Cooper and Priestley (2011). Liu and Zhang (2008) highlight that momentum anomalies are associated with IP growth. Our results in Table 7 present the empirical evidence that the covariances with UMD play important roles for the World and Asia-Pacific portfolios, and including the IP growth may affect estimation results. Following Chen et al. (1986) and Cooper and Priestley (2011), we lead the growth rate by one month to keep a contemporaneous relation with other state variables.

The second variable is the short-term interest rate ($short_t$) and is associated with business cycles. We select the three-month interest rate as the short-term rate (Fama and Schwert, 1977; Ang and Bekaert, 2007). The third variable is the term spread between three month and 10-year interest rates ($term_t$), which is adopted by Ferson and Harvey (1999) and Maio and Santa-Clara (2012).

World and regional values for the three variables are calculated as the GDP-weighted averages proposed by Cooper et al. (2020). When we employ the regional values, the GDP-weighted averages are calculated by countries that are included in the corresponding regions. The GDP weights are constructed using GDP per capita denominated in the U.S. dollars. The GDP, three-month and 10-year interest rates, and industrial production data sets are obtained from the OECD. The SUR model that has the four factors and three macroeconomic variables is described as:

$$\mu_{t+1} - r_{f,t+1} = C + A \cdot Cov_t(r_{t+1}, r_{mkt,t+1}) + S_1 \cdot Cov_t(r_{t+1}, r_{smb,t+1}) \quad (13)$$

$$+ S_2 \cdot Cov_t(r_{t+1}, r_{hml,t+1}) + S_3 \cdot Cov_t(r_{t+1}, r_{umd,t+1})$$

$$+M_1 \cdot IP_t + \ M_2 \cdot short_t + M_3 \cdot term_t$$

where M_1, M_2 and M_3 are the common slope coefficients for all 25 test portfolios.

Table A6 presents the estimation results after controlling for the macroeconomic variables and Table A7 shows the results excluding the pandemic period. We confirm the same pattern, as reported in Tables 2 and 3. The common slope on HML is positive for World, World ex US and Europe, while that on UMD is negative for World, World ex US and Asia-Pacific. In addition, no macroeconomic variable is statistically significant for all test portfolios and we summarise the results in Table A10.

5.5. *Controlling for economic policy uncertainty index*

Given our robust results after controlling for the macroeconomic effects, we consider whether uncertainty influences our results. We deploy an economic policy uncertainty (EPU) index proposed by Baker et al. (2016). This index is constructed by frequencies of specific words in the U.S. newspapers with the specific words representing economic conditions, policies and uncertainty. Political uncertainty has negative impacts on firm activities and Bonaime et al. (2018) find that it is associated with a firm's merger decision. Davis (2016) adopt the same approach and construct indices for 13 countries and the world index, which is calculated as the GDP-weighted average.[14] These indices are appealing since we have regional test portfolios and need variables that capture country or regional specific uncertainty. We use the index corresponding to each regional analysis and take a difference from the previous month (*dEPUI*). These data are obtained from an economic policy uncertainty website.[15] We focus upon the following four regions due to the data availability: World, US, Europe and Japan. Following Bali and Engle (2010) and Campbell et al. (2018), we consider whether a covariance term between the portfolio returns and the change in the policy uncertainty index is linked to the expected returns and our SUR regression is written as:

$$\mu_{t+1} - r_{f,t+1} = C + A \cdot Cov_t\left(r_{t+1}, r_{mkt,t+1}\right) + S_1 \cdot Cov_t\left(r_{t+1}, r_{smb,t+1}\right) + S_2 \cdot Cov_t\left(r_{t+1}, r_{hml,t+1}\right) + S_3 \cdot Cov_t\left(r_{t+1}, r_{umd,t+1}\right) + U_1 \cdot Cov_t\left(r_{t+1}, dEPUI_t\right) \tag{14}$$

where U_1 is the common slope coefficient for all 25 test portfolios. The covariance term $Cov_t(r_{t+1}, dEPUI_t)$ is estimated by the DCC-GARCH proposed by Engle (2002), since we do not obtain $dEPUI_t$ at a daily frequency and do not employ the DCC-MIDAS.

Tables A10, A13 and A14 demonstrate that long-run covariances with HML are

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[14] The index of Japan is updated by Arbatli et al. (2019).

[15] https://www.policyuncertainty.com/

positively linked to the expected returns for the World and European portfolios and those with UMD are negatively linked for the World portfolios.[16] One notable thing is that *dEPUI* is negatively associated with the expected returns for all four regional portfolios. Three out of the four test portfolios demonstrate that the estimates (U_1) are statistically significant at least at the 5% level for all regions.

In summary, we confirm our results that the long-run covariances with HML predict expected returns on the World and European portfolios before the COVID-19 period, which are robust after controlling for political uncertainty.

6. Conclusion

This study investigates whether time-varying long-run covariances of risk factors are linked to expected returns. Long-run and short-run risks entail different information, as shown by Adrian and Rosenberg (2008) and Liu (2021). In this paper, we focus upon long-run risk and adopt the time-series and cross-sectionally consistent ICAPM framework proposed by Bali and Engle (2010).

We employ global and five regional portfolios that are sorted by size and book-

[16] These results do not change when we employ *dEPUI* as a state variable, see Tables A8 and A9.

to-market (Size-B/M), and size and momentum (Size-Mom). Important long-run covariance risks are different between the World and US portfolios. We find that the long-run covariance risk with HML is positively linked to the expected returns for the World, World excluding US and European portfolios. In contrast, the long-run risk with UMD is negatively related to the expected return for the World and World excluding US portfolios. These results stem from the fact that the long-run covariances provide sufficient dispersion in explaining the expected returns on the test portfolios, which is a contrast to the long-run covariances with the market return. Moreover, we observe that the covariance risk with CMA plays an important role for the US portfolios. These findings are linked to those of Fama and French (2015) and Hou et al. (2015) who report that investment factors drive out HML.

We also observe that long-run value premiums become weaker after the COVID-19 pandemic period. Value firms are burdened with more unproductive real capital and economic recessions have more impacts on value firms (Zhang, 2005). Our results uncover that the recession triggered by the pandemic is different from that triggered by the global financial crisis, and hence the normal mechanism that generates the value premiums does not function. This finding is related to the work of Arnott et al. (2021) who present that the importance of the intangible assets causes a decline of traditional value premiums. Our results pose the problem that the pandemic impact on the value premiums is persistent. We reveal that our results are robust after controlling for macroeconomic and economic policy uncertainty effects.

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Table 1 Risk return trade-off: Market factor

Panel A	Size-B/M							
	MKT		Wald			Size-Mom MKT		Wald	
World	-0.04		107.39	***	World	0.65	***	135.71	***
	(0.16)		[0.00]			(0.11)		[0.00]	
US	-0.09	*	99.02	***	US	0.27	***	48.97	***
	(0.05)		[0.00]			(0.07)		[0.00]	
World ex US	0.04		77.07	***	World ex US	0.30	**	169.71	***
	(0.11)		[0.00]			(0.14)		[0.00]	
EU	-0.09		60.19	***	EU	0.04		157.01	***
	(0.11)		[0.00]			(0.09)		[0.00]	
Japan	-0.05		32.56	***	Japan	0.13		36.93	*
	(0.14)		[0.14]			(0.15)		[0.06]	
Asia-Pacific	0.10		81.23	***	Asia-Pacific	0.61	***	163.95	***
	(0.15)		[0.00]			(0.19)		[0.00]	

Panel B	Risk premium MKT		MKT
World		World	1.45
US	-0.21	US	0.62
World ex US		World ex US	0.75
EU		EU	
Japan		Japan	
Asia-Pacific		Asia-Pacific	2.62

Notes: This table shows the common slope estimate A using the system of Equation (1) and standard errors are reported in parentheses of Panel A. We report the long-run risk premium estimated by Equation (10) in Panel B. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. We employ a market factor. The long-run covariance matrix is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the p-values are reported in brackets of Panel A. The test portfolios are the 25 size and book-to-market (Size-B/M), and size and momentum (Size-mom) portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 2 Risk return trade-off: Four-factor model

Panel A	Size-B/M				
	MKT	SMB	HML	UMD	Wald
World	-0.01	0.26	0.55	-2.32 *	100.11 ***
	(0.17)	(0.30)	(0.41)	(1.19)	[0.00]
US	-0.17 **	0.09	0.16	0.02	96.98 ***
	(0.08)	(0.19)	(0.13)	(0.07)	[0.00]
World ex US	-0.29	-0.29	1.12 ***	-0.92 ***	173.04 ***
	(0.19)	(0.49)	(0.43)	(0.23)	[0.00]
EU	-0.15	0.25	0.65	-0.90	58.33 ***
	(0.22)	(0.55)	(0.44)	(1.17)	[0.00]
Japan	-0.03	-0.03	0.46	0.35	31.45
	(0.16)	(0.36)	(0.39)	(0.23)	[0.17]
Asia-Pacific	0.27	0.46	0.34	-0.70	79.22 ***
	(0.21)	(0.47)	(0.50)	(0.48)	[0.00]

Panel B	Risk premium			
	MKT	SMB	HML	UMD
World				-4.33
US	-0.39			
World ex US			0.68	-1.40
EU				
Japan				
Asia-Pacific				

Panel C	Size-Mom				
	MKT	SMB	HML	UMD	Wald
World	0.50 ***	-0.01	0.73 **	-0.36	128.42 ***
	(0.13)	(0.31)	(0.37)	(0.24)	[0.00]
US	0.21 **	0.14	0.09	-0.16	51.65 ***
	(0.11)	(0.31)	(0.22)	(0.21)	[0.00]
World ex US	-0.08	-1.00 *	0.60 *	-1.05 ***	173.04 ***
	(0.23)	(0.52)	(0.36)	(0.27)	[0.00]
EU	-0.19	-0.51	0.52	-2.01 **	165.94 ***
	(0.17)	(0.53)	(0.41)	(0.90)	[0.00]
Japan	0.06	-0.46	0.09	-0.08	37.95 **
	(0.16)	(0.30)	(0.30)	(0.10)	[0.05]
Asia-Pacific	0.84 ***	0.30	1.62 *	-1.99 ***	173.59 ***
	(0.26)	(0.50)	(0.95)	(0.41)	[0.00]

Panel D	Risk premium			
	MKT	SMB	HML	UMD
World	1.12		0.54	
US	0.49			
World ex US		-0.46	0.37	-1.60
EU				-3.84
Japan				
Asia-Pacific	3.63		1.89	-4.64

Notes: This table shows the common slope estimates A, S_1, S_2, S_3 and constant terms C using the system of Equation (11) and standard errors are reported in parentheses of Panels A and C. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We report the long-run risk premium estimated by Equation (10) in Panels B and D. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, and size and momentum portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 3 Four-factor model and excluding the COVID-19 period

Panel A	Size-B/M				
	MKT	SMB	HML	UMD	Wald
World	-0.08	0.02	0.81 **	-4.90 ***	109.80 ***
	(0.18)	(0.34)	(0.42)	(1.30)	[0.00]
US	-0.22 ***	0.13	0.13	-0.09	99.49 ***
	(0.08)	(0.19)	(0.14)	(0.07)	[0.00]
World ex US	-0.47 **	-0.53	1.34 ***	-1.01 ***	82.22 ***
	(0.21)	(0.51)	(0.45)	(0.23)	[0.00]
EU	-0.07	0.43	0.84 *	-1.69	64.59 ***
	(0.25)	(0.61)	(0.46)	(1.21)	[0.00]
Japan	-0.05	-0.15	0.70 *	0.33	33.88
	(0.16)	(0.37)	(0.40)	(0.23)	[0.11]
Asia-Pacific	0.15	0.28	0.64	-0.56	81.83 ***
	(0.21)	(0.47)	(0.51)	(0.48)	[0.00]

Panel B	Risk premium			
	MKT	SMB	HML	UMD
World			0.55	-9.19
US	-0.49			
World ex US	-1.14		0.76	-1.53
EU			0.61	
Japan			0.71	
Asia-Pacific				

Panel C	Size-Mom				
	MKT	SMB	HML	UMD	Wald
World	0.35 ***	-0.11	1.06 ***	-0.58 **	141.36 ***
	(0.13)	(0.32)	(0.40)	(0.25)	[0.00]
US	0.02	-0.36	0.20	-0.23	69.54 ***
	(0.13)	(0.34)	(0.26)	(0.16)	[0.00]
World ex US	-0.16	-1.19 **	0.62 *	-1.12 ***	177.34 ***
	(0.24)	(0.53)	(0.37)	(0.27)	[0.00]
EU	-0.34	-0.74	0.83 *	-2.35 **	171.16 ***
	(0.21)	(0.60)	(0.42)	(0.94)	[0.00]
Japan	0.09	-0.38	0.18	-0.12	38.44 **
	(0.16)	(0.31)	(0.31)	(0.10)	[0.04]
Asia-Pacific	0.70 ***	0.05	2.01 **	-2.08 ***	174.56 ***
	(0.27)	(0.50)	(0.98)	(0.42)	[0.00]

Panel D	Risk premium			
	MKT	SMB	HML	UMD
World	0.75		0.72	-1.09
US				
World ex US		-0.54	0.35	-1.70
EU			0.61	-4.50
Japan				
Asia-Pacific	2.94		2.25	-4.87

Notes: This table shows the common slope estimates A, S_1, S_2, S_3 and constant terms C using the system of Equation (11) and standard errors are reported in parentheses of Panels A and C. We report the long-run risk premium estimated by Equation (10) in Panels B and D. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, and size and momentum portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to December 2019 and excludes the COVID-19 period. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 4 Mean excess returns for the World portfolios: Crisis periods

Panel A: Global Financial Crisis						Panel B: COVID19					
	Low B/M	2	3	4	High B/M		Low B/M	2	3	4	High B/M
Small	-4.23	-2.94	-2.88	-2.76	-2.73	Small	1.51	0.32	-0.10	-0.84	-1.83
2	-2.54	-2.74	-2.64	-2.62	-2.41	2	1.46	0.35	-0.91	-1.23	-2.38
3	-2.76	-2.55	-2.07	-2.26	-2.36	3	1.51	1.00	-1.36	-1.70	-2.58
4	-2.19	-2.00	-2.13	-2.32	-2.45	4	1.89	1.17	-0.61	-1.76	-3.27
Big	-2.06	-1.81	-2.48	-2.79	-3.00	Big	2.84	1.06	-0.48	-2.06	-3.32
	Low OP	2	3	4	High OP		Low OP	2	3	4	High OP
Small	-3.95	-2.62	-2.74	-2.74	-2.63	Small	0.02	-1.54	-1.47	-0.82	-0.50
2	-2.64	-2.28	-2.84	-2.71	-2.46	2	-0.73	-1.44	-1.15	-0.63	-0.51
3	-2.68	-2.30	-2.25	-2.16	-2.35	3	-0.48	-1.09	-1.17	-0.74	-0.49
4	-2.37	-2.09	-2.29	-2.14	-2.11	4	0.58	-1.13	-0.85	-0.26	-0.40
Big	-3.13	-2.49	-2.88	-2.23	-1.67	Big	-1.02	-0.66	-0.80	0.96	1.60
	Low Inv	2	3	4	High Inv		Low Inv	2	3	4	High Inv
Small	-3.66	-3.10	-3.47	-3.89	-4.35	Small	-0.41	-1.27	-1.33	-0.97	0.11
2	-3.26	-2.68	-3.21	-3.52	-4.12	2	-1.72	-2.08	-1.28	-0.45	0.06
3	-3.09	-2.77	-2.93	-3.49	-3.79	3	-1.32	-1.62	-1.77	-0.84	0.85
4	-3.04	-2.58	-2.94	-2.94	-3.53	4	-0.92	-1.97	-1.09	-0.58	2.37
Big	-2.66	-2.55	-3.06	-3.10	-3.28	Big	0.37	-1.04	-0.44	0.98	2.55
	Low Mom	2	3	4	High Mom		Low Mom	2	3	4	High Mom
Small	-4.78	-3.79	-3.35	-2.96	-3.63	Small	-0.76	-1.08	-0.94	-0.82	1.46
2	-3.83	-3.38	-3.00	-3.07	-3.39	2	-1.19	-1.32	-1.29	-0.74	1.21
3	-3.81	-3.30	-3.10	-3.11	-3.33	3	-1.56	-1.31	-1.43	0.02	0.98
4	-3.91	-3.11	-2.89	-2.77	-2.85	4	-2.10	-1.01	-0.41	-0.14	1.26
Big	-4.58	-2.77	-2.37	-2.61	-2.73	Big	-2.59	-1.02	-0.13	0.67	2.50

Notes: This table presents monthly mean excess returns for World portfolios during the global financial crisis and COVID19 periods. We consider 25 test portfolios sorted by size and book-to-market, size and operating profitability, size and investment and size and momentum. All returns are calculated using the U.S. dollars and the U.S. one-month Treasury-Bill yield is used as the risk-free rate. The global financial crisis period covers from August 2007 to March 2008 (Bekaert et al., 2014) and the COVID19 period covers from February 2020 to July 2020.

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Table 5 Risk return trade-off: Five-factor model

Panel A	Size-B/M					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.16	-0.01	0.51	2.05 *	-0.02	99.13 ***
	(0.21)	(0.27)	(0.39)	(1.08)	(0.56)	[0.00]
US	-0.12	-0.12	0.07	-0.17	1.82 ***	103.91 ***
	(0.11)	(0.20)	(0.15)	(0.40)	(0.52)	[0.00]
World ex US	0.00	-0.54	0.77 **	0.63	0.40	81.60 ***
	(0.20)	(0.47)	(0.38)	(1.39)	(0.49)	[0.00]
EU	-0.17	0.30	0.81 *	0.11	-0.34	69.18 ***
	(0.23)	(0.56)	(0.44)	(0.53)	(0.34)	[0.00]
Japan	-0.09	-0.03	0.49	0.20	-0.63	33.15
	(0.16)	(0.37)	(0.40)	(0.89)	(0.41)	[0.13]
Asia-Pacific	0.34	0.32	1.20 **	1.60 **	-0.11	73.73 ***
	(0.25)	(0.48)	(0.60)	(0.69)	(0.78)	[0.00]

Panel B	Risk premium				
	MKT	SMB	HML	RMW	CMA
World				0.53	
US					0.93
World ex US			0.44		
EU			0.59		
Japan					
Asia-Pacific			1.35	1.43	

Panel C	Size-Mom					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.60 ***	-0.38	0.76 **	-0.08	0.89 **	122.29 ***
	(0.15)	(0.33)	(0.34)	(0.77)	(0.39)	[0.00]
US	0.28 **	-0.09	0.03	-0.63	3.05 *	49.04 ***
	(0.14)	(0.32)	(0.22)	(0.45)	(1.42)	[0.00]
World ex US	-0.11	-1.56 ***	0.78 **	2.86 **	0.63	181.24 ***
	(0.22)	(0.52)	(0.33)	(1.21)	(0.43)	[0.00]
EU	-0.22	-0.63	0.62	0.20	0.14	170.51 ***
	(0.18)	(0.53)	(0.42)	(0.58)	(0.31)	[0.00]
Japan	0.13	-0.49 *	0.12	0.52	0.26	39.23 **
	(0.18)	(0.29)	(0.31)	(0.97)	(0.71)	[0.03]
Asia-Pacific	-0.27	-0.52	-1.58 **	0.39	0.72 *	114.21 ***
	(0.27)	(0.57)	(0.65)	(0.73)	(0.42)	[0.00]

Panel D	Risk premium				
	MKT	SMB	HML	RMW	CMA
World	1.26		0.52		0.38
US	0.62				1.56
World ex US		-0.71	0.44	-1.40	
EU					
Japan		-0.53			
Asia-Pacific			-1.77		0.50

Notes: This table shows the common slope estimates A, S_1, S_2, S_3, S_4 and constant terms C using the system of Equation (12) and standard errors are reported in parentheses of Panels A and C. We report the long-run risk premium estimated by Equation (10) in Panels B and D. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. We employ four factors: market (MKT), size (SML), value (HML), profitability (RMW) and investment (CMA) factors (Fama and French, 2015). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 6 Five-factor model excluding the COVID-19 period

Panel A	Size-B/M					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.04	-0.05	0.80 *	1.73	-0.06	106.84 ***
	(0.22)	(0.29)	(0.42)	(1.12)	(0.53)	[0.00]
US	-0.18 *	-0.09	0.12	-0.38	1.88 ***	117.08 ***
	(0.11)	(0.20)	(0.15)	(0.40)	(0.51)	[0.00]
World ex US	-0.24	-0.83 *	0.88 **	-0.43	0.17	86.16 ***
	(0.22)	(0.49)	(0.42)	(1.41)	(0.47)	[0.00]
EU	-0.20	0.32	1.12 **	0.13	-0.61 *	77.57 ***
	(0.25)	(0.61)	(0.47)	(0.54)	(0.32)	[0.00]
Japan	-0.13	-0.17	0.67	-0.28	-0.67	35.92 *
	(0.16)	(0.37)	(0.41)	(0.91)	(0.41)	[0.07]
Asia-Pacific	0.14	0.19	1.16 *	0.75	-0.30	78.36 ***
	(0.25)	(0.48)	(0.60)	(0.71)	(0.79)	[0.00]
Panel B	Risk premium					
	MKT	SMB	HML	RMW	CMA	
World			0.54			
US	-0.40				0.96	
World ex US		-0.38	0.50			
EU			0.82		-0.25	
Japan						
Asia-Pacific			1.30			
Panel A	Size-Mom					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.43 ***	-0.50	1.18 ***	0.15	0.59	129.59 ***
	(0.15)	(0.34)	(0.38)	(0.80)	(0.37)	[0.00]
US	-0.03	-0.16	0.42 *	-1.30 *	2.76 **	66.83 ***
	(0.16)	(0.32)	(0.24)	(0.54)	(1.41)	[0.00]
World ex US	-0.22	-1.79 ***	0.82 **	2.85 **	0.50	185.80 ***
	(0.23)	(0.54)	(0.35)	(1.21)	(0.40)	[0.00]
EU	-0.51 **	-1.14 *	1.01 **	0.35	-0.12	175.06 ***
	(0.21)	(0.61)	(0.43)	(0.59)	(0.28)	[0.00]
Japan	0.18	-0.45	0.23	0.45	0.36	40.55 **
	(0.18)	(0.31)	(0.32)	(0.97)	(0.72)	[0.03]
Asia-Pacific	-0.42	-0.71	-1.32 **	0.39	0.62	113.42 ***
	(0.27)	(0.56)	(0.68)	(0.77)	(0.43)	[0.00]
Panel B	Risk premium					
	MKT	SMB	HML	RMW	CMA	
World	0.92		0.80			
US			0.46	-1.14	1.41	
World ex US		-0.82	0.47	0.63		
EU	-1.43	-0.63	0.74			
Japan						
Asia-Pacific			-1.48			

Notes: This table shows the common slope estimates A, S_1, S_2, S_3, S_4 and constant terms C using the system of Equation (12) and standard errors are reported in parentheses of Panels A and C. We report the long-run risk premium estimated by Equation (10) in Panels B and D. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. We employ four factors: market (MKT), size (SML), value (HML), profitability (RMW) and investment (CMA) factors (Fama and French, 2015). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to December 2019 and excludes the COVID-19 period. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table 7 summary of results

Panel A: Four factor model

	All periods				Excluding COVID-19			
	MKT	SMB	HML	UMD	MKT	SMB	HML	UMD
World				◎			◎	○
US								
World ex US			○	◎			○	◎
EU							◎	
Japan								
Asia-Pacific				○				○

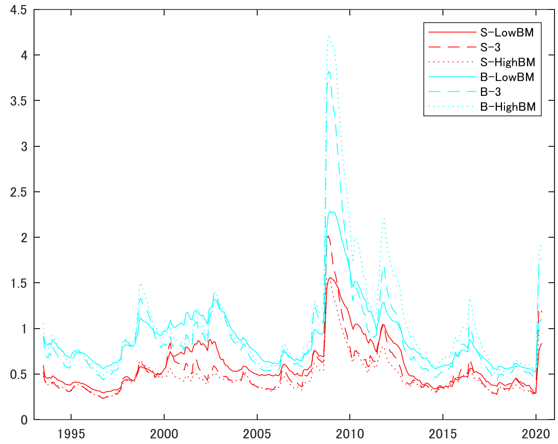
Panel B: Five factor model

	All periods					Excluding COVID-19				
	MKT	SMB	HML	RMW	CMA	MKT	SMB	HML	RMW	CMA
World								◎		
US					◎					◎
World ex US							◎			
EU								◎		
Japan										
Asia-Pacific										

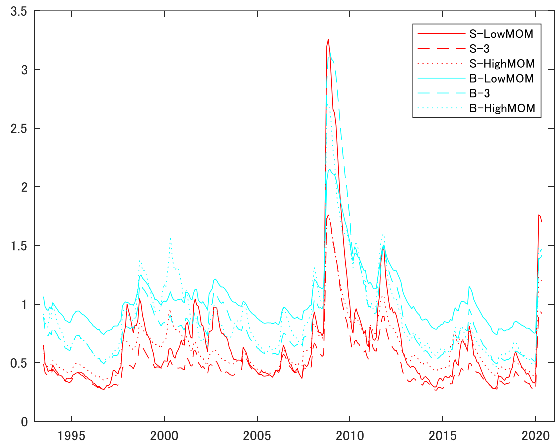
Notes: This table shows the summary of four and five factor model results. The single circle (○) indicates that three out of four parameter estimates are statistically significant at least at the 10% level and the double circle (◎) indicates that all parameter estimates are statistically significant at least at the 10% level. The grey areas mean that the parameter estimates are negatively linked to the expected returns. We use four types of the test portfolios: 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. All periods cover from August 1993 to June 2020 and the excluding COVID-19 periods cover from August 1993 to December 2019.

Figure 1 Long-run conditional covariances with the market factor

Size-B/M



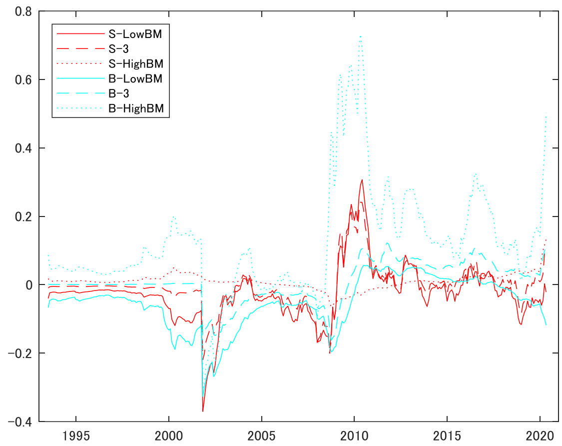
Size-MOM



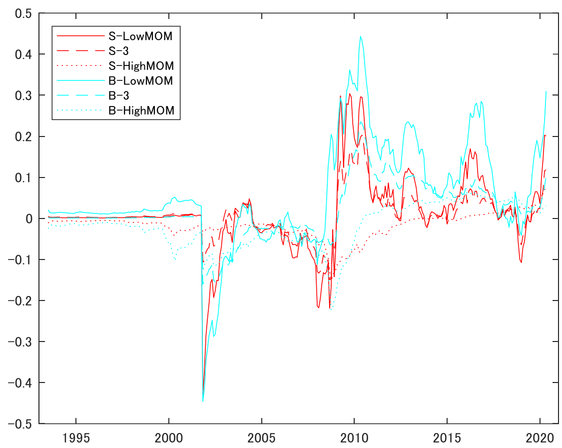
Notes: This figure illustrates the long-run conditional covariance with the market factor for the World ex US portfolios. The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The upper panel shows the results for the portfolios sorted by Size-B/M, and the lower panel does the results for the portfolios sorted by Size-Mom.

Figure 2 Long-run conditional covariances with the HML factor

Size-B/M



Size-MOM



Notes: This figure illustrates the long-run conditional covariance with the HML factor for the World ex US portfolios. The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The upper panel shows the results for the portfolios sorted by Size-B/M, and the lower panel does the results for the portfolios sorted by Size-Mom.

The long-run risk premium in the ICAPM: International evidence

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A1. DCC-MIDAS model

Let $\boldsymbol{r}_t \sim N(\mu, H_t)$ be the $n \times 1$ return vector of portfolios and μ is the vector of unconditional mean and H_t is the conditional covariance matrix. We follow Engle (2002) and H_t is decomposed as $H_t = D_t R_t D_t$, where D_t is the diagonal matrix with standard deviations of returns on the diagonal and R_t is the conditional correlation matrix of the standardised return residuals and written as:

$$D_t \xi_t = (\boldsymbol{r}_t - \mu) \tag{A1}$$

$$R_t = E_{t-1}[\xi_t \xi_t'] \tag{A2}$$

The conditional correlation R_t is decomposed as:

$$R_t = \text{diag}(Q_t)^{-\frac{1}{2}} Q_t \text{diag}(Q_t)^{-\frac{1}{2}} \tag{A3}$$

The element of Q_t is obtained as Equation (6).

A2. Beta weights

Following Colacito et al. (2011), we use a Beta weight scheme for Equations (4) and (7) and it is denoted as:

$$\varphi_k(w) = \frac{\left(1 - \frac{L}{k}\right)^{w-1}}{\sum_{j=1}^{k} \left(1 - \frac{j}{k}\right)^{w-1}}$$

where L is the number of lags for the weighting function.

Table A1 Mean excess returns for the 25 global and regional test portfolios

Panel A: Size-B/M

World

	Low B/M	2	3	4	High B/M
Small	0.12	0.39	0.60	0.60	0.83
2	0.25	0.46	0.48	0.54	0.58
3	0.39	0.45	0.52	0.55	0.58
4	0.60	0.52	0.53	0.53	0.53
Big	0.54	0.53	0.48	0.47	0.44

World ex US

	Low B/M	2	3	4	High B/M
Small	0.10	0.30	0.44	0.56	0.79
2	0.04	0.30	0.42	0.52	0.55
3	0.25	0.38	0.33	0.43	0.57
4	0.36	0.40	0.44	0.47	0.38
Big	0.24	0.40	0.38	0.42	0.37

US

	Low B/M	2	3	4	High B/M
Small	0.33	0.88	0.77	0.96	0.93
2	0.68	0.87	0.80	0.72	0.77
3	0.69	0.84	0.75	0.82	0.81
4	0.89	0.86	0.71	0.76	0.65
Big	0.83	0.69	0.75	0.37	0.58

Europe

	Low B/M	2	3	4	High B/M
Small	0.12	0.41	0.50	0.65	0.79
2	0.35	0.56	0.57	0.71	0.80
3	0.53	0.69	0.60	0.66	0.72
4	0.70	0.64	0.61	0.60	0.63
Big	0.46	0.58	0.53	0.61	0.42

Japan

	Low B/M	2	3	4	High B/M
Small	0.26	0.33	0.41	0.32	0.46
2	0.16	-0.05	0.07	0.26	0.19
3	-0.07	-0.02	0.04	0.07	0.23
4	-0.09	0.08	0.08	0.13	0.11
Big	-0.02	0.05	0.06	0.15	0.34

Asia-Pacific

	Low B/M	2	3	4	High B/M
Small	0.28	0.28	0.45	0.67	1.14
2	-0.20	0.03	0.08	0.43	0.67
3	-0.04	0.24	0.50	0.54	0.67
4	0.60	0.59	0.53	0.73	0.79
Big	0.51	0.71	0.71	0.57	0.68

Panel B: Size-OP

World

	Low OP	2	3	4	High OP
Small	0.45	0.76	0.76	0.82	0.85
2	0.26	0.52	0.59	0.63	0.77
3	0.30	0.52	0.64	0.61	0.67
4	0.35	0.55	0.60	0.64	0.64
Big	0.03	0.36	0.51	0.59	0.65

World ex US

	Low OP	2	3	4	High OP
Small	0.33	0.63	0.73	0.82	0.90
2	0.16	0.42	0.49	0.57	0.68
3	0.20	0.42	0.49	0.51	0.60
4	0.17	0.39	0.50	0.55	0.53
Big	-0.03	0.28	0.42	0.42	0.42

US

	Low OP	2	3	4	High OP
Small	0.67	0.94	0.82	0.83	0.72
2	0.59	0.70	0.85	0.88	0.98
3	0.66	0.72	0.77	0.80	0.93
4	0.63	0.79	0.79	0.86	0.93
Big	0.25	0.57	0.63	0.77	0.80

Europe

	Low OP	2	3	4	High OP
Small	0.28	0.73	0.79	0.93	0.80
2	0.34	0.63	0.67	0.79	1.02
3	0.35	0.71	0.82	0.65	0.88
4	0.34	0.59	0.69	0.82	0.79
Big	0.20	0.51	0.52	0.51	0.64

Japan

	Low OP	2	3	4	High OP
Small	0.27	0.43	0.37	0.38	0.67
2	0.01	0.15	0.21	0.24	0.26
3	0.04	0.04	0.12	0.12	0.17
4	-0.12	0.05	0.18	0.22	0.08
Big	-0.05	-0.01	0.15	0.08	0.11

Asia-Pacific

	Low OP	2	3	4	High OP
Small	0.50	0.99	0.95	0.88	0.97
2	-0.06	0.41	0.48	0.56	0.61
3	0.03	0.61	0.41	0.79	0.64
4	0.34	0.64	0.64	0.76	0.84
Big	0.48	0.57	0.67	0.83	0.60

Notes: See the next page.

Table A1 Continued

Panel C: Size-Inv

World

	Low Inv	2	3	4	High Inv
Small	0.72	0.80	0.76	0.71	0.31
2	0.53	0.62	0.58	0.57	0.23
3	0.58	0.56	0.64	0.57	0.25
4	0.58	0.63	0.57	0.60	0.42
Big	0.55	0.46	0.51	0.49	0.48

World ex US

	Low Inv	2	3	4	High Inv
Small	0.60	0.67	0.73	0.66	0.33
2	0.39	0.58	0.52	0.44	0.19
3	0.46	0.52	0.46	0.39	0.26
4	0.42	0.43	0.47	0.46	0.34
Big	0.33	0.37	0.31	0.34	0.36

US

	Low Inv	2	3	4	High Inv
Small	1.05	0.96	1.00	0.77	0.37
2	0.80	0.80	0.89	0.88	0.54
3	0.85	0.80	0.81	0.82	0.65
4	0.81	0.78	0.86	0.90	0.76
Big	0.80	0.65	0.69	0.80	0.77

Europe

	Low Inv	2	3	4	High Inv
Small	0.58	0.75	0.74	0.70	0.31
2	0.62	0.75	0.76	0.69	0.46
3	0.69	0.67	0.73	0.58	0.49
4	0.62	0.61	0.72	0.72	0.55
Big	0.52	0.57	0.46	0.45	0.54

Japan

	Low Inv	2	3	4	High Inv
Small	0.34	0.30	0.47	0.33	0.46
2	0.16	0.14	0.17	0.23	0.06
3	0.10	0.12	0.09	0.07	0.03
4	0.08	0.08	0.16	-0.01	0.11
Big	-0.03	0.00	-0.03	0.12	0.05

Asia-Pacific

	Low Inv	2	3	4	High Inv
Small	0.82	1.00	0.96	0.89	0.33
2	0.30	0.66	0.55	0.49	-0.18
3	0.38	0.79	0.56	0.61	0.01
4	0.47	0.65	0.77	0.75	0.47
Big	0.80	0.66	0.54	0.62	0.50

Panel D: Size-Mom

World

	Low Mom	2	3	4	High Mom
Small	-0.05	0.55	0.76	0.98	1.26
2	0.11	0.49	0.58	0.77	0.97
3	0.24	0.47	0.55	0.63	0.84
4	0.20	0.49	0.59	0.59	0.86
Big	0.13	0.45	0.51	0.61	0.69

World ex US

	Low Mom	2	3	4	High Mom
Small	-0.25	0.46	0.69	0.97	1.28
2	-0.14	0.31	0.50	0.69	0.94
3	-0.06	0.28	0.39	0.64	0.82
4	0.04	0.36	0.45	0.47	0.81
Big	-0.03	0.23	0.43	0.51	0.47

US

	Low Mom	2	3	4	High Mom
Small	0.36	0.66	0.90	1.06	1.26
2	0.54	0.84	0.87	0.92	1.10
3	0.56	0.77	0.78	0.72	0.95
4	0.33	0.76	0.85	0.83	0.95
Big	0.33	0.67	0.67	0.73	0.83

Europe

	Low Mom	2	3	4	High Mom
Small	-0.35	0.41	0.71	1.02	1.63
2	-0.12	0.47	0.71	1.02	1.37
3	0.07	0.51	0.66	0.91	1.14
4	0.15	0.59	0.69	0.80	1.11
Big	0.09	0.45	0.59	0.68	0.70

Japan

	Low Mom	2	3	4	High Mom
Small	0.36	0.47	0.48	0.56	0.36
2	0.07	0.09	0.19	0.25	0.30
3	0.11	0.01	0.07	0.19	0.20
4	0.13	0.12	0.04	0.04	0.24
Big	-0.06	-0.11	-0.11	0.09	0.20

Asia-Pacific

	Low Mom	2	3	4	High Mom
Small	-0.01	0.66	0.98	1.42	1.37
2	-0.73	0.38	0.54	0.82	0.99
3	-0.26	0.38	0.57	0.87	0.83
4	0.14	0.49	0.64	0.71	0.77
Big	0.78	0.55	0.73	0.76	0.78

Notes: This table presents monthly mean excess returns for global and regional portfolios. We consider World, World excluding US, US, Europe, Japan and Asia Pacific as in Fama and French (2012, 2017). Each region has 25 test portfolios sorted by size and book-to-market (Panel A), size and operating profitability (Panel B), size and investment (Panel C) and size and momentum (Panel D). All returns are calculated using the U.S. dollars and the U.S. one-month Treasury-Bill yield is used as the risk-free rate. The sample period covers from August 1993 to June 2020 (323 months).

Table A2 Four-factor model: Size-OP and Size-Inv

Panel A	Size-OP								
	MKT		SMB		HML		UMD		Wald
World	0.10		-0.10		0.36		-2.32	**	92.27 ***
	(0.20)		(0.33)		(0.47)		(1.13)		[0.00]
US	0.13		-0.24		0.09		-0.17		58.43 ***
	(0.13)		(0.32)		(0.23)		(0.16)		[0.00]
World ex US	-0.21		-0.61		0.82	**	-1.42	***	118.43 ***
	(0.22)		(0.49)		(0.43)		(0.32)		[0.00]
EU	-0.04		0.44		1.27	**	-1.20		157.47 ***
	(0.24)		(0.56)		(0.50)		(1.17)		[0.00]
Japan	0.17		-0.11		0.33		0.26	*	35.48 *
	(0.15)		(0.43)		(0.31)		(0.14)		[0.08]
Asia-Pacific	0.78	***	1.23	**	0.19		-4.11	***	90.52 ***
	(0.24)		(0.48)		(0.57)		(0.83)		[0.00]
Panel B	Size-Inv								
	MKT		SMB		HML		UMD		Wald
World	-0.03		-0.23		0.46		-2.41	***	124.75 ***
	(0.13)		(0.33)		(0.32)		(0.70)		[0.00]
US	0.32	*	-0.77	**	-0.67	**	-5.25	***	76.33 ***
	(0.17)		(0.37)		(0.31)		(1.12)		[0.00]
World ex US	-0.16		-0.45		0.58		-1.46	***	101.09 ***
	(0.21)		(0.50)		(0.63)		(0.36)		[0.00]
EU	-0.52	**	-0.81		0.75	*	0.25		55.35 ***
	(0.26)		(0.61)		(0.45)		(1.31)		[0.00]
Japan	0.01		-0.30		0.08		-0.09		27.67
	(0.11)		(0.38)		(0.29)		(0.17)		[0.32]
Asia-Pacific	-0.27		-0.42		-2.15	***	-3.39	***	133.12 ***
	(0.27)		(0.59)		(0.68)		(0.88)		[0.00]

Notes: This table shows the common slope estimates A, S_1, S_2, S_3 and constant terms C using the system of Equation (11) and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts,$C_i$equal zero and the p-values are reported in brackets. The test portfolios are the 25 size and operating profitability, and size and investment portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A3 Four-factor model: Size-OP, Size-Inv and excluding the COVID19 period

Panel A	Size-OP				
	MKT	SMB	HML	UMD	Wald
World	-0.12	-0.12	0.85 *	-1.73	99.95 ***
	(0.22)	(0.37)	(0.49)	(1.19)	[0.00]
US	0.02	-0.36	0.20	-0.23	69.54 ***
	(0.13)	(0.34)	(0.26)	(0.16)	[0.00]
World ex US	-0.49 *	-1.11 **	0.82 *	-1.38 ***	143.02 ***
	(0.24)	(0.51)	(0.44)	(0.32)	[0.00]
EU	-0.20	0.13	1.52 ***	-1.21	177.01 ***
	(0.27)	(0.62)	(0.51)	(1.19)	[0.00]
Japan	0.10	-0.32	0.39	0.27 *	38.78 **
	(0.15)	(0.44)	(0.31)	(0.14)	[0.04]
Asia-Pacific	0.80 ***	1.14 **	0.25	-4.17 ***	93.33 ***
	(0.24)	(0.47)	(0.57)	(0.84)	[0.00]
Panel B	**Size-Inv**				
	MKT	SMB	HML	UMD	Wald
World	-0.05	-0.32	0.83 **	-3.14 ***	129.86 ***
	(0.14)	(0.37)	(0.35)	(0.74)	[0.00]
US	0.15	-0.67 *	-0.13	-4.69 ***	81.47 ***
	(0.18)	(0.37)	(0.34)	(1.21)	[0.00]
World ex US	-0.29	-0.70	0.48	-1.39 ***	106.40 ***
	(0.23)	(0.54)	(0.65)	(0.36)	[0.00]
EU	-0.54 *	-0.86	0.85 *	0.00	56.25 ***
	(0.28)	(0.66)	(0.47)	(1.36)	[0.00]
Japan	-0.07	-0.51	0.16	-0.11	32.49
	(0.12)	(0.39)	(0.30)	(0.17)	[0.14]
Asia-Pacific	-0.38	-0.63	-1.76 **	-3.55 ***	133.38 ***
	(0.28)	(0.58)	(0.71)	(0.89)	[0.00]

Notes: This table shows the common slope estimates A, S_1, S_2, S_3 and constant terms C using the system of Equation (11) and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts,$C_i$equal zero and the p-values are reported in brackets. The test portfolios are the 25 size and operating profitability, and size and investment portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to December 2019, and excludes the COVID-19 period. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A4 Five-factor model: Size-OP and Size-Inv

Panel A	Size-OP					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.32	-0.21	0.43	2.27 **	0.41	68.05 ***
	(0.22)	(0.31)	(0.46)	(1.01)	(0.52)	[0.00]
US	0.72 ***	-0.64 *	-0.43 *	1.51 ***	5.08 ***	47.20 ***
	(0.17)	(0.33)	(0.26)	(0.47)	(1.35)	[0.00]
World ex US	-0.04	-0.71	0.57	0.60	0.97 **	110.22 ***
	(0.22)	(0.48)	(0.42)	(0.94)	(0.47)	[0.00]
EU	-0.22	-0.63	0.62	0.20	0.14	170.51 ***
	(0.18)	(0.53)	(0.42)	(0.58)	(0.31)	[0.00]
Japan	0.13	-0.49 *	0.12	0.52	0.26	39.23 **
	(0.18)	(0.29)	(0.31)	(0.97)	(0.71)	[0.03]
Asia-Pacific	-0.27	-0.52	-1.58 **	0.39	0.72 *	114.21 ***
	(0.27)	(0.57)	(0.65)	(0.73)	(0.42)	[0.00]
Panel B	Size-Inv					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.16	-0.20	0.50 *	1.31	0.55	111.88 ***
	(0.14)	(0.31)	(0.29)	(0.86)	(0.44)	[0.00]
US	0.27	-0.68 *	-0.49	-0.28	4.25 ***	72.39 ***
	(0.18)	(0.37)	(0.30)	(0.60)	(0.91)	[0.00]
World ex US	0.05	-0.69	0.28	2.21	0.70	89.37 ***
	(0.22)	(0.50)	(0.61)	(1.49)	(0.45)	[0.00]
EU	-0.47 *	-1.02	0.80 *	1.06	0.91 ***	60.49 ***
	(0.26)	(0.63)	(0.45)	(0.68)	(0.34)	[0.00]
Japan	0.05	-0.20	0.12	0.78	-0.23	26.06
	(0.14)	(0.38)	(0.29)	(0.86)	(0.63)	[0.40]
Asia-Pacific	-0.42	-0.42 *	-1.06	0.82	-0.88 ***	116.88 ***
	(0.31)	(0.57)	(0.73)	(0.81)	(0.72)	[0.00]

Notes: This table shows the common slope estimates A, S_1, S_2, S_3, S_4 and constant terms C using the system of Equation (12) and standard errors are reported in parentheses. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. We employ four factors: market (MKT), size (SML), value (HML), profitability (RMW) and investment (CMA) factors (Fama and French, 2015). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the p-values are reported in brackets. The test portfolios are the 25 size and operating profitability, and size and investment portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A5 Five-factor model: Size-OP, Size-Inv excluding the COVID19 period

Panel A	Size-OP					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.12	-0.19	0.87 *	1.62	0.20	78.95 ***
	(0.25)	(0.33)	(0.49)	(1.06)	(0.48)	[0.00]
US	0.51 ***	-0.63 *	-0.19	0.94	5.09 ***	58.13 ***
	(0.19)	(0.35)	(0.29)	(0.58)	(1.40)	[0.00]
World ex US	-0.41	-1.34 ***	0.65	0.72	0.75 *	135.55 ***
	(0.22)	(0.49)	(0.41)	(0.95)	(0.42)	[0.00]
EU	-0.24	-0.02	1.58 ***	0.34	0.21	175.04 ***
	(0.28)	(0.67)	(0.56)	(0.89)	(0.32)	[0.00]
Japan	0.05	-0.39	0.34	0.56	-0.03	35.43 *
	(0.16)	(0.44)	(0.31)	(0.83)	(0.36)	[0.08]
Asia-Pacific	0.30	0.70	0.47	-0.33	-0.76	94.73 ***
	(0.30)	(0.46)	(0.68)	(0.69)	(0.77)	[0.00]
Panel C	Size-Inv					
	MKT	SMB	HML	RMW	CMA	Wald
World	0.18	-0.24	0.81 **	1.59	0.51	114.34 ***
	(0.19)	(0.32)	(0.34)	(1.00)	(0.41)	[0.00]
US	-0.01	-0.61	0.11	-0.55	3.67 ***	79.13 ***
	(0.21)	(0.38)	(0.33)	(0.68)	(0.94)	[0.00]
World ex US	-0.06	-0.95 *	0.25	2.15	0.66	95.58 ***
	(0.24)	(0.53)	(0.62)	(1.49)	(0.42)	[0.00]
EU	-0.56 **	-1.17	0.92 *	0.97	0.64 *	61.57 ***
	(0.28)	(0.68)	(0.48)	(0.69)	(0.34)	[0.00]
Japan	-0.03	-0.45	0.17	0.49	-0.14	29.79
	(0.14)	(0.40)	(0.29)	(0.86)	(0.63)	[0.23]
Asia-Pacific	-0.62 *	-0.58	-1.08	-0.04	-0.97	118.63 ***
	(0.32)	(0.56)	(0.74)	(0.84)	(0.72)	[0.00]

Notes: This table shows the common slope estimates A, S_1, S_2, S_3, S_4 and constant terms C using the system of Equation (12) and standard errors are reported in parentheses. The long-run risk premium is presented when the common slope estimate is statistically significant at least at the 10% level. We employ four factors: market (MKT), size (SML), value (HML), profitability (RMW) and investment (CMA) factors (Fama and French, 2015). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the p-values are reported in brackets. The test portfolios are the 25 size and operating profitability, and size and investment portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to December 2019, and excludes the COVID-19 period. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A6 Four-factor model with macroeconomic variables

Panel A	Size-B/M							
	MKT	SMB	HML	UMD	IP	short	term	Wald
World	-0.05	0.11	0.62	-2.36 **	0.02	0.00	0.15	105.19 ***
	(0.17)	(0.27)	(0.41)	(1.18)	(0.03)	(0.06)	(0.22)	[0.00]
US	-0.17 **	0.11	0.16	0.02	0.03	0.01	0.10	98.43 ***
	(0.08)	(0.19)	(0.13)	(0.07)	(0.03)	(0.05)	(0.12)	[0.00]
World ex US	-0.28	-0.37	1.12 **	-0.82 ***	0.03	-0.06	0.15	80.74 ***
	(0.19)	(0.48)	(0.43)	(0.22)	(0.03)	(0.06)	(0.24)	[0.00]
EU	-0.21	0.21	0.80 *	-0.86	0.00	-0.07	0.31	67.85 ***
	(0.22)	(0.55)	(0.44)	(1.16)	(0.03)	(0.06)	(0.24)	[0.00]
Japan	0.02	0.07	0.53	0.34	0.06 **	-0.33	0.72	39.56 **
	(0.16)	(0.34)	(0.37)	(0.22)	(0.03)	(1.08)	(0.45)	[0.03]
Asia-Pacific	0.26	0.33	0.34	-0.66	-	0.03	-0.21	84.55 ***
	(0.21)	(0.47)	(0.50)	(0.48)	-	(0.13)	(0.31)	[0.00]
Panel B	**Size-OP**							
	MKT	SMB	HML	UMD	IP	short	term	Wald
World	0.10	-0.20	0.35	-2.26 *	0.01	0.07	0.03	92.33 ***
	(0.20)	(0.31)	(0.47)	(1.11)	(0.03)	(0.05)	(0.19)	[0.00]
US	0.11	-0.26	0.08	-0.18	-0.02	-0.03	-0.07	61.82 ***
	(0.13)	(0.33)	(0.23)	(0.16)	(0.03)	(0.05)	(0.12)	[0.00]
World ex US	-0.22	-0.67	0.79 *	-1.43 ***	0.00	0.12 **	0.41 *	126.70 ***
	(0.21)	(0.48)	(0.44)	(0.32)	(0.03)	(0.05)	(0.23)	[0.00]
EU	-0.05	0.46	1.22 **	-1.72	0.01	-0.04	0.17	156.89 ***
	(0.24)	(0.56)	(0.49)	(1.14)	(0.03)	(0.05)	(0.23)	[0.00]
Japan	0.17	-0.25	0.32	0.21 *	0.01	-0.99	0.51	58.32 ***
	(0.15)	(0.40)	(0.30)	(0.13)	(0.03)	(0.80)	(0.42)	[0.00]
Asia-Pacific	0.67 ***	1.08 **	-0.19	-4.13 ***	-	0.10	0.03	86.32 ***
	(0.23)	(0.48)	(0.53)	(0.83)	-	(0.12)	(0.28)	[0.00]

Notes: See the next page.

Table A6 Continued

Panel C	Size-Inv														
	MKT		SMB		HML		UMD		IP		short		term		Wald
World	-0.04		-0.18		0.48		-2.25	***	0.01		0.02		0.10		123.45 ***
	(0.12)		(0.32)		(0.31)		(0.70)		(0.03)		(0.05)		(0.18)		[0.00]
US	0.29	*	-0.75	**	-0.59	*	-5.05	***	-0.03		0.00		-0.14	***	76.66 ***
	(0.16)		(0.37)		(0.30)		(1.10)		(0.03)		(0.05)		(0.12)		[0.00]
World ex US	-0.21		-0.50		0.57		-1.31	***	0.01		0.01		0.27		99.40 ***
	(0.22)		(0.50)		(0.64)		(0.36)		(0.03)		(0.05)		(0.21)		[0.00]
EU	-0.55	**	-0.81		0.82	*	0.06		0.00		0.02		0.33	*	56.89 ***
	(0.25)		(0.61)		(0.45)		(1.27)		(0.03)		(0.06)		(0.23)		[0.00]
Japan	-0.06		-0.39		0.08		-0.07		0.00		-1.14		0.58		41.45 **
	(0.12)		(0.33)		(0.27)		(0.15)		(0.03)		(0.72)		(0.42)		[0.02]
Asia-Pacific	-0.22		-0.42		-1.95	***	-3.46	***	-		0.09		-0.17		136.27 ***
	(0.27)		(0.59)		(0.63)		(0.88)		-		(0.14)		(0.27)		[0.00]
Panel D	Size-Mom														
	MKT		SMB		HML		UMD		IP		short		term		Wald
World	0.49	***	0.14		0.76	**	-0.44	*	0.02		-0.05		0.06		122.33 ***
	(0.13)		(0.30)		(0.37)		(0.24)		(0.03)		(0.04)		(0.19)		[0.00]
US	0.18	*	0.17		0.15		-0.17		-0.01		-0.09		-0.03		52.75 ***
	(0.10)		(0.31)		(0.22)		(0.22)		(0.03)		(0.06)		(0.12)		[0.00]
World ex US	-0.11		-0.96	*	0.66	*	-1.07	***	0.03		-0.03		0.41	*	178.18 ***
	(0.23)		(0.52)		(0.36)		(0.27)		(0.03)		(0.05)		(0.21)		[0.00]
EU	-0.20		-0.45		0.48		-1.93	**	0.03		0.01		0.09		172.15 ***
	(0.17)		(0.53)		(0.41)		(0.89)		(0.03)		(0.05)		(0.23)		[0.00]
Japan	0.00		-0.49	*	0.20		-0.22	**	0.05	*	-0.76		0.82	*	50.91 **
	(0.17)		(0.29)		(0.27)		(0.10)		(0.03)		(0.73)		(0.42)		[0.00]
Asia-Pacific	0.74	***	0.12		1.61		-2.04	***	-		-0.15		-0.10		169.50 ***
	(0.26)		(0.49)		(0.93)		(0.41)		-		(0.12)		(0.24)		[0.00]

Notes: This table shows the common slope estimates and constant terms using the system of Equation (13) and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We also use three macroeconomic variables: growth rate of industrial production (IP), short-term interest rate (short) and term spread between three month and 10-year interest rates (term). World and regional values for the three variables are calculated as the GDP-weighted averages proposed by Cooper et al. (2020). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A7 Four-factor model with macroeconomic variables excluding the COVID-19 period

Panel A	Size-B/M														
	MKT		SMB		HML		UMD		IP		short		term		Wald	
World	-0.11		0.02		0.84	**	-4.75	***	0.03		0.00		0.22		115.75	***
	(0.18)		(0.31)		(0.41)		(1.28)		(0.05)		(0.06)		(0.22)		[0.00]	
US	-0.23	***	0.15		0.13		-0.08		0.04		-0.02		0.13		101.77	***
	(0.08)		(0.19)		(0.14)		(0.07)		(0.05)		(0.05)		(0.13)		[0.00]	
World ex US	-0.45	**	-0.62		1.30	***	-0.88	***	0.03		-0.06		0.17		83.24	***
	(0.20)		(0.51)		(0.45)		(0.22)		(0.05)		(0.06)		(0.24)		[0.00]	
EU	-0.15		0.35		1.01	**	-1.61		-0.01		-0.06		0.29		78.68	***
	(0.25)		(0.61)		(0.47)		(1.20)		(0.05)		(0.06)		(0.24)		[0.00]	
Japan	0.01		-0.01		0.83	**	0.31		0.07	**	-0.31		0.79	*	44.29	**
	(0.16)		(0.34)		(0.38)		(0.22)		(0.03)		(1.09)		(0.44)		[0.01]	
Asia-Pacific	0.15		0.21		0.63		-0.55		-		0.03		-0.19		84.86	***
	(0.21)		(0.47)		(0.51)		(0.49)		-		(0.13)		(0.30)		[0.00]	

Panel B	Size-OP															
	MKT		SMB		HML		UMD		IP		short		term		Wald	
World	-0.06		-0.22		0.80		-1.73		0.02		0.07		0.07		96.56	***
	(0.22)		(0.35)		(0.49)		(1.16)		(0.04)		(0.05)		(0.19)		[0.00]	
US	-0.02		-0.36		0.21		-0.24		-0.05		-0.04		-0.04		73.20	***
	(0.14)		(0.35)		(0.26)		(0.16)		(0.05)		(0.06)		(0.12)		[0.00]	
World ex US	-0.49	**	-1.16	**	0.78	*	-1.35	***	0.03		0.11	**	0.47	**	148.76	***
	(0.23)		(0.50)		(0.44)		(0.32)		(0.04)		(0.05)		(0.22)		[0.00]	
EU	-0.22		0.13		1.50	***	-1.70		0.01		-0.05		0.21		177.58	***
	(0.27)		(0.62)		(0.51)		(1.16)		(0.04)		(0.05)		(0.22)		[0.00]	
Japan	0.10		-0.45		0.41		0.22	*	0.02		-0.92		0.58		63.55	***
	(0.15)		(0.41)		(0.31)		(0.13)		(0.03)		(0.78)		(0.42)		[0.00]	
Asia-Pacific	0.69	***	0.96	**	-0.20		-4.22	***	-		0.11		0.08		89.50	***
	(0.23)		(0.46)		(0.54)		(0.84)		-		(0.12)		(0.28)		[0.00]	

Notes: See the next page.

Table A7 Continued

Panel C	Size-Inv							
	MKT	SMB	HML	UMD	IP	short	term	Wald
World	-0.08	-0.31	0.80 **	-2.91 ***	0.20	0.00	0.25	132.84 ***
	(0.14)	(0.34)	(0.34)	(0.73)	(0.20)	(0.01)	(0.22)	[0.00]
US	0.12	-0.64 *	-0.09	-4.66 ***	-0.02	-0.01	-0.06	80.84 ***
	(0.18)	(0.37)	(0.34)	(1.18)	(0.05)	(0.06)	(0.12)	[0.00]
World ex US	-0.33	-0.76	0.44	-1.24 ***	0.00	0.01	0.31	103.29 ***
	(0.24)	(0.54)	(0.66)	(0.36)	(0.04)	(0.05)	(0.20)	[0.00]
EU	-0.59 **	-0.88	0.95 **	-0.04	0.02	0.01	0.39 *	57.00 ***
	(0.28)	(0.66)	(0.48)	(1.32)	(0.04)	(0.06)	(0.22)	[0.00]
Japan	-0.14	-0.60 *	0.21	-0.14	0.01	-1.28 *	0.68	52.20 ***
	(0.12)	(0.34)	(0.28)	(0.16)	(0.03)	(0.71)	(0.42)	[0.00]
Asia-Pacific	-0.34	-0.63	-1.63 **	-3.62 ***	-	0.10	-0.12	135.43 ***
	(0.28)	(0.58)	(0.66)	(0.89)	-	(0.14)	(0.27)	[0.00]
Panel D	Size-Mom							
	MKT	SMB	HML	UMD	IP	short	term	Wald
World	0.35 ***	0.13	1.04 ***	-0.70 ***	0.04	-0.07	0.12	132.59 ***
	(0.13)	(0.31)	(0.40)	(0.25)	(0.04)	(0.04)	(0.19)	[0.00]
US	0.02	0.22	0.43 *	-0.24	-0.01	-0.09	0.02	67.38 ***
	(0.11)	(0.31)	(0.23)	(0.23)	(0.05)	(0.06)	(0.12)	[0.00]
World ex US	-0.22	-1.15 **	0.70 *	-1.14 ***	0.01	-0.03	0.40 *	181.78 ***
	(0.23)	(0.53)	(0.37)	(0.27)	(0.04)	(0.05)	(0.21)	[0.00]
EU	-0.34	-0.65	0.78 **	-2.23 ***	0.04	0.00	0.09	173.36 ***
	(0.21)	(0.60)	(0.43)	(0.94)	(0.04)	(0.05)	(0.22)	[0.00]
Japan	0.01	-0.47	0.33	-0.32 ***	0.07 **	-0.80	0.86 **	52.82 ***
	(0.17)	(0.30)	(0.29)	(0.11)	(0.03)	(0.71)	(0.42)	[0.00]
Asia-Pacific	0.60 **	-0.15	1.94 **	-2.14 ***	-	-0.14	-0.04	170.67 ***
	(0.26)	(0.49)	(0.95)	(0.42)	-	(0.12)	(0.24)	[0.00]

Notes: This table shows the common slope estimates and constant terms using the system of Equation (13) and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We also use three macroeconomic variables: growth rate of industrial production (IP), short-term interest rate (short) and term spread between three month and 10-year interest rates (term). World and regional values for the three variables are calculated as the GDP-weighted averages proposed by Cooper et al. (2020). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following six regions: World, US, World excluding US, Europe, Japan, and Asia-Pacific as in Fama and French (2012, 2017). The sample period covers from August 1993 to December 2019, and excludes the COVID-19 period. The asterisk *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A8 Four-factor model with the EPU index

Panel A	Size-B/M					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	-0.01	0.10	0.62	-2.39 *	0.00	88.31 ***
	(0.18)	(0.28)	(0.42)	(1.24)	(0.01)	[0.00]
US	-0.16 *	0.09	0.16	0.02	0.00	73.86 ***
	(0.09)	(0.20)	(0.14)	(0.07)	(0.00)	[0.00]
EU	-0.16	0.15	0.70	-0.87	-0.01	61.82 ***
	(0.23)	(0.57)	(0.46)	(1.21)	(0.01)	[0.00]
Japan	-0.08	-0.08	0.47	0.36	-0.03 ***	28.61
	(0.16)	(0.37)	(0.41)	(0.23)	(0.01)	[0.28]
Panel B	Size-OP					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	0.09	-0.27	0.37	-2.29 **	0.00	74.33 ***
	(0.20)	(0.33)	(0.48)	(1.15)	(0.01)	[0.00]
US	0.20	-0.28	0.00	-0.21	0.00	51.15 ***
	(0.13)	(0.34)	(0.24)	(0.16)	(0.00)	[0.00]
EU	0.00	0.45	1.04 **	-1.77	0.00	133.95 ***
	(0.24)	(0.58)	(0.51)	(1.18)	(0.01)	[0.00]
Japan	0.07	-0.28	0.34	0.31 **	-0.03 ***	41.59 **
	(0.15)	(0.45)	(0.31)	(0.14)	(0.01)	[0.02]
Panel C	Size-Inv					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	-0.06	-0.32	0.47	-2.31 ***	0.00	103.43 ***
	(0.13)	(0.33)	(0.32)	(0.73)	(0.01)	[0.00]
US	0.38 **	-0.77 **	-0.73 **	-5.45 ***	0.00	67.42 ***
	(0.17)	(0.38)	(0.31)	(1.13)	(0.00)	[0.00]
EU	-0.60 **	-0.97	0.73	0.14	0.00	45.86 ***
	(0.26)	(0.63)	(0.45)	(1.30)	(0.01)	[0.00]
Japan	-0.08	-0.46	0.08	-0.02	-0.02 **	29.14
	(0.12)	(0.38)	(0.30)	(0.17)	(0.01)	[0.26]
Panel D	Size-Mom					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	0.53 ***	0.14	0.70 *	-0.50 **	-0.01	104.69 ***
	(0.14)	(0.30)	(0.38)	(0.25)	(0.01)	[0.00]
US	0.24 **	0.22	0.12	-0.15	-0.01 *	44.46 ***
	(0.11)	(0.33)	(0.23)	(0.23)	(0.00)	[0.00]
EU	-0.17	-0.54	0.51	-2.10 **	-0.01 **	151.21 ***
	(0.17)	(0.54)	(0.42)	(0.94)	(0.01)	[0.00]
Japan	-0.07	-0.52 *	0.11	-0.17	-0.02 ***	39.14 **
	(0.16)	(0.31)	(0.31)	(0.10)	(0.01)	[0.04]

Notes: See the next page.

Notes: This table shows the common slope estimates and constant terms and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We also use a change in economic policy uncertainty (dEPU) index proposed by Baker et al. (2016). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following four regions: World, US, Europe and Japan as in Fama and French (2012, 2017). The sample period covers from February 1997 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A9 Four-factor model with the EPU index during the COVID19 period

Panel A	Size-B/M					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	-0.09	-0.06	0.85 **	-4.77 ***	-0.01	97.20 ***
	(0.19)	(0.35)	(0.43)	(1.35)	(0.01)	[0.00]
US	-0.22 ***	0.13	0.13	-0.09	0.00	76.40 ***
	(0.08)	(0.19)	(0.14)	(0.07)	(0.01)	[0.00]
EU	-0.10	0.29	0.89 *	-1.68	-0.01 *	70.89 ***
	(0.26)	(0.63)	(0.48)	(1.26)	(0.01)	[0.00]
Japan	-0.11	-0.20	0.70 *	0.35	-0.04 ***	30.74
	(0.16)	(0.38)	(0.42)	(0.23)	(0.01)	[0.20]
Panel B	**Size-OP**					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	-0.12	-0.33	0.85 *	-1.75	-0.01	79.69 ***
	(0.23)	(0.39)	(0.50)	(1.22)	(0.01)	[0.00]
US	0.07	-0.41	0.14	-0.26 *	0.00	61.00 ***
	(0.13)	(0.35)	(0.26)	(0.16)	(0.01)	[0.00]
EU	-0.20	0.06	1.34 **	-1.75	-0.01	153.91 ***
	(0.28)	(0.64)	(0.53)	(1.21)	(0.01)	[0.00]
Japan	-0.01	-0.50	0.40	0.32 **	-0.03 ***	46.91 **
	(0.15)	(0.46)	(0.32)	(0.13)	(0.01)	[0.01]
Panel C	**Size-Inv**					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	-0.14	-0.55	0.82 **	-3.10 ***	0.00	110.18 ***
	(0.14)	(0.37)	(0.35)	(0.77)	(0.01)	[0.00]
US	0.18	-0.67 *	-0.16	-4.95 ***	0.00	70.76 ***
	(0.19)	(0.38)	(0.35)	(1.22)	(0.01)	[0.00]
EU	-0.64 **	-1.05	0.82 *	0.00	-0.01	47.45 ***
	(0.29)	(0.68)	(0.48)	(1.36)	(0.01)	[0.00]
Japan	-0.16	-0.68 *	0.16	-0.04	-0.02 ***	34.48
	(0.12)	(0.40)	(0.30)	(0.17)	(0.01)	[0.10]
Panel D	**Size-Mom**					
	MKT	SMB	HML	UMD	dEPUI	Wald
World	0.35 **	0.04	1.02 **	-0.80 ***	-0.01 *	117.48 ***
	(0.14)	(0.31)	(0.42)	(0.26)	(0.01)	[0.00]
US	0.06	0.23	0.43 *	-0.22	-0.01 *	57.42 ***
	(0.11)	(0.32)	(0.24)	(0.24)	(0.00)	[0.00]
EU	-0.35 *	-0.84	0.81 *	-2.40 **	-0.01 ***	155.41 ***
	(0.21)	(0.62)	(0.43)	(0.99)	(0.01)	[0.00]
Japan	-0.05	-0.44	0.20	-0.22 **	-0.03 ***	39.29 **
	(0.17)	(0.33)	(0.32)	(0.11)	(0.01)	[0.03]

Notes: See the next page.

Notes: This table shows the common slope estimates and constant terms and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We also use a change in economic policy uncertainty (dEPU) index proposed by Baker et al. (2016). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following four regions: World, US, Europe and Japan as in Fama and French (2012, 2017). The sample period covers from February 1997 to December 2019. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A10 Summary of results: Macroeconomic variables and EPUI

Panel A: Four factor model with macroeconomic variables

	All periods					Excluding COVID-19				
	MKT	SMB	HML	UMD		MKT	SMB	HML	UMD	
World				◎				○	○	
US										
World ex US			○	◎				○	◎	
EU			○					◎		
Japan										
Asia-Pacific				○					○	

Panel B: Four factor model with EPUI

	All periods					Excluding COVID-19				
	MKT	SMB	HML	UMD	EPUI	MKT	SMB	HML	UMD	EPUI
World				◎	○			◎	○	○
US					○					○
EU			○		◎			◎		◎
Japan					◎					○

Notes: This table shows the summary of four and five factor model results. The single circle (○) indicates that three out of four parameter estimates are statistically significant at least at the 10% level and the double circle (◎) indicates that all parameter estimates are statistically significant at least at the 10% level. The grey areas mean that the parameter estimates are negatively linked to the expected returns. We use four types of the test portfolios: 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. Panel A shows the results which control for three macroeconomic variables: growth rate of industrial production (IP), short-term interest rate (short) and term spread between three month and 10-year interest rates (term). World and regional values for the three variables are calculated as the GDP-weighted averages proposed by Cooper et al. (2020). Panel B reports that the results which control for a change in economic policy uncertainty (dEPU) index proposed by Baker et al. (2016). All periods in Panel A cover from August 1993 to June 2020 and the excluding COVID-19 periods in Panel A cover from August 1993 to December 2019. The starting date in Panel B is February 1997.

Table A11 Mean excess returns for World ex US portfolios: Crisis periods

Panel A: Global Financial Crisis

	Low B/M	2	3	4	High B/M
Small	-4.49	-4.31	-4.18	-4.15	-3.47
2	-4.13	-4.09	-3.69	-3.77	-3.20
3	-3.69	-3.57	-3.96	-3.54	-3.05
4	-3.31	-3.28	-3.42	-3.11	-3.32
Big	-2.82	-2.49	-3.27	-3.42	-4.06

	Low OP	2	3	4	High OP
Small	-4.08	-3.60	-3.77	-3.80	-3.74
2	-3.75	-3.06	-4.08	-3.97	-3.76
3	-3.40	-3.28	-3.57	-3.58	-3.80
4	-3.15	-3.41	-3.27	-3.17	-3.42
Big	-3.65	-3.44	-3.55	-3.25	-2.38

	Low Inv	2	3	4	High Inv
Small	-3.71	-3.13	-3.48	-4.18	-4.57
2	-3.26	-2.73	-3.27	-3.97	-4.77
3	-3.01	-2.90	-3.49	-3.71	-4.26
4	-3.08	-2.72	-3.01	-3.64	-3.86
Big	-2.54	-2.81	-3.27	-3.57	-3.66

	Low Mom	2	3	4	High Mom
Small	-4.96	-3.78	-3.42	-2.88	-3.64
2	-4.43	-3.65	-3.29	-3.21	-3.11
3	-4.04	-3.90	-3.41	-3.17	-3.52
4	-4.07	-3.40	-3.14	-3.21	-2.66
Big	-4.38	-2.94	-2.91	-2.96	-2.85

Panel B: COVID19

	Low B/M	2	3	4	High B/M
Small	1.02	0.54	-0.25	-0.72	-1.40
2	1.25	0.23	-0.01	-1.70	-2.12
3	1.41	0.15	-1.22	-1.56	-2.29
4	1.78	-0.47	-1.05	-2.22	-2.86
Big	0.94	0.57	-0.72	-2.54	-3.64

	Low OP	2	3	4	High OP
Small	0.03	-1.12	-1.23	-0.98	-0.09
2	-0.51	-1.40	-1.11	0.00	-0.73
3	-1.32	-0.29	-1.36	-0.59	-0.50
4	-1.48	-0.78	-1.57	-0.21	-0.18
Big	-1.66	-1.17	-0.90	-0.48	-0.22

	Low Inv	2	3	4	High Inv
Small	-0.52	-1.18	-0.95	-0.53	0.27
2	-1.82	-1.38	-0.97	-0.37	0.17
3	-1.83	-1.39	-1.05	-0.30	0.09
4	-1.82	-2.36	-1.21	-0.93	0.99
Big	-1.57	-1.47	-1.63	0.08	1.46

	Low Mom	2	3	4	High Mom
Small	-0.76	-0.67	-0.71	-0.43	1.27
2	-1.65	-0.91	-0.90	-0.72	0.97
3	-2.18	-1.52	-1.53	-0.61	0.73
4	-2.18	-1.41	-0.92	-0.57	1.68
Big	-3.73	-2.20	-1.16	0.42	1.13

Notes: This table presents monthly mean excess returns for World ex US portfolios during the global financial crisis and COVID19 periods. We consider 25 test portfolios sorted by size and book-to-market, size and operating profitability, size and investment and size and momentum. All returns are calculated using the U.S. dollars and the U.S. one-month Treasury-Bill yield is used as the risk-free rate. The global financial crisis period covers from August 2007 to March 2008 (Bekaert et al., 2014) and the COVID19 period does from February 2020 to July 2020.

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Table A12 Mean excess returns for EU portfolios: Crisis periods

Panel A: Global Financial Crisis						Panel B: COVID19					
	Low B/M	2	3	4	High B/M		Low B/M	2	3	4	High B/M
Small	-4.83	-4.32	-4.56	-4.27	-4.28	Small	2.05	0.65	0.33	-0.69	-1.40
2	-4.09	-4.06	-4.30	-4.49	-4.14	2	2.19	1.43	-1.06	-1.94	-2.55
3	-3.98	-3.99	-3.78	-4.25	-3.55	3	2.09	0.72	-1.19	-0.94	-2.86
4	-3.63	-3.34	-4.16	-3.83	-4.70	4	0.95	1.72	-0.63	-1.99	-2.76
Big	-2.73	-2.43	-3.27	-3.81	-4.31	Big	0.62	0.37	-0.35	-1.48	-3.58
	Low OP	2	3	4	High OP		Low OP	2	3	4	High OP
Small	-4.72	-3.91	-4.32	-3.94	-4.46	Small	0.83	-0.84	-0.97	0.00	-1.02
2	-4.61	-3.84	-4.24	-4.19	-3.98	2	-1.10	-0.99	-0.89	0.14	-0.17
3	-3.87	-3.87	-4.21	-4.03	-3.67	3	-1.32	-0.39	-0.91	-0.01	0.14
4	-3.99	-4.48	-4.25	-3.33	-3.71	4	-1.03	-0.34	-1.24	0.72	-0.67
Big	-4.06	-3.53	-3.74	-3.58	-2.32	Big	-1.24	-1.33	-0.65	0.02	-0.55
	Low Inv	2	3	4	High Inv		Low Inv	2	3	4	High Inv
Small	-4.31	-3.70	-3.77	-4.41	-5.17	Small	-0.33	-0.84	-0.43	-0.65	0.97
2	-3.98	-3.82	-3.59	-4.40	-4.88	2	-2.31	-1.68	-0.93	0.05	0.39
3	-4.17	-3.06	-3.67	-4.31	-4.33	3	-1.36	-1.97	-1.41	-0.47	1.41
4	-4.41	-3.69	-3.51	-3.33	-4.56	4	-1.69	-2.19	-0.54	-0.01	0.67
Big	-2.73	-2.78	-3.68	-3.86	-3.64	Big	-2.12	-0.86	-1.40	0.44	0.90
	Low Mom	2	3	4	High Mom		Low Mom	2	3	4	High Mom
Small	-5.91	-4.62	-4.20	-3.61	-3.19	Small	-0.84	0.02	0.01	-1.00	1.36
2	-4.94	-4.56	-4.16	-3.71	-3.48	2	-2.05	-1.09	-0.85	-0.53	2.27
3	-4.95	-4.41	-4.16	-3.52	-3.30	3	-2.15	-1.69	-1.80	0.05	0.08
4	-5.05	-3.75	-3.54	-4.04	-2.73	4	-2.54	-1.00	0.75	-0.21	1.00
Big	-5.33	-3.35	-2.92	-2.68	-2.79	Big	-3.97	-1.90	-0.71	1.01	0.19

Notes: This table presents monthly mean excess returns for European portfolios during the global financial crisis and COVID19 periods. We consider 25 test portfolios sorted by size and book-to-market, size and operating profitability, size and investment and size and momentum. All returns are calculated using the U.S. dollars and the U.S. one-month Treasury-Bill yield is used as the risk-free rate. The global financial crisis period covers from August 2007 to March 2008 (Bekaert et al., 2014) and the COVID19 period does from February 2020 to July 2020.

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Table A13 Four-factor model with the covariance of the EPU index

Panel A	Size-B/M					
	MKT	SMB	HML	UMD	EPUI	Wald
World	-0.13	0.07	0.67	-2.12 *	-0.30 **	88.15 ***
	(0.18)	(0.30)	(0.43)	(1.24)	(0.14)	[0.00]
US	-0.04	-0.33	-0.42	-0.47	-0.32 ***	57.85 ***
	(0.24)	(0.38)	(0.36)	(0.29)	(0.11)	[0.00]
EU	-0.28	0.10	0.89 *	-0.40	-0.66 ***	68.48 ***
	(0.24)	(0.58)	(0.47)	(1.23)	(0.19)	[0.00]
Japan	-0.13	-0.12	0.45	0.37	-0.27 **	27.15
	(0.16)	(0.38)	(0.41)	(0.23)	(0.12)	[0.35]
Panel B	**Size-OP**					
	MKT	SMB	HML	UMD	EPUI	Wald
World	-0.02	-0.33	0.44	-2.20 *	-0.22 ***	73.46 ***
	(0.21)	(0.34)	(0.48)	(1.15)	(0.11)	[0.00]
US	0.14	-0.22	0.01	-0.19	-0.22 *	53.14 ***
	(0.13)	(0.33)	(0.24)	(0.16)	(0.11)	[0.00]
EU	-0.22	0.24	1.14 **	-1.18	-0.46 **	131.59 ***
	(0.26)	(0.59)	(0.53)	(1.20)	(0.19)	[0.00]
Japan	0.05	-0.22	0.33	0.30 **	-0.26 *	38.36 **
	(0.16)	(0.45)	(0.30)	(0.14)	(0.13)	[0.04]
Panel C	**Size-Inv**					
	MKT	SMB	HML	UMD	EPUI	Wald
World	-0.12	-0.41	0.54 *	-2.33 ***	-0.46 ***	107.61 ***
	(0.12)	(0.35)	(0.33)	(0.72)	(0.17)	[0.00]
US	0.34 **	-0.77 **	-0.58 *	-5.33 ***	-0.43 ***	68.37 ***
	(0.17)	(0.38)	(0.31)	(1.13)	(0.10)	[0.00]
EU	-0.72 ***	-1.05 *	0.92 *	0.50	-0.32 *	43.43 **
	(0.26)	(0.63)	(0.47)	(1.31)	(0.19)	[0.01]
Japan	-0.16	-0.45	0.07	-0.04	-0.42 ***	29.19
	(0.12)	(0.38)	(0.29)	(0.17)	(0.12)	[0.26]
Panel D	**Size-Mom**					
	MKT	SMB	HML	UMD	EPUI	Wald
World	0.46 ***	0.08	0.72 *	-0.47 *	-0.18	105.74 ***
	(0.14)	(0.30)	(0.38)	(0.25)	(0.13)	[0.00]
US	0.19 *	0.24	0.10	-0.17	-0.14	44.62 ***
	(0.11)	(0.32)	(0.22)	(0.23)	(0.10)	[0.00]
EU	-0.31 *	-0.56	0.69	-1.40	-0.53 ***	150.12 ***
	(0.18)	(0.54)	(0.44)	(0.94)	(0.16)	[0.00]
Japan	-0.15	-0.58 *	0.07	-0.15	-0.28 **	39.86 **
	(0.17)	(0.31)	(0.30)	(0.11)	(0.13)	[0.03]

Notes: See the next page.

Notes: This table shows the common slope estimates and constant terms using the system of Equation (14) and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We also use the covariance of a change in the economic policy uncertainty (EPU) index proposed by Baker et al. (2016). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following four regions: World, US, Europe and Japan. The sample period covers from February1997 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Table A14 Four-factor model with the covariance of the EPUI excluding the COVID19 period

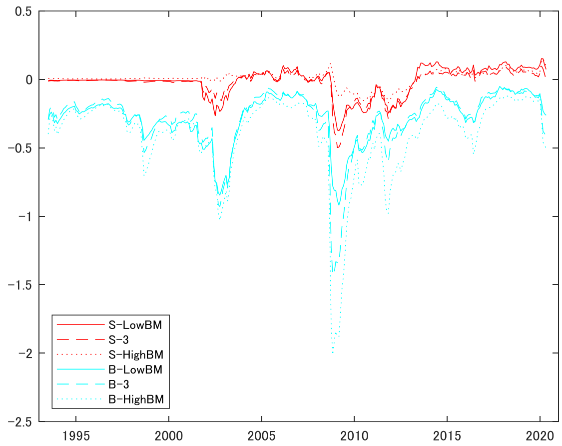
Panel A	Size-B/M					
	MKT	SMB	HML	UMD	EPUI	Wald
World	-0.20	-0.07	0.93 **	-4.61 ***	-0.33 **	97.05 ***
	(0.19)	(0.36)	(0.44)	(1.35)	(0.16)	[0.00]
US	-0.36	-0.32	0.22	-0.67 **	-0.56 ***	73.26 ***
	(0.24)	(0.37)	(0.38)	(0.32)	(0.14)	[0.00]
EU	-0.20	0.29	1.07 **	-1.30	-0.60 ***	75.83 ***
	(0.27)	(0.64)	(0.49)	(1.28)	(0.20)	[0.00]
Japan	-0.16	-0.23	0.69	0.36	-0.27 **	29.09
	(0.16)	(0.38)	(0.43)	(0.23)	(0.12)	[0.26]
Panel B	Size-OP					
	MKT	SMB	HML	UMD	EPUI	Wald
World	-0.24	-0.38	0.93 *	-1.64	-0.36 ***	77.08 ***
	(0.23)	(0.40)	(0.51)	(1.22)	(0.13)	[0.00]
US	0.00	-0.34	0.20	-0.24	-0.29 *	63.57 ***
	(0.14)	(0.35)	(0.26)	(0.16)	(0.15)	[0.00]
EU	-0.39	-0.12	1.40 ***	-1.05	-0.54 ***	148.89 ***
	(0.29)	(0.65)	(0.55)	(1.22)	(0.19)	[0.00]
Japan	-0.02	-0.42	0.40	0.31 **	-0.16	43.12 **
	(0.16)	(0.46)	(0.31)	(0.14)	(0.14)	[0.00]
Panel C	Size-Inv					
	MKT	SMB	HML	UMD	EPUI	Wald
World	-0.22	-0.65 *	0.91 **	-3.31 ***	-0.58 ***	113.48 ***
	(0.14)	(0.38)	(0.37)	(0.78)	(0.20)	[0.00]
US	0.12	-0.68 *	0.02	-4.92 ***	-0.69 ***	69.23 ***
	(0.19)	(0.38)	(0.35)	(1.22)	(0.15)	[0.00]
EU	-0.74 **	-1.12	0.97 **	0.33	-0.24	45.09 ***
	(0.29)	(0.68)	(0.49)	(1.36)	(0.20)	[0.00]
Japan	-0.23 *	-0.67 *	0.14	-0.07	-0.38 ***	34.28
	(0.12)	(0.40)	(0.30)	(0.17)	(0.12)	[0.10]
Panel D	Size-Mom					
	MKT	SMB	HML	UMD	EPUI	Wald
World	0.37 ***	0.06	0.99 **	-0.77 ***	0.15	114.40 ***
	(0.14)	(0.32)	(0.43)	(0.26)	(0.17)	[0.00]
US	0.03	0.24	0.40	-0.20	-0.01	57.22 ***
	(0.11)	(0.32)	(0.24)	(0.24)	(0.14)	[0.00]
EU	-0.43 **	-0.71	0.96 **	-1.79 *	-0.54 ***	155.20 ***
	(0.22)	(0.62)	(0.45)	(0.99)	(0.17)	[0.00]
Japan	-0.11	-0.48	0.15	-0.20 *	-0.25 *	40.10 **
	(0.17)	(0.33)	(0.31)	(0.11)	(0.13)	[0.03]

Notes: See the next page.

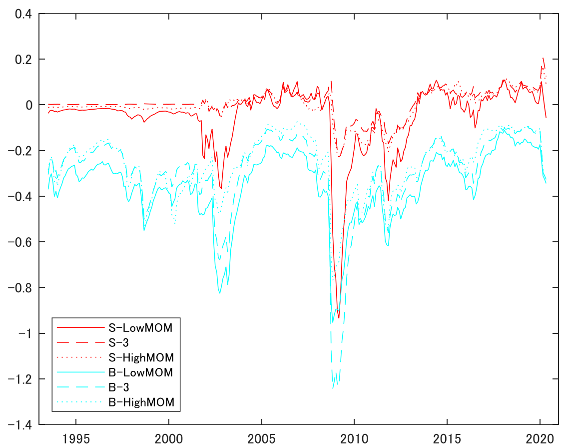
Notes: This table shows the common slope estimates and constant terms using the system of Equation (14) and standard errors are reported in parentheses. We employ four factors: market (MKT), size (SML), value (HML) and momentum (UMD) factors (Fama and French, 1993; Carhart, 1997). We also use the covariance of a change in the economic policy uncertainty (EPU) index proposed by Baker et al. (2016). The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The joint null hypothesis is that all intercepts, C_i equal zero and the *p*-values are reported in brackets. The test portfolios are the 25 size and book-to-market, size and operating profitability, size and investment, and size and momentum portfolios. We consider the following four regions: World, US, Europe and Japan. The sample period covers from February1997 to June 2020. The asterisks *,**, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

Figure A1 Long-run conditional covariances with the SMB factor: World ex US

Size-B/M



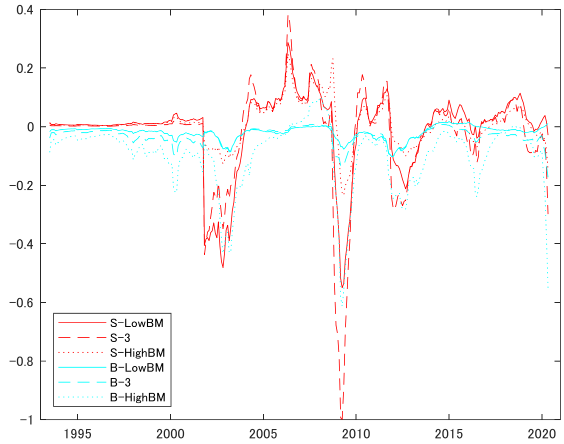
Size-Mom



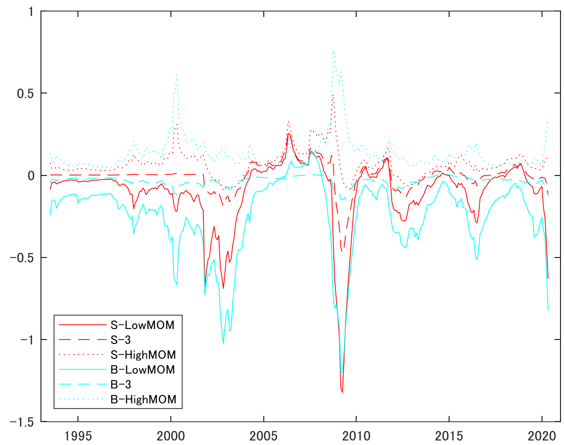
Notes: This figure illustrates the long-run conditional covariance with the SMB factor for the World ex US portfolios. The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The upper panel shows the results for the portfolios sorted by Size-B/M, and the lower panel does the results for the portfolios sorted by Size-Mom.

Figure A2 Long-run conditional covariances with the UMD factor: World ex US

Size-B/M



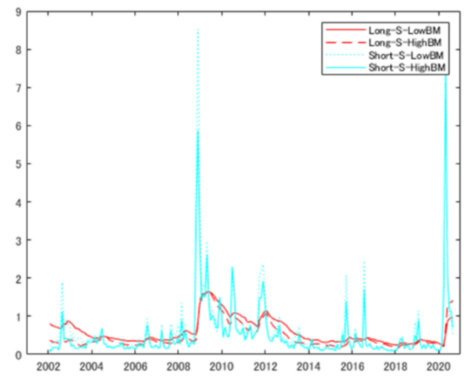
Size-Mom



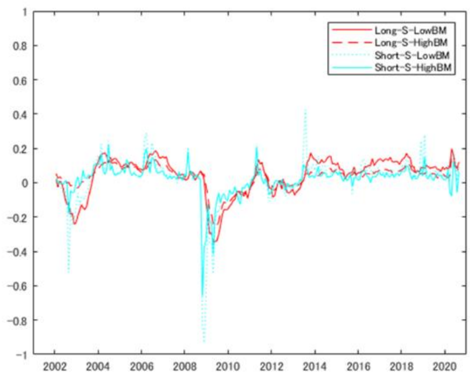
Notes: This figure illustrates the long-run conditional covariance with the UMD factor for the World ex US portfolios. The long-run covariance is estimated by the DCC-MIDAS proposed by Colacito et al. (2011). The upper panel shows the results for the portfolios sorted by Size-B/M, and the lower panel does the results for the portfolios sorted by Size-Mom.

Figure A3 Long-run and short-run conditional covariances: World

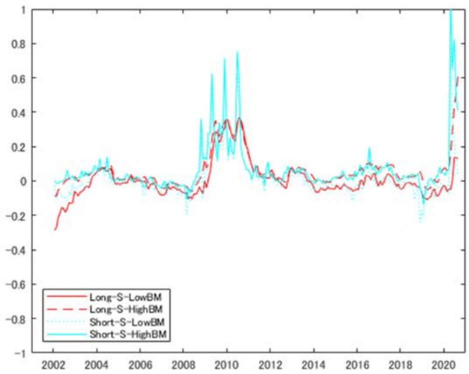
MKT (upper left)



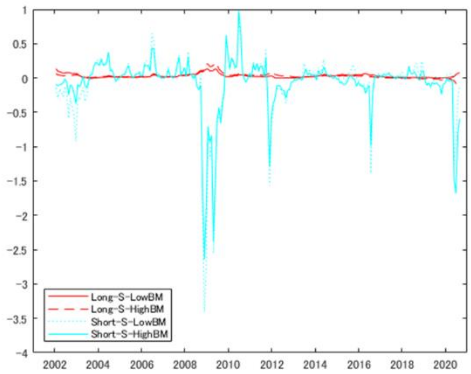
SMB (upper right)



HML (lower left)



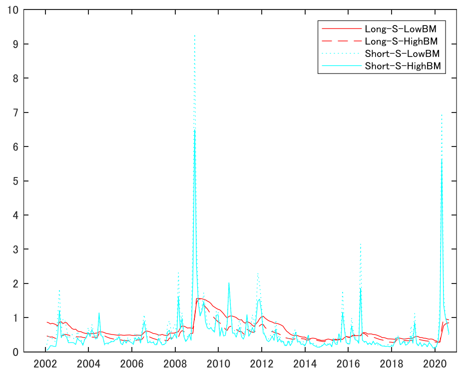
UMD (lower right)



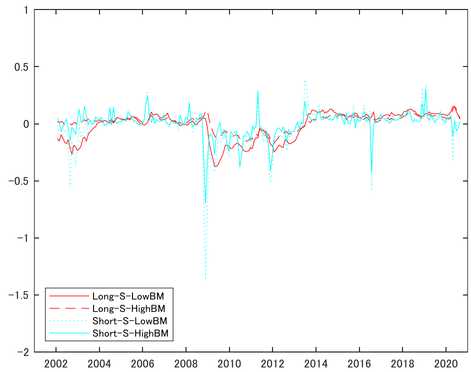
Notes: This figure illustrates the long-run and short-run conditional covariances with the MKT, SMB, HML and UMD factors for the World portfolios. The covariances are estimated by the DCC-MIDAS proposed by Colacito et al. (2011). We employ the small-low B/M and small-high B/M portfolios.

Figure A4 Long-run and short-run conditional covariances: World ex US

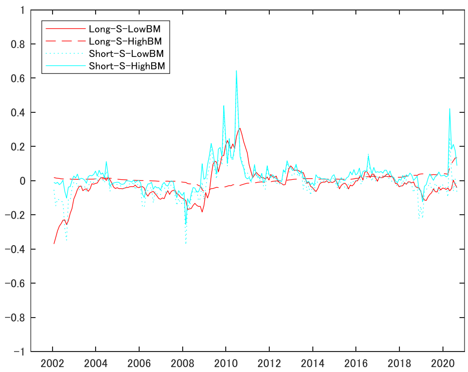
MKT (upper left)



SMB (upper right)



HML (lower left)

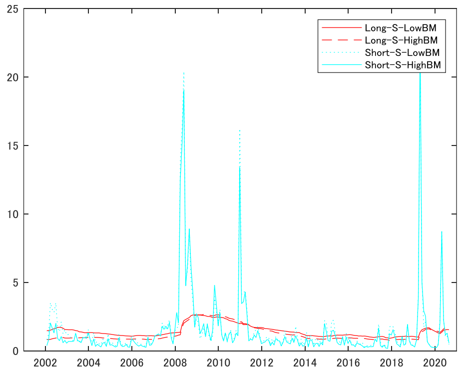


UMD (lower right)

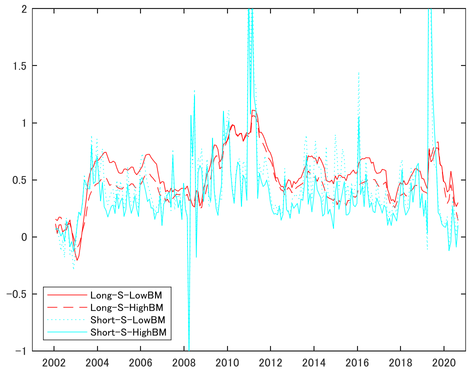
Notes: This figure illustrates the long-run and short-run conditional covariances with the MKT, SMB, HML and UMD factors for the World ex US portfolios. The covariances are estimated by the DCC-MIDAS proposed by Colacito et al. (2011). We employ the small-low B/M and small-high B/M portfolios.

Figure A5 Long-run and short-run conditional covariances: US

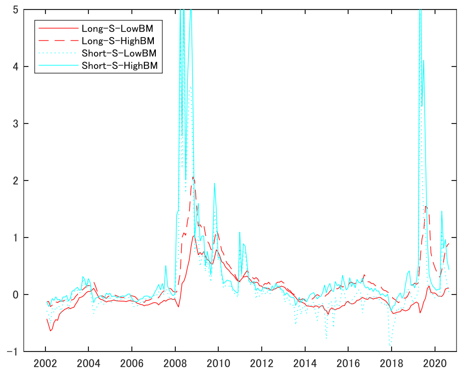
MKT (upper left)



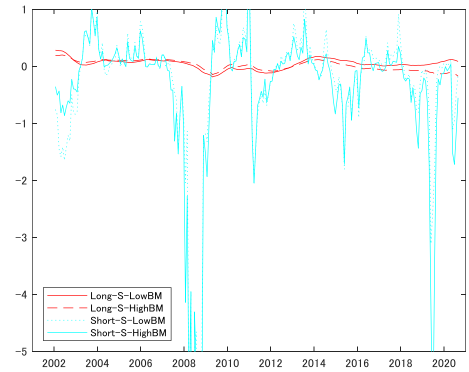
SMB (upper right)



HML (lower left)



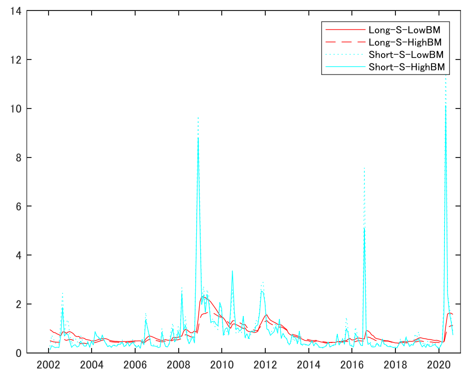
UMD (lower right)



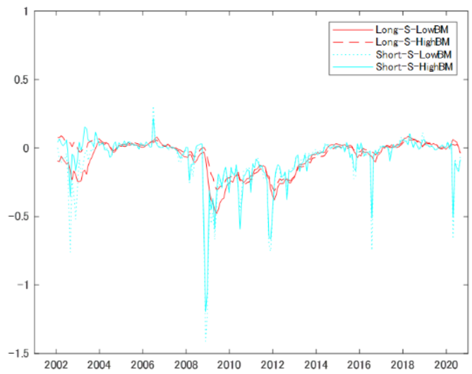
Notes: This figure illustrates the long-run and short-run conditional covariances with the MKT, SMB, HML and UMD factors for the US portfolios. The covariances are estimated by the DCC-MIDAS proposed by Colacito et al. (2011). We employ the small-low B/M and small-high B/M portfolios.

Figure A6 Long-run and short-run conditional covariances: Europe

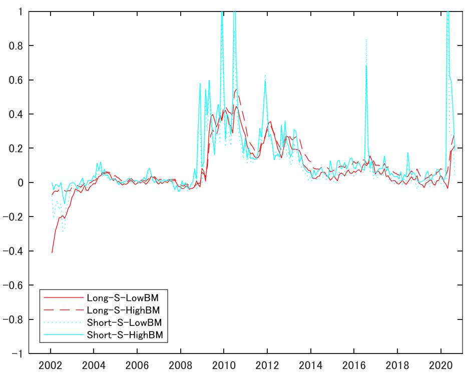
MKT (upper left)



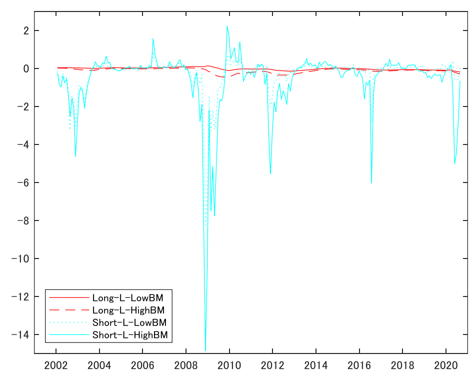
SMB (upper right)



HML (lower left)



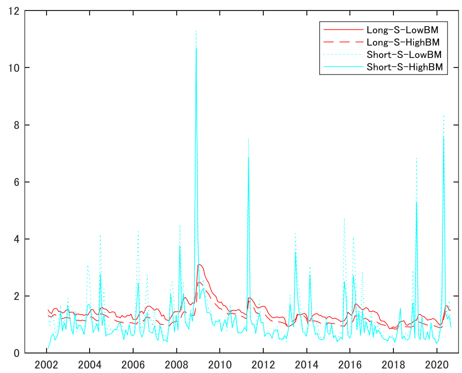
UMD (lower right)



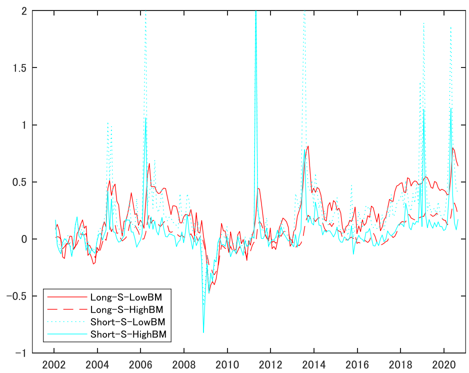
Notes: This figure illustrates the long-run and short-run conditional covariances with the MKT, SMB, HML and UMD factors for the European portfolios. The covariances are estimated by the DCC-MIDAS proposed by Colacito et al. (2011). We employ the small-low B/M and small-high B/M portfolios.

Figure A7 Long-run and short-run conditional covariances: Japan

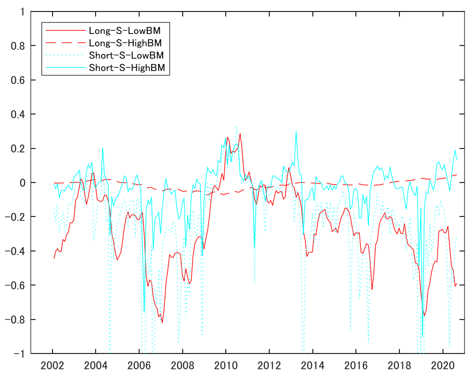
MKT (upper left)



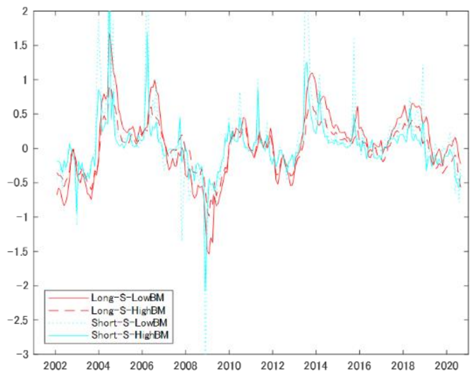
SMB (upper right)



HML (lower left)



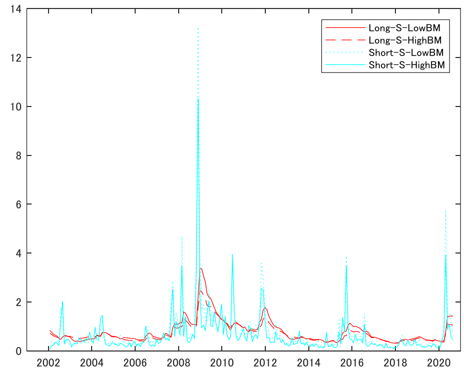
UMD (lower right)



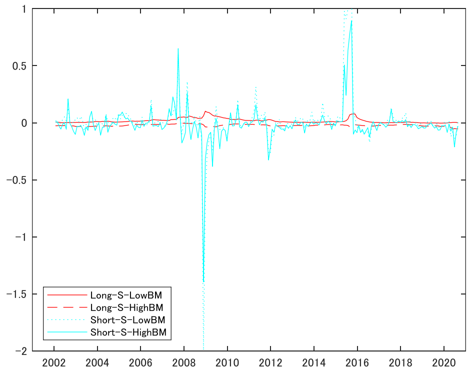
Notes: This figure illustrates the long-run and short-run conditional covariances with the MKT, SMB, HML and UMD factors for the Japanese portfolios. The covariances are estimated by the DCC-MIDAS proposed by Colacito et al. (2011). We employ the small-low B/M and small-high B/M portfolios.

Figure A8 Long-run and short-run conditional covariances: Asia-Pacific

MKT (upper left)



SMB (upper right)



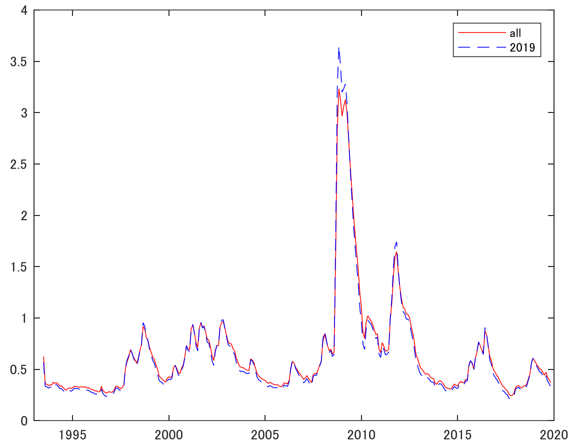
HML (lower left)

UMD (lower right)

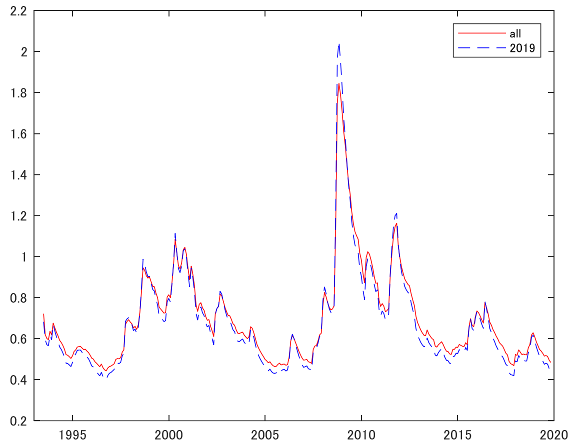
Notes: This figure illustrates the long-run and short-run conditional covariances with the MKT, SMB, HML and UMD factors for the Asia-Pacific portfolios. The covariances are estimated by the DCC-MIDAS proposed by Colacito et al. (2011). We employ the small-low B/M and small-high B/M portfolios.

Figure A9 Long-run conditional covariance comparison: MKT factor

Small and Low momentum portfolio



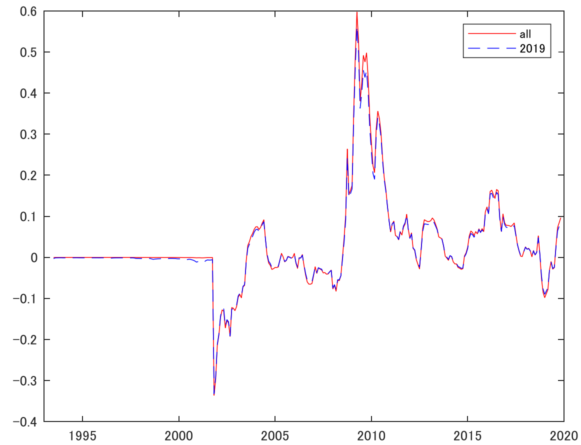
Large and High momentum portfolio



Notes: This figure illustrates the long-run conditional covariance with the MKT factor for the World portfolios. All is estimated by the dataset for the all period and 2019 is estimated by the dataset excluding the COVID-19 period. The upper panel uses the Small and Low momentum portfolio, and the lower panel does the Large and High momentum portfolio.

Figure A10 Long-run conditional covariance comparison: HML factor

Small and Low momentum portfolio



Large and High momentum portfolio

Notes: This figure illustrates the long-run conditional covariance with the HML factor for the World portfolios. All is estimated by the dataset for the all period and 2019 is estimated by the dataset excluding the COVID-19 period. The upper panel uses the Small and Low momentum portfolio, and the lower panel does the Large and High momentum portfolio.