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A Global Macroeconomic Risk Model for Value, Momentum, and Other Asset Classes

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Abstract

Value and momentum returns and combinations of them across both countries and asset classes are explained by their loadings on global macroeconomic risk factors. These loadings describe why value and momentum have positive return premia, although being negatively correlated. The global macroeconomic risk factors also perform well in capturing the returns on other characteristic-based portfolios. The findings identify a global macroeconomic source of the common variation in returns across countries and asset classes.

I. Introduction

In this article, we ask if there is a common factor structure related to global macroeconomic risk that can explain anomalies present across many countries and asset classes. Consider value and momentum, which are two of the most debated anomalies in financial markets.[1] Asness, Moskowitz, and Pedersen (2013) find consistent return premia on value and momentum strategies across asset classes such as equities, fixed income, currencies, and commodities, as well as across

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[1]The value effect in U.S. equities is documented by Stattman (1980) and Rosenberg, Reid, and Lanstein (1985). Fama and French (1992), (1993) thoroughly examine the value effect in an asset pricing framework. Jegadeesh and Titman (1993) and Asness (1994) identify the momentum effect in U.S. equities. Fama and French (1998), Rouwenhorst (1998), Liew and Vassalou (2000), Griffin, Ji, and Martin (2003), and Chui, Titman, and Wei (2010) document cross-country equity market value and momentum effects. Momentum effects are also present in currencies (Shleifer and Summers (1990), Kho (1996), and LeBaron (1999)) and commodities (Erb and Havey (2006), Gorton, Hayashi, and Rouwenhorst (2008)).

countries. Their findings uncover three puzzling phenomena. First, even though these return premia are positive, they are negatively correlated. Second, despite this negative correlation, a simple equal-weighted combination of value and momentum produces a positive return premium. Third, various risk factors, such as the market portfolio and liquidity, cannot explain these return premia. Instead, global value and momentum factors are required to describe portfolios sorted on value and momentum characteristics.

The findings of Asness et al. (2013) raise an important challenge for asset pricing models to explain. Asset pricing models based on the *q*-theory of investment and growth options of firms have been useful in explaining value and momentum for equities.[2] However, no such models exist to explain value and momentum in the nonequity asset classes studied by Asness et al. (2013). Furthermore, other asset classes and characteristic-sorted portfolios also require their own characteristic-based factors to explain their returns, such as betting against beta (BAB), quality, profitability, investment, and size.[3] We ask if there is a unified factor model that can explain these characteristics across both asset classes and countries.

Our contribution is to show that a version of Ross's (1976) arbitrage pricing theory (APT) that uses a global representation of Chen, Roll, and Ross's (1986) macroeconomic risk factors (henceforth *CRR factors*) can describe the cross section of value and momentum stock returns. In addition, the global CRR factors capture the negative correlations of the value and momentum premia across both countries and asset classes. Furthermore, although value and momentum return premia are negatively correlated, the global CRR factors can also explain the positive return premia on combinations of value and momentum found in the data. Investment-based asset pricing models offer explanations for why value and momentum premia among equities are exposed to systematic risk. However, these models do not specify what this risk is. We identify the nature of this systematic risk, namely, global macroeconomic risk, and we show that the exposure to global macroeconomic risk factors summarizes both the average returns of equity portfolios sorted on value and momentum as well as nonequity portfolios sorted on value and momentum, namely, currencies, fixed income, and commodities. This finding alleviates some of the concerns that a risk-based explanation for value and momentum exists only for equities.

The findings are not confined to value and momentum. We find that the global CRR factors can explain a reasonable fraction of the cross section of returns on other international portfolios that are sorted on characteristics that have been recently proposed in the literature, such as profitability, investment, BAB, quality, and size. Our findings are consistent with those in recent articles that employ the CRR factors

[2]See, for example, Berk, Green, and Naik (1999), Johnson (2002), Gomes, Kogan, and Zhang (2003), Carlson, Fisher, and Giammarino (2004), Zhang (2005), Cooper (2006), Sagi and Seasholes (2007), Li, Livdan, and Zhang (2009), Liu, Whited, and Zhang (2009), Belo (2010), Li and Zhang (2010), and Li (2018). Goncalves, Xue, and Zhang (2020) explain value and momentum (as well as investment and return on equity decile returns on average) simultaneously in an investment model via structural estimation.

[3]Investment and profitability characteristics are closely linked to investment-based asset pricing models from which these types of risk factors arise for equities; see Hou, Xue, and Zhang (2015).

to explain U.S. asset pricing anomalies in equity markets. For example, Liu and Zhang (2008) find that the growth rate of industrial production is a priced risk factor, and exposure to it explains more than half of momentum profits in the U.S. Cooper and Priestley (2011) show that the average return spread between low- and high-asset-growth portfolios in the U.S. is largely accounted for by their spread in loadings with respect to the CRR factors.

Using the global CRR factors to measure risk across countries and asset classes, we present a number of new results. First, the global CRR factors do a good job of describing the excess returns on the 48 value and momentum portfolios studied by Asness et al. (2013).[4] This is the case across countries and across asset classes, suggesting a common global factor structure and hinting at the possibility of extensive market integration.[5] When regressing average excess returns on the estimated global CRR factor loadings, the cross-sectional R^2 is 51%. The pricing errors are small, averaging 0.14% per month, and the median ratio of actual average excess returns to expected excess returns is 1.06. Considering that these are non-return-based macroeconomic factors, these metrics are impressive.

The second result shows that the 22 high-minus-low value and momentum return premia constructed from long and short positions, which have positive average returns but are negatively correlated, generally have opposite sign exposures with respect to each of the global macroeconomic factors.[6] We take the fitted values of the value and momentum return premia from the global CRR factor model and compare their correlations with the correlations of the actual return premia. It turns out that the global CRR model captures the negative correlation between the value and momentum return premia, underscoring the ability of the global CRR factors to describe actual value and momentum returns.

The third result focuses on the return premia of 50/50 combinations of value and momentum return premia. We show that these 11 combination portfolios have positive return premia because they have nonzero loadings on the global CRR factors, and consequently, these factors can account for their positive average returns. This is a particularly interesting finding because Asness et al. (2013) note that because of the opposite sign exposure of value and momentum to liquidity risk, the combination portfolios are neutral to liquidity risk. That is, liquidity risk cannot explain why combinations of value and momentum premia earn positive return premia. However, we show that the combination portfolios are not neutral to global macroeconomic risk even if the value and momentum return premia have opposite

[4]The 48 portfolios consist of 3 portfolios sorted by value and 3 portfolios sorted by momentum in each of the following markets and asset classes: U.S. stocks, U.K. stocks, European stocks, Japanese stocks, country equity index futures, currencies, fixed income, and commodities. These portfolios are used as test assets to estimate the prices of risk of the CRR factors.

[5]Markets are completely integrated if assets with the same risk have identical expected returns irrespective of the market (Bekaert and Harvey (1995)). Integration can be across countries and across asset classes.

[6]The 22 return premia are value and momentum premia in each of the 8 markets and asset classes studied by Asness et al. (2013) and value and momentum factor premia when aggregating across all assets, across equities, and across nonequity assets.

sign exposures with respect to the global macroeconomic factors. The reason is that the exposures have different magnitudes.

Unlike characteristic-based factor models, the global CRR factors model ties the factor structure of value and momentum directly to global macroeconomic risk. The fourth set of results we present compares the performance of the global CRR model with that of two other empirical asset pricing models. The first is the 3-factor model of Asness et al. (2013), which includes a global market factor and global value and momentum factors. The second model is the global 5-factor model of Fama and French (2017), which includes a market factor and size, value, profitability, and investment factors. We find that the global CRR model performs better than these other two factor models when the test assets are based on value and momentum.

Given the success of the global CRR factors in describing the value and momentum portfolios, the fifth set of results we present assesses whether the returns on other assets can be explained by the global macroeconomic factors. If the global CRR factors are a common source of global risk that drives the different factor structures across markets and across asset classes, and asset markets are to some extent integrated, then the global CRR factors should be able to summarize the returns on other characteristic-sorted portfolios. We show that the global CRR factors can provide a reasonable description of the cross sections of broad sets of assets. Along with the 48 value and momentum portfolios, we include portfolios sorted on size, book-to-market ratio, investment, and operating profitability; BAB portfolios; and quality portfolios. The global CRR model performs roughly the same as the Fama and French (2017) 5-factor model in describing the cross section of this extended set of test assets that includes portfolios on which the Fama and French (2017) factors are built.

The results we present offer a clear indication that global macroeconomic risks have a role in describing the returns on value and momentum strategies and combinations of these strategies across countries and asset classes. Furthermore, the differences in the loadings on the global CRR factors provide a means of describing the negative correlation between value and momentum return premia. Coupled with the ability of the global CRR factors to describe additional test asset returns, this points to a common factor structure across asset classes and countries based on global macroeconomic risk. This is an important step in understanding return premia in global asset markets because, as Cochrane (2011) notes in his Presidential Address, this empirical project is in its infancy, and we still lack a deep understanding of the real macroeconomic risks that drive the cross section of expected returns across markets and asset classes. This article provides the first evidence for a macroeconomic explanation for a common factor structure and shows that a global specification of the CRR macroeconomic model does a good job of capturing the expected returns across multiple markets and asset classes.

The remainder of the article is as follows: In Section II, we discuss some recent literature on return premia across countries and asset classes. In Section III, we describe the data. In Section IV, we present cross-sectional tests and compare the correlations between value and momentum return premia implied by the global CRR model and those in the data. We also compare the performance of the global CRR model with the performance of other factor models, and we introduce other characteristic-sorted portfolios to examine if the global CRR factors can price them. Section V concludes.

II. Evidence on Return Premia Across Countries and Asset Classes

Our work is related to extant studies that have identified common patterns in returns across different countries and asset classes. For example, Asness et al. (2013) find that a 3-factor model consisting of a global market factor, a global value factor, and a global momentum factor performs well in describing the cross section of average returns on value and momentum strategies across asset classes and countries. Hou, Karolyi, and Kho (2011) show that a multifactor model of both global and local factors based on momentum and the ratio of cash flow to price performs well in explaining the cross-sectional and time-series variation of global stock returns. Karolyi and Wu (2014) identify sets of globally accessible and locally accessible stocks and build global and local size, value, and momentum factors. They show that their model captures strong common variation in global stock returns and has relatively low pricing errors, but only when local factors are included. Fama and French (2012) use a 4-factor model based on firm characteristics at a regional level to explain international stock returns. However, a global version of their 4-factor model cannot explain the return premia on their international stock market returns. Fama and French (2017) show that an international version of the Fama and French (2015) 5-factor model summarizes well the cross section of portfolios sorted on size, book-to-market ratio, operating profitability, and investment for developed markets.

Frazzini and Pedersen (2014) show that BAB factors that go long low-beta securities and short high-beta securities earn positive average excess returns across markets (U.S. and international equities) and across asset classes such as U.S. Treasuries, corporate bonds, futures and forwards on country equity indices, country bond indices, foreign exchanges, and commodities.

Koijen, Moskowitz, Pedersen, and Vrugt (2018) study the carry effect attributed to currencies and find evidence of its existence in the cross section and time series of global equities, global bonds, commodities, U.S. Treasuries, U.S. credit portfolios, and U.S. equity index call and put options. These global carry returns are related to global return factors such as value, momentum, and time-series momentum (Asness et al. (2013), Moskowitz, Ooi, and Pedersen (2012)) but also include additional information about the cross section of returns.

Menkhoff, Sarno, Schmeling, and Schrimpf (2012) link the carry-trade effect to global foreign exchange volatility risk. The proposed volatility factor is also able to price the cross section of 5 foreign exchange momentum returns, 10 U.S. stock momentum portfolios, 5 U.S. corporate bond portfolios, and the individual currencies used in their sample.

Lettau, Maggiori, and Weber (2014) specify a downside risk capital asset pricing model (DR-CAPM) that can jointly explain the cross section of currencies, equity, equity index options, commodities, and sovereign bond returns because the spread in average returns is accompanied by a spread in betas, conditional on the market being in a downturn. However, Lettau et al. (2014) stress that the DR-CAPM cannot explain the returns corresponding to momentum portfolios, corporate bonds, and U.S. Treasuries. Asness, Frazzini, and Pedersen (2019) find that a factor that goes long high-quality stocks and short low-quality stocks earns significant risk-adjusted returns across many countries.

What is striking about the extant literature is the number of separate factors required to explain the different cross sections. It is clear that to date, research has not uncovered a unifying factor model for all asset classes and all countries. Although some factors can explain some returns that are formed by some characteristic across some countries and asset classes, the factor structures required to explain these returns in the previously mentioned articles differ considerably. Furthermore, factor models that use characteristic-based factors do not have a straightforward economic interpretation for the sources of common risk these characteristic-based factors are related to.[7] However, if the characteristic-based factors are diversified portfolios that provide different combinations of exposures to underlying sources of macroeconomic risk, there should be some set of macroeconomic factors that performs well in describing the patterns in average returns.

In this article, we seek to provide a common factor structure across several asset classes and markets that is related to underlying global macroeconomic sources of risk. An appealing feature of the factor model we present is that it measures risk directly as exposure to macroeconomic conditions that affect cash flows and discount rates (see the discussion in Chen et al. (1986)). There is an established economic interpretation for the risks underlying the CRR factors, namely, their variation over the business cycle. For example, the forecasting ability of the term spread for aggregate output is demonstrated by, among others, Harvey (1998), Chen (1991), Estrella and Hardouvelis (1991), Estrella and Mishkin (1998), Estrella (2005), Stock and Watson (2003), and Ang, Piazzesi, and Wei (2006). Movements in the default spread are known to contain important signals regarding the evolution of the real economy and risks to the economic outlook, as shown by, among others, Friedman and Kuttner (1992), (1998), Emery (1996), Gertler and Lown (1999), Mueller (2009), Gilchrist, Yankov, and Zakrajšek (2009), and Faust, Gilchrist, Wright, and Zakrajšek (2011). A further macroeconomic variable we use is industrial production growth, which is clearly related to the business cycle. For example, the National Bureau of Economic Research (NBER) Business Cycle Dating Committee refers to industrial production as an economic indicator for the state of the economy.[8] The CRR factors provide an easy-to-interpret description of risk across global markets based on macroeconomic conditions. This article takes a first step toward examining whether many characteristic-sorted portfolios share a common source of macroeconomic risk.

III. Data

Our main analysis examines the returns on 3 portfolios sorted by value and 3 portfolios sorted by momentum in each of the following 8 markets and asset classes: U.S. stocks, U.K. stocks, continental European stocks, Japanese stocks, country equity index futures (country indices), currencies, government bonds

[7]Exceptions to this are the investment- and profitability-based factors of Hou et al. (2015), which are inspired by the q-theory of investment.

[8]See http://www.nber.org/cycles/jan2003.html.

(fixed income), and commodity futures (commodities), for a total of 48 portfolios. The data are an extended version of the data used by Asness et al. (2013) and are available from Applied Quantitative Research (AQR) Capital Management's website (http://www.aqr.com). The sample period is from Apr. 1983 to Dec. 2018. We also collect 22 value and momentum factors and their combinations from AQR that are updated versions of those used by Asness et al. (2013). These factors are zero-cost long-minus-short positions where every asset is weighted such that the sum of weights is 0.[9] The combination portfolios are 50/50 combinations of the value and momentum return premia.

A. Summary Statistics

We present summary statistics of the returns on the 48 value and momentum portfolios, the returns on the 22 value and momentum risk premia (high-minus-low portfolios), and the returns on the 11 combination factor premia presented by Asness et al. (2013) but updated to 2018. Securities are sorted by value (V) and momentum (M) into 3 groups, with V_1 and M_1 indicating the lowest group, V_2 and M_2 the medium group, and V_3 and M_3 the highest group.

Panel A of Table 1 shows the average excess returns (in excess of the 1-month U.S. T-bill rate) on the 48 value and momentum portfolios and the 16 value and momentum return premia corresponding to the 8 markets and asset classes. We also include value and momentum portfolios that are aggregated over all assets (global all), over equities (global equity), and over nonequities (global other) and the 11 return premia formed from combining value and momentum. We include t-statistics to test the null hypothesis that the average returns are 0.

The value effect and the momentum effect show up in all of the asset classes and across all countries and are statistically significant in most cases. Panel A of Table 1 shows that over the different markets and asset classes, the securities in the high third (V_3 and M_3) have higher average returns than those in the low third (V_1 and M_1). This finding is confirmed in the final 3 columns when examining the return premia defined previously. In all cases, the return premia are positive, and in many cases, they are statistically significant.[10] The statistically significant value premia range from 0.19% to 0.69% on a monthly basis. The value premia are higher in equity markets than in nonequity markets. For example, aggregating across equity markets (global equity) yields an average excess return of 0.31% compared with 0.19% when aggregating across all nonequity classes (global others).

The momentum return premia that are statistically significant range from 0.79% per month for U.K. stocks to 0.42% per month for U.S. stocks (which is marginally statistically significant). The aggregated premia across the equity classes is 0.50% per month, and across the nonequity classes, it is 0.23% per month, both of which are statistically significant. Therefore, just as in the case of the value return premia, the momentum return premia are higher in equity markets than in

[9]Results using the simple high-minus-low portfolio return are very similar. Asness et al. (2013) provide a detailed description of the data and factor construction.

[10]The lack of statistical significance for some markets, as opposed to what Asness et al. (2013) report, stems from the fact that we use a different sample period.

TABLE 1

Summary Statistics

Panel A of Table 1 reports average excess returns along with t-statistics on portfolios sorted on value and momentum, as well as value and momentum factors and an equal-weighted (50/50) combination premium in each market and asset class we study: U.S. stocks (U.S.), U.K. stocks (U.K.), European stocks (EU), Japanese stocks (JP), country futures equity indices (EI), currencies (CR), fixed-income government bonds (FI), and commodities (CM). Securities are sorted by value characteristics and momentum into thirds, with V_1 (M_1) indicating the lowest-value (momentum) group; V_2 (M_2), the medium value (momentum) group; and V_3 (M_3), the highest value (momentum) group. The value and momentum factors are the spread in the returns of high (V_3 or M_3) minus low (V_1 or M_1) and are denoted V and M, respectively. The combination portfolios are a 50/50 combination of the value and momentum thirds (in the last column, denoted C). We also consider value and momentum premia across all markets and asset classes (denoted "All"), for value and for momentum, across all stock markets (denoted "Eq"), and across all nonequity asset classes (denoted "O"). Panel B reports the average correlation of value and momentum return premia within each market and asset class. The t-statistics are in parentheses. The sample period starts in Apr. 1983 and ends in Dec. 2018.

Panel A. Average Excess Returns

	V_1	V_2	V_3	M_1	M_2	M_3	V	M	C
U.S.	0.59	0.62	0.68	0.52	0.59	0.79	0.17	0.42	0.29
	(2.56)	(3.11)	(3.20)	(2.10)	(3.06)	(3.38)	(0.81)	(1.84)	(3.26)
U.K.	0.46	0.56	0.76	0.17	0.75	0.85	0.32	0.79	0.55
	(1.97)	(2.21)	(2.81)	(0.55)	(3.17)	(3.20)	(1.65)	(3.56)	(6.19)
EU	0.68	0.75	0.90	0.47	0.74	0.91	0.16	0.61	0.39
	(2.68)	(3.07)	(3.46)	(1.56)	(3.08)	(3.53)	(1.14)	(3.28)	(4.97)
JP	0.07	0.41	0.72	0.22	0.25	0.38	0.69	0.20	0.45
	(0.23)	(1.47)	(2.51)	(0.67)	(0.91)	(1.26)	(3.57)	(0.88)	(4.99)
EI	0.42	0.59	0.70	0.28	0.65	0.78	0.25	0.44	0.35
	(1.97)	(2.72	(3.08	(1.26	(3.09	(3.49	(2.09	(2.96	(4.86)
CR	0.02	0.11	0.22	0.00	0.14	0.19	0.23	0.15	0.19
	(0.19)	(0.93)	(2.01)	(0.01)	(1.26)	(1.65)	(2.16)	(1.32)	(3.18)
FI	0.21	0.30	0.28	0.27	0.23	0.29	0.05	0.06	0.05
	(2.32)	(4.00)	(3.82)	(3.50)	(3.11)	(3.64)	(0.69)	(0.91)	(1.25)
CM	−0.03	0.20	0.41	−0.12	0.07	0.57	0.42	0.64	0.53
	(−0.14)	(0.98)	(1.89)	(−0.52)	(0.40)	(2.38)	(1.53)	(2.48)	(3.72)

Global	V	M	C
All	0.24	0.34	0.29
	(3.07)	3.49)	(7.62)
Eq	0.31	0.50	0.41
	(2.07)	(2.86)	(6.19)
O	0.19	0.23	0.21
	(2.95)	(3.15)	(5.85)

Panel B. Correlations

U.S.	U.K.	EU	JP	EI	CR	FI	All	Eq	O
−0.67	−0.64	−0.57	−0.65	−0.46	−0.42	−0.23	−0.64	−0.68	−0.46

nonequity markets. Aggregating across all asset classes (global all), the momentum return premium is 0.34% per month, which is also statistically significant.

Across all countries and in every asset class, the combination return premia are positive and statistically significant, with the exception of fixed income, which has a positive average return, albeit statistically insignificant. The combined equity classes have, when aggregated, a higher return premium of 0.41% per month than do the combined nonequity classes, which have a return premium of 0.21% per month. Over all asset classes, the combination return premia range from 0.19% for currencies to 0.55% for U.K. stocks.

Panel B of Table 1 displays the correlation coefficients between the value and momentum strategies. As documented by Asness et al. (2013), there is a strong negative correlation between the two strategies within each market and asset class. These negative correlations are also present when aggregating across all markets, across all equities, and across all nonequity asset classes. The negative correlations range from –0.68 for global equity to –0.23 for fixed income. The average correlation coefficient is –0.53.

These summary statistics raise important challenges for any asset pricing model. First, why do value and momentum have positive return premia over many asset classes and countries? Second, why are the momentum and value return premia negatively correlated? Third, in spite of this negative correlation, why does a 50/50 combination of value and momentum portfolios earn a positive return? Does this combination return premium indicate mispricing, or is it related to risk? The rest of the article provides answers to these questions.

B. Global Risk Factors

Global macroeconomic variables are used to construct the global CRR factors in order to provide sources of global macroeconomic risk. The factors are given by the GDP-weighted averages of the CRR factors of all countries in our sample. More specifically, our global sample consists of continental Europe (Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Portugal, Spain, and Sweden), Japan, the U.K., and the U.S.[11] To compute the GDP weights, we use Organisation for Economic Co-Operation and Development (OECD) data on GDP per capita denominated in U.S. dollars.

The factors are formed as follows: The growth rate of industrial production, MP, is defined as $\text{MP}_t = \log(\text{IP})_t - \log(\text{IP})_{t-1}$, where IP_t is the global index of industrial production in month t, and log is the natural logarithm.[12] Data on industrial production are from the OECD. We define unexpected inflation as $\text{UI}_t \equiv I_t - E[I_t|t-1]$ and the change in expected inflation as $\text{DEI}_t \equiv E[I_{t+1}|t] - E[I_t|t-1]$. We measure the inflation rate as $I_t = \log(\text{CPI})_t - \log(\text{CPI})_{t-1}$, where CPI_t is the seasonally adjusted Consumer Price Index at time t collected from Datastream. Expected inflation is given as $E[I_t|t-1] = r_{f,t} - E[\text{RHO}_t|t-1]$, where $r_{f,t}$ is the short-term rate, and $\text{RHO}_t \equiv r_{f,t} - I_t$ is the realized real short-term return.[13]

Guided by the methodology of Fama and Gibbons (1984), to measure the ex ante real rate, $E[\text{RHO}_t|t-1]$, the change in the global real rate on Treasury bills is modeled as a moving average process, $\text{RHO}_t - \text{RHO}_{t-1} = u_t + \theta u_{t-1}$, and subsequently, we back out the expected real return from $E[\text{RHO}_t|t-1] = (r_{f,t-1} - I_{t-1}) - \widehat{u}_t - \theta\widehat{u}_{t-1}$. The global term premium, UTS, is the GDP-weighted long-term government bond yield minus the GDP-weighted short-term government bond yield. The long-term interest rate data for the U.S. are from the Federal Reserve Bank of St. Louis. For the remaining countries, long-term interest rate data are from Datastream. Because of the lack of data on corporate bond yields, the default factor is proxied for by the

[11]In Switzerland's industrial production, one of the factors we consider is available only as a volume index. Therefore, we drop Switzerland from our sample of countries to maintain a uniform approach to the construction of all macroeconomic factors.

[12]Following Chen et al. (1986), Liu and Zhang (2008), and Cooper and Priestley (2011), we lead the MP variable by 1 month to align the timing of macroeconomic and financial variables.

[13]The global short-term risk-free rate is calculated as a GDP-weighted average of individual country short-term rates. For the U.S., we use the 1-month Treasury bill from CRSP. For the countries within Europe and for Japan, we use short-term rates from Datastream. Not all countries have short-term rates starting in 1983. As each country's short-term rate becomes available, we introduce it into the GDP-weighted average. The same procedure is used when calculating a global long-term rate.

U.S. default spread. We define the default spread, UPR, as the spread between Moody's Baa and Aaa corporate bond yields. Data are from the Federal Reserve Bank of St. Louis.

IV. Cross-Sectional Asset Pricing Tests

The first step in trying to understand if the global macroeconomic factors can explain the various puzzles that the Asness et al. (2013) article unearths involves estimating the prices of risk of the 5 CRR global macroeconomic risk factors and examining whether these factors can explain the cross section of returns. Therefore, we undertake cross-sectional asset pricing tests. We specify a linear multifactor model for expected returns:

$$E(r_{i,t}) = \lambda_0 + \beta' \lambda, \quad (1)$$

where $r_{i,t}$ is the excess return on asset i, λ_0 is a constant, β is a vector of regression coefficients that are obtained from a multiple regression of excess returns on the global CRR factors, and λ is a vector of prices of risk. This model is consistently estimated using the Fama and MacBeth (1973) cross-sectional regression methodology, which follows two steps. Step 1 involves a time-series regression of excess returns on the 5 factors using the full sample period:

$$r_{i,t} = \alpha_i + \beta_{i,\mathrm{MP}} \mathrm{MP}_t + \beta_{i,\mathrm{UI}} \mathrm{UI}_t + \beta_{i,\mathrm{DEI}} \mathrm{DEI}_t + \beta_{i,\mathrm{UTS}} \mathrm{UTS}_t + \beta_{i,\mathrm{UPR}} \mathrm{UPR}_t + \epsilon_{i,t}, \quad (2)$$

where $r_{i,t}$ is the excess return on asset i; MP_t, UI_t, DEI_t, UTS_t, and UPR_t are industrial production growth, unexpected inflation, the change in expected inflation, the term spread, and the default spread, respectively; $\beta_{i,\mathrm{MP}}$ is the estimated factor loading on the industrial production factor; $\beta_{i,\mathrm{UI}}$ is the estimated factor loading on the unexpected inflation factor; $\beta_{i,\mathrm{DEI}}$ is the estimated factor loading on the change in the expected inflation factor; $\beta_{i,\mathrm{UTS}}$ is the estimated factor loading on the unexpected term spread factor; $\beta_{i,\mathrm{UPR}}$ is the estimated factor loading on the unexpected default spread factor; and $\epsilon_{i,t}$ is a residual.

In the second step of the Fama–MacBeth methodology, we estimate a single cross-sectional regression of average excess returns on the factor loadings from step 1:

$$\bar{r}_i = \lambda_0 + \widehat{\beta}_{i,\mathrm{MP}} \lambda_{\mathrm{MP}} + \widehat{\beta}_{i,\mathrm{UI}} \lambda_{\mathrm{UI}} + \widehat{\beta}_{i,\mathrm{DEI}} \lambda_{\mathrm{DEI}} + \widehat{\beta}_{i,\mathrm{UTS}} \lambda_{\mathrm{UTS}} + \widehat{\beta}_{i,\mathrm{UPR}} \lambda_{\mathrm{UPR}} + \eta_i, \quad (3)$$

where $\bar{r}_i$ is the average excess return on portfolio i, λ_{MP} is the estimated price of risk associated with the industrial production factor, λ_{UI} is the estimated price of risk associated with the unexpected inflation factor, λ_{DEI} is the estimated price of risk associated with the change in expected inflation factor, λ_{UTS} is the estimated price of risk associated with the unexpected term-spread factor, λ_{UPR} is the estimated price of risk associated with the unexpected default-spread factor, and η_i is the residual.

Table 2 reports the estimates of the prices of risk for the 5 global macroeconomic factors from the second step of the Fama and MacBeth (1973) procedure, where we use the average excess returns on the 48 value and momentum returns

TABLE 2

Estimates of Prices of Risk from a 2-Step Estimation

Table 2 reports estimates of prices of risk for the 5 global Chen et al. (1986) (CRR) factors, including industrial production (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR), using the Fama–MacBeth (1973) 2-step estimation methodology. The test assets are the 48 value and momentum portfolios from Asness et al. (2013). The first step estimates the factor loadings for each of the 48 portfolios with a time-series regression of the portfolio excess returns on the 5 global CRR portfolios, using the entire sample period, as in equation (2). The second step is a cross-sectional regression of average excess portfolio returns on the estimated loadings as in equation (3). We report results from the second step, including the intercepts ($\widehat{\gamma}_0$), the price of risk ($\widehat{\gamma}$), the cross-sectional regression R^2s as calculated by Lettau and Ludvigson (2001), and the average pricing error (denoted "Avg. P.E."). The average pricing error is the square root of the squared values of the residuals in the 2-step regression in equation (3). The intercept and the prices of risk are in percentage per month. The sample period is Apr. 1983–Dec. 2018.

	$\widehat{\gamma}_0$	$\widehat{\gamma}_{MP}$	$\widehat{\gamma}_{UI}$	$\widehat{\gamma}_{DEI}$	$\widehat{\gamma}_{UTS}$	$\widehat{\gamma}_{UPR}$	$\overline{R}^2$ (%)	Avg. P.E.
Price of risk	0.272	0.371	−0.027	−0.217	−0.021	−0.017	50.5	0.144
t-statistic	4.212	3.521	−0.662	−4.513	−1.059	−4.164		

as the testing assets. The prices of risk associated with MP, DEI, and UPR are statistically significant and economically meaningful. The price of risk associated with MP is 0.37, which means that if a portfolio has a unit beta with respect to MP, this contributes 0.37% per month, or approximately 4.45% per year, to the average excess return of that portfolio. Except for three betas associated with fixed income that are negative (perhaps due to flight to safety), all the betas associated with MP are positive, and the average across all 48 portfolios is 0.42. There are differences in the betas across asset classes, where the average beta for equity classes is 0.53, and for nonequity classes, it is 0.22. Thus, the average contribution to expected returns of equities is 2.36% per annum, and for nonequity classes, it is 0.98% per annum. The positive sign on MP is consistent with the findings of Chen et al. (1986) and Liu and Zhang (2008) and can be thought of as a reward for bearing a systematic production risk. The risk associated with MP is most likely larger in equities than in nonequity classes because the cash flows of equities are more closely linked to production in the economy. This difference in MP risk exposure is consistent with the average returns across equity markets being higher than the average returns across nonequity classes.

The price of risk of DEI is estimated to be −0.22. The negative sign of the price of risk of DEI is consistent with the estimate of Chen et al. (1986) and suggests that investors view positive shocks to expected inflation as adverse shocks. Across the equity classes, the betas are all negative and range from −1.90 to −0.02, with an average of −0.81. Given the negative estimated price of risk, this translates into an annual average expected excess return of 2.14%. The negative loadings of equities with respect to DEI are consistent with estimates from the extant literature (see, e.g., Bodie (1976), Fama (1981)). Fama (1981) shows that the negative stock return expected-inflation relation is induced by the negative relation between expected inflation and future real activity (e.g., future gross national product (GNP) and future real investment). Bekaert and Engstrom (2010) find that high expected inflation has tended to coincide with periods of heightened uncertainty about real economic growth and unusually high risk aversion, both of which reduce stock prices.

For fixed-income portfolios, the loadings with respect to DEI are also negative and large and average −0.70, implying a contribution to the annual expected excess return of 1.87%. This contribution is not surprising because an increase in expected inflation reduces the real value of future fixed nominal cash flows. Commodities load positively on DEI. A potential explanation for this positive loading is that when expected inflation rises, so does inflation uncertainty (see Ball (1992), Grier and Perry (1998)). High inflation risk raises investors' hedging demand, and purchasing a broad basket of commodities provides protection against inflation (see Bodie (1983)).

The estimated price of risk of UPR is −0.02. Rising default spreads are commonly interpreted as worsening credit conditions (see, e.g., Hahn and Lee (2006)), and therefore assets with negative loadings on UPR serve as hedges against poor credit conditions. Additionally, Boons (2016) finds that the default spread negatively predicts industrial production growth and the Chicago Fed National Activity Index. Thus, the negative price of risk of UPR is consistent with Merton's (1973) intertemporal capital asset pricing model (ICAPM). That is, assets that are positively correlated with UPR can be used to hedge against worsening investment opportunities (see Maio and Santa-Clara (2012), Cooper and Maio (2019)). Most of the loadings on UPR are positive, with the exception of U.S. equities, equity futures indices, and some commodities, which have negative loadings. The positive loadings of fixed-income securities and currencies with respect to UPR possibly reflect flight to safety (given that the currencies are developed-market currencies).

The R^2 of the cross-sectional regression, calculated following Lettau and Ludvigson (2001), is 51%, which indicates a good fit for non-return-based factors. To obtain a visual impression of how well the global CRR factors describe average excess returns, Figure 1 presents a plot of the average realized excess returns of the 48 portfolios versus their predicted expected excess returns from equation (3). The scatter plot of the average excess returns and the expected excess returns from the CRR global factor model line up well along the 45-degree line, illustrating that the 5 global CRR factors do a reasonable job of capturing the differences in value and momentum returns across asset classes and countries.

In Table 2, we also report the average absolute pricing error, which is small at 0.14% per month. We can obtain a better impression of the extent of the pricing errors in Table 3, where we report each portfolio's pricing error along with the ratio of the average excess return to the expected excess return. The expected excess return is simply the sum of the betas times their prices of risk. The pricing errors are small over most of the countries and asset classes. This is reflected in the ratios of average to expected returns, which have a mean value of 1.19 and a median value of 1.06. The pricing errors are similar across the asset classes and across value and momentum portfolios. For example, across the four equity markets, the average pricing error is 0.17% per month. Across the remaining asset classes, the pricing error is 0.13% per month. The average pricing errors across all the value portfolios is 0.16% per month, and across all the momentum portfolios, it is 0.14% per month. The global CRR factor model performs equally well across asset classes and investment styles.

In summary, Tables 2 and 3, along with Figure 1, indicate that the 5 global macroeconomic factors explain a good part of the cross-sectional variation in the 48 value and momentum return portfolios. This explanatory power indicates, at least to some extent, that markets are integrated across countries and asset classes

FIGURE 1

Asset Pricing Tests of the Cross Section of Expected Returns: 48 Value and Momentum Portfolios

Figure 1 plots the actual average excess portfolio returns versus the model-implied expected returns of the 48 value and momentum low, middle, and high portfolios in each market and asset class. The expected returns are from the Chen et al. (1986) (CRR) factor model consisting of the 5 global CRR factors, that is, industrial production growth (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR). A 45-degree line that passes through the origin is added to highlight pricing errors given by the vertical distances to the 45-degree line. The sample period is Apr. 1983–Dec. 2018, for a total of 429 observations.

TABLE 3

Pricing Errors: 48 Value and Momentum Portfolios

Table 3 reports the pricing errors (denoted "P.E.") of the Chen et al. (1986) (CRR) model consisting of the 5 global CRR factors (i.e., industrial production growth (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR)) for the 48 value and momentum portfolios of Asness et al. (2013). Also reported is the ratio of average actual excess portfolio returns to expected excess portfolio returns (denoted "AR/ER"), where expected excess returns are the sum of the products of the factor loadings (estimated using the entire sample period) and the estimated prices of risk. Securities are sorted by value and momentum into thirds, with V_1 (M_1) indicating the lowest-value (momentum) group; V_2 (M_2), the medium value (momentum) group; and V_3 (M_3), the highest value (momentum) group. The sample period is Apr. 1983–Dec. 2018.

		V_1	V_2	V_3	M_1	M_2	M_3
U.S.	P.E.	0.086	0.108	0.299	0.125	0.234	0.211
	AR/ER	1.171	1.211	1.794	1.317	1.651	1.366
U.K.	P.E.	–0.114	0.013	0.261	–0.389	0.228	0.058
	AR/ER	0.803	1.023	1.518	0.302	1.436	1.074
EU	P.E.	–0.120	0.087	0.146	–0.232	–0.014	0.128
	AR/ER	0.850	1.132	1.194	0.668	0.981	1.164
JP	P.E.	–0.371	0.101	0.549	0.078	–0.156	–0.122
	AR/ER	–0.157	1.330	4.187	1.544	0.618	0.760
EI	P.E.	–0.229	–0.020	0.247	–0.122	0.025	0.096
	AR/ER	0.648	0.967	1.550	0.699	1.040	1.140
CU	P.E.	–0.247	0.007	0.057	–0.155	0.029	–0.064
	AR/ER	0.085	1.075	1.355	0.009	1.256	0.752
FI	P.E.	–0.146	–0.078	–0.060	–0.167	–0.072	–0.071
	AR/ER	0.589	0.796	0.824	0.618	0.763	0.805
CM	P.E.	–0.274	0.053	0.079	–0.102	–0.172	0.191
	AR/ER	–0.139	1.352	1.238	8.853	0.294	1.501

and that macroeconomic sources of global risk can account for a reasonable amount of value and momentum returns.

We now turn to examining if the global macroeconomic risk factors can explain why the 22 value and momentum return premia have a positive return despite being negatively correlated. Moreover, can the macroeconomic factors account for the puzzling fact that given the negative correlation between value and momentum return premia, equal-weighted combinations of them also have positive risk premia? A first step in trying to answer these questions is to simply examine the factor loadings of the 22 value and momentum return premia and the combination return premia.

Figure 2 provides the factor loadings, allowing for easy comparisons across return premia. Graph A plots the loadings on the global industrial production factor, MP. There are opposite factor loadings of value and momentum in 7 of the 11 pairs of

FIGURE 2

Factor Loadings of Value and Momentum Premia

Figure 2 plots the loadings with respect to the 5 Chen, Roll, and Ross (1986) (CRR) global factors for the value and momentum strategies. Graph A presents the loadings with respect to industrial production growth (MP). Graph B plots the loadings on unexpected inflation (UI). The loadings with respect to the change in expected inflation (DEI) are plotted in Graph C. The loadings with respect to the term spread (UTS) and with respect to the default spread (UPR) are plotted in Graphs D and E, respectively. The sample period is Apr. 1983.

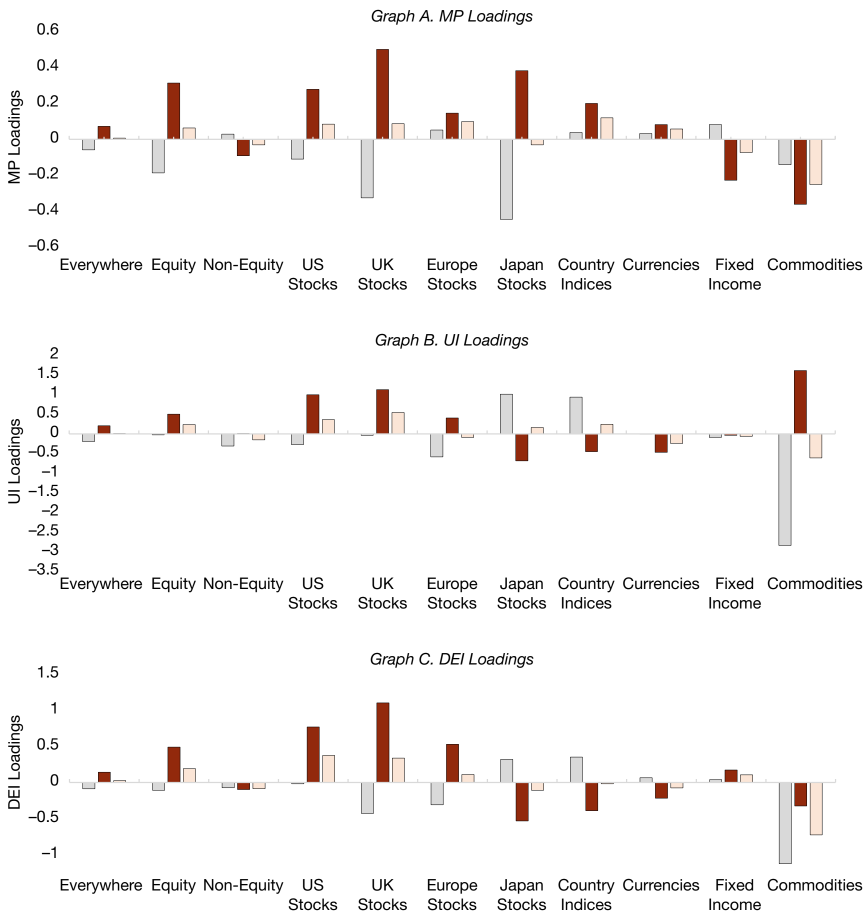
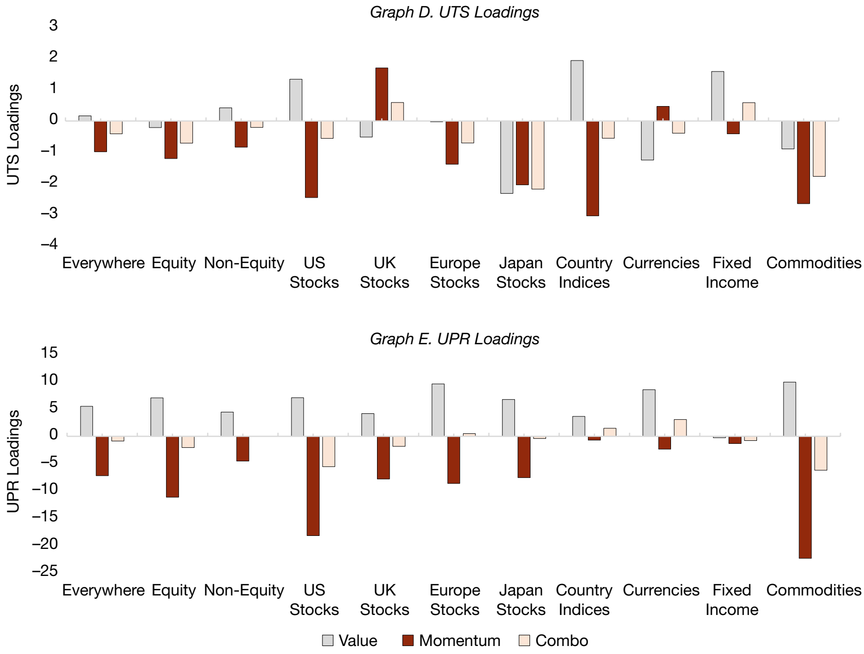


FIGURE 2 (continued)



value and momentum factors. Consistent with Liu and Zhang (2008), momentum factors load positively on MP in most cases. For all equity markets, as well as for currencies, momentum has positive loadings on MP In contrast, 6 of the 11 value returns have negative loadings on the MP factor. The magnitudes of the MP loadings are different for value and momentum return premia across the different asset classes. Consequently, in most cases, the combination return premia have positive loadings on the MP factor, and therefore there is a positive expected return contribution for value and momentum combinations from exposure to the MP factor.

We also observe similar patterns in the factor loadings for the other two statistically significant prices of risk: DEI, plotted in Graph C of Figure 2, and UPR, plotted in Graph E. The factor loadings on DEI for the value and momentum portfolios have the opposite signs in 8 cases and are negative for the value return premia and positive for the momentum return premia. The negative price of risk of DEI implies that value stocks are risky because of their exposure to expected inflation shocks. The combination return premia tend to have negative loadings on DEI, which contributes to a positive expected return for these strategies.

In the case of the factor loadings on UPR, the value and momentum portfolios have opposite factor loadings, apart from fixed income. Ten of the value premia across countries and asset classes load positively on UPR. In contrast, all of the 11 factor loadings on the momentum return premia are negative. These negative loadings imply that momentum strategies yield low returns during periods of high uncertainty and poor credit conditions, rendering these strategies risky. Overall, the positive loadings of momentum premia on MP and their negative loadings on UPR are consistent with the finding that momentum profits are procyclical, as also found by Chordia and Shivakumar (2002), and with the finding that momentum profits occur only during expansionary periods. The combination factor loadings on UPR are negative in all but 3 cases, contributing to a positive expected return for the combination return premia.

Taken together, the plots show that value and momentum premia have generally opposite exposures to global macroeconomic risk and that the equal-weighted combinations of value and momentum premia are not neutral to global macroeconomic risk. These combinations have sizable factor loadings even if the value and momentum portfolios' return premia have opposite sign exposures with respect to the global macroeconomic factors. Because the combination strategies, across markets and across asset classes, do not have neutral loadings with respect to the global macroeconomic factors, and given the estimated prices of risk in Table 2, the combination strategies have a positive expected return. The pricing errors for the combination portfolios are small, with an average absolute pricing error of 0.13% per month.

To illustrate more precisely that the global CRR model captures the negative correlation between the actual return premia of value and momentum strategies, we compute the correlation between value expected return premia and momentum expected return premia that is implied by the global CRR factor model and then compare this correlation with the correlation between the actual value return premia and the actual momentum return premia. The implied correlation is the correlation between the value-return-premia fitted values and the momentum-return-premia fitted values from the global CRR model. We then compare this correlation coefficient with the correlation coefficient of value and momentum return premia calculated from their respective return series.

Table 4 presents the actual and implied correlation coefficients of value and momentum strategies for the various markets and asset classes as well as for the global equity, global other, and global all asset classes. The global CRR model captures the negative correlation between the value and momentum strategies.

TABLE 4

Implied Correlations

Table 4 presents actual and implied time-series correlation coefficients between value and momentum strategies in the different markets and asset classes. The implied correlations are the correlations between the time series of the fitted values of the value and momentum return premia within the market or asset class. The fitted values are obtained from time-series regressions of the value and momentum return premia on the 5 global Chen et al. (1986) macroeconomic factors (i.e., industrial production growth (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR)). The sample period is Apr. 1983–Dec. 2018.

	U.S.	U.K.	EU	JP
$\rho_{V,M}$	−0.67	−0.64	−0.57	−0.65
ρ_{implied}	−0.95	−0.89	−0.89	−0.75
	EI	CR	FI	CM
$\rho_{V,M}$	−0.46	−0.42	−0.23	−0.43
ρ_{implied}	−0.77	−0.62	−0.53	−0.63
	Global All	Global Stocks	Global Other	
$\rho_{V,M}$	−0.64	−0.68	−0.46	
ρ_{implied}	−0.97	−0.94	−0.82	

The actual correlations between value and momentum return premia for U.S., U.K., European, and Japanese stock returns and for the equity futures country indices are −0.67, −0.64, −0.57, −0.65, and −0.46, respectively. The implied correlation coefficients from the fitted values of the global CRR factor model are −0.95, −0.89, −0.89, −0.75, and −0.77, respectively. The actual correlations for nonequity asset classes are smaller at −0.42 for currencies, −0.23 for fixed income, and −0.43 for commodities. The implied correlation coefficients that we calculate from the CRR factor model are −0.62 for currencies, −0.53 for fixed income, and −0.63 for commodities. When the assets are aggregated globally into global all, global equity, and global other, the actual return correlations are −0.64, −0.68, and −0.46, respectively. The implied correlations from the CRR factor model are −0.97, −0.94, and −0.82. For all of the value and momentum strategies, irrespective of asset class or country, it is reassuring to find that the global CRR factor model is able to match the sign of the actual correlation coefficients. This finding strengthens the interpretation that the negative correlation between the value and momentum returns that is observed in the data is driven by the differing loadings that value and momentum portfolios have with respect to the global CRR factors.

The evidence presented so far indicates that the differing factor loadings are the source of the empirical success of the global CRR factor model in describing both the negative correlation between the value and momentum strategies and the return premia on these portfolios and on combinations of their factors. The results show that the ability of global macroeconomic factors to price value and momentum portfolios is not unique to equities. It is also present in other nonequity asset classes. This evidence contributes to the recent and ongoing research that aims to offer a unified risk-based explanation of expected returns across asset classes. We view our results as a step toward a better understanding of the factor structure that drives the cross section of expected returns in multiple asset classes and countries, a factor structure that has its roots in observable macroeconomic risks.

A. Time Variation in Factor Loadings

In the empirical analysis so far, we have assumed that the betas on the macroeconomic factors are constant across the entire sample period. It is relevant to inquire whether this is actually the case and to assess if there are trends in the estimated factor loadings that might make the assumption of constant betas questionable. To illustrate the issue, we plot the loadings on all the factors for value and momentum returns when the loadings are estimated using a 60-month rolling window. Figure 3 plots the loadings for global all assets, Figure 4 for global equity, and Figure 5 for global others.[14]

The first noticeable pattern in all three figures is the negative correlation of the factor loadings of value and momentum. It is clear from this pattern that the negative correlation between value and momentum factor returns, which, in the previous section, we showed was driven by the opposite signs of their factor loadings with respect to the global CRR factors, is evident in these plots period by period. This is the case for all assets, equities separately, and other asset classes separately.

[14]Similar patterns are observed for the individual asset classes.

FIGURE 3

Rolling-Window Estimation of the Factor Loadings (Global All Assets)

Figure 3 presents the estimates of the factor loadings with respect to the 5 global Chen et al. (1986) (CRR) factors (i.e., industrial production growth (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR)) of the value and momentum premia within global all assets. The estimated loadings at each point in time are based on a 60-month time-series multiple regression of the premia on the 5 global CRR factors. The beginning of the estimation window is month $t-60$, and the end of the window is month $t-1$. For global all assets, the value and momentum premia are averages of the value and momentum factors across all markets and asset classes. For global equities, the value and momentum premia are averages of the value and momentum factors across all markets (U.S., U.K., Europe, Japan, and equity futures indices). For global other assets, the value and momentum premia are averages of the value and momentum factors for currencies, fixed incomes, and commodities. The sample period is Apr. 1983–Dec. 2018.

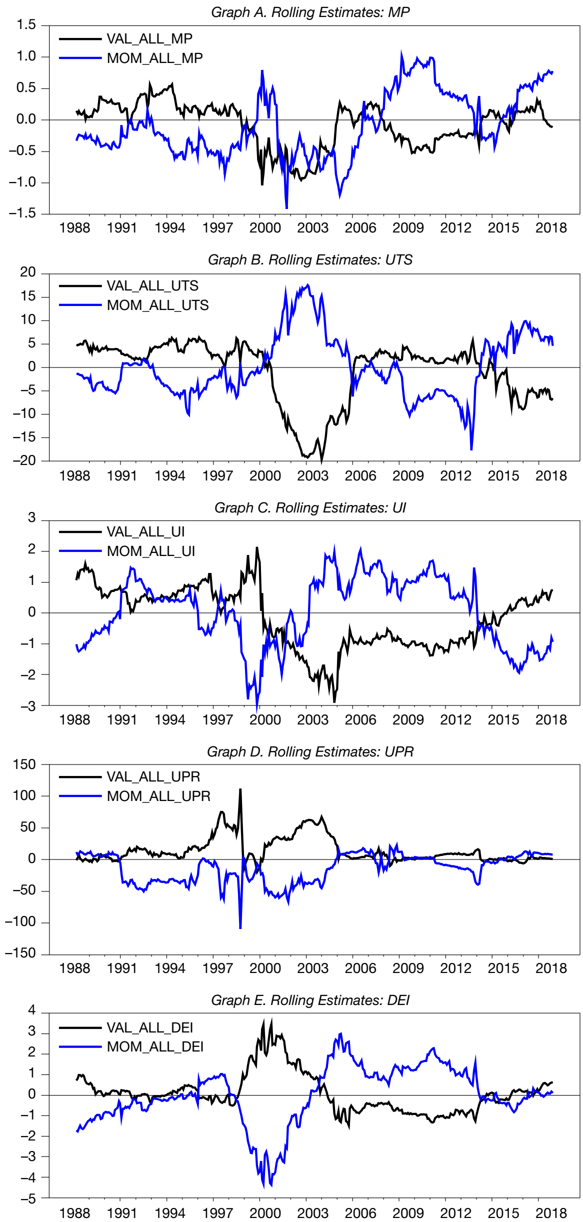


FIGURE 4

Rolling-Window Estimation of the Factor Loadings (Global Equities)

Figure 4 presents the estimates of the factor loadings with respect to the 5 global Chen et al. (1986) (CRR) factors (i.e., industrial production growth (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR)) of the value and momentum premia within global equities. The estimated loadings at each point in time are based on a 60-month time-series multiple regression of the premia on the 5 global CRR factors. The beginning of the estimation window is month $t-60$, and the end of the window is month $t-1$. For global all assets, the value and momentum premia are averages of the value and momentum factors across all markets and asset classes. For global equities, the value and momentum premia are averages of the value and momentum factors across all markets (U.S., U.K., Europe, Japan, and equity futures indices). For global other assets, the value and momentum premia are averages of the value and momentum factors for currencies, fixed incomes, and commodities. The sample period is Apr. 1983–Dec. 2018.

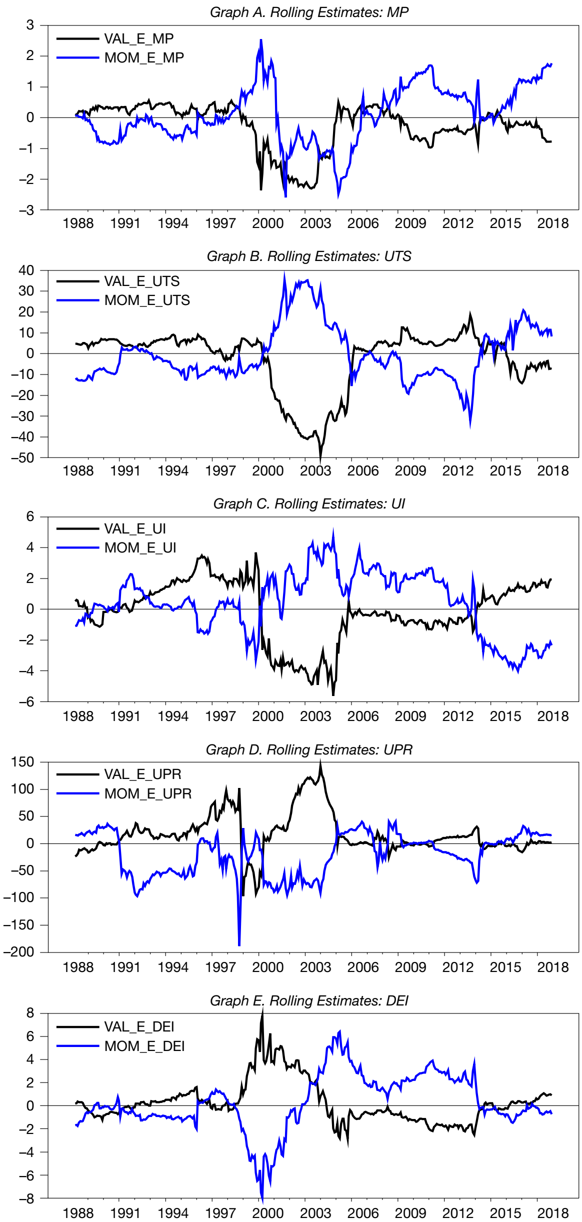


FIGURE 5

Rolling-Window Estimation of the Factor Loadings (Global Nonequity Assets)

Figure 5 presents the estimates of the factor loadings with respect to the 5 global Chen et al. (1986) (CRR) factors (i.e., industrial production growth (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR)) of the value and momentum premia within global nonequity assets. The estimated loadings at each point in time are based on a 60-month time-series multiple regression of the premia on the 5 global CRR factors. The beginning of the estimation window is month $t-60$, and the end of the window is month $t-1$. For global all assets, the value and momentum premia are averages of the value and momentum factors across all markets and asset classes. For global equities, the value and momentum premia are averages of the value and momentum factors across all markets (U.S., U.K., Europe, Japan, and equity futures indices). For global other assets, the value and momentum premia are averages of the value and momentum factors for currencies, fixed incomes, and commodities. The sample period is Apr. 1983–Dec. 2018.

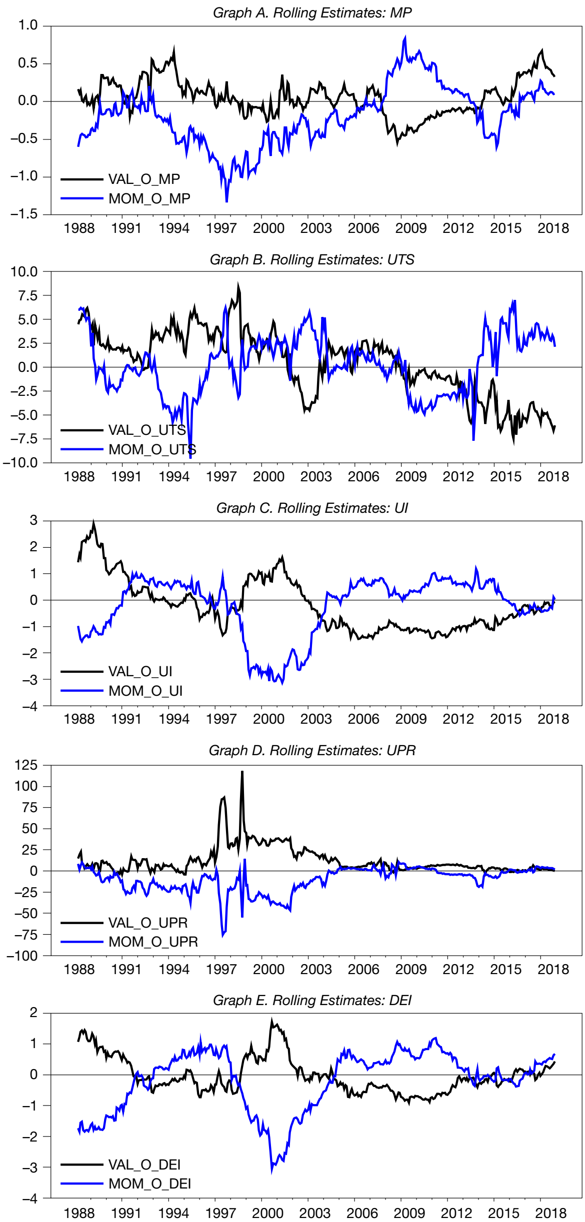
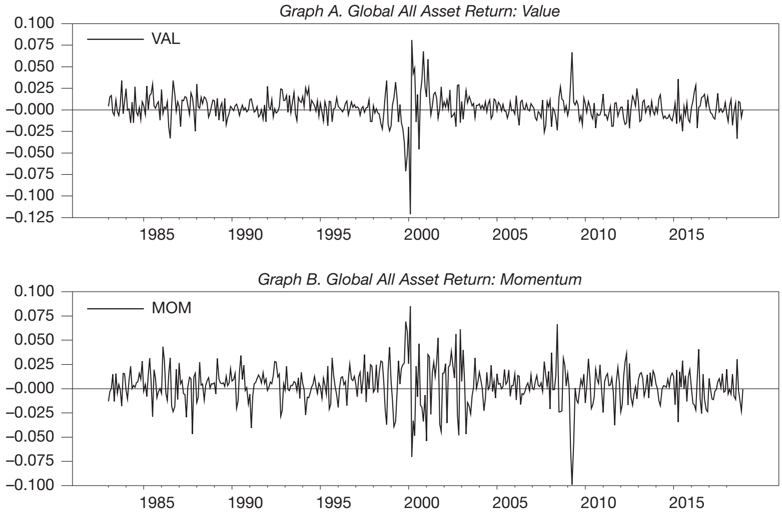


FIGURE 6

Value and Momentum Premia Returns

Figure 6 presents the returns on the value and momentum premia for global all asset classes. The value and momentum premia are averages of the value and momentum factors across all markets and asset classes. The sample period is Apr. 1983–Dec. 2018.



It is apparent from the figures that there is some volatility in the factor loadings, which appears to be concentrated around the late 1990s and early 2000s. To try to understand why this is the case, in Figure 6, we plot the returns on the global value and momentum factors throughout the full sample period. There is a large increase in the volatility of returns around the late 1990s and early 2000s, which corresponds to an increase in the volatility in the loadings. For example, over the full sample period, the mean return on the global value factor is 0.24% per month, with a standard deviation of 1.61%. In the shorter sample period around the increased volatility of the factor loadings, the mean return and standard deviation of the value factor are 0.20% and 2.9% per month, respectively. Over the full sample period, the momentum factor has a mean return of 0.34% per month and a monthly standard deviation of 2.00%. In the shorter sample period, the momentum return premium is 0.75%, with a standard deviation of 3.1% per month. Therefore, we see a substantial increase in the volatility of returns for both factors, as well as a noticeable difference in momentum mean returns. These patterns in both returns and volatility are captured by the factors in that the factor loadings change during the period of high return volatility, driving the returns on value and momentum portfolios.

It is important to note that in Figures 2–4, there are no trends in the factor loadings. After the period of high volatility in the factor loadings in the late 1990s and the early 2000s corresponding to the high return volatility in this period, the factor loadings revert back to roughly their 1990s values. This reversion means that full sample betas are a good approximation of the factor loadings and are useful for estimating the cross-sectional regressions.

B. Comparing Factor Models

We now compare the performance of the CRR global macroeconomic factor model with that of other factor models. We consider the 3-factor model of Asness et al. (2013) and the 5-factor model of Fama and French (2017). It is important to remember that the 3-factor model of Asness et al. (2013) and the 5-factor model of Fama and French (2017) use return-based factors sorted on characteristics. Factors formed in this way have an advantage over macroeconomic variables because using returns to form portfolios reduces the noise in the factors compared with using the macroeconomic factors. Furthermore, if we were to form return-based factor-mimicking portfolios of the macroeconomic variables using the same assets as Asness et al. (2013) use when forming their value and momentum risk factors, then the mimicking macroeconomic factors would be based on linear combinations of value and momentum portfolios. One might be concerned that we would capture the cross-sectional variation in the value and momentum returns because the mimicking portfolios of the macroeconomic factors would simply be a repackaging of the test assets themselves.

By using the raw macroeconomic factors, we avoid the aforementioned problems. The drawback as far as the raw macroeconomic variables are concerned is that they are likely to lead to noisier estimates of the factor loadings and of prices of risk.[15] This possibility should be considered when comparing factor models that are return based and factor models that use raw macroeconomic variables.

The 3 factors of the Asness et al. (2013) model are the excess returns on the Morgan Stanley Capital International (MSCI) world stock market index, a global value factor, and a global momentum factor. The Fama and French (2017) international 5 factors include, in addition to the global market excess return, global return-based factors sorted by size (SMB), value (HML), operating profitability (RMW), and investment (CMA). The data on the Fama and French (2017) factors are available for the sample period of July 1990–Dec. 2018. Details of these factors can be found in Fama and French (2017). Given the shorter sample period that the Fama and French (2017) factors are available for, we reestimate the global CRR factor model for the shorter period. Not only does this allow us to compare the performance of the models for the same sample period, but it also provides for subsample analysis of the global CRR factor model.

Table 5 presents the performance of the 3 models in pricing the 48 value and momentum portfolios. Panel A shows that the 3-factor model of Asness et al. (2013) has relatively low explanatory power, with an R^2 of 25%. However, the pricing error is quite low at 0.18% per month. The market and momentum factors have statistically significant positive prices of risk, but the value factor does not help describe the cross section of the 48 value and momentum returns.

The global 5-factor model of Fama and French (2017) also has a relatively low explanatory power, as shown in Panel B of Table 5. The R^2 is 27%, and the average pricing error is 0.17% per month. The market factor's price of risk is estimated to be positive and statistically significant. The investment factor, CMA, and the size

[15] See, for example, the discussion in Vassalou (2003).

TABLE 5
Model Comparison

Table 5 presents estimates of prices of risk. The test assets are the 48 value and momentum portfolios. The estimation methodology is the same as the methodology described in Table 2. In Panel A, we estimate the prices of risk of the Asness et al. (2013) 3-factor model. The factors are the global market return and the global value and momentum factors. Panel B presents the results for the global 5-factor model of Fama and French (2017). The estimation results for the global Chen et al. (1986) (CRR) factors, including industrial production (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR), appear in Panel C. $\widehat{\gamma}_m$ is the estimated price of risk of the global market portfolio, and $\widehat{\gamma}_{\text{VAL}}$ and $\widehat{\gamma}_{\text{MOM}}$ are the estimated prices of risk of the global value factor and global momentum factor, respectively. $\widehat{\gamma}_{\text{SMB}}$, $\widehat{\gamma}_{\text{HML}}$, $\widehat{\gamma}_{\text{RMW}}$, and $\widehat{\gamma}_{\text{CMA}}$ are the estimated prices of risk of the size, value, profitability, and investment factors, respectively. The intercepts and risk premiums are in percentage per month. The R^2 values are calculated following Lettau and Ludvigson (2001). The average pricing error (denoted "Avg. P.E.") is the square root of the squared values of the residuals in the 2-step regression in equation (3). The sample period is July 1990–Dec. 2018.

Panel A. AMP Factors

	$\widehat{\gamma}_0$	$\widehat{\gamma}_m$	$\widehat{\gamma}_{\text{VAL}}$	$\widehat{\gamma}_{\text{MOM}}$	R^2 (%)	Avg. P.E.
Price of risk	0.115	0.301	0.092	0.249	25.3	0.181
t-statistic	1.703	3.471	0.989	2.850		

Panel B. Fama–French Factors

	$\widehat{\gamma}_0$	$\widehat{\gamma}_m$	$\widehat{\gamma}_{\text{SMB}}$	$\widehat{\gamma}_{\text{HML}}$	$\widehat{\gamma}_{\text{RMW}}$	$\widehat{\gamma}_{\text{CMA}}$	R^2 (%)	Avg. P.E.
Price of risk	0.209	0.185	−0.385	−0.164	0.248	−0.274	27.0	0.165
t-statistic	3.010	2.145	−2.164	−1.190	1.795	−2.183		

Panel C. Global CRR Factors

	$\widehat{\gamma}_0$	$\widehat{\gamma}_{\text{MP}}$	$\widehat{\gamma}_{\text{UI}}$	$\widehat{\gamma}_{\text{DEI}}$	$\widehat{\gamma}_{\text{UTS}}$	$\widehat{\gamma}_{\text{UPR}}$	R^2 (%)	Avg. P.E.
Price of risk	0.340	0.414	−0.049	−0.057	−0.037	−0.022	46.4	0.138
t-statistic	5.553	3.741	−1.234	−0.841	−2.644	−4.592		

factor, SMB, both have prices of risk that are estimated to be negative, and both are statistically significant. It is clear from Table 5 that the Fama and French (2017) 5-factor model struggles somewhat to describe the 48 value and momentum portfolios, at least in terms of the R^2, although the pricing errors are low. Although the Fama and French (2017) model has 5 factors, it performs very similarly to the 3-factor model of Asness et al. (2013).

The results from estimating the global CRR model over the shorter sample period are presented in Panel C of Table 5. The pricing ability of the model is substantially better than that of the Asness et al. (2013) global 3-factor model and that of the Fama and French (2017) global 5-factor model. Specifically, the R^2 is larger at 46%, and the average pricing error is somewhat smaller at 0.14% per month. Based on this shorter sample period, the global CRR model compares well with other factor models in pricing the 48 value and momentum portfolios. Compared with the full-sample-period estimates in Table 2, the estimated price of risk for MP retains its sign and statistical significance. The price of risk is 0.41% per month in this shorter sample period, as compared with 0.37% in Table 2. The estimated prices of risk for the remaining factors are negative, as they were in Table 2. However, DEI loses its statistical significance, possibly because inflation has moderated in this more recent sample. UPR retains its economic and statistical significance, and UTS becomes significant, with a negative price of risk of −0.04% per month. The estimated prices of risk and the model performance metrics from the shorter sample period illustrate that the performance of the global CRR model is quite stable.

C. Explaining the Returns on Other Assets

If the global CRR factors are common sources of global risks that drive the different factor structures across markets and assets classes, and if markets are to some extent integrated, then the global CRR factors should be able to explain the risk premia associated with the cross sections of other assets. Therefore, we now explore the relation between the global macroeconomic CRR factors and other cross sections of returns.

We test the pricing ability of the model for three sets of assets, all of which include 103 portfolios. These three sets of assets share the following common portfolios: the 48 value and momentum portfolios, 13 international BAB portfolios, and 10 international quality portfolios from AQR. The BAB portfolios correspond to equities markets used in the Asness et al. (2013) article (excluding Portugal), as well as to global equities markets. The BAB portfolios are long low-beta securities and short high-beta securities. The quality portfolios are long high-quality stocks and short low-quality (junk) stocks. Quality is measured as a combination of a firm's profitability, growth, stability, and payout.[16] The first set of test assets adds to these portfolios 32 portfolios of international stock returns sorted on size, book-to-market ratio, and operating profitability constructed by Fama and French (2017).

The second set of test assets uses an alternative set of Fama and French portfolios that includes 32 portfolios sorted on size, book-to-market ratio, and investment. The third set of test assets uses a third set of Fama and French portfolios consisting of 32 portfolios formed on size, operating profit, and investment.

We choose to examine the ability of the global CRR factor model to price the 3 sets of 32 portfolios because Fama and French (2017) claim that size, book-to-market ratio, investment, and profitability, which make up the assets in their various portfolios, dominate and span the huge set of characteristics that have been identified in the literature and that have led them to form their 5-factor model. Details of these test assets can be found in Fama and French (2017). As noted earlier, the sample period is shorter than that of the 48 value and momentum portfolios, ranging from July 1990 to Dec. 2018.

Table 6 reports the results from estimating the global CRR factor model for these 3 sets of 103 test assets. Panel A presents the results for the first set of additional test assets and shows that there are 3 statistically significant prices of risk associated with DEI, UPR, and UI. Relative to the results in Table 2, which are based on employing only the 48 value and momentum portfolios, the price of risk on UI is now statistically significant, and the price of risk on MP is no longer statistically significant. The price of risk associated with DEI has changed sign, which is not necessarily a concern, given that we are pricing a different set of assets relative to those in Table 2.[17] The R^2 is 32%, and the pricing errors are reasonably small, with an average of 0.19% per month.

Panel B of Table 6 shows that the model performs slightly worse when pricing the second set of assets, producing an R^2 of 25% and an average pricing error of 0.22%

[16]Details on the construction of the BAB portfolios and the quality portfolios can be found in Frazzini and Pedersen (2014) and Asness et al. (2019). These data are from http://aqr.com.

[17]The change in the sign of the estimated prices of risk when using different test assets also occurs when we consider other factor models; see Table 7.

TABLE 6

Global Macroeconomic Risk and Other Cross Sections of Returns

Table 6 presents estimates of prices of risk for the global Chen et al. (1986) (CRR) factors, including industrial production (MP), unexpected inflation (UI), change in expected inflation (DEI), term spread (UTS), and default spread (UPR), using the Fama and MacBeth (1973) 2-step estimation methodology. The test assets in Panel A are the 48 value and momentum portfolios of Asness et al. (2013); 32 international portfolios sorted on size, book-to-market ratio (BM), and operating profitability (OP), formed across developed markets and constructed by Fama and French (2017); 13 international zero-investment betting-against-beta (BAB) factors (zero-investment portfolios) from Applied Quantitative Research (AQR); and 10 U.S. portfolios sorted on quality from AQR, for a total of 103 test assets. In the test assets in Panel B, 32 international portfolios sorted on size, BM, and investment replace the 32 Fama and French portfolios in Panel A, and the rest of the assets are the same as in Panel A. Panel C includes, in addition to the 48 value and momentum portfolios, 32 international Fama–French portfolios sorted on size, investment, and operating profitability; 13 international zero-investment BAB portfolios; and 10 U.S. portfolios sorted on quality. In the first step, we estimate the factor loadings for each of the test assets with a time-series regression of the portfolio excess returns (or zero-investment portfolio) on the 5 global CRR portfolios using the entire sample period as in equation (2). The second step is a cross-sectional regression of average excess portfolio returns on the estimated loadings as in equation (3). We report results from the second step, including the intercepts ($\widehat{\gamma}_0$), prices of risk ($\widehat{\gamma}$), a second-stage cross-sectional regression R^2 calculated following Lettau and Ludvigson (2001), and the average pricing errors (denoted "Avg. P.E."). The average pricing error is the square root of the squared values of the residuals in the 2-step regression in equation (3). The intercepts and the prices of risk are in percentage per month. The sample period is July 1990–Dec. 2018.

	$\widehat{\gamma}_0$	$\widehat{\gamma}_{MP}$	$\widehat{\gamma}_{UI}$	$\widehat{\gamma}_{DEI}$	$\widehat{\gamma}_{UTS}$	$\widehat{\gamma}_{UPR}$	R^2 (%)	Avg. P.E.
Panel A. 48 Value and Momentum; 32 Size, BM, and OP; 13 BAB; and 10 Quality Portfolios								
Price of risk	0.430	0.119	−0.137	0.155	0.003	−0.019	31.7	0.186
t-statistic	6.933	1.385	−4.226	3.436	0.442	−4.919		
Panel B. 48 Value and Momentum; 32 Size, BM, and Investment; 13 BAB; and 10 Quality Portfolios								
Price of risk	0.429	0.060	−0.144	0.218	−0.009	−0.013	25.3	0.224
t-statistic	6.066	0.603	−3.814	4.224	−0.860	−2.922		
Panel C. 48 Value and Momentum; 32 Size, OP, and Investment; 13 BAB; and 10 Quality Portfolios								
Price of risk	0.466	0.038	−0.180	0.226	−0.008	−0.012	26.7	0.234
t-statistic	6.048	0.352	−4.421	3.952	−0.782	−2.446		

per month. The prices of risk have the same sign as those in Panel A, except the sign on UTS changes; however, this price of risk is not statistically significant in either panel. The remaining prices of risk are quite similar in magnitude and statistical significance to those in Panel A. The results for the third set of test assets in Panel C are very similar to those in Panel B in terms of the estimated prices of risk and the R^2, which is 27%, and the average pricing error, which is 0.23% per month. When compared with the performance of the global CRR factor model for the 48 value and momentum portfolios, there is a deterioration in the performance of the global CRR factor model for this extended set of test assets.

We now turn to examine how well the Fama and French (2017) model performs on this extended set of assets. This is an interesting exercise and comparison for the global CRR factor model because the Fama and French (2017) factors are based on the 3 sets of Fama and French (2017) test assets. Panel A of Table 7 shows the result for pricing the first broad set of assets, a set that includes the 48 value and momentum portfolios; the 32 international portfolios sorted on size, book-to-market ratio, and operating profitability; the 13 BAB portfolios; and the 10 quality portfolios. Although the prices of risk of all 5 Fama and French (2017) factors are positive, the only statistically significant factor is the profitability factor, RMW. The R^2 is 33%, and the average pricing error is 0.18% per month, compared with an R^2 of 31% and an average pricing error of 0.19% per month, respectively, for the global CRR factor, as shown in Panel A of Table 6.

Panel B of Table 7 shows that the international 5-factor model performs better than the global CRR factor model in pricing the second large set of test assets, at least in terms of the R^2, which is 42%. The average of the pricing errors is 0.23% per

TABLE 7

Estimates of Prices of Risk: Fama and French Factors

Table 7 reports estimates of prices of risk for the 5 global Fama–French (2017) factors, including a global market portfolio, a global size factor (SMB), a global value factor (HML), a global profitability factor (RMW), and a global investment factor (CMA). The test assets in Panel A are the 48 value and momentum portfolios of Asness et al. (2013); 32 international portfolios sorted on size, book-to-market ratio (BM), and operating profitability (OP), formed across developed markets and constructed by Fama and French; 13 international zero-investment betting-against-beta (BAB) factors from Applied Quantitative Research (AQR); and 10 international portfolios sorted on quality from AQR, for a total of 103 test assets. In the test assets in Panel B, 32 international portfolios sorted on size, BM, and investment replace the 32 Fama and French (2017) portfolios in Panel A, and the rest of the assets are the same as in Panel A. Panel C includes, in addition to the 48 value and momentum portfolios, 32 international Fama and French portfolios sorted on size, investment, and OP; 13 international zero-investment BAB portfolios; and 10 U.S. portfolios sorted on quality. The estimation follows the Fama and MacBeth (1973) 2-step methodology. In the first step, we estimate the factor loadings on the Fama and French 5 international factors for each of the test assets with a time-series regression of the portfolio excess returns (or zero-investment portfolio) on the 5 global Chen et al. (1986) (CRR) portfolios, using the entire sample period. The second step is a cross-sectional regression of average excess portfolio returns on the estimated loadings. We report results from the second step, including the intercepts ($\widehat{\gamma}_0$), prices of risk ($\widehat{\gamma}$), a second-stage cross-sectional regression R^2 calculated following Lettau and Ludvigson (2001), and the average pricing errors (denoted "Avg. P.E."). The average pricing error is the square root of the squared values of the residuals in the 2-step regression. The intercepts and the prices of risk are in percentage per month. The sample period is July 1990–Dec. 2018.

	$\widehat{\gamma}_0$	$\widehat{\gamma}_m$	$\widehat{\gamma}_{SMB}$	$\widehat{\gamma}_{HML}$	$\widehat{\gamma}_{RMW}$	$\widehat{\gamma}_{CMA}$	R^2 (%)	Avg. P.E.
Panel A. 48 Value and Momentum; 32 Size, BM, and OP; 13 BAB; and 10 Quality Portfolios								
Price of risk	0.325	0.071	0.066	0.140	0.394	0.017	33.0	0.179
t-statistic	5.581	1.064	0.976	1.787	5.572	0.198		
Panel B. 48 Value and Momentum; 32 Size, BM, and Investment; 13 BAB; and 10 Quality Portfolios								
Price of risk	0.379	−0.160	−0.110	0.194	0.479	0.038	42.3	0.231
t-statistic	5.797	−2.134	−1.516	1.852	6.357	0.447		
Panel C. 48 Value and Momentum; 32 Size, OP, and Investment; 13 BAB; and 10 Quality Portfolios								
Price of risk	0.395	−0.178	−0.065	0.121	0.432	−0.003	0.286	0.233
t-statistic	5.828	−2.333	−0.857	1.300	4.609	−0.035		

month. For comparison, the corresponding R^2 and average pricing errors for the global CRR factor model in Panel B of Table 6 are 25% and 0.22% per month, respectively. Thus, the explanatory power of the Fama and French (2017) model is better, but in terms of the pricing errors, the models perform similarly. The only estimated price of risk that is positive and statistically significant is RMW. The market factor has a statistically significant price of risk, but it has a negative sign.

Panel C of Table 7 presents the result for pricing the set of test assets that includes the 32 portfolios sorted on size, operating profits, and investment. The estimated prices of risk have the same sign as those in Panel B, and those that are statistically significant in Panel C are the same as those in Panel B. The values of the R^2, 29%, and the average pricing error, 0.23% per month, are very similar to the result produced by the global CRR factor model in Panel C of Table 6.

When comparing the results in Table 7 with those in Table 5, we see that there are numerous changes in sign of the Fama and French (2017) estimated prices of risk when pricing the 48 value and momentum portfolios (Table 5) and when pricing the various sets of extended assets (Table 7). For example, in Table 5, the market factor and the profitability factor were both estimated to be positive. The size, book-to-market ratio, and investment factors all have estimated prices of risk that are negative. In Panel A of Table 7, all of the Fama and French (2017) factors are estimated to be positive. In Panel B, the estimates of the market and size factors become negative, and the remaining factors have positive estimates of their prices of risk. In Panel C, there is also a change in the sign of the estimate of the investment factor's price of risk. The choice of test assets does have an effect on the sign of the prices of risk for both the global CRR factor model and the Fama and French (2017) 5-factor model.

In summary, the Fama and French (2017) 5-factor model performs about the same as the global CRR factor model even though we might expect the Fama and French model to perform better because the Fama and French factors are sorts of stocks based on size, operating profitability, and investment, the same testing portfolio that the model is pricing.

The evidence presented in this section that the global CRR factor model performs approximately the same as the Fama–French (2017) model in describing these additional assets, coupled with the earlier findings that the value and momentum returns across markets and asset classes are related to global macroeconomic risk, strengthens our interpretation that the global CRR factors represent common sources of risk driving the various factor structures across asset classes and countries.

V. Conclusion

This article shows that global risk in the form of exposure to the global CRR macroeconomic factors plays an important role in summarizing the average returns on value and momentum portfolios as well as combinations of value and momentum strategies across many markets and asset classes. Importantly, the global CRR factor model accounts for the negative correlations of value and momentum strategies.

A major advantage of the global CRR factor model is that risks in financial markets are associated with global macroeconomic variables and the global business cycle. Therefore, the global macroeconomic model enhances our understanding of the underlying economic sources of risk driving the patterns in returns across markets and across asset classes, something that is more challenging when using characteristic-based factors.

In addition to the global CRR factor model's success in summarizing the 48 value and momentum portfolios' returns from Asness et al. (2013), the model also performs quite well in describing the cross sections of international portfolios' returns sorted on size, book-to-market ratio, operating profitability, investment, BAB, and quality.

Linking the variation of expected returns across asset classes and countries and identifying their common factor structure are important research questions. Our results provide support for a unified risk view across asset classes and across countries, thus contributing to the asset pricing literature that explores the joint cross section of expected returns in multiple asset classes and countries.

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