A Global Macroeconomic Risk Explanation for Momentum and Value

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June 23, 2016

Abstract

Value and momentum returns and combinations of them are explained by their loadings on global macroeconomic risk factors across both countries and asset classes. These loadings describe why value and momentum have positive return premia and why they are negatively correlated. The global macroeconomic risk factor model also performs well in capturing the expected returns of various additional asset classes. The findings identify the source of the common variation in expected returns across asset classes and countries suggesting that markets are integrated.

JEL Classification: G1, G11, G12

Keywords: Value, momentum, global macroeconomic risk, market integration.

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1 Introduction

Value and momentum 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 both asset classes and countries. They uncover three puzzling findings. First, these return premia are negatively correlated. Second, in spite of this negative correlation, a simple equal-weighted combination of value and momentum produces a positive return premium. Third, various risk factors such as the CAPM beta and liquidity cannot explain these return premia. Instead they rely on global value and momentum factors to describe value and momentum characteristic sorted portfolios. Consequently, it is not clear how these factors relate to macroeconomic state variables.

Asness, Moskowitz, and Pedersen's (2013) findings raise an important challenge for asset pricing: can any asset pricing model explain the negative correlation of the value and momentum return premia and the fact that an equal-weighted combination strategy earns a positive average return? This is challenging because asset pricing models based on real investment and growth options of firms, that have been useful in explaining value and momentum, are based on firm equity.[2] However, no such models exist to explain value and momentum in the non-equity asset classes studied in Asness, Moskowitz, and Pedersen (2013).

Our contribution is to show that a version of Ross's (1976) Arbitrage Pricing Theory (APT) based on global macroeconomic factors that mirror the Chen, Roll, and Ross (1986) (CRR) U.S. macreconomic risk factors can describe the return premia on both value and momentum strategies, and combinations of them across both countries and

[1]The value effect in U.S. equities is documented by Stattman (1980) and Rosenberg, Reid, and Lanstein (1985), whereas Fama and French (1992, 1993) thoroughly examine the value effect in an asset pricing framework. Jagadeesh and Titman (1993), and Asness (1994) identify the momentum effect in U.S. equities. Fama and French (1998), Rouwenhurst (1998), Liew and Vassalou (2000), Griffin, Ji, and Martin (2003), and Chui, Wei, and Titman (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) and Gorton, Hayashi, and Rouwenhorst (2008).

[2]See, for example, Berk, Green, and Niak (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) and Li and Zhang (2010).

asset classes.[3] In addition, it can explain the negative correlation between these two return premia. We present three main results. First, the positive return premia on value and momentum, across both asset classes and countries, can be explained by loadings on the global risk factors. For example, the value, momentum, and combination return premia that are aggregated across all asset classes and all countries are 0.29%, 0.34%, and 0.32% per month, respectively, and they are statistically significant. The global macroeconomic factor model produces alphas that are very small and statistically insignificant at 0.04%, 0.02%, and 0.02% per month, respectively. We find similar results for separate asset classes and across different countries, thus, offering a unified macroeconomic risk explanation of value and momentum return premia.

The second result is that the negative correlation between the return premia can be explained by their differing factor loadings. For example, for the aggregated value, momentum, and combination return premia, the factor loadings on the global industrial production factor are -0.34 for value, 1.77 for momentum, and 0.80 for the combination. For global unexpected inflation they are -2.20, 7.81, and 3.16. For the change in expected inflation they are -1.69, 3.92, and 1.31. For global term structure they are 0.35, -0.01, and 0.17, and for global default risk they are -0.04, 0.17, and 0.07. Based on these loadings, we calculate the expected returns of the return premia and compare the expected return correlations with the correlations of the return premia. The actual correlation between the value and momentum strategies for the aggregated portfolio across all assets and countries is -0.48, whereas the implied correlation of the two strategies from their expected returns is -0.47. Similar results are obtained for value and momentum strategies across separate asset classes and countries.

The third result shows that the global macroeconomic factor model does a good job in explaining the return premia on the combinations of the value and momentum strategies. This is interesting since Asness, Moskowitz, and Pedersen (2013) note that because of the opposite sign exposure of value and momentum to liquidity risk, the equal-weighted (50/50) combination is neutral to liquidity risk. However, we show that this 50/50 com-

[3]The multifactor model we estimate can also be thought of as empirical versions of the Merton (1973) model.

bination is not neutral to global macroeconomic risk even if the value and momentum return premia have opposite sign exposures with respect to the global macroeconomic factors.[4] The reason for this is that the exposures have different magnitudes.

The success in explaining the return premia on value and momentum strategies leads us to assess whether the return premia on other asset classes can be explained by the global macroeconomic factors. If the five macroeconomic factors are a common source of global risk that drives the different factor structures across assets and across markets, and asset markets are integrated, then the macroeconomic factors should be able to explain the returns on other assets as well. We show that the global macroeconomic factor model performs well in capturing the returns on most of the portfolios studied in Lettau, Maggiori, and Weber (2014).[5]

The results we present offer a clear indication that global macroeconomic risks have a role in describing the return premia on value and momentum strategies and combinations of these strategies across countries and asset classes. Furthermore, the differences in loadings on the factors provide a means of describing the negative correlation between value and momentum return premia. Coupled with the ability of the global factor model to describe additional test assets, this points to a common factor structure across asset classes and countries based on global risk factors that indicates that markets are integrated across both countries and asset classes.[6] This is an important step in understanding return premia in global asset markets since, 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 assets and asset classes. This paper puts forth an economic explanation for a common factor structure and shows that a global specification of the CRR (1986) macroeconomic

[4]Our global macroeconomic factors fully explain the Pástor and Stambaugh (2003) liquidity measure, that is, the time series of liquidity innovations.

[5]These portfolios include currency portfolios sorted on the interest rate differential, commodity futures portfolios sorted on the basis, sovereign bond portfolios sorted on the probability of default and bond beta, U.S. stock portfolios sorted on CAPM betas, U.S. betting against beta factor, Fama and French industry portfolios, put and call options portfolios on the S&P 500, Fama and French portfolios sorted on size and momentum, and corporate bond portfolios sorted on credit spread.

[6]Fama and French (2012, 2015) note that examining models that use global factors to explain global and regional returns sheds some light on the extent to which asset pricing is integrated across markets.

model does a good job in capturing the expected returns across multiple asset classes and markets.

We undertake robustness checks that confirm the strong pricing ability of the macroeconomic factors. We provide simulation evidence that the probability that random "noise" factors could spuriously replicate our time-series results, in terms of GRS statistics, is close to zero. We also conduct mean-variance analysis and find that a combination of the mimicking portfolios for the CRR factors is close to the tangency portfolio on the efficient frontier generated by the value and momentum portfolios across countries and across markets.

The remainder of the paper is as follows: in section 2 we discuss briefly recent literature on return premia across countries and asset classes. Section 3 describes the data. Section 4 presents the empirical results. In section 5, we assess the performance of our model in summarizing the returns on the set of assets studied in Lettau, Maggiori, and Weber (2014). In section 6, we address robustness issues related to the construction of factor mimicking portfolios. Section 7 concludes.

2 Evidence on Return Premia Across Countries and Asset Classes

Various studies have identified common patterns in return premia across different countries and asset classes. However, extant studies have not identified a common factor structure across asset clasess and countries. For example, Asness, Moskowitz, and Pedersen (2013) find that a three-factor model consisting of a global market index, a global value factor, and a global momentum factor performs well in describing the cross section of average returns 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 a cash flow-to-price factors 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 four-factor model based on firm characteristics at a regional level to explain international stocks returns. However, a global version of their four-factor model cannot explain the return premia on their international stock market returns.

Frazzini and Pedersen (2014) show that beta-sorted portfolios display a spread in average returns and this pattern emerges for both U.S. and international equities as well as for various asset classes such as U.S. Treasuries, corporate bonds, futures and forwards on country equity indices, country bond indices, foreign exchange, and commodities. To capture this effect in the data, they construct a betting against beta factor that goes long low-beta securities and short high-beta securities. The betting against beta factor earns positive average excess returns across the asset classes.

Koijen, Moskowitz, Pedersen, and Vrugt (2015) 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. Furthermore, they ask whether the returns to carry strategies represent a unique risk dimension or are a repackaging of the global return factors such as value, momentum, and time series momentum (following Asness, Moskowitz, and Pedersen (2013), and Moskowitz, Ooi, and Pedersen (2012)). They find that the carry factors within each asset class as well as across all asset classes are related to those factors, but also include additional information.

Menkhoff, Sarno, Schmeling, and Schrimpf (2012) link the carry trade effect to global foreign exchange volatility risk and find that the volatility factor has a negative price of risk. In addition, low interest currencies have a positive covariance with the volatility factor, whereas high interest currencies display a negative covariance. This evidence coupled with the negative price of risk suggests that low interest currencies provide a hedge against volatility risk and high interest rate currencies demand a risk premium as they perform poorly in bad times. Moreover, 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) also look at the cross section of currency returns and find that high interest rate currencies have a larger covariance with the aggregate market factor conditional on bad market returns than low interest currencies. They specify a downside risk capital asset pricing model (DR-CAPM) which 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.[7] Lettau, Maggiori, and Weber (2014) note that: "we view these results as not only confirming the empirical performance of the model (the DR-CAPM) but also as a first step in reconciling discount factors across asset classes. The performance of the model across asset classes contrasts with the failure of models designed for a specific asset class in pricing other asset classes." However, Lettau, Maggiori, and Weber (2014) stress that the DR-CAPM cannot explain the returns corresponding to momentum portfolios, corporate bonds, and U.S. Treasuries.[8]

The findings of previous studies point towards a common factor structure across markets and across asset classes. However, considered jointly, the extant literature has not uncovered a unifying factor model: the factor structures in the above studies differ considerably. Furthermore, factor models that use characteristics-based factors do not have an economic interpretation for the sources of common risk these characteristics-based factors are related to. 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. Consequently, an appealing feature of the factor model we present is that we have an economic interpretation for the CRR factors, namely their variation over the business cycle. For example, the forecasting ability of the term spread for aggregate

[7]For the cross section, they use as follows: the six Fama and French portfolios sorted on size and book-to-market; five commodity futures portfolios sorted by the commodity basis; six sovereign bond portfolios sorted by the probability of default and bond beta.

[8]That is, six U.S. equity portfolios sorted on size and momentum; five corporate bond portfolios sorted on credit spread; and bond portfolios sorted on maturity.

output is demonstrated in, among others, Harvey (1988), Stock and Watson (1989), Chen (1991), Estrella and Hardouvelis (1991), Estrella and Mishkin (1998), Estrella (2005), 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 in, 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 Zakrajsek (2011). A further macroeconomic variable we use is industrial production growth which is clearly related to the business cycle. For example, the NBER Business Cycle Dating Committee refers to industrial production as an economic indicator for the state of the economy.[9]

Recent papers employ the CRR factors to explain asset pricing anomalies. Griffin, Ji and Spencer (2003) examine whether exposure to the CRR factors can explain momentum profits internationally. 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.

Our results show that there exists a simple model based on global macroeconomic factors that provides a good description of the return premia that exists across many asset types and many countries. This is a useful first step in understanding the common risks that drive multiple asset returns across many countries.

3 Data

Our main analysis examines the return premia of value and momentum portfolios as well as combinations of value and momentum. The test assets consist of eight different markets and asset classes, namely U.S. stocks, U.K. stocks, continental Europe stocks, Japanese stocks, country equity index futures (country indices), currencies, government

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

bonds (fixed income), and commodity futures (commodities) for a total of 48 portfolios.[10] Data are from the website of Tobias Moskowitz. The sample period is from January 1982 to June 2010. In our empirical tests, we study jointly the return premia of value and momentum as well as combinations of these two. Because data on the host of test assets have different starting dates, the length of our sample is restricted to a total of 342 monthly observations for each portfolio. For a detailed description of the test assets, please refer to Asness, Moskowitz, and Pedersen (2013).

3.1 Global Risk Factors

Global measures of the CRR factors are constructed as sources of 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 United Kingdom, and the United States.[11] To compute the GDP weights, we use data on GDP per capita denominated in U.S. dollars available from the OECD.

The factors are formed as follows. The growth rate of industrial production, MP, is defined as $MP_t = logIP_t - logIP_{t-1}$, where IP_t is the global index of industrial production in month t.[12] For the United States, we use data on industrial production from the Federal Reserve Bank of St. Louis. For the remaining countries, data on industrial production are from Datastream. We define unexpected inflation as $UI_t \equiv I_t - E[I_t|t-1]$ and the change in expected inflation as $DEI_t \equiv E[I_{t+1}|t] - E[I_t|t-1]$. We measure the inflation rate as $I_t = logCPI_t - logCPI_{t-1}$, where CPI_t is the seasonally adjusted consumer price index at time t and data are from Datastream. The expected inflation is $E[I_t|t-1] = r_{f,t} - E[RHO_t|t-1]$, where $r_{f,t}$ is the Treasury bill rate and $RHO_t \equiv r_{f,t} - I_t$

[10] Low, middle, and high portfolios for each of the two value and momentum characteristics in each of the eight asset classes.

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

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

is the realized real return on Treasury bills. For the United States, we use the one-month Treasury bill from CRSP. For the countries within Europe, the United Kingdom, and Japan, we use the money market rate from Datastream.

Guided by the methodology in Fama and Gibbons (1984), to measure the ex ante real rate, $E[RHO_t|t-1]$, the change in the global real rate on Treasury bills is modelled as a moving average process, $RHO_t - RHO_{t-1} = u_t + \theta u_{t-1}$, and subsequently we back out the expected real return from $E[RHO_t|t-1] = (r_{f,t-1} - I_{t-1}) - \widehat{u}_t - \theta \widehat{u}_{t-1}$. The global term premium, UTS, is the GDP-weighted yield spread between the ten-year and the one-year Treasury bonds (for the United States) and the difference between the long term interest rate (government bond) and the money market rate for the remaining countries. Data for the United States are from the Federal Reserve Bank of St. Louis, whereas for the remaining countries data are from Datastream. Due to the lack of data on corporate bond yields, the default factor is proxied for by the U.S. default spread. We define the default spread, UPR, as the yield spread between Moody's Baa and Aaa corporate bonds. Data are from the Federal Reserve Bank of St. Louis.

3.1.1 Construction of the mimicking portfolios

The macroeconomic factors are noisy and might include some information that is not relevant for the pricing of assets. Moreover, among the five CRR factors three are non-traded assets. Therefore, we adopt the existing methodology in the literature and construct mimicking portfolios, that is, portfolios of traded assets that mimic the factors.[13]

Lehmann and Modest (1988) note that using mimicking portfolios helps to shed light on the common factors underlying asset pricing relations. However, constructing mimicking portfolios that reflect the behavior of such common factors depends on having well diversified portfolios as base assets, that is, the assets used to form the mimicking portfolios, and the portfolios should display sufficient dispersion in the loadings with respect to the common factors.

Our base assets consist of the excess returns of the six value and momentum portfolios

[13] Cochrane (2005, p.125) and Ferson, Siegel,and Xu (2006), among others, recommend using mimicking portfolios when the risk factors are not traded assets. See also the discussion in Vassalou (2003).

that Asness, Moskowitz, and Pedersen (2013) employ to form their global value and momentum risk factors. These portfolios use the same assets as the 48 value and momentum portfolios. More specifically, to construct value and momentum factors across all markets and asset classes, Asness, Moskowitz, and Pedersen (2013) rank all the securities, across markets and asset classes, by value and momentum and sort them into three equal groups. Thus, using the entire cross section of securities, they generate three portfolios - low, middle, and high - for value and momentum, producing six well-diversified portfolios which we use as our base assets. In addition, Asness, Moskowitz, and Pedersen (2013) show that the value and momentum everywhere factors summarize a large fraction of the return space across markets and asset classes. However, the weakness of using characteristic-based portfolios as risk factors is that they are silent on the the exposures to the macroeconomic sources of risk the returns on these global characteristic-based factors are correlated with. Consequently, it seems reasonable to use the mimicking portfolio approach to extract the information related to the macroeconomic factors from the returns of the assets used to create the global factors. This should shed some light on the macroeconomic risk the value and momentum factors are exposed to.

Vassalou (2003) proceeds in a similar way when choosing the base assets to create the mimicking portfolio of news related to future GDP growth. Specifically, Vassalou (2003, page 56) uses the excess returns over the T-bill rate of the same six size and book-to-market portfolios that are also used to form the HML and SMB factors. Adrian, Etula, and Muir (2014) also construct a mimicking portfolio for their broker-dealer leverage factor. In particular, they project their measure of leverage on the excess returns of the six Fama and French benchmark portfolios sorted by size and book-to-market along with the momentum factor. They note that the choice of base assets is dictated by their ability to summarize well a large amount of the return space.

We follow the methodology in Lehmann and Modest (1988) to construct the mimicking portfolios. This methodology produces unit-beta mimicking portfolios, that is, the mimicking portfolio for a specific factor has a beta of unity with respect to that factor and a beta of zero with respect to all other factors. The procedure is as follows. The excess returns on each of the six portfolios are regressed on the five CRR factors. That is, we estimate six time series regressions producing a (6 x 5) matrix B of slope coefficients against the five factors.[14] Let V be the (6 x 6) covariance matrix of error terms (assumed to be diagonal), then the weights on the mimicking portfolios are given by: $w = (B'V^{-1}B)^{-1}B'V^{-1}$. The weights w are stacked in a 5 x 6 matrix and the mimicking portfolios are given by wR', where R is a T x 6 matrix of returns and T denotes the length of our sample.

The estimated weights w are: $w_{MP} = [1.11, 0.14, 0.19, 0.49, -2.29, 0.65]$, $w_{UI} = [0.42, -0.39, 0.48, -0.27, 0.46, -0.60]$, $w_{DEI} = [-1.00, 0.77, -0.66, -0.01, -0.41, 0.93]$, $w_{UTS} = [-2.76, 3.81, 3.36, -3.20, -1.60, -0.38]$, $w_{UPR} = [-8.02, -0.87, -8.35, 2.02, 12.4, 4.82]$. The weights indicate that there is substantial dispersion in the loadings with respect to the original CRR factors. According to Lehmann and Modest (1988), one of the conditions for constructing mimicking portfolios that reflect well the behavior of the common factors is for the base assets to display differing loadings with respect to the proposed common factors. Consequently, the substantial dispersion we document provides evidence that our choice of base assets allows us to construct portfolios that mimic well the common factors.

3.2 Summary Statistics

In this part of the paper, for completeness, we present summary statistics of the value, momentum, and combination return premia that are presented in Asness, Moskowitz, and Pedersen (2013). Securities are sorted by value and momentum into three groups, with P1 indicating the lowest group; P2 the medium group; and P3 the highest. The value and momentum return premia are the high (P3) minus low (P1) spread in returns. The combination portfolios are a 50/50 combination of the value and momentum premia. Thus, the equal-weighted (50/50) combination return premia are defined as the high combination minus the low combination. Panel A of Table 1 shows the average excess

[14] The excess returns on the base assets are stacked in a matrix in the following order: value (P1,P2,P3) and momentum (P1,P2,P3), with P1 indicating the lowest group; P2 the medium group; and P3 the highest.

returns (in excess of the 1-month U.S. T-bill rate) on the 48 value and momentum portfolios, the 22 value and momentum return premia corresponding to the eight markets and assets classes as well as aggregation over all assets, over equities, and over non-equities, and the 11 return premia of the combinations of value and momentum. We also present t-statistics testing the null hypothesis that the average returns are zero.

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 shows that over the different markets and asset classes, the securities in the high third (P3) have higher returns than those in the low third (P1). This finding is confirmed in the final three columns when examining the return premia defined as the difference between the highest and lowest portfolios. In all cases these are positive and in many cases statistically significant.[15] The statistically significant value premia range from 0.43% to 1.01% on a monthly basis and aggregating across equity markets yields an excess return of 0.47% which is twice the size of the value premium observed when aggregating across all non-equity classes (Global other asset classes).

Considering the momentum return premia, the statistically significant premia range from 0.62% per month for European stocks to 0.88% per month for commodities. When aggregating across all equity and non-equity asset classes, momentum generates return premia of 0.41% and 0.32% per month, respectively, both of which are statistically significant. Across all asset classes the momentum return premium is 0.34% per month which is also statistically significant.

Across all countries and in every asset class with the exception of fixed income, the combination return premia are positive and statistically significant. These combination return premia have similar values across asset classes and countries, ranging from 0.53% to 0.60%, with the exception of U.S. stocks and currencies which have lower return premia of 0.25% and 0.26%, although they are statistically significant. The combination return premium for aggregated equity (Global stocks) is 0.45% per month and larger than the return premium of 0.27% corresponding to aggregated non-equity asset classes.

[15] The lack of statistical significance for some markets as opposed to what Asness, Moskowitz, and Pedersen (2013) report stems from the fact that we use a somewhat different time period.

To illustrate the failure of the CAPM, both when defining the market portfolio as country (asset class) specific and global, in Panel A of Table 1, we report the alphas and their t-statistics from time series regressions of each value, momentum, and combination return premia on the return of the market portfolio for each asset class:

$$r_{i,t} = \alpha_i + \beta_i * rm_t + e_t \tag{1}$$

where $r_{i,t}$ is the excess return on asset i, (or a long-short value or momentum return premium, or a combination of a value and momentum return premium), alpha is the intercept and interpreted as the pricing error of the model, β_i is the estimated beta of the portfolio i against the excess return on the market portfolio, rm_t, and e_t is an error term. The market portfolio for the stock strategies is the MSCI index for each country and the MSCI World portfolio when aggregating across all equities (Global stocks). For country index futures, currencies, fixed income, commodities as well as global all asset classes and global non-equity asset classes the market portfolio is an equal-weighted index of the securities within each asset class or across all asset classes. For example, for fixed income, the market portfolio is an equal-weighted portfolio of all the country bond returns available at any point in time.[16] Also reported are alphas produced by time-series regressions of each of the return series on the global market portfolio, namely the MSCI World Index.

The alphas produced from regressing the return premia on the individual market returns are not statistically different from zero for the value and momentum premia in U.S. equities. However, it should be noted that the estimated alphas are economically large (0.28% and 0.40% per month) and are actually higher than the average return premia. The combination of the value and momentum strategy for U.S. equities has an alpha of 0.34% per month that is statistically significant with a t-statistic of 2.93. We also report alphas for value return premia in U.K. equities, European equities, currencies, fixed income, and commodities that are not statistically different from zero. Much like

[16] Asness, Moskowitz, and Pedersen (2013) use government bond data for the following countries: Australia, Canada, Denmark, Germany, Japan, Norway, Sweden, Switzerland, the U.K., and the U.S.

the findings for U.S. equities, the economic sizes of the alphas are large at 0.32%, 0.34%, 0.27%, 0.16%, and 0.38% per month, respectively.

Estimates of alphas for the momentum and the combination return premia are statistically significant in all other cases except fixed income. It should be noted that the average returns on the fixed income return premia are low at 0.20%, 0.03%, and 0.06% for value, momentum, and the combination, so it is not surprising that the alphas are not statistically significant or large.

The estimates of alphas for the aggregated global value, momentum, and combination risk premia range from 0.24% to 0.49% and are all statistically significant. Panel A of Table 1 also shows that the findings regarding the estimated alphas across all of the different return premia are largely similar when substituting the return on the individual market portfolios with the global market portfolio return. These findings are in line with the evidence in Asness, Moskowitz, and Pedersen (2013) who document that a global CAPM does a poor job in describing both the value and momentum premia, and a combination of the two strategies.

Thus far, Table 1 provides convincing evidence that the return premia on value, momentum, and a combination of these two strategies are positive and economically large and that a simple asset pricing model with a market portfolio, either local or global, cannot explain these return premia.

Panel B of Table 1 displays the coefficients of correlation between the value and momentum strategies. As documented by Asness, Moskowitz, and Pedersen (2013), there is a strong negative correlation between the two strategies within each market and asset class, as well as when aggregating across markets, across all equities, and across all non-equity asset classes. These negative correlations rnage from -0.59 for U.S. and Japanese equity to -0.17 for fixed income. The average correlation coefficient is -0.45.

4 Empirical Results

4.1 Time Series Regressions: 48 Portfolios

The previous section showed that an asset pricing model with a market portfolio, either local or global, leaves large unexplained returns on value, momentum, and combination strategies. In this section, we consider whether a global macroeconomic factor model, in which the factors are the global CRR factors, can explain these return premia. We begin by undertaking time series regressions of each of the 48 portfolio excess returns on the mimicking portfolios of the five global CRR factors in order to assess the pricing errors (alphas):

$$r_{i,t} = \alpha_i + \beta_{i,MP} * MP_t + \beta_{i,UI} * UI_t + \beta_{i,DEI} * DEI_t + \beta_{i,UTS} * UTS_t + \beta_{i,URP} * UPR + \varepsilon_{i,t} \quad (2)$$

where $r_{i,t}$ is the excess return on asset i (or a long-short value or momentum return premium, or a combination of a value and momentum return premia, which we use as dependent variables in subsequent regressions), α_i is the pricing error, $\beta_{i,MP}$ is the factor loading with respect to the mimicking portfolio for MP, $\beta_{i,UI}$ is the factor loading on the mimicking portfolio for UI, $\beta_{i,DEI}$ is the factor loading on the mimicking portfolio for DEI, $\beta_{i,UTS}$ is the factor loading on the mimicking portfolio for UTS, $\beta_{i,UPR}$ is the factor loading with respect to the mimicking portfolio for UPR, and $\varepsilon_{i,t}$ is an error term. If the factor exposures account for all the variation in expected returns then the estimate of α_i will be equal to zero for all return premia.

Table 2 presents the estimates of the alphas along with the factor loadings with respect to the mimicking portfolios for the global macroeconomic factors. We first examine the magnitude of the alphas and then consider the factor loadings. Of the 48 portfolios considered, 29 of the estimated alphas are actually negative. There are only two statistically significant alphas across all 48 portfolios, of which one is negative. In particular, the model leaves a negative unexplained return on the loser portfolio of country indices and a positive unexplained return on the loser portfolio group of fixed income. For most of the individual return series the alphas from the global macroeconomic model are small and less than the single market portfolio models.[17] Therefore, it appears that a global macroeconomic factor model can explain a large proportion of value and momentum return premia.

Next, we consider the factor loadings. Instead of discussing the loadings of each of our 48 test assets, we focus on the average time series beta with respect to each macroeconomic factor within and across asset classes and the dispersion of the loadings as measured by the standard deviation. If an asset's exposure to the mimicking portfolios for the global macroeconomic factors captures cross-sectional differences in their average returns then the difference in average returns should be accompanied by a large spread in the factor loadings with respect to the global macroeconomic factors. The standard deviation of the factor loadings with respect to each of the macroeconomic factors gives us a sense of the size of the spread in the factor loadings across the assets.

In the pool of all asset classes and markets, the average time series betas with respect to each of the global macroeconomic factors, that is, MP, UI, DEI, UTS, and UPR, are 1.10, -2.12, -2.89, 0.38, and 0.27, with standard deviations of 1.01, 4.08, 2.44, 0.23, and 0.16. By asset class, we observe considerable risk dispersion as well. For example, within the equity class across the U.S., the U.K., Europe, and Japan the average time series betas with respect to each of the global macroeconomic factors, MP, UI, DEI, UTS, and UPR, are 1.48, -3.02, -4.08, 0.51, and 0.38, with standard deviations of 0.93, 4.32, 2.29, 0.15, and 0.10. Moving to country indices, the average time series factor loadings are 1.58, -1.02, -2.99, 0.50, and 0.33, and standard deviations of 0.62, 2.98, 1.49, 0.07, and 0.06. Currencies value and momentum portfolios display average time series betas of 0.21, -2.03, -1.63, 0.14, and 0.11, with standard deviations of 0.64, 3.29, 1.65, 0.14, and 0.06. Similar dispersion is observed for the fixed income value and momentum portfolios with average time series factor loadings of 0.30, 0.32, -0.10, 0.04, and 0.06, and standard deviations of 0.34, 1.61, 0.69, 0.07, and 0.04. Finally, for the commodities portfolios the

[17] We investigate separately the alphas when the return series have different starting dates as in Asness, Moskowitz, and Pedersen (2013). The results are quantitatively similar, that is, the estimated alphas have similar magnitudes, with two exceptions: U.S. value high third (P3) becomes significant and Country indices value low third (P1) becomes significant.

average time series betas are 0.80, -2.13, -2.09, 0.31, and 0.13, with standard deviations of 1.35, 5.97, 2.76, 0.27, and 0.11. Overall, there is a considerable spread in the factor loadings which indicates a spread in the expected returns of the various return premia.

4.2 Model Comparison: 48 Portfolios

We want to judge the performance of our model relative to the performance of the global CAPM and the model proposed by Asness, Moskowitz, and Pedersen (2013). Table 3 shows the GRS statistics of Gibbons, Ross, and Shanken (1989) which tests the hypothesis that the alphas are jointly zero for the 48 value and momentum excess returns. The test rejects all the models we consider. However, while the GRS test indicates that all models are imperfect in describing the average returns, we are interested in which of the three models performs best. To this end, first, we compute the Hansen and Jagannathan (1997) distance (HJ), defined as:

$$HJ = \sqrt{\alpha'(E[rr]'^{-1})\alpha}$$

where α is the vector of the pricing errors, r is the vector of excess returns on the test assets, and $E[rr]'^{-1}$ is the inverse of the second moment matrix of the excess returns on the test assets. The GRS test scales the alphas by the covariance matrix of the estimated pricing errors. Instead, the HJ distance uses the second moment matrix of the test assets to scale the alphas. Because the alphas produced by each of the models are scaled by the same second moment matrix, the HJ distance is better suited to compare models. To quantify the difference in terms of the HJ distance across models, we also compute the squared HJ distance of the global CAPM (the Asness, Moskowitz, and Pedersen model) less the global CRR model. Table 3 reports the HJ distance and differences in the squared HJ distance and shows that the global CRR model outperforms both the global CAPM and the Asness, Moskowitz, and Pedersen model.

Second, to evaluate the models further, we follow Fama and French (2016) in reporting the average absolute alpha and three ratios that measure the dispersion of the alphas produced by a model relative to the dispersion in the average returns on our test assets in excess of the average excess return on the global market index, $\overline{r}_i$. The first ratio is $A\left|\alpha_i\right|/A\left|\overline{r}_i\right|$, the average absolute alpha divided by the average absolute value of $\overline{r}_i$, where A denotes the average. The second ratio is $A\alpha_i^2/A\overline{r}_i^2$, the average squared alpha over the average squared value of $\overline{r}_i$. According to Fama and French (2016), if these two ratios have low values, it means that the dispersion of the unexplained returns is low relative to the dispersion of the returns on our test assets. The third ratio is $As^2(\alpha_i)/A\alpha_i^2$, the average of the estimates of the variances of the sampling errors of the estimated alphas over the average squared alphas. If the model is a good description of the average returns, this third ratio should have a high value. This implies that much of the dispersion in the alphas stems from sampling error rather than dispersion in the true alphas (Fama and French, 2016, page 10). We also report the average value of the time series regressions adjusted R^2.

The average absolute alphas produced by the Asness, Moskowitz, and Pedersen (2013) characteristic-based factor model and our global macroeconomic model have similar magnitudes, 0.19% and 0.18%, respectively, which are considerably smaller than the average absolute alpha produced by the global CAPM, 0.2453%. The ratio $A\left|\alpha_i\right|/A\left|\overline{r}_i\right|$ is 0.43 for both the Asness, Moskowitz, and Pedersen (2013) model and our model, versus 0.57 for the global CAPM, meaning that the dispersion of the estimated alphas is 43% as large as the dispersion in the average excess returns on the 48 value and momentum portfolios. In units of return squared, $A\alpha_i^2/A\overline{r}_i^2$, the dispersion in the alphas produced by our model is only 18% of the dispersion in the average returns. This ratio is the lowest across the three models.

On the metric of how much of the dispersion in the average alphas is due to sampling error rather than dispersion in true alphas, $As^2(\alpha_i)/A\alpha_i^2$, for our model all dispersion is due to sampling error, versus 50% and 85% for the global CAPM and the Asness, Moskowitz, and Pedersen (2013) model, respectively.

In general, on all metrics, the tests suggest that our global macroeconomic model performs much better than the global CAPM and often better than the Asness, Moskowitz, and Pedersen (2013) model in describing the average returns. It should be noted that the aim of the global macroeconomic model is not necessarily to perform better than the Asness, Moskowitz, and Pedersen (2013) model, since their model performs quite well in describing the return premia. The advantage of the global economic model that we explore is its ability to tie return premia to macroeconomic risk whilst producing low pricing errors.

To obtain a visual impression of how well our model describes average returns, Figure 1 presents a plot of the average realized returns of the 48 portfolios versus their predicted expected returns from equation (2). We see that our global macroeconomic model fitted returns line up well along the 45-degree line.

Cochrane (2005) notes that a factor model is true if and only if a linear combination of the factors is mean-variance efficient. Figure 2 plots the mean-variance frontier of the 48 value and momentum portfolios along with the tangency portfolio T of these portfolios. The figure also shows portfolio M which is the linear combination of the global CRR factors that gives the largest Sharpe ratio. We display the location of portfolio M as well as the line connecting it to the origin, whereas for the tangency portfolio we show the line connecting it to the risk free rate.[18] The slopes of these lines give the Sharpe ratios. From Figure 2, we note that the maximum Sharpe ratio of our mimicking portfolios, that is, the Sharpe ratio of portfolio M, is comparable to the Sharpe ratio of the tangency portfolio P. In annualized terms (monthly multiplied by $\sqrt{12}$), the Sharpe ratio of the tangency portfolio is 1.04, compared to 0.86, the Sharpe ratio of portfolio M. Thus, the close proximity of portfolio M to the mean-variance frontier, as captured by the value of the Sharpe ratio which is close to the value of the maximum Sharpe ratio (tangency portfolio), represents evidence that our global macroeconomic model provides a good approximation of the common discount factor driving the returns across market and across asset classes.[19]

[18]For the given risk free rate, the tangency portfolio T gives the highest Sharpe ratio. If a discount factor can price the set of returns, it should be on the mean-variance frontier. Consequently, if our macroeconomic model is a good representation of the discount factor across assets and across markets, then a linear combination of our macroeconomic factors should have a maximum Sharpe ratio comparable to the Sharpe ratio of the tangency portfolio.

[19]Adrian, Etula, and Muir (2014) conduct a similar analysis to compare the Sharpe ratio of their traded factor with the maximum possible Sharpe using any combination of the Fama-French factors and momentum factor.

4.3 Time Series Regressions: 33 Return Premia

Table 4 reports estimated alphas and factor loadings from the global macroeconomic model for the 33 return premia based on value, momentum, and a combination of the two. For the 33 return premia, 21 have positive alphas of which seven are statistically significant and 12 have negative alphas of which two are statistically significant.

For the return premia based on aggregating across all asset classes and countries, the alphas are very small and statistically insignificant at 0.04%, 0.02%, and 0.02% per month for value, momentum, and the combination, respectively. Recall that the alphas from the CAPM model estimated in Table 1 are 0.30%, 0.36%, and 0.33% per month and the average returns are 0.29%, 0.34%, and 0.32 % per month. Thus, the global macroeconomic factor model can explain almost all of the aggregated return premia across value, momentum, and a combination of the two. This evidence suggests that the the global macroeconomic factors span the long-short value and momentum premia and is in line with the mean-variance evidence discussed in the previous section.

Studying how well the global macroeconomic factors describe the expected returns across markets and across asset classes separately is a direct test of asset pricing integration across markets and across asset classes. We see that for most of the return premia based on value and momentum portfolios, as well as combinations of them, the pricing errors from the global macroeconomic model are small and less than single market portfolio models. The average absolute alpha across markets and asset classes is small at 0.19% and judging by the value of the GRS statistic of 1.40 and the p-value of 0.1033, the GRS test cannot reject that our global macroeconomic model describes the expected returns across markets and across asset classes.[20]

Even in the case of Japanese equity and the equity indices where we observe statistically significant alphas, these alphas are in general reduced relative to the CAPM. For example, considering Japanese equity the local CAPM regressions produce alphas of 1.08%, 0.09%, and 0.59% per month for the value, momentum, and combination premia, respectively. The global CAPM alphas for these return premia for Japan are 1.11%,

[20]These GRS statistics are not reported in Table 4.

0.12%, and 0.62% per month. In contrast, the corresponding global macroeconomic alphas are 0.85%, -0.28%, and 0.29% per month.

For equity indices the CAPM and global CAPM alphas from Table 1 for the value, momentum, and combination premia are 0.47%, 0.69%, and 0.58 % per month and 0.50%, 0.71%, and 0.60% per month, respectively. All of the three corresponding global macroeconomic model alphas are statistically significant but are substantially lower at 0.36% per month. Thus, even in the cases where the alphas are statistically different from zero, we find they are substantially reduced.[21]

These results inform us that assets from different markets are to a large extent integrated in that they share the same factor structure based on macroeconomic factors. We are also able to infer from the results that assets in different countries share the same factor structure and hence financial markets appear to be integrated internationally.

4.4 Correlations and Implied Correlations

Overall, the global macroeconomic factor model does a good job in accounting for the return premia on the value, momentum, and combination portfolios. Can the model explain the negative correlation between the value and the momentum returns? In order to understand the source of the correlations, we need to look at the factor loadings across the value and momentum portfolios. Beginning with the value and momentum return premia aggregated across asset classes and countries, the factor loadings on the global industrial production factor are -0.34 for value, 1.77 for momentum, and 0.80 for the combination, as seen in Table 4. For global unexpected inflation they are -2.20, 7.81, and 3.16, for the change in expected inflation, -1.69, 3.92, and 1.31, for global term structure 0.35, -0.01, and 0.17, and for global default risk -0.04, 0.17, and 0.07.

[21] We separately study the alphas when the return series for both value and momentum strategies, and a combination of the two have inception dates as in Asness, Moskowitz, and Pedersen (2013). The results are quantitatively similar, that is, the estimated alphas have similar magnitudes with a few exceptions: the alphas of value and combination strategy across all markets and asset classes, and across all equities become statistically significant.

Table 4 also shows that the differences in factor loadings across value and momentum that are observed for the aggregated return premia are also observed across different asset classes and countries. A general pattern for return premia is that value across all asset classes and markets tends to have negative loadings except on UTS. Momentum has a positive, sometime negative or very small loading on UTS and in most cases positive loadings with respect to the other CRR factors. Thus, the pattern in loadings explains why they have positive premia but negative correlation.

To illustrate more precisely that our global macroeconomic model captures the negative correlation in the return premia, we compute the correlation between value and momentum that is implied by the model. The implied correlation between two portfolios is computed as follows. First, using the full sample period, we estimate the loadings with respect to the five CRR factors. Second, we generate two series of fitted values, one for momentum and one for value, by multiplying the loadings with the returns on the mimicking portfolios for the CRR factors. The implied correlation is the correlation between the two time series of fitted values (expected returns). We then compare these correlation coefficients to the correlation coefficients between value and momentum return premia calculated from their respective return series.

Table 5 presents the actual and implied correlation coefficients of value and momentum strategies for the various asset classes and markets as well as for value and momentum for all equity, all non-equity, and everywhere. In general (except for fixed income where the correlation coefficient between the two return premia is small), we capture the negative correlation between the value and momentum strategies, strengthening the interpretation that the negative correlation between the two strategies is explained by the differing loadings with respect to the mimicking portfolios for the CRR global factors. For example, the actual correlation between the value and momentum strategies everywhere is -0.48, whereas the implied correlation of the two expected returns is -0.47. For all equities the actual correlation is of -0.58 and the implied correlation is -0.45. For all non-equity assets, the implied correlation and the actual correlation are -0.30 and

-0.38.[22]

Considered jointly, the evidence presented in this section suggests that the differing factor loadings are crucial for the empirical success of our macroeconomic model in describing both the negative correlation between the value and momentum strategies as well as the return premia on these strategies and a combination of them.

This section indicates that the global CRR model does a good job in capturing the average returns on the individual value and momentum portfolios as well as the return premia on the value, momentum, and combination factors. We show that the association of the asset returns and macroeconomic factors is not unique to equities but it is also present in other 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 towards a better understanding of the factor structure that drives the expected returns in multiple asset classes and countries. This is an important question as emphasized by Cochrane in his Presidential Address (2011). Our findings suggest that the differences in the loadings with respect to the macroeconomic factors can match the variation in returns across multiple asset classes. Moreover, our findings go a step further by showing that the factor structure drives the returns across multiple countries not just multiple asset classes. This provides evidence of global market integration amongst those set of countries we are examining.

5 Explaining the Returns on Other Assets

If the five macroeconomic factors are a common source of global risk that drives the different factor structures across assets and across markets, and asset markets are integrated, then the macroeconomic factors should be able to explain the returns on other assets as well. This is interesting since the extant literature documents factor structures that are considerably different and has not uncovered a unifying model. Therefore, we now explore whether the global CRR factors can explain the returns on a different set

[22] Our results are quantitatively similar when we use the longer return series as in Asness, Moskowitz, and Pedersen (2013).

of assets. Specifically, we examine the assets studied in Lettau, Maggiori, and Weber (2014).

These assets include the U.S. excess market return, six currency portfolios sorted on interest rate differentials, six U.S. equity portfolios sorted on size and book-to-market, five commodities futures portfolios sorted on the basis, six sovereign bond portfolios sorted on the probability of default and bond beta, five U.S. stock portfolios sorted on the CAPM beta, a U.S. betting against beta (BAB) factor, five Fama and French industry portfolios, nine put options and nine call options on the S&P 500, six U.S. Fama and French portfolios sorted on size and momentum, and five U.S. corporate bond portfolios sorted on credit spreads.

Table 6 reports the portfolio average returns as well as the global macroeconomic model alphas. For comparison, we also report the U.S. CAPM alphas and the MSCI world portfolio alphas. Average returns of high yield currencies exceed those of low yield currencies, implying that the carry trade strategy earns a positive premium. For all three factor models the alphas increase with the yield. The CRR model yields the smallest alphas across the three models, and the alphas are statistically indistinguishable from zero. Turning to the six portfolios sorted on size and book-to-market, the global macroeconomic model performs well with none of the alphas being statistically significant. The global CAPM also performs well for these portfolios, with the exception of the small low portfolio, which has a statistically significant alpha of -0.66%.

The global macroeconomic model performs well for the beta sorted portfolios, where none of the alphas are statistically significant as opposed to one statistically significant alpha for the global CAPM model and all five local CAPM alphas are statistically significant. The global CRR model does not explain well the BAB factor, with a positive alpha of 0.76% and a t-statistic of 2.58. However, this alpha is considerably smaller than the local CAPM and global CAPM alphas which are 1.20% and 1.21%, respectively, and statistically significant with t-statistics 4.27 and 4.24, respectively.

The global CRR factors explain well the returns on the five industry portfolios, the six portfolios sorted on size and momentum, and for the five corporate bond portfolios. The commodities futures portfolios returns are also captured well by the model, with none of the alphas being statistically significant. The model also performs better than the CAPM and the global CAPM in explaining the sovereign bond portfolios, with each of the alphas being smaller than the corresponding CAPM alpha and global CAPM alpha. However, the global macroeconomic model fails to explain the returns on the equity index call options portfolios, for which all nine alphas are statistically significant. The model performs roughly the same as the CAPM and somewhat better than the global CAPM for the call options portfolios. The global CRR model performs reasonably for the equity index put options portfolios with only three of the nine alphas being statistically significant.

So far, we have focused on the magnitudes of the alphas yielded by the CAPM, the global CAPM, and our model. To judge the performance of our model relative to the performance of the two specifications of the CAPM, we next show in Table 7 the GRS statistics, the HJ distance, as well as the three ratios proposed by Fama and French (2016) for various sets of test assets that Lettau, Maggiori, and Weber (2014) examine. In particular, we look at test assets that include currencies and commodities together plus one other of the set of tests assets (six size and book-to-market portfolios, BAB, five beta portfolios, five industry portfolios, six size and momentum portfolios, eighteen call and put options on the equity index, and six credit spread portfolios). We also report all metrics for a set of test assets that include currencies, the six size and book-to-market portfolios, and six sovereign portfolios.

As seen in Table 7, according to the GRS test statistic the model is rejected for all sets of assets. Nevertheless, in terms of HJ distance, the global macroeconomic factor model outperforms both the CAPM and the global CAPM and produces the lowest HJ distance relative to the HJ distances of the other two models for each of the sets of assets. Moreover, the global macroeconomic factor model produces an average absolute alpha with a value lower than the the corresponding alphas of both the CAPM and the global CAPM for each of the sets of assets. Averaging across all cases, the absolute value of alpha is lower for the global macroeconomic factor model (0.197) than for the domestic

CAPM (0.296). This is also the case when we compare the absolute value of alpha from the global macroeconomic model (0.197) and the global CAPM (0.261). We also see a similar pattern for the remaining metrics. For instance, the ratio $A|\alpha_i|/A|\overline{r}_i|$ is 0.64 for the global macroeconomic model, versus 0.96 and 0.87 for the domestic CAPM and the global CAPM. In units of return squared, $A\alpha_i^2/A\overline{r}_i^2$, the dispersion in the alphas produced by our model is 44% of the dispersion in the average returns as compared with 97% and 89% for the domestic and global CAPM. On the metric of how much of the dispersion in the average alphas is due to sampling error rather than dispersion in true alphas, $As^2(\alpha_i)/A\alpha_i^2$, for our model all dispersion is due to sampling error, versus 32% and 49% for local and global specifications of the CAPM.

The evidence presented in this section 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 macroeconomic factors represent common sources of risk driving the various factor structures across asset classes and countries. Moreover, the fact that our global macroeconomic factors perform well in describing the average returns on a different set of assets than those base assets used to form the mimicking portfolios for the global CRR factors represents out-of-sample evidence. Consequently, we interpret this evidence as an out-of-sample robustness test of our results from the time series asset pricing tests on the 48 value and momentum portfolios.

6 Mimicking Portfolio Construction: Robustness

One might still be concerned that our results are driven by the use of mimicking portfolios which are linear combinations of portfolio returns with strong pricing abilities. However, as seen in Table 6, the model describes well the average returns of not only the set of assets we use to form the mimicking portfolios but also a broad set of other asset returns. Nevertheless, as a robustness check we follow Jagannathan and Wang (2007), and Adrian, Etula, and Muir (2014) and conduct a simulation exercise with noisy macroeconomic factors and verify that the results from the time series asset pricing tests can not happen if the macroeconomic factors are random noise. To this end, we randomly pick observations from the empirical distributions of each of the five macroeconomic factors with replacement. We construct these noise factors to have the same length as the original macroeconomic factors, that is, 342 months. Clearly, since these noisy factors have been picked at random, they should have no pricing information.

Next, we form mimicking portfolios for these noise macroeconomic factors. Our base assets consist of the excess returns of the six value and momentum portfolios that Asness, Moskowitz, and Pedersen (2013) employ to form their global value and momentum risk factors. The excess returns on each of these six portfolios are regressed on the five noise CRR factors, that is, we estimate six time series regressions producing a (6 x 5) matrix B of slope coefficients against the five noise factors. Let V be the (6 x 6) covariance matrix of error terms (assumed to be diagonal), then the weights on the mimicking portfolios are given by: $w = (B'V^{-1}B)^{-1}B'V^{-1}$. The weights w are stacked in a 5 x 6 matrix and the mimicking portfolios are given by wR', where R is a T x 6 matrix of returns and T denotes the length of our sample. This gives us a set of mimicking portfolios for the noise macroeconomic factors. We repeat this exercise 100,000 times and compute the probability of these mimicking portfolios being able to replicate the pricing ability of our mimicking portfolios for the macroeconomic factors.

We find that the likelihood of obtaining an average absolute alpha and GRS equal to the values reported in Table 3 is very close to zero. These findings suggest that it is unlikely that the pricing ability of our mimicking portfolios is due to chance. Moreover, these findings also suggest that the macroeconomic factors include relevant information for the pricing of the test assets as opposed to the noise macroeconomic factors and forming mimicking portfolios helps to retain this relevant information.

7 Conclusion

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

The model can also explain the returns on portfolios of currencies, U.S. portfolios sorted on size and book-to-market, U.S. portfolios sorted on the CAPM beta, U.S. industry portfolios, U.S. portfolios sorted on size and momentum, corporate bond portfolios sorted on credit spread, and commodities futures portfolios sorted on basis. The model captures reasonably well the returns on equity index option portfolios, and sovereign bond portfolios sorted on credit ratings.

The CRR factors are macroeconomic variables related to the business cycle. Therefore, the global macroeconomic model enhances our understanding of the underlying economic sources driving the patterns in returns across markets and across asset classes, something which is more challenging when using characteristic-based factors.

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. Our results provide evidence that asset classes within a country are integrated and asset markets across countries are integrated.

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Figure 1: Asset pricing tests of the cross section of expected returns. Plotted are the actual average returns versus model-implied expected returns of the 48 value and momentum low, middle, and high portfolios in each market and asset class under the global macroeconomic model consisting of the mimicking portfolios for the 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° line that passes through the origin is added to highlight pricing errors given by the vertical distances to the 45° line. The sample period is January 1982 to June 2010 for a total of 342 observations.

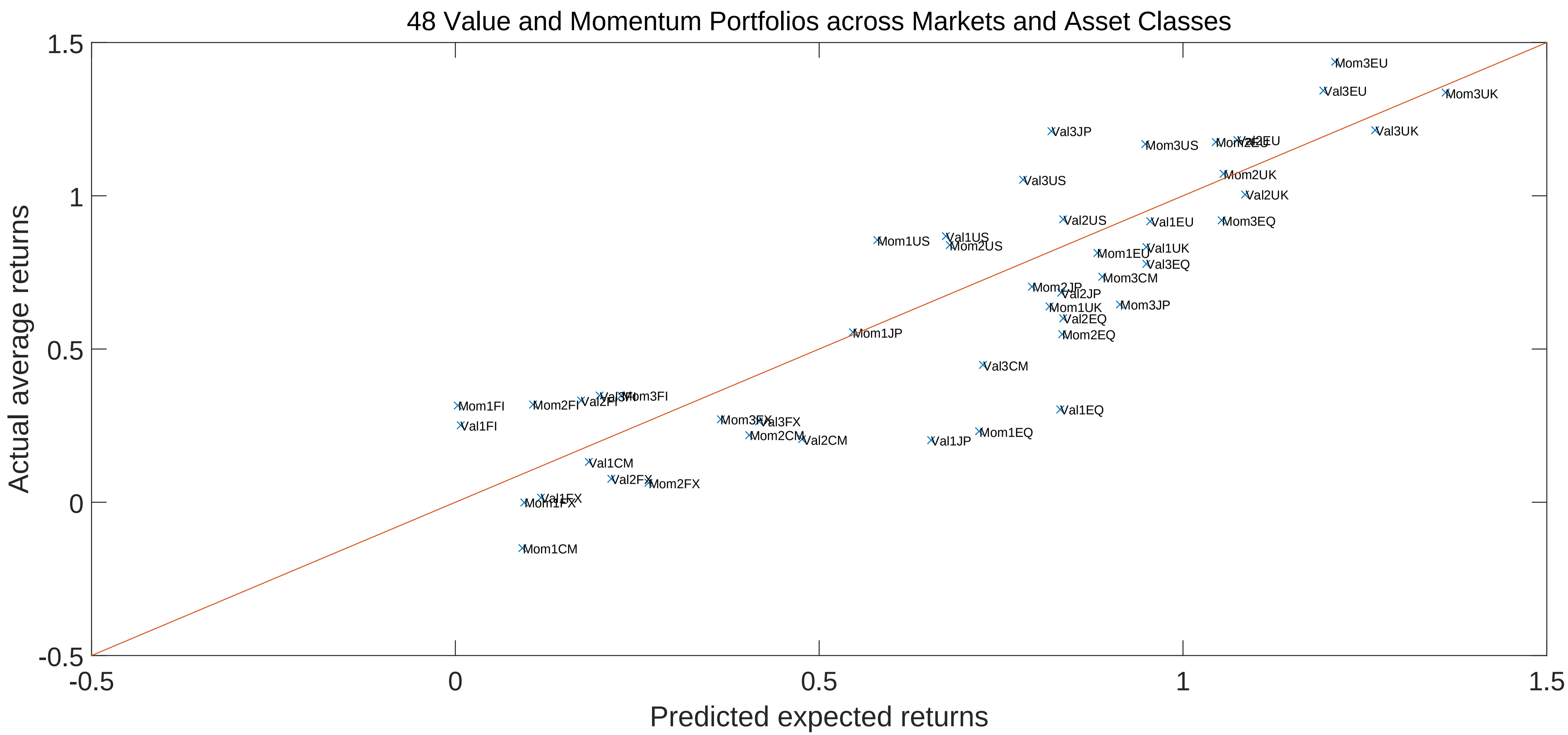

Figure 2: Mean-standard deviation space. The hyperbola is the mean standard deviation frontier of the 48 value and momentum low, middle, and high portfolios in each market and asset class. T is the tangency portfolio of the 48 assets. We connect the tangency portfolio to the given risk free rate. Portfolio M is the linear combination of the mimicking portfolios for the global CRR factors that gives the largest Sharpe ratio.

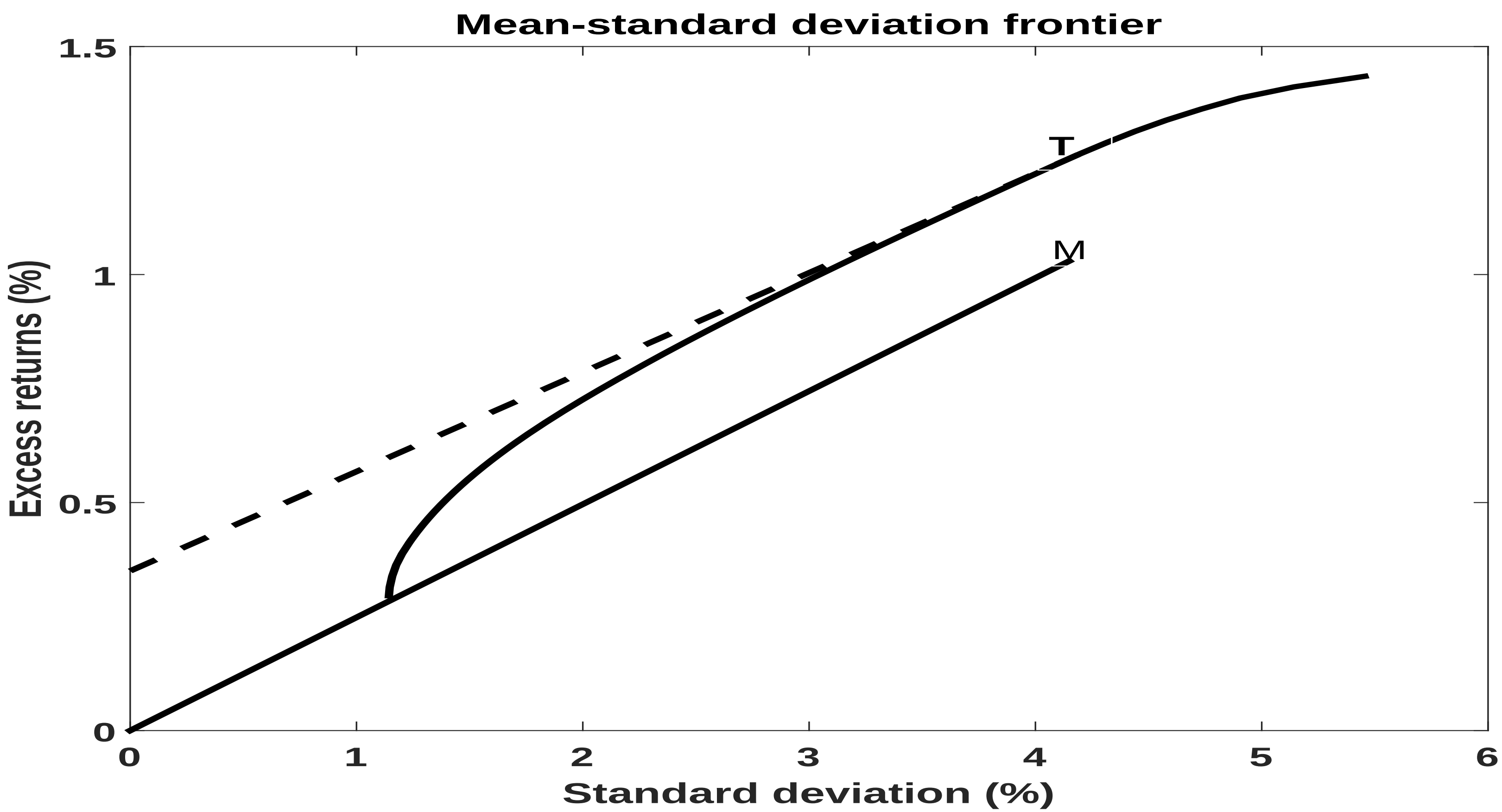

Table 1: Value and Momentum Portfolios across Markets and Asset Classes

Panel A of Table 1 reports average excess returns along with their t-statistics on value, momentum, and equal-weighted 50/50 value and momentum combination strategy in each market and asset class we study: U.S. stocks, U.K. stocks, Europe stocks, Japan stocks, country index futures, currencies, fixed income government bonds, commodities. We also consider average strategies across all markets and asset classes ("Global all asset classes"), across all stock markets ("Global stocks"), and across all nonstock asset classes ("Global other asset classes "). Securities are sorted by value characteristics and momentum into thirds, with P1 indicating the lowest group; P2, the medium group; and P3, the highest. The value, momentum, and combination factors are the high (P3) minus low (P1) spread in returns. The thirds of combination portfolios are a 50/50 combination of the value and momentum thirds. The panel also shows the intercepts and their t-statistics from time-series regressions of each value, momentum, and combination return premia on the return of the market index for each asset class. Also reported are intercepts produced by time-series regressions of each of the return series on the global market index. The market index for the stock strategies is the MSCI index for each country; for country index futures, currencies, fixed income, and commodities, the market index is an equal-weighted index of the securities within each asset class, and the global market index is the MSCI World Index. Panel B reports the average correlation of value and momentum return premia within each market and asset class. The sample period starts in January 1982 and ends in June 2010.

Panel A: Summary statistics

		Value (V)			Momentum (M)			Factors		
		P1	P2	P3	P1	P2	P3	V	M	Combo
U.S. stocks	$\overline{r}$	0.87	0.92	1.05	0.86	0.84	1.17	0.18	0.31	0.25
	(t-stat)	(3.20)	(3.88)	(4.23)	(2.94)	(3.74)	(4.10)	(0.97)	(1.19)	(2.32)
	α-market	-0.11	0.03	0.17	-0.15	-0.01	0.24	0.28	0.40	0.34
	(t-stat)	(-0.87)	(0.42)	(1.44)	(-1.15)	(-0.08)	(1.45)	(1.22)	(1.50)	(2.93)
	α-global	0.06	0.17	0.29	0.00	0.15	0.37	0.23	0.36	0.29
	(t-stat)	(0.32)	(1.24)	(1.89)	(0.02)	(1.08)	(1.77)	(0.98)	(1.44)	(2.68)
U.K. stocks	$\overline{r}$	0.83	1.01	1.21	0.64	1.07	1.34	0.38	0.69	0.54
	(t-stat)	(2.94)	(3.37)	(3.97)	(1.98)	(3.86)	(4.26)	(1.81)	(2.63)	(4.22)
	α-market	-0.05	0.05	0.27	-0.33	0.17	0.40	0.32	0.73	0.52
	(t-stat)	(-0.37)	(0.47)	(1.81)	(-1.96)	(1.78)	(2.47)	(1.37)	(2.52)	(3.59)

(*Continued*)

Table 1 – continued

		Value (V)			Momentum (M)			Factors		
		P1	P2	P3	P1	P2	P3	V	M	Combo
U.K. stocks	α-global	-0.01	0.07	0.29	-0.33	0.20	0.45	0.30	0.77	0.54
	(t-stat)	(-0.06)	(0.42)	(1.39)	(-1.66)	(1.28)	(2.01)	(1.31)	(2.64)	(3.57)
Europe stocks	$\overline{r}$	0.92	1.18	1.34	0.81	1.18	1.44	0.43	0.62	0.53
	(t-stat)	(3.19)	(4.20)	(4.37)	(2.47)	(4.30)	(4.85)	(2.42)	(2.56)	(5.03)
	α-market	-0.07	0.18	0.26	-0.31	0.20	0.45	0.34	0.76	0.55
	(t-stat)	(-0.56)	(2.21)	(2.27)	(-2.26)	(2.47)	(3.03)	(1.67)	(3.19)	(5.12)
	α-global	-0.01	0.26	0.33	-0.24	0.26	0.53	0.35	0.77	0.56
	(t-stat)	(-0.06)	(1.70)	(1.84)	(-1.33)	(1.67)	(2.60)	(1.59)	(3.16)	(5.08)
Japan stocks	$\overline{r}$	0.20	0.68	1.21	0.55	0.70	0.65	1.01	0.09	0.55
	(t-stat)	(0.54)	(1.97)	(3.51)	(1.43)	(2.08)	(1.72)	(4.18)	(0.30)	(4.29)
	α-market	-0.47	0.04	0.61	-0.10	0.08	-0.01	1.08	0.09	0.59
	(t-stat)	(-2.89)	(0.34)	(3.79)	(-0.49)	(0.74)	(-0.03)	(3.97)	(0.27)	(4.70)
	α-global	-0.79	-0.28	0.33	-0.42	-0.25	-0.30	1.11	0.12	0.62
	(t-stat)	(-2.46)	(-1.08)	(1.16)	(-1.37)	(-0.94)	(-0.90)	(4.19)	(0.36)	(4.86)

(*Continued*)

Table 1 – continued

		Value (V)			Momentum (M)			Factors		
		P1	P2	P3	P1	P2	P3	V	M	Combo
Country indices	$\overline{r}$	0.30	0.60	0.78	0.23	0.55	0.92	0.48	0.69	0.58
	(t-stat)	(1.19)	(2.37)	(3.03)	(0.87)	(2.23)	(3.53)	(3.20)	(3.80)	(6.18)
	α-market	-0.26	0.04	0.21	-0.34	-0.00	0.35	0.47	0.69	0.58
	(t-stat)	(-2.96)	(0.51)	(2.05)	(-3.35)	(-0.02)	(4.25)	(2.71)	(4.07)	(6.07)
	α-global	-0.52	-0.18	-0.03	-0.59	-0.24	0.12	0.50	0.71	0.60
	(t-stat)	(-2.79)	(-1.09)	(-0.15)	(-3.33)	(-1.45)	(0.66)	(2.64)	(4.04)	(6.06)
Currencies	$\overline{r}$	0.02	0.08	0.27	0.00	0.06	0.27	0.25	0.27	0.26
	(t-stat)	(0.11)	(0.60)	(2.08)	(0.00)	(0.50)	(2.11)	(1.62)	(1.70)	(3.11)
	α-market	-0.11	-0.05	0.16	-0.12	-0.06	0.17	0.27	0.29	0.28
	(t-stat)	(-1.22)	(-0.91)	(1.85)	(-1.50)	(-1.18)	(2.24)	(1.63)	(2.01)	(3.26)
	α-global	-0.18	-0.11	0.07	-0.21	-0.14	0.11	0.25	0.32	0.28
	(t-stat)	(-1.02)	(-0.69)	(0.50)	(-1.37)	(-0.87)	(0.77)	(1.35)	(2.25)	(2.83)
Fixed income	$\overline{r}$	0.25	0.33	0.35	0.32	0.32	0.35	0.10	0.03	0.06
	(t-stat)	(2.31)	(3.58)	(3.76)	(3.42)	(3.50)	(3.28)	(0.97)	(0.35)	(1.03)
	α-market	-0.11	0.02	0.05	0.02	0.02	-0.01	0.16	-0.03	0.07
	(t-stat)	(-1.86)	(0.51)	(1.06)	(0.34)	(0.54)	(-0.19)	(1.69)	(-0.29)	(1.18)
	α-global	0.21	0.27	0.31	0.29	0.27	0.30	0.10	0.02	0.06
	(t-stat)	(1.63)	(2.30)	(2.94)	(2.48)	(2.45)	(2.38)	(1.13)	(0.16)	(1.02)

(*Continued*)

Table 1 – continued

		Value (V)			Momentum (M)			Factors		
		P1	P2	P3	P1	P2	P3	V	M	Combo
Commodities	$\overline{r}$	0.13	0.21	0.45	-0.15	0.22	0.73	0.32	0.88	0.60
	(t-stat)	(0.45)	(0.88)	(1.83)	(-0.60)	(1.11)	(2.55)	(0.95)	(2.81)	(3.29)
	α-market	-0.17	-0.05	0.21	-0.41	0.01	0.42	0.38	0.83	0.61
	(t-stat)	(-0.97)	(-0.38)	(1.25)	(-2.65)	(0.07)	(2.50)	(1.21)	(2.80)	(3.27)
	α-global	-0.13	0.04	0.21	-0.38	-0.00	0.50	0.34	0.88	0.61
	(t-stat)	(-0.36)	(0.13)	(0.77)	(-1.42)	(-0.01)	(1.35)	(0.99)	(2.64)	(2.98)
		Global all asset classes			Global stocks			Global other asset classes		
		V	M	Combo	V	M	combo	V	M	Combo
	$\overline{r}$	0.29	0.34	0.32	0.47	0.41	0.45	0.23	0.32	0.27
	(t-stat)	(3.80)	(3.73)	(6.97)	(3.22)	(2.41)	(5.62)	(2.73)	(3.42)	(5.58)
	α-market	0.30	0.36	0.33	0.47	0.48	0.49	0.26	0.31	0.29
	(t-stat)	(3.54)	(3.88)	(7.07)	(2.46)	(2.99)	(5.43)	(2.88)	(3.25)	(5.87)
	α-global	0.30	0.37	0.33	0.47	0.48	0.49	0.24	0.33	0.28
	(t-stat)	(3.47)	(3.89)	(6.82)	(2.46)	(2.99)	(5.43)	(2.60)	(3.36)	(5.42)

Panel B: Correlation of value and momentum

	U.S. stocks	U.K. stocks	Europe stocks	Japan stocks
$\rho_{V,M}$	-0.59	-0.44	-0.54	-0.59

(*Continued*)

Table 1 – continued

Panel B: Correlation of value and momentum				
	Country indices	Currencies	Fixed income	Commodities
$\rho_{V,M}$	-0.36	-0.43	-0.17	-0.36
	Global all asset classes	Global stocks	Global other asset classes	
$\rho_{V,M}$	-0.46	-0.57	-0.39	

Table 2: Global macroeconomic exposure of value and momentum across markets and asset classes

This table presents loadings with respect to the mimicking portfolios of the five Chen, Roll, and Ross (1986) (CRR) global factors for all portfolios described in Table 1. The loadings are estimated from monthly regressions of portfolio excess returns on the five mimicking portfolios for the global CRR factors. MP is the growth rate of industrial production, UI is unexpected inflation, DEI is the change in expected inflation, UTS is the term spread, and UPR is the default spread. Along with the factor loadings we also report the t-statistics. The sample is monthly from January 1982 to June 2010.

	Value and momentum portfolio returns											
	U.S. stocks						U.K. stocks					
	V			M			V			M		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
α	0.19	0.09	0.27	0.28	0.16	0.22	-0.12	-0.08	-0.05	-0.18	0.02	-0.03
(t-stat)	(0.79)	(0.41)	(1.37)	(1.33)	(0.80)	(0.86)	(-0.52)	(-0.41)	(-0.24)	(-0.80)	(0.09)	(-0.10)
β_{MP}	1.59	1.35	0.93	-0.00	1.14	2.75	2.19	1.51	2.06	0.34	1.88	3.32
(t-stat)	(3.54)	(3.55)	(2.83)	(-0.00)	(3.08)	(6.31)	(5.34)	(4.15)	(5.61)	(0.72)	(5.75)	(7.85)
β_{UI}	0.07	-1.47	-3.04	-7.84	-0.63	4.09	0.89	-4.17	-1.44	-9.24	-0.68	3.90
(t-stat)	(0.04)	(-0.82)	(-1.84)	(-3.37)	(-0.40)	(2.24)	(0.49)	(-2.38)	(-0.79)	(-4.25)	(-0.43)	(2.07)
β_{DEI}	-2.03	-3.19	-4.22	-6.57	-2.53	0.01	-2.08	-4.67	-4.22	-7.49	-3.11	-0.79
(t-stat)	(-2.43)	(-4.06)	(-5.47)	(-6.10)	(-4.01)	(0.01)	(-2.79)	(-6.44)	(-4.94)	(-8.13)	(-4.47)	(-1.00)
β_{UTS}	0.27	0.52	0.56	0.49	0.38	0.33	0.43	0.60	0.84	0.62	0.55	0.62
(t-stat)	(2.70)	(6.06)	(7.09)	(5.09)	(4.77)	(3.37)	(4.54)	(7.10)	(9.17)	(7.38)	(7.95)	(6.39)
β_{UPR}	0.35	0.30	0.26	0.20	0.29	0.46	0.43	0.45	0.40	0.29	0.44	0.56
(t-stat)	(7.53)	(8.16)	(7.50)	(5.00)	(7.94)	(9.51)	(10.39)	(12.90)	(11.23)	(7.08)	(13.74)	(13.47)

(*Continued*)

Table 2 – continued

	Europe stocks						Japan stocks					
	V			M			V			M		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
α	-0.04	0.11	0.15	-0.07	0.13	0.23	-0.45	-0.15	0.39	0.01	-0.09	-0.27
(t-stat)	(-0.17)	(0.56)	(0.79)	(-0.30)	(0.78)	(1.05)	(-1.32)	(-0.56)	(1.52)	(0.03)	(-0.33)	(-0.71)
β_{MP}	2.29	1.84	1.48	0.38	1.71	3.13	1.37	0.80	0.67	-0.36	0.95	2.24
(t-stat)	(6.29)	(6.38)	(5.67)	(1.14)	(6.49)	(10.45)	(3.04)	(2.33)	(1.68)	(-0.87)	(2.47)	(4.61)
β_{UI}	-0.14	-2.05	-4.86	-9.56	-1.94	3.03	-4.98	-7.19	-6.60	-12.38	-5.61	-0.75
(t-stat)	(-0.08)	(-1.46)	(-3.41)	(-5.22)	(-1.51)	(1.99)	(-2.15)	(-3.65)	(-3.05)	(-5.47)	(-2.68)	(-0.32)
β_{DEI}	-2.49	-3.71	-5.86	-7.95	-3.71	-0.96	-4.37	-5.86	-6.04	-8.58	-5.19	-2.38
(t-stat)	(-2.94)	(-5.74)	(-8.01)	(-8.59)	(-6.43)	(-1.25)	(-3.85)	(-5.71)	(-5.78)	(-7.45)	(-5.09)	(-2.12)
β_{UTS}	0.38	0.55	0.79	0.66	0.53	0.47	0.24	0.49	0.59	0.47	0.44	0.33
(t-stat)	(4.46)	(8.10)	(10.25)	(7.67)	(9.74)	(5.60)	(2.44)	(5.23)	(6.07)	(4.32)	(4.67)	(3.22)
β_{UPR}	0.46	0.46	0.42	0.32	0.46	0.56	0.37	0.36	0.28	0.21	0.36	0.46
(t-stat)	(12.67)	(15.69)	(13.14)	(8.41)	(17.49)	(18.82)	(8.03)	(10.36)	(7.48)	(5.83)	(11.05)	(8.50)

(*Continued*)

Table 2 – continued

	Country indices						Currencies					
	V			M			V			M		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
α	-0.53	-0.23	-0.17	-0.49	-0.28	-0.13	-0.10	-0.14	-0.15	-0.09	-0.20	-0.09
(t-stat)	(-1.92)	(-1.07)	(-0.71)	(-2.13)	(-1.21)	(-0.54)	(-0.60)	(-0.96)	(-1.28)	(-0.78)	(-1.34)	(-0.68)
β_{MP}	1.83	1.43	1.51	0.70	1.45	2.59	0.53	-0.09	0.25	-0.76	0.19	1.16
(t-stat)	(4.20)	(3.69)	(4.33)	(2.01)	(3.77)	(6.29)	(2.05)	(-0.40)	(1.35)	(-3.62)	(0.86)	(5.29)
β_{UI}	0.57	-1.98	-1.65	-5.86	-0.26	3.04	0.27	-3.60	-2.42	-7.20	-1.63	2.37
(t-stat)	(0.29)	(-1.08)	(-1.05)	(-3.43)	(-0.15)	(1.70)	(0.24)	(-3.61)	(-2.37)	(-7.02)	(-1.60)	(2.49)
β_{DEI}	-2.25	-3.08	-3.64	-5.40	-2.64	-0.94	-0.28	-2.15	-2.35	-4.08	-1.56	0.64
(t-stat)	(-2.68)	(-3.50)	(-4.99)	(-6.42)	(-3.22)	(-1.26)	(-0.53)	(-4.75)	(-4.67)	(-8.22)	(-3.49)	(1.42)
β_{UTS}	0.43	0.46	0.62	0.55	0.46	0.49	-0.06	0.12	0.37	0.18	0.13	0.11
(t-stat)	(4.09)	(5.18)	(7.68)	(6.39)	(4.82)	(5.67)	(-0.92)	(2.40)	(8.80)	(3.17)	(2.67)	(1.88)
β_{UPR}	0.35	0.33	0.32	0.22	0.34	0.43	0.14	0.11	0.08	0.00	0.14	0.17
(t-stat)	(7.95)	(8.40)	(8.47)	(5.84)	(8.94)	(10.12)	(4.54)	(5.09)	(4.33)	(0.25)	(5.82)	(7.92)

(Continued)

Table 2 – continued

	Fixed income						Commodities					
	V			M			V			M		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
α	0.24	0.16	0.15	0.31	0.21	0.12	-0.05	-0.27	-0.28	-0.24	-0.18	-0.16
(t-stat)	(1.74)	(1.32)	(1.12)	(2.38)	(1.86)	(0.87)	(-0.17)	(-1.06)	(-1.09)	(-0.95)	(-0.74)	(-0.54)
β_{MP}	0.50	-0.04	0.56	-0.07	0.14	0.72	1.96	-0.51	0.94	-0.85	0.64	2.62
(t-stat)	(1.99)	(-0.26)	(2.41)	(-0.33)	(0.79)	(2.74)	(4.72)	(-1.41)	(2.43)	(-2.59)	(1.94)	(6.83)
β_{UI}	1.47	-1.87	1.64	-1.56	0.79	1.47	4.06	-8.85	-1.88	-9.92	0.95	2.85
(t-stat)	(1.37)	(-2.67)	(1.67)	(-1.85)	(0.99)	(1.39)	(1.92)	(-5.28)	(-1.18)	(-5.55)	(0.73)	(1.59)
β_{DEI}	0.46	-1.03	0.28	-0.90	0.09	0.50	1.03	-4.50	-2.91	-5.79	-0.82	0.48
(t-stat)	(0.99)	(-3.26)	(0.71)	(-2.37)	(0.25)	(1.18)	(1.04)	(-5.51)	(-3.95)	(-6.73)	(-1.38)	(0.54)
β_{UTS}	-0.07	0.10	0.12	0.02	-0.00	0.07	-0.14	0.42	0.67	0.27	0.19	0.44
(t-stat)	(-1.52)	(2.80)	(2.57)	(0.50)	(-0.12)	(1.47)	(-1.78)	(5.13)	(7.29)	(3.61)	(2.89)	(4.90)
β_{UPR}	0.05	0.07	0.06	-0.00	0.10	0.10	0.20	0.11	0.08	-0.05	0.20	0.27
(t-stat)	(1.76)	(3.44)	(2.45)	(-0.15)	(4.83)	(3.81)	(4.06)	(2.26)	(1.75)	(-1.50)	(4.42)	(5.12)

Table 3: Summary statistics for tests of (1) Global CAPM, (2) Asness, Moskowitz, and Pedersen model (AMP), and the global CRR models, January 1982 - June 2010

This table tests how well the (1) Global CAPM, (2) Asness, Moskowitz, and Pedersen model (AMP), and the global CRR model explain monthly excess returns on the 48 value and momentum portfolios. The table shows (1) the GRS statistic, (2) p(GRS) the p-value for the GRS statistic, (3) HJ, the Hansen and Jagannathan (1997) distance, defined as $HJ = \sqrt{\alpha'(E[rr']^{-1})\alpha}$, (4) Diff HJ^2, the squared HJ distance of the global CAPM (AMP model) less the global CRR model,(5) the average absolute value of the alphas, $A\,|\alpha_i|$, (6) $A\,|\alpha_i|/A\,|\overline{r}_i|$, the average absolute value of the alphas over the average absolute value of $\overline{r}_i$, which is the average excess return on portfolio i minus the average global market portfolio excess return, (7) $A\alpha_i^2/A\overline{r}_i^2$, the average squared alpha over the average squared value of $\overline{r}_i$, (8) $As^2(\alpha_i)/A\alpha_i^2$, the average of the estimates of the variances of the sampling errors of the estimated intercepts over the average squared alphas, and (9) AR^2, the average value of the regression adjusted R^2.

Model	GRS	p(GRS)	HJ	Diff HJ^2	$A\,\|\alpha_i\|$	$A\,\|\alpha_i\|/A\,\|\overline{r}_i\|$	$A\alpha_i^2/A\overline{r}_i^2$	$As^2(\alpha_i)/A\alpha_i^2$	AR^2
Global CAPM	3.99	0.000	0.816	0.1980	0.2453	0.57	0.33	0.50	0.39
AMP	3.99	0.000	0.750	0.0946	0.1848	0.43	0.21	0.85	0.43
Global CRR	2.82	0.000	0.684		0.1824	0.43	0.18	1.06	0.44

Table 4: Global macroeconomic exposure of value and momentum across markets and asset classes

This table presents loadings with respect to the mimicking portfolios of the five Chen, Roll, and Ross (1986) (CRR) global factors for the value, momentum, and a 50/50 combination of value and momentum strategies. The loadings are estimated from monthly regressions of portfolio excess returns on the five mimicking portfolios for the global CRR factors. MP is the growth rate of industrial production, UI is unexpected inflation, DEI is the change in expected inflation, UTS is the term spread, and UPR is the default spread. Along with the factor loadings we also report the t-statistics. We also present the absolute value of the intercepts, $|\alpha|$, the GRS statistic testing whether the expected values of the intercept estimates are zero and its corresponding p-values. The sample is monthly from January 1982 to June 2010.

	Value, momentum, and a combination of value and momentum factor returns											
	U.S. stocks			U.K. stocks			Europe stocks			Japan stocks		
	V	M	C	V	M	C	V	M	C	V	M	C
α	0.08	-0.06	0.01	0.07	0.15	0.11	0.20	0.30	0.25	0.85	-0.28	0.29
(t-stat)	(0.38)	(-0.26)	(0.11)	(0.31)	(0.56)	(0.80)	(1.13)	(1.34)	(2.38)	(3.20)	(-0.83)	(2.32)
β_{MP}	-0.65	2.75	1.05	-0.13	2.99	1.43	-0.82	2.74	0.96	-0.70	2.61	0.95
(t-stat)	(-2.19)	(6.39)	(5.38)	(-0.41)	(6.52)	(6.19)	(-2.63)	(9.32)	(4.41)	(-1.45)	(4.84)	(4.75)
β_{UI}	-3.11	11.93	4.41	-2.33	13.15	5.41	-4.73	12.59	3.93	-1.63	11.63	5.00
(t-stat)	(-2.42)	(5.89)	(4.56)	(-1.59)	(6.23)	(4.71)	(-3.21)	(7.41)	(3.77)	(-0.77)	(5.27)	(5.56)
β_{DEI}	-2.19	6.58	2.19	-2.14	6.71	2.28	-3.37	6.99	1.81	-1.67	6.20	2.27
(t-stat)	(-3.59)	(6.58)	(4.96)	(-2.84)	(7.05)	(4.55)	(-4.65)	(7.82)	(4.01)	(-1.64)	(5.87)	(5.61)
β_{UTS}	0.29	-0.17	0.06	0.41	0.00	0.21	0.41	-0.19	0.11	0.35	-0.14	0.10
(t-stat)	(3.55)	(-1.83)	(1.31)	(3.80)	(0.05)	(3.85)	(4.51)	(-2.26)	(2.14)	(4.29)	(-1.30)	(1.98)
β_{UPR}	-0.09	0.26	0.09	-0.03	0.27	0.12	-0.05	0.24	0.09	-0.08	0.26	0.09
(t-stat)	(-2.28)	(5.26)	(4.75)	(-0.95)	(6.36)	(5.66)	(-1.37)	(6.58)	(4.90)	(-1.59)	(4.23)	(4.10)

(*Continued*)

Table 4 – continued

	Country indices			Currencies			Fixed income			Commodities		
	V	M	C	V	M	C	V	M	C	V	M	C
α	0.36	0.36	0.36	-0.05	0.00	-0.02	-0.10	-0.19	-0.14	-0.23	0.09	-0.07
(t-stat)	(1.96)	(2.31)	(3.84)	(-0.29)	(0.01)	(-0.32)	(-0.93)	(-2.50)	(-2.52)	(-0.70)	(0.29)	(-0.41)
β_{MP}	-0.32	1.89	0.78	-0.28	1.91	0.81	0.07	0.79	0.43	-1.03	3.47	1.22
(t-stat)	(-1.19)	(7.10)	(5.83)	(-1.10)	(8.13)	(5.80)	(0.41)	(4.79)	(3.41)	(-1.99)	(8.96)	(4.16)
β_{UI}	-2.22	8.90	3.34	-2.69	9.57	3.44	0.17	3.03	1.60	-5.94	12.77	3.41
(t-stat)	(-1.72)	(6.93)	(4.51)	(-2.14)	(9.15)	(5.12)	(0.19)	(3.83)	(2.74)	(-2.37)	(5.71)	(2.43)
β_{DEI}	-1.39	4.47	1.54	-2.07	4.71	1.32	-0.17	1.40	0.61	-3.94	6.27	1.17
(t-stat)	(-2.26)	(7.50)	(4.16)	(-3.26)	(8.88)	(4.11)	(-0.44)	(3.88)	(2.49)	(-3.59)	(6.08)	(1.91)
β_{UTS}	0.20	-0.05	0.07	0.43	-0.07	0.18	0.19	0.05	0.12	0.81	0.17	0.49
(t-stat)	(3.07)	(-0.82)	(2.07)	(6.35)	(-1.01)	(5.12)	(4.21)	(1.37)	(4.89)	(7.43)	(1.79)	(6.15)
β_{UPR}	-0.03	0.21	0.09	-0.06	0.17	0.06	0.01	0.10	0.06	-0.12	0.33	0.10
(t-stat)	(-1.01)	(7.61)	(6.34)	(-1.72)	(6.95)	(3.39)	(0.51)	(6.34)	(4.84)	(-2.21)	(8.56)	(3.90)

(*Continued*)

Table 4 – continued

	Global all asset classes			Global stocks			Global other assets		
	V	M	C	V	M	C	V	M	C
α	0.04	0.02	0.02	0.28	0.13	0.15	-0.04	-0.02	-0.03
(t-stat)	(1.79)	(0.78)	(1.79)	(1.92)	(0.90)	(2.43)	(-0.63)	(-0.28)	(-1.13)
β_{MP}	-0.34	1.77	0.80	-0.59	2.07	1.09	-0.25	1.67	0.71
(t-stat)	(-9.55)	(74.08)	(49.66)	(-2.42)	(6.99)	(6.75)	(-2.62)	(14.81)	(11.83)
β_{UI}	-2.20	7.81	3.16	-3.05	9.51	4.62	-1.91	7.24	2.66
(t-stat)	(-14.15)	(56.36)	(44.22)	(-2.81)	(7.30)	(5.94)	(-4.53)	(14.21)	(9.13)
β_{DEI}	-1.69	3.92	1.31	-2.38	5.06	2.13	-1.46	3.54	1.04
(t-stat)	(-20.99)	(53.28)	(35.45)	(-4.23)	(8.19)	(6.40)	(-6.77)	(14.01)	(8.17)
β_{UTS}	0.35	-0.01	0.17	0.36	-0.09	0.11	0.35	0.02	0.18
(t-stat)	(42.75)	(-1.43)	(43.63)	(5.46)	(-1.70)	(3.17)	(13.67)	(0.75)	(13.10)
β_{UPR}	-0.04	0.17	0.07	-0.06	0.18	0.10	-0.03	0.17	0.07
(t-stat)	(-10.03)	(53.97)	(38.74)	(-2.40)	(6.16)	(7.69)	(-3.01)	(14.63)	(14.33)

Table 5: Coefficients of correlation and implied correlation

This table presents actual and implied correlation coefficients between value and momentum strategies. The implied correlations are calculated using full-sample betas. Expected returns are given by the product between full-sample betas and the returns on the mimicking portfolios for the global CRR factors. The sample period starts in January 1982 and ends in June 2010.

	U.S. stocks	U.K. stocks	Europe stocks	Japan stocks
$\rho_{V,M}$	-0.61	-0.43	-0.58	-0.60
$\rho_{implied}$	-0.35	-0.21	-0.47	-0.30
	Country indices	Currencies	Fixed income	Commodities
$\rho_{V,M}$	-0.41	-0.32	-0.29	-0.38
$\rho_{implied}$	-0.17	-0.28	0.04	-0.19
	Global all asset classes	Global stocks	Global other asset classes	
$\rho_{V,M}$	-0.48	-0.58	-0.38	
$\rho_{implied}$	-0.47	-0.45	-0.30	

Table 6: Currencies, equity, commodities, sovereign bond, beta-sorted equities, industry, equity index options, and corporate bond portfolios

This table reports average excess returns along with their t-statistics on a host of portfolios. In addition, the table shows the intercepts and their t-statistics from time-series regressions of each portfolio return on US market index, MSCI World Index, and our global macroeconomic model. Currencies are sorted into six portfolios in ascending order of the interest rate differential with respect to the US interest rate. The equity portfolios consist of various Fama and French portfolios, that is, six portfolios sorted on size and book-to-market, five industry portfolios, and six portfolios sorted on size and momentum. In addition, we also study CAPM-beta sorted equity portfolios along with the betting against beta factor. Commodities are sorted into five portfolios in ascending order of the commodity basis. The six sovereign bond portfolios are sorted by the probability of default (proxied by credit rating) and bond beta. The corporate bond portfolios come from a sort on the credit spread, from lowest to highest. Equity index options are sorted into portfolios by moneyness and maturities. Data are monthly and cover as follows: currencies and equity portfolios, from January 1981 to March 2010; commodities, from January 1982 to December 2008; sovereign bond portfolios, from January 1995 to March 2010; equity option return series, from April 1986 to June 2010.

Panel A: Summary statistics												
	Currencies						Fama and French size and book-to-market					
	Low	2	3	4	5	High	SL	SM	SH	BL	BM	BH
$\overline{r}$	-0.16	0.11	0.14	0.27	0.36	0.44	0.35	0.90	1.02	0.59	0.62	0.71
t-stat	(-1.44)	(0.93)	(1.18)	(2.47)	(2.88)	(2.58)	(0.93)	(3.23)	(3.61)	(2.30)	(2.57)	(2.80)
α_{USmkt}	-0.17	0.08	0.12	0.23	0.30	0.36	-0.40	0.33	0.47	0.01	0.10	0.21
t-stat	(-1.30)	(0.54)	(0.83)	(1.83)	(2.01)	(1.84)	(-2.25)	(2.05)	(2.36)	(0.14)	(0.84)	(1.24)
$\alpha_{MSCIglobal}$	-0.30	-0.07	-0.02	0.08	0.12	0.20	-0.66	0.10	0.23	-0.24	-0.17	-0.06
t-stat	(-2.28)	(-0.47)	(-0.11)	(0.64)	(0.82)	(1.02)	(-2.34)	(0.44)	(0.88)	(-1.46)	(-1.03)	(-0.27)
α_{CRR}	-0.27	-0.05	-0.01	0.04	0.13	0.19	-0.01	0.19	0.17	0.15	-0.07	-0.41
t-stat	-1.73	(-0.35)	(-0.05)	(0.32)	(0.85)	(0.87)	(-0.04)	(0.62)	(0.61)	(0.54)	(-0.28)	(-1.55)

(*Continued*)

Table 6 – continued

	CAPM beta-sorted						Fama and French industry				
	Low	2	3	4	High	BAB	Consumer	Manuf	High tech	Health	Other
$\overline{r}$	1.03	1.13	1.05	1.08	1.06	1.11	0.76	0.65	0.59	0.74	0.58
t-stat	(5.03)	(4.37)	(3.53)	(3.11)	(2.21)	(5.41)	(3.07)	(2.83)	(1.73)	(2.85)	(2.02)
α_{USmkt}	0.67	0.62	0.46	0.39	0.18	1.20	0.25	0.18	-0.12	0.30	-0.03
t-stat	(3.65)	(3.38)	(2.39)	(1.87)	(0.61)	(4.27)	(1.82)	(1.55)	(-0.71)	(1.69)	(-0.19)
$\alpha_{MSCIglobal}$	0.52	0.42	0.22	0.13	-0.13	1.21	0.02	-0.10	-0.41	0.10	-0.30
t-stat	(2.30)	(1.69)	(0.84)	(0.45)	(-0.35)	(4.24)	(0.12)	(-0.70)	(-1.65)	(0.47)	(-1.36)
α_{CRR}	0.34	0.29	0.17	0.14	0.05	0.76	0.03	-0.21	-0.24	0.19	-0.15
t-stat	(1.22)	(0.92)	(0.48)	(0.38)	(0.10)	(2.58)	(0.10)	(-1.11)	(-0.78)	(0.65)	(-0.57)
	Fama and French size and momentum						Corporate bonds				
	SL	SM	SH	BL	BM	BH	Low	2	3	4	High
$\overline{r}$	0.21	0.78	1.13	0.45	0.53	0.79	-0.01	0.03	0.03	0.16	0.44
t-stat	(0.53)	(2.92)	(3.43)	(1.31)	(2.28)	(3.08)	(-0.14)	(0.37)	(0.25)	(1.57)	(3.21)
α_{USmkt}	-0.56	0.24	0.48	-0.22	0.02	0.24	-0.03	0.01	0.00	0.11	0.33
t-stat	(-2.44)	(1.54)	(2.53)	(-1.12)	(0.29)	(2.42)	(-0.31)	(0.14)	(0.01)	(1.05)	(2.02)

(Continued)

Table 6 – continued

	Fama and French size and momentum						Corporate bonds				
	SL	SM	SH	BL	BM	BH	Low	2	3	4	High
$\alpha_{MSCIglobal}$	-0.87	0.01	0.24	-0.54	-0.21	-0.02	-0.02	0.00	-0.01	0.08	0.27
t-stat	(-3.01)	(0.03)	(0.84)	(-2.45)	(-1.45)	(-0.11)	(-0.24)	(0.05)	(-0.08)	(0.76)	(1.60)
α_{CRR}	-0.71	-0.03	0.19	-0.16	-0.14	-0.13	-0.11	-0.07	-0.07	0.01	0.15
t-stat	(-1.86)	(-0.11)	(0.48)	(-0.67)	(-0.62)	(-0.54)	(-1.07)	(-0.67)	(-0.57)	(0.12)	(0.89)

	Commodities					Sovereign bonds					
	Low	2	3	4	High	SB1	SB2	SB3	SB4	SB5	SB6
$\overline{r}$	0.70	0.52	0.45	0.13	-0.08	0.23	0.42	0.67	0.66	1.00	1.39
t-stat	(2.73)	(2.38)	(1.92)	(0.61)	(-0.33)	(1.15)	(1.87)	(2.08)	(3.34)	(4.09)	(3.45)
α_{USmkt}	0.66	0.47	0.40	0.09	-0.16	0.11	0.27	0.43	0.54	0.80	1.04
t-stat	(2.30)	(1.83)	(1.48)	(0.39)	(-0.62)	(0.64)	(1.34)	(1.31)	(2.79)	(3.64)	(3.20)
$\alpha_{MSCIglobal}$	0.60	0.41	0.31	-0.00	-0.26	0.07	0.22	0.37	0.50	0.77	0.95
t-stat	(1.87)	(1.44)	(1.06)	(-0.01)	(-0.96)	(0.42)	(1.07)	(1.08)	(2.51)	(3.31)	(2.83)
α_{CRR}	-0.57	0.05	0.14	-0.14	-0.23	-0.10	0.07	0.25	0.40	0.58	0.83
t-stat	(-1.36)	(0.15)	(0.43)	(-0.55)	(-1.13)	(-0.50)	(0.29)	(0.59)	(1.85)	(2.61)	(2.41)

(Continued)

Table 6 – continued

Equity index call options									
	C1	C2	C3	C4	C5	C6	C7	C8	C9
$\overline{r}$	-0.03	-0.28	-0.52	-0.02	-0.24	-0.46	0.00	-0.13	-0.28
t-stat	(-0.12)	(-1.15)	(-2.18)	(-0.08)	(-0.96)	(-1.90)	(0.01)	(-0.55)	(-1.11)
α_{USmkt}	-0.46	-0.67	-0.77	-0.44	-0.63	-0.78	-0.41	-0.53	-0.62
t-stat	(-4.00)	(-4.52)	(-3.60)	(-3.80)	(-4.45)	(-3.92)	(-3.48)	(-3.78)	(-3.33)
$\alpha_{MSCIglobal}$	-0.62	-0.82	-0.87	-0.61	-0.78	-0.90	-0.58	-0.68	-0.76
t-stat	(-4.31)	(-4.80)	(-3.91)	(-4.22)	(-4.75)	(-4.22)	(-4.09)	(-4.22)	(-3.64)
α_{CRR}	-0.50	-0.60	-0.52	-0.48	-0.60	-0.64	-0.46	-0.52	-0.49
t-stat	(-2.60)	(-2.77)	(-1.92)	(-2.51)	(-2.89)	(-2.44)	(-2.44)	(-2.59)	(-1.97)

Equity index put options									
	P1	P2	P3	P4	P5	P6	P7	P8	P9
$\overline{r}$	1.71	0.54	0.23	1.03	0.45	0.19	0.60	0.37	0.21
t-stat	(4.69)	(1.81)	(0.85)	(2.97)	(1.53)	(0.70)	(1.80)	(1.28)	(0.77)
α_{USmkt}	1.17	0.04	-0.23	0.49	-0.04	-0.27	0.08	-0.12	-0.26
t-stat	(4.93)	(0.30)	(-1.98)	(2.43)	(-0.33)	(-2.37)	(0.42)	(-0.95)	(-2.19)
$\alpha_{MSCIglobal}$	0.93	-0.17	-0.42	0.27	-0.25	-0.47	-0.15	-0.33	-0.45
t-stat	(3.15)	(-0.96)	(-2.89)	(1.06)	(-1.49)	(-3.18)	(-0.64)	(-2.05)	(-3.07)
α_{CRR}	0.74	-0.20	-0.35	0.16	-0.27	-0.41	-0.25	-0.33	-0.40
t-stat	(2.04)	(-0.92)	(-1.84)	(0.49)	(-1.25)	(-2.15)	(-0.84)	(-1.54)	(-2.09)

Table 7: Summary statistics for tests of CAPM, global CAPM, and the global CRR models

This table tests how well the domestic CAPM, the global CAPM, and the CRR model explain monthly excess returns on various combinations of the portfolios described in Table 8. The table shows (1) the GRS statistic, (2) p(GRS) the p-value for the GRS statistic, (3) HJ, the Hansen and Jagannathan (1997) distance, defined as $HJ = \sqrt{\alpha'(E[rr']^{-1})\alpha}$, (4) Diff HJ^2, the squared HJ distance of the global CAPM (AMP model) less the global CRR model,(5) the average absolute value of the alphas, $A\,|\alpha_i|$, (6) $A\,|\alpha_i|/A\,|\overline{r}_i|$, the average absolute value of the alphas over the average absolute value of $\overline{r}_i$, which is the average excess return on portfolio i minus the average global market portfolio excess return, (7) $A\alpha_i^2/A\overline{r}_i^2$, the average squared alpha over the average squared value of $\overline{r}_i$, (8) $As^2(\alpha_i)/A\alpha_i^2$, the average of the estimates of the variances of the sampling errors of the estimated intercepts over the average squared alphas, and (9) AR^2, the average value of the regression adjusted R^2.

	GRS	p(GRS)	HJ	Diff HJ^2	$A\,\|\alpha_i\|$	$A\,\|\alpha_i\|/A\,\|\overline{r}_i\|$	$A\alpha_i^2/A\overline{r}_i^2$	$As^2(\alpha_i)/A\alpha_i^2$	AR^2
currencies+commodities+6 FF ME BM									
CAPM	6.84	0.000	0.5836	0.1833	0.2687	1.04	0.99	0.36	0.28
Global CAPM	6.43	0.000	0.5846	0.1845	0.2263	0.88	0.90	0.55	0.22
Global CRR	4.63	0.000	0.3966		0.1658	0.64	0.47	1.33	0.26
currencies+commodities+BAB factor									
CAPM	5.85	0.000	0.4277	0.1555	0.3493	1.11	1.47	0.22	0.01
Global CAPM	5.23	0.000	0.4367	0.1633	0.2925	0.93	1.31	0.28	0.07
Global CRR	2.87	0.000	0.1656		0.2031	0.64	0.55	0.65	0.16
currencies+commodities+5 Beta portfolios									
CAPM	4.23	0.000	0.4040	0.1046	0.3061	0.97	0.99	0.35	0.22
Global CAPM	3.29	0.000	0.17	0.1083	0.2221	0.70	0.59	0.78	
Global CRR	1.89	0.021	0.2421		0.1667	0.53	0.30	1.92	0.23
currencies+commodities+5 FF industry									
CAPM	3.58	0.000	0.3844	0.0658	0.2428	1.06	0.95	0.44	0.24
Global CAPM	2.84	0.000	0.3828	0.0645	0.2062	1.06	0.80	0.65	0.21
Global CRR	1.90	0.020	0.2864		0.1565	0.68	0.39	1.63	0.25
currencies+commodities+6 FF ME Momentum									
CAPM	5.61	0.000	0.5523	0.1307	0.2964	0.99	0.97	0.29	0.28
Global CAPM	5.42	0.000	0.5511	0.1294	0.2673	0.88	1.09	0.36	0.22
Global CRR	3.97	0.000	0.4175		0.1789	0.60	0.45	1.11	0.27
currencies+commodities+ 18 Equity index call and put options									
CAPM	7.00	0.000	0.8992	0.2286	0.3804	0.91	0.80	0.16	0.46
Global CAPM	6.92	0.000	0.8992	0.2286	0.4370	1.04	0.96	0.17	0.36
Global CRR	5.23	0.000	0.7616		0.3469	0.83	0.57	0.37	0.33
currencies+commodities+6 credit spread									
CAPM	2.94	0.000	0.2963	0.0626	0.2130	0.63	0.49	0.45	0.02
Global CAPM	2.38	0.002	0.3000	0.0648	0.1654	0.49	0.35	0.71	0.06
Global CRR	1.66	0.053	0.1588		0.1308	0.39	0.18	1.41	0.13
currencies+6 FF ME BM+6 sovereign portfolios									
CAPM	3.97	0.000	0.6412	0.1498	0.3106	1.02	1.13	0.30	0.37
Global CAPM	3.86	0.000	0.6375	0.1451	0.2697	0.94	1.13	0.41	0.35
Global CRR	3.04	0.000	0.5112		0.2329	0.77	0.67	0.74	0.40