NBER WORKING PAPER SERIES

GLOBAL PORTFOLIO DIVERSIFICATION FOR LONG-HORIZON INVESTORS

Luis M. Viceira
Zixuan (Kevin) Wang

Working Paper 24646
http://www.nber.org/papers/w24646

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
May 2018, Revised July 2018

John Zhou, Ph.D., was listed as coauthor on an earlier version of this work that circulated under the same tittle. We are deeply grateful to John for his contributions to that earlier version of this work while he was completing his Ph.D. in Business Economics at Harvard University. John is now at Key Square Capital Management, LLC. We are also grateful to Malcolm Baker, John Campbell, Owen Lamont, Christian Lundblad (discussant), Christopher Polk, Gonzalo Rubio (discussant), Jeremy Stein, Adi Sunderam, Fredrik Willumsen, and participants in the NBIM Allocation Advisory Board, the 2015 ICPM Discussion Forum on Long-Horizon Investing, the XXIV Finance Forum (Madrid), the INQUIRE Europe 2016 Autumn Seminar (Frankfurt), the Stockholm School of Economics Finance Seminar, the Research Affiliates Advisory Panel Conference, the CEMFI Workshop on Asset Management, the HBS Finance Unit Research Retreat, and the 2018 American Finance Association Meetings for helpful comments and suggestions. This work has been the recipient of the 2018 Research Award of the International Centre For Pension Management at the University of Toronto. This material is based upon work supported by Harvard Business School Research Funding. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Global Portfolio Diversification for Long-Horizon Investors
Luis M. Viceira and Zixuan (Kevin) Wang
NBER Working Paper No. 24646
May 2018, Revised July 2018
JEL No. F21,F3,G11,G12

ABSTRACT

This paper conducts a theoretical and empirical investigation of global portfolio diversification for long-horizon investors in the presence of permanent cash flow shocks and transitory discount rate shocks to asset prices and returns. An increase in the cross-country correlations of cash flow shocks raises the risk of a globally diversified portfolio at all horizons. By contrast, an increase in the cross-country correlations of discount rate shocks has a muted effect on portfolio risk at long horizons and does not diminish the benefits of global portfolio diversification to long-term investors. Empirically, we find that increased correlations of discount rate shocks resulting from financial globalization appear to be the main driver of an estimated secular increase in the cross-country correlations of both stock and bond returns since the late 1990's. Increased correlations of inflation shocks are also an important source of the shift in bond correlations. By contrast, we don't find evidence of an increase in the cross-country correlations of equity cash flow news or stock market volatility shocks. Our findings imply that the benefits of global equity diversification have not declined for long horizon investors despite the secular increase in global stock correlations, while the benefits of global bond diversification have declined.

Luis M. Viceira
George E. Bates Professor
Harvard Business School
Baker Library 367
Boston, MA 02163
and NBER
lviceira@hbs.edu

Zixuan (Kevin) Wang
Harvard Business School
Baker Library
Boston MA 02163
zwang@hbs.edu

A data appendix is available at http://www.nber.org/data-appendix/w24646

1 Introduction

A large body of empirical research in Finance has documented the existence of significant benefits from global portfolio diversification stemming from the average low level of correlation of global equity market returns.[1] Given these correlations, investors would need implausibly large and mutually inconsistent return expectations on their own stock markets to justify holding a domestically biased equity portfolio (French and Poterba, 1991). The cross-country correlations of long-term government bond returns are also low historically, suggesting that the case for holding a globally diversified bond portfolio is also strong (Campbell, Serfaty-de-Medeiros, and Viceira, 2010).

However, in recent decades global equity return correlations have experienced a significant increase resulting from trade and financial globalization (Goetzmann, Li, and Rouwenhorst 2005, Quinn and Voth, 2008, Solnik and McLeavey 2009 and Bekaert and Hodrick 2017). Figure 1 documents this empirical phenomenon. It plots cross-country averages of 3-year rolling correlations of monthly equity and bond excess returns across seven major markets that account for the bulk of global stock and bond market capitalization: Australia, Canada, France, Germany, Japan, United Kingdom, and the United States. The figure plots these correlations for the 1970-2016 period. The figure shows a secular increase in the cross-country correlations of stock and bond returns since 1970, and a further temporary significant increase in global stock return correlations during the global financial crisis of 2008-2009. Goetzmann, Li, and Rouwenhorst (2005) reports a similar figure for stock returns dating back to the second half of the 19th century, and shows that historical episodes of trade and capital flow liberalizations appear to be associated with increased correlations of global equity markets.

This significant secular increase in global return correlations raises the question of whether the gains from international portfolio diversification have correspondingly declined.[2] If in-

[1]See Grubel (1968), Levy and Sarnat (1970), Odier and Solnik (1993), Erb et al. (1994, 1995), Longin and Solnik (1995), Karolyi and Stulz (1996), De Santis and Gerard (1997), Bekaert et al. (2009), Goetzmann, Li, and Rouwenhorst (2005), and the textbook treatment of this topic in Solnik and McLeavey (2009) and Bekaert and Hodrick (2017).

[2]The gains from global portfolio diversification have also been questioned on other fronts. It has been argued that global stock returns become more correlated in falling markets and exhibit negative co-skewness. However, empirically this effect is not enough to eliminate the gains from global equity portfolio diversification; moreover, there is no evidence of negative co-skewness at longer horizons (De Santis and Gerard 1997, Ang and Bekaert 2002, Longin and Solnik 2001, Hartmann et al. 2004, Chua et al. 2009, Leibovitz and Bova

vestment opportunities are constant, the answer to this question is unambiguosly affirmative, unless there is a compensating increase in expected returns.[3]

However, there is considerable academic research documenting time variation in investment opportunities in the form of predictable variation in discount rates, volatility, and risk.[4] If investment opportunities are not constant, is it still true that an increase in cross-country return correlations implies a reduction in the benefits of global portfolio diversification, all else equal?

This paper explores this question both theoretically and empirically. We examine global portfolio diversification in the presence of time variation in discount rates, both real interest rates and risk premia, and in market volatility. We show that in such environment, both the risk of globally diversified portfolios and optimal international portfolio diversification are a function of investment horizon, and an increase in return correlations does not necessarily imply a reduction in the benefits of global portfolio diversification for long horizon investors.

Our argument builds on the distinction between shocks to cash flows or fundamentals ("cash flow news") and shocks to discount rates ("discount rate news") that arises when discount rates are time varying. This distinction implies that asset returns can be correlated because either cash flows are correlated, or discount rates are correlated.[5] Empirically, cash flow shocks appear to be highly persistent, while discount rate shocks appear to be transitory (Campbell and Shiller, 1988, Campbell 1991, Campbell and Vuolteenaho 2004).

2009, Asness et al. 2011). A second argument is that domestic portfolios focused on global companies could potentially produce the same diversification gains as a global portfolio, but the empirical evidence suggests the two are not substitutes, especially when including medium and small capitalization stocks (Errunza et al. 1999, Cheol et al. 2010). A third argument relies not so much on questioning that there are gains from global diversification but on attributing them to sector diversification (Carrieri, Errunza, and Sarkissian, 2012). However, the empirical evidence suggests that the diversification benefits of global equities come from both country factors and industry factors (Heston and Rouwenhorst 1994, Campa and Fernandes 2006)

[3]See Grubel (1968), Solnik (1974), French and Poterba (1991), De Santis and Gerard (1997).

[4]There appears to be predictable variation in discount rates, both real interest rates and risk premia, at the asset class level and at the individual stock level (Campbell 1991, Cochrane, 2008 and 2011, Vuolteeenaho 2002). There is also predictable variation in asset return volatility and correlations (Engle, 1982, Bollerslev, 1986, French, Schwert, and Stambaugh, 1987, Schwert, 1989, Campbell and Hentschel, 1992, Erb, Harvey, and Viskanta, 1994, Andersen and Bollerslev, 1998, Ang and Bekaert 2002, Engle, Ghysels, and Sohn, 2013, Campbell, Giglio, Polk, and Turley, 2017). A key implication of time-varying investment opportunities is that optimal portfolios are a function of investors' horizon (Merton, 1969; see Campbell and Viceira, 2002, for a textbook treatment).

[5]Of course cash flows and discount rates can be cross-correlated too, but empirically these correlations appear to be small.

We show that the impact of correlated persistent cash flow shocks on annualized portfolio risk is independent of investment horizon, while the impact of correlated transitory discount rate shocks is a decreasing function of investment horizon. Therefore if cash flows become more correlated across markets, the scope for global portfolio diversification declines for all investors regardless of their investment horizon. By contrast, if discount rates become more correlated, the scope for global portfolio diversification declines for short-term investors, but less so for long-term investors, since discount rates have only a temporary impact on valuations and returns. An increase in the cross-country correlation of shocks to market volatility increases annualized portfolio risk at all horizons.

We conduct an empirical investigation of global portfolio diversification in equities and sovereign bonds in the period 1986-2016.[6] Using the return news decomposition and news estimation framework of Campbell (1991), we estimate the sources of cross-country return correlations for stocks and bonds in the entire sample period as well as in two superiods, 1986-1999 and 2000-2016. There is disagreement in the literature about how precisely one can estimate time variation in expected returns and therefore returns news.[7] Although we do not account explicitly for estimation uncertainty in our analysis, we use simultaneously the whole cross-section of countries in our estimation to increase power; we also provide ample auxiliary evidence that supports the main conclusions derived from our main news estimation approach.

Our empirical analysis documents an economically and statistically significant increase in the average cross-country correlation of discount rate news, both real rate news and risk premia news, from the 1986-1999 period to the 2000-2016 period for both stocks and bonds. The increase in the correlation of risk premia news has been more pronounced for equities than for bonds. We also find a significant increase in the average cross-country correlation of nominal bond cash flow news, or inflation news. However, we do not find a significant increase in the correlation of cash flow news for stocks. Multiple direct measures of equity cash flows corroborate this finding.

We also estimate market volatility news for the cross-section of stock markets included in our sample following the methodology of Campbell, Giglio, Polk, and Turley (2017).

[6]Our start date is constrained by availability of data on all state variables for the seven countries included in Figure 1.

[7]See Campbell and Yogo (2006), Campbell and Thompson (2008), Goyal and Welch (2008), and Pastor and Stambaugh (2009 and 2012).

We find that the average cross-country correlation of persistent shocks to market volatility has remained fairly stable and low over the entire sample period, with the exception of a temporary but significant increase during the financial crisis of 2008-2009.

Our results add to an extensive empirical literature measuring financial integration, particularly to a nascent but growing body of research that explores the sources and effects of globalization on capital markets.[8] Following Ammer and Mei (1996), we interpret the increase in the cross-country correlations of discount rate news across subperiods as an indicator of increased financial market integration. Accordingly our estimates suggest that a stronger degree of financial integration of global markets in the most recent period is the main driver of the increase in one-period stock return correlations shown in Figure 1. Arguably today the marginal investor in developed markets is more likely to be a global investor, and more so for equity markets than for bond markets, for which regulatory capture or "financial repression" might induce a lesser degree of integration (Reinhart and Rogoff, 2014). We show that our results are robust to considering the alternative measure of capital market integration proposed by Pukthuanthong and Roll (2009), which we extend to accommodate the distinction between cash flow news and discount rate news.

The increase in the cross-country correlations of bond cash flow news reflects an increase in the cross-country correlation of inflation news, since their real cash flows vary inversely with inflation. Our results suggest that increased correlation of inflation news across monetary areas has also been an important contributor to the increase in one-period bond return correlations in the most recent period. Our findings add to research that documents a large increase in the average cross-country correlation of inflation, suggesting the presence of a global factor in inflation.[9] This increased correlation in inflation could be the result of successful inflation targeting by central banks, which has operated as an implicit mechanism of coordination in monetary policy and has reduced country-specific variation in inflation expectations (Cecchetti and Schoenholtz, 2014, 2015).

The final section in this paper investigates the implications of our empirical findings

[8]See Ammer and Mei (1996)[1], Karolyi and Stulz (2003), Baele (2005), De Santis and Gerard (2009), Pukthuanthong and Roll (2009), Carrieri, Errunza, and Hogan (2007), Bekaert, Harvey, Lundblad, and Siegel (2011, 2013), Lustig, Stathopoulus, and Verdelhan (2016), and Davis and van Wincoop (2017), among others.

[9]See Wang and Wen (2007), Mumtaz, Simonelli and Surico (2011), Neely and Rapach (2011), and Henriksen, Kydland and Sustek (2013).

for global portfolio diversification in two related ways. First, we compute the risk of global portfolios of stocks and bonds as a function of investment horizon for each subperiod following Campbell and Viceira (2005). Second, we compute optimal intertemporal global equity portfolio allocations and expected utility implied by our estimates across periods for investors with different degrees of relative risk aversion and investment horizons as in Campbell, Chan, and Viceira (2003) and Jurek and Viceira (2011).

Our portfolio risk analysis shows that, consistent with our theoretical findings, the upward shift in one-period return correlations in the 2000-2016 period relative to the 1986-1999 period has increased the short-run risk of global equity portfolios but not their long-run risk. In fact, we estimate a decline in long-run global equity portfolio risk in the second subperiod. This decline is the result of both a correlation effect and a volatility effect. The correlation effect is that increased correlation of transitory discount rate news is the main driver of the increase in return correlations, and we have shown that correlated discount rate shocks have a minimal effect on long-run return correlations. The volatility effect is an estimated increase in the degree of stock return predictability in the second subperiod which in turn implies a reduction in stock return volatility at long horizons. It is well known that the persistent run up in global stock market valuations in the late 1980's and the 1990's weakened the evidence of stock return predictability, which has been restored in the most recent period.

By contrast, we estimate that the risk of global bond portfolios has increased at all horizons in the second subperiod, as a result of the increase in the correlations of bond cash flow news. This upward shift in the risk of global bond portfolios is detrimental to long-only bond investors, but beneficial to investors with long-term liabilities such as pension funds. For such investors, increased bond return correlations expand the universe of bonds they can use to hedge their local pension liabilities. These benefits can be especially large to investors whose liabilities are large relative to the size of their domestic bond markets and are exposed to adverse price pressure when they try to hedge their liabilities in their local markets (Greenwood and Vayanos 2008, Hamilton and Wu 2012).

Our analysis of the optimal intertemporal global equity portfolio allocations and expected utility implied by our news estimates shows that the increase in the cross-country correlations of stock returns has not led to reduction in the benefits of global equity portfolio diversification at long horizons. Because the increase in return correlations results from correlated discount rate news, long-horizon investors still find that holding global equity portfolios helps diversify cash flow risk.

The paper is organized as follows. Section 2 introduces the basic asset return decomposition into cash flow news and discount rate news. Section 3 explores long-run portfolio risk and optimal intertemporal global portfolio diversification in a stylized symmetrical model of global markets. This section provides insights into the differential effects of each type of return news on long-run global portfolio risk and portfolio choice. Section 4 conducts an empirical analysis of the changes in cross-country stock and bond return correlations over time and the sources of these changes. Section 5 introduces auxiliary supporting evidence of the empirical results in Section 4 and investigates correlated persistent shocks to market risk. Section 6 examines the implications of our estimates of cash flow news and discount rate news for the risk of globally diversified portfolios of stocks and bonds across investment horizons, and for optimal intertemporal portfolio choice. Finally, Section 7 concludes. An Online Appendix provides full details on all the derivations of the results in the paper and all supplementary empirical results not reported in the main body of the paper.[10]

2 Asset Return Decomposition

The starting point of our analysis is the log-linear approximation to present value relations of Campbell and Shiller (1988) and the return decomposition of Campbell (1991). A log-linearization of the return on an asset around the unconditional mean of its dividend-price ratio—where dividend is a proxy for cash flow—implies the following decomposition of realized returns:

$$r_{s,t+1} - \mathbb{E}_t\left[r_{s,t+1}\right] = \left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\sum_{j=0}^{\infty}\rho_s^j \Delta d_{t+1+j} - \left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\sum_{j=1}^{\infty}\rho_s^j r_{t+1+j} \tag{1}$$

$$\equiv N_{CF,s,t+1} - N_{DR,s,t+1}. \tag{2}$$

where $r_{s,t}$ denotes the natural log of the gross total return on the asset and Δd_{t+1} the change in its log dividend (or cash flow). The constant $\rho_s \equiv 1/\left(1+\exp\left(\overline{d-p}\right)\right)$ is a log-linearization parameter, where $\overline{d-p}$ denotes the unconditional mean of the log dividend-price ratio.

[10] This Appendix is available at http://www.people.hbs.edu/lviceira/publications.html.

Equation (1) shows that the unexpected log return on an asset reflects changes in either its expected future cash flows or in its expected future returns (or discount rates). Following standard terminology in this literature, we will refer to the former as cash flow shocks or cash flow news ($N_{CF,s,t+1}$), and to the latter as discount rate shocks or discount rate news ($N_{DR,s,t+1}$). We can further decompose $N_{DR,s,t+1}$ into the sum of news about excess log returns or risk premia ($N_{RP,s,t+1}$) and news about the return on the reference asset used to measure excess returns ($N_{RR,s,t+1}$). In our empirical analysis we follow standard practice and use cash (i.e., a short-term nominal bond like a T-bill in the US) as the reference asset.

We also consider nominal bonds with fixed maturities in addition to equities. Nominal bond cash flows (i.e., coupons) are fixed in nominal terms and thus vary inversely with the price level in real terms. Therefore in logs bond cash flow news are the negative of inflation news. Section A in the Appendix provides detailed expressions of the news components of stock and bond returns.

Asset return news components are not directly observable, but we can infer them from a return generating model. We follow Campbell (1991) and assume that the asset return generating process follows a first-order vector autoregressive (VAR) model. It is important to note three observations about this VAR specification.

First, a VAR(1) specification is not restrictive in the sense that it can easily accommodate higher order lags through a straightforward change in the state vector. Second, it is also well know that return decompositions are sensitive to the particular specification of the components of the state vector (Chen and Zhao 2009). Our empirical specification of the state vector includes variables for which there is wide consensus that they capture time variation in risk premia, inflation, and real interest rates. We also conduct an additional analysis in Section 5 that corroborates that our results are robust to our specification of the VAR. Third, our main empirical analysis is based on a homoskedastic version of the VAR, but we also consider a heteroskedastic specification along the lines of Campbell, Giglio, Polk, and Turley (2017) in Section 5.

3 Global Portfolio Diversification with Time-Varying Discount Rates

The return decomposition (1) implies that there are two potential sources of correlation in asset returns when discount rates are time varying: correlated cash flows and correlated discount rates. This section develops a symmetrical model of investment opportunities with N asset markets (or "countries") to analyze the contribution of each source of correlation to portfolio risk across invesment horizons, portfolio choice, and the benefits of portfolio diversification at long horizons.

Our return generating model is a direct extension to a multi-market setting of the canonical model of time-varying investment opportunities of Campbell and Viceira (1999), Barberis (2000), and Pastor and Stambaugh (2009, 2012). This stylized model is particularly helpful to interpret the results of our subsequent empirical analysis of global portfolio risk and portfolio choice at long horizons. Please refer to Section B in the Appendix for derivations of all results in this section.

3.1 Model

Consider N ex-ante identical markets with identical return generating process described by the following single-state variable VAR(1) model:

$$r_{i,t+1} = \mu_1 + \beta s_{i,t} + u_{i,t+1} \tag{3}$$

$$s_{i,t+1} = \mu_2 + \phi s_{i,t} + u_{si,t+1}, \tag{4}$$

where $r_{i,t+1}$ denotes the log return on country i, and $s_{i,t+1}$ denotes a state variable that drives the time variation in the conditional expected return on country i: $\mathbb{E}_t[r_{i,t+1}] = \mu_1 + \beta s_{i,t}$. The parameters μ_1, μ_2, β, and ϕ are identical across countries. Without loss of generality we normalize $\beta > 0$. To preserve stationarity, we must have $|\phi| < 1$.

The conditional within-country variance-covariance matrix of the innovations to the VAR is also identical across countries and constant over time:

$$\mathbb{V}_t\left[\mathbf{u}_{i,t+1}\right] = \begin{bmatrix} \sigma_{uu}^{wc} & \sigma_{us}^{wc} \\ \sigma_{us}^{wc} & \sigma_{ss}^{wc} \end{bmatrix}. \tag{5}$$

where $\mathbf{u}_{i,t+1} = (u_{i,t+1}, u_{si,t+1})'$ and the superscript wc denotes within-country quantities.

Finally, the conditional cross-country covariance matrix of VAR innovations between any pair of countries is also identical across country pairs and constant over time:

$$\mathbb{C}_t\left[\mathbf{u}_{i,t+1}, \mathbf{u}_{j,t+1}\right] = \begin{bmatrix} \sigma_{uu}^{xc} & \sigma_{us}^{xc} \\ \sigma_{us}^{xc} & \sigma_{ss}^{xc} \end{bmatrix} \tag{6}$$

for all i and j. The superscript xc denotes cross-country quantities.

The stylized model of country returns defined by equations (3)-(6) implies that countries are identical and symmetrical with respect to the structure of their return dynamics and the cross-country correlation structure of returns and state variables. Of course the realized paths of returns and the state variable in each country will vary across countries. For example, in this model the expected excess return on country i is given by $\mu_1 + \beta s_{i,t}$, whose realizations depend on the realizations of the country-specific state variable $s_{i,t}$.

A straightforward application of the return decomposition (1) to the VAR(1) model (3)-(6) shows that the shocks to the model (3)-(4) are related to structural cash flow and discount rate shocks as follows:

$$N_{DR,i,t+1} = \lambda u_{si,t+1}, \tag{7}$$

$$N_{CF,i,t+1} = u_{i,t+1} + \lambda u_{si,t+1}, \tag{8}$$

with

$$\lambda = \frac{\rho\beta}{1-\rho\phi}.$$

Therefore discount rate news are proportional to innovations to the state variable driving expected returns, with proportionality constant λ. This constant is increasing in the persistence (ϕ) of the state variable or expected returns, the loading of expected returns on the state variable (β), and the log-linearization parameter ρ. Note that $\lambda = 0$ when expected returns are constant, i.e., when $\beta = 0$. In that case all variation in realized returns is driven exclusively by cash flow news: $u_{i,t+1} = N_{CF,i,t+1}$.

Our assumptions about the conditional covariance structure of the innovations to the VAR (5)-(6), together with equations (7) and (8), imply that the conditional variances and covariances of news are constant over time and identical both within country and across countries. To fix notation, we write

$$\mathbb{C}_t[N_{CF,i,t+l}, N_{CF,j,t+l}] \equiv \sigma^m_{CF,CF}, \tag{9}$$

$$\mathbb{C}_t[N_{CF,i,t+l}, N_{DR,j,t+l}] \equiv \sigma^m_{CF,DR}, \tag{10}$$

$$\mathbb{C}_t[N_{DR,i,t+l}, N_{DR,j,t+l}] \equiv \sigma^m_{DR,DR}, \tag{11}$$

where $m \equiv wc$ when $i = j$, and $m \equiv xc$ when $i \neq j$. For example, $\sigma^{xc}_{CF,CF}$ denotes the conditional cross-country covariance of cash flows news.

3.2 Correlated Return News and Portfolio Risk Across Investment Horizons

The symmetrical model of Section 3.1 provides a convenient framework to explore the impact of the cross-country correlation of each type of return news on portfolio risk and portfolio choice across investment horizons.

Consider the equally-weighted portfolio of the N identical and symmetrical markets, which is also the mean-variance optimal portfolio. The risk of this portfolio at horizon k, defined as the conditional variance of the k-horizon log portfolio return normalized by the investment horizon, is a weighted average of the normalized within-country conditional variance and the normalized cross-country covariance of k-horizon returns:

$$\frac{1}{k}\mathbb{V}_t[r^{(k)}_{p,t+k}] = \frac{1}{N}\frac{1}{k}\mathbb{V}_t[r^{(k)}_{i,t+k}] + (1-\frac{1}{N})\frac{1}{k}\mathbb{C}_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}]. \tag{12}$$

where $r^{(k)}_{i,t+k} = \sum_{l=1}^{k} r_{i,t+l}$ is the log return at horizon k,

$$\mathbb{C}_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}] = \sum_{l=1}^{k}\mathbb{C}_t[r_{i,t+l}, r_{j,t+l}] + 2\sum_{l=1}^{k-1}\sum_{m=1}^{k-l}\mathbb{C}_t[r_{i,t+l}, r_{j,t+l+m}], \tag{13}$$

and the expression for $\mathbb{V}_t[r^{(k)}_{i,t+k}]$ follows immediately from (13) by noting that $\mathbb{V}_t[r^{(k)}_{i,t+k}] = \mathbb{C}_t[r^{(k)}_{i,t+k}, r^{(k)}_{i,t+k}]$. [11]

[11] We normalize by k because $V_t[r^{(k)}_{p,t+k}]/k$ is a constant independent of investment horizon in the absence of return predictability. To see that, note from the definition of k-horizon log return that the moments on the right hand side of (12) are all proportional to k when returns are unpredictable.

We are interested in expressing the conditional within-country and cross-country moments of k-period returns as a function of the conditional moments of return news. A forward recursion of the dynamic equations of the VAR(1) model (3)-(4) shows that future one-period realized returns are given by

$$r_{i,t+l} - E_t[r_{i,t+l}] = N_{CF,i,t+l} - N_{DR,i,t+l} + \frac{\beta}{\lambda} \sum_{m=1}^{l-1} \phi^{m-1} N_{DR,i,t+l-m}, \tag{14}$$

where we have replaced the reduced-form shocks $u_{i,t+l}$ and $u_{si,t+l}$ with the structural shocks $N_{CF,i,t+l}$ and $N_{DR,i,t+l}$ using (7) and (8). Note that $\beta/\lambda > 0$.

Equation (14) illustrates the permanent and transitory nature of cash flow news and discount rate news respectively. It shows that, conditional on information at time t, the realized return on an asset l periods ahead depends only of the contemporaneous cash flow shock but it depends on the entire history of discount rate shocks between $t+1$ and $t+l$. This dependence is such that a positive discount rate shock drives realized returns down contemporaneously, but this effect reverses over time at a rate determined by the persistence of expected returns (ϕ).

Using the forward recursion (14) it is straightforward to show that the cross-country component (13) of portfolio risk at horizon k is given by:

$$\frac{1}{k}\mathbb{C}_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}] = \sigma^{xc}_{CF,CF} + \left[a(\mathrm{k})^2 + b(\mathrm{k})\right] \times \sigma^{xc}_{DR,DR} - 2 \times a(\mathrm{k}) \times \sigma^{xc}_{CF,DR}. \tag{15}$$

The coefficients $a(k) \equiv a(k;\beta,\phi,\rho)$ and $b(k) \equiv b(k;\beta,\phi,\rho)$ are given in Section B in the Appendix.

For $k = 1$, $a(1) = 1$, $b(1) = 0$ and equation (15) reduces to

$$\mathbb{C}_t[r_{i,t+1}, r_{j,t+1}] = \sigma^{xc}_{CF,CF} + \sigma^{xc}_{DR,DR} - 2\sigma^{xc}_{CF,DR}. \tag{16}$$

Equations (15) and (16) show how correlated cash flow news and correlated discount rate news impact portfolio risk across investment horizons. At a one-period horizon, the cross-country covariance of each type of news has identical impact on the cross-country covariance of returns and portfolio risk per period. However, at horizons ($k > 1$) equation (15) shows that each type of return news cross-country covariance has a different effect on portfolio risk.

Specifically, the unit coefficient on $\sigma^{xc}_{CF,CF}$ implies that its effect on portfolio risk remains the same at all horizons, while the horizon-dependent coefficient on $\sigma^{xc}_{DR,DR}$—and on $\sigma^{xc}_{CF,DR}$—implies that its effect changes with investment horizon. The Appendix shows that in the limit the cross-country component of portfolio risk per period (15) converges to

$$lim_{k\rightarrow+\infty}\,\frac{1}{k}\mathbb{C}_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}] = \sigma^{xc}_{CF,CF} + \left(1-\frac{1-\rho\phi}{\rho-\rho\phi}\right)^2 \times \sigma^{xc}_{DR,DR} - 2\times\left(1-\frac{1-\rho\phi}{\rho-\rho\phi}\right)\times\sigma^{xc}_{CF,DR} \tag{17}$$

where the coefficient on $\sigma^{xc}_{DR,DR}$ is smaller than one whenever $\rho > \phi$ and sufficiently close to one, and zero when $\rho = 1$.[12] These conditions hold in all the cases we consider in our empirical analysis.

Figure 2 plots the coefficient on $\sigma^{xc}_{DR,DR}$ for values of β, ϕ, and ρ calibrated to U.S. data in our sample. The figure shows that, for this empirically relevant calibration, the coefficient on $\sigma^{xc}_{DR,DR}$ declines monotonically as k increaess and rapidly approaches values well under 0.3 at horizons of 10 years or more, consistent with the intuition that correlated discount rate news matter less for portfolio risk than correlated cash flow news at long horizons. Equivalently, at long horizons the covariance of asset returns is primarily determined by the covariance structure of cash flow innovations. The covariance of discount rate innovations matters for long-run return correlations only if discount rate news are extremely persistent.

A similar logic applies to the variation of the within-country component of portfolio risk. Since $\mathbb{V}_t[r^{(k)}_{i,t+k}] = \mathbb{C}_t[r^{(k)}_{i,t+k}, r^{(k)}_{i,t+k}]$, it follows that:

$$\frac{1}{k}\mathbb{V}_t[r^{(k)}_{i,t+k}] = \sigma^{wc}_{CF,CF} + \left[a(\mathrm{k})^2 + b(\mathrm{k})\right] \times \sigma^{wc}_{DR,DR} - 2 \times a(\mathrm{k}) \times \sigma^{wc}_{CF,DR}. \tag{18}$$

Of course, the within-country k-return portfolio variance (18) is also the k-horizon risk of a single-country portfolio.

Campbell and Viceira (2005), Pastor and Stambaugh (2012), and others have studied the properties of single-market portfolio $\mathbb{V}_t[r^{(k)}_{i,t+k}]/k$ as a function of the moments of the shocks to the VAR(1) (3)-(4). By writing $\mathbb{V}_t[r^{(k)}_{i,t+k}]/k$ as a function of the moments of cash flow news and discount rate news we gain intuition into why empirically annualized portfolio

[12]Note that ρ measures the importance of distant cash flow news and discount rate for valuations and returns (see equation [1]), while ϕ determines the persistence of discount rate news. Therefore, the conditions $\rho > \phi$ and $\rho \rightarrow 1$ essentially say that in the limit correlated discount rate news do not matter for long-run portfolio risk if they are not sufficiently persistent.

risk declines at long horizons when asset returns are predictable: Discount rate shocks are transitory shocks whose impact on long-run portfolio return variability is smaller than the impact of permanent cash flow shocks.

When returns are not predictable (i.e., $\beta = 0$) and all return variation comes from cash flow news, equations (15) and (18) reduce to $\sigma^{xc}_{CF,CF}$ and $\sigma^{wc}_{CF,CF}$ respectively. Portfolio risk per period is the same across all investment horizons and equals

$$\frac{1}{k}\mathbb{V}_t[r^{(k)}_{p,t+k}] = \frac{1}{N}\sigma^{wc}_{CF,CF} + (1 - \frac{1}{N})\sigma^{xc}_{CF,CF}.$$

3.3 Calibrated Example

We now illustrate how the cross-country covariance of each return news component affects portfolio risk across investment horizons within the context of this symmetrical model. We calibrate the VAR(1) return dynamics (3)-(4) to US excess stock returns, with the log dividend-price ratio as the state variable.

We use these parameter values to compute two objects: portfolio risk per period $\sqrt{\mathbb{V}_t[r^{(k)}_{p,t+k}]/k}$ on an equally-weighted portfolio of seven U.S. stock market clones as in Campbell and Viceira (2005), and the optimal intertemporal allocation to global equities and cash of an investor who maximizes expected utility of terminal wealth at a finite horizon as in Jurek and Viceira (2011). We set the coefficient of relative risk aversion of this investor to 5.

We consider three different scenarios for the cross-country correlations of return news. In the first scenario (and baseline case) we set all cross-country news correlations to zero. In the second scenario and in the third scenario we set the cross-country correlation of one-period returns to the same positive value. However, the source of this correlation is different in each scenario: The second scenario ("CF integration") generates positive cross-country return correlations exclusively from correlated cash flow news;[13] the third scenario ("DR integration") generates positive cross-country return correlations exclusively from correlated discount news.[14]

[13]In U.S. data, $\sigma^{wc}_{DR,DR}/\sigma^{wc}_{CF,CF} = 2.6$, that is, discount rate news are 2.6 times more volatile than cash flow news. Holding this ratio to 2.6 for all countries and setting all other cross-country news correlations to zero, the maximum admissible value of the cross-country correlation of cash flow news that ensures a positive semidefinite variance-covariance matrix of shocks across all markets is 0.60. This in turn implies a cross-country correlation of returns of 0.062.

[14]The value of the cross-country correlation of discount rate news that generates the same value of the

Figure 3 plots annualized portfolio risk in Panel A and the mean optimal equity portfolio allocation in Panel B as a function of investment horizon for each of the three scenarios. The intercepts in Panel B reflect the one-period or instantaneously mean-variance efficient allocation to risky assets, while the deviations from the intercepts reflect intertemporal hedging demands. To facilitate interpretation, we set the unconditional expected returns and the risk-free rate such that the mean-variance allocation to cash is zero in the baseline scenario, which in turn implies a positive allocation to cash in the other two scenarios with correlated returns.

Consistent with our results in Section 3.2, Panel A shows that portfolio risk per period declines as investment horizon increases as a result of return predictability, with a magnitude that depends on the source of cross-country return correlations. Uncorrelated news generate a more pronounced decline than correlated news. Most interestingly, correlated discount rate news generate a much larger decline in long-horizon portfolio risk than correlated cash flow news, even though both imply the same level of portfolio risk at short horizons.

Panel B shows that total portfolio demand for stocks is increasing in investment horizon in all three scenarios because shocks to the state variable—or equivalently expected excess returns—are negatively correlated with realized stock excess returns, implying that long positions in the risky assets help hedge against a fall in expected returns. However, the increase in optimal portfolio demand also depends critically on the source of cross-country return correlations. Intertemporal hedging demands are significantly smaller when correlated cash flow news is the driver of cross-country return correlation.

Figure 3 illustrates the main point of our argument. Investors can achieve a significantly larger reduction in long-run portfolio risk through global portfolio diversification when the driver of cross-country return correlations is correlated discount rate news than when the driver is correlated cash flow news, even if both result in the same level of short-run portfolio risk and the same short-run or myopic portfolio allocations. Equivalently, if global return correlations increase, the risk of a globally diversified portfolio increases at short horizons regardless of the source of the increase in cross-country return correlations. But it increases much less at long horizons when the source of the increase is capital market integration (or

cross-county correlation of one-period returns as in the second scenario is 0.10. It is much smaller than the cross-correlation of cash flow news because the volatiliy of discount rate news is much larger than the volatility of cash flows news.

correlated discount rates) than when it is real markets integration (or correlated cash flows).

4 Empirical Investigation of the Sources of Return Correlations in Global Capital Markets

4.1 VAR Specification and Estimation of Return Decomposition

The stylized symmetrical model presented in Section 3 highlights the importance of understanding the sources of cross-country correlations of returns to evaluate the benefits of international portfolio diversification at long horizons. We now present an empirical analysis of the return news decomposition presented in Section 2 for stocks and government bonds of seven major developed economies that account for at least 80% of total global stock market capitalization throughout our sample period: Australia, Canada, France, Germany, Japan, the U.K., and the U.S. The sample period expands January 1986 through December 2016, the longest period for which we have complete data on returns and state variables for all these countries.

We estimate a homoskedastic pooled VAR(1) model for the seven countries in our sample with a country-specific vector of intercepts and a common matrix of slope coefficients. Our specification of the state vector for the VAR(1) model includes the log return on equities and bonds in excess of the return on their domestic T-bill to ensure that the return decomposition is currency independent (Campbell, Sefarty de Medeiros, and Viceira, 2010). It also includes state variables known to predict excess returns on stocks and bonds—log dividend-price ratios and yield spreads—and variables that help capture the dynamics of real interest rates and inflation—log nominal short-term interest rates and log inflation (Campbell, Chan, and Viceira, 2003, Campbell and Viceira, 2005). We obtain monthly data for the state variables in all seven countries from a variety of sources. Section D in the Appendix provides a detailed description of the data and its sources. We consider a heteroskedastic version of this VAR in Section 5.

We estimate a pooled VAR(1) model for the entire sample in an attempt to use as much cross-country and time-series information as possible to estimate the process for expected returns, because our sample is relatively short in the time series dimension and we also want to analyze changes in the cross-country correlation of news components in our sample period. We extract estimates of the news components of stock and bond excess returns for each country from the estimates of this VAR(1) system using the return decomposition described in Section 2. We estimate news components for both the entire sample period and two subperiods, 1986-1999 and 2000-2016. We obtain subperiod estimates by splitting the vector of innovations while holding the coefficients at their full sample estimates.

We hold the slope coefficients constant across subperiods for two reasons. First, the state variables that capture expected excess returns, inflation, and the nominal short-rate follow highly persistent processes that require long samples to be precisely estimated. Second, we don't have strong priors as to why the slopes of the VAR system might have changed across periods, while we do have strong priors as to why the correlation structure of the shocks, particularly across countries, might have changed.

Of course, if the expected return processes for stocks and bonds differ across markets and change over time, a full-sample pooled estimation can introduce biases in the estimation of news components and their volatilities and correlations. However, estimates based on individual country VAR's do no appear to fundamentally change our results, and the analysis of cash flow correlations based on direct measures of cash flows presented in Section 5 suggests that our results do not depend on changes over time in the structure of return predictability. Accordingly, we use our entire sample period to estimate the slope coefficients. In practice, this procedure tempers the evidence of return predictability for those markets for which there is more in-sample evidence of return predictability, such as the U.K. and the U.S.

For stocks, our specification of the state vector allows us to explicitly identify unexpected stock excess returns and the discount rate news componens of stock returns—real rate news and risk premium news—from equations in the VAR, and obtain cash flow news as the sum of unexpected excess returns and discount rate news. Section 5 provides evidence that our results are robust to this identification strategy for equity cash flow news. For bonds, our specification allows us to explicitly identify bond cash flow news from the inflation equation in the VAR, and obtain the risk premium news component of bond returns as the residual. Section A in the Appendix provides details of the return decomposition for stocks and bonds.

4.2 Summary Statistics and VAR Estimates

Table 1 and Table 2 present summary statistics for stock and bond excess returns over the entire sample period and the subperiods 1986.01-1999.12 and 2000.01-2016.12. This partition of the sample is motivated by our interest in exploring the sources of the changes in cross-country stock and bond return correlations that have occurred during our sample period, illustrated in Figure 1, and their impact on international portfolio diversification across investment horizons.

Table 1 shows that the sample Sharpe Ratio of bonds in every country is significantly larger than the Sharpe Ratio of equities, both in the whole sample and in each subperiod, with the sole exception of the U.K. and the U.S. during the 1986-1999 period. The superior sample performance of bonds reflects that the cross-country average bond excess return has remained stable at about 3.2% per annum, while the average stock excess return has declined from 5.1% to 1.9% p.a. between the first and the second half of the sample period. By contrast, excess return volatility in each market has experienced only a small decline between the first and the second subperiod in each country, and on average it has been around 6% p.a. for bonds and 18% p.a. for stocks.

Table 2 reports average within-country and cross-country correlations of bond and stock excess returns over the entire sample period and the two subperiods.[15] Complementing Figure 1, it shows that cross-country return correlations have increased significantly from the early to the late subperiod for both stocks and bonds.

Section E of the Appendix reports estimates of the pooled VAR(1) model and for each individual country. The top panel in each table reports coefficient estimates with *t*-statistics in parentheses and the R^2 statistic for each equation in the model. The bottom panel reports the correlation matrix of residuals, with the diagonal elements showing annualized standard deviations multiplied by 100 and the off-diagonal elements showing correlations.

We summarize here the estimation results. Our estimates reproduce the well-known results that the dividend-price ratio forecasts positively stock excess returns and that the yield spread forecasts positively bond excess returns. The estimates for the equations corresponding to the log dividend-price ratio, the nominal short-term interest rate, and the log yield spread show that each variable is generally well-described by a persistent univariate AR(1)

[15] Section D of the Appendix reports the full correlation matrices.

process. Log inflation follows a less persistent process.

The correlation matrix of residuals shows a large negative average correlation between unexpected stock excess returns and shocks to the log dividend-price ratio, both within countries and across countries, and both in the full sample and in each subperiod. We also estimate a negative average correlation between unexpected bond excess returns and shocks to the yield spread, although its magnitude is much smaller than the stock return-dividend-price ratio correlation.[16] Because the dividend-price ratio and the yield spread are the main predictors of stock and bond excess returns, respectively, these negative correlations imply that shocks to expected excess returns are negatively correlated with realized excess returns. That is, stocks and bonds tend to do well when expected excess returns fall, making them desirable assets to hold to hedge against a deterioration in investment opportunities.

4.3 News Decomposition of Cross-Country Correlations of Stock and Bond Returns

Our VAR estimates allow us to extract estimates of the news components of stock and bond returns to explore the sources of cross-country return correlations and their changes between the 1986-1999 subperiod and the 2000-2016 subperiod. Table 3 reports the average cross-country correlations of the news components of excess stock and bond returns for each subperiod and the p-values of the differences between subperiods based on bootstrap and Fisher transformation methods. Figure 4 plots the proportional contribution of each component to the average cross-country excess return covariance of stock and bond returns. Section F in the Appendix describes the statistical tests and the calculation of the contribution of each component to total correlation.

Following Ammer and Mei (1996), we refer to cross-country discount rate news correlations as a measure of capital markets integration. To understand this terminology, consider a world in which capital markets are perfectly integrated, so there is a unique marginal investor pricing all assets. Since discount rates are determined by investors, we would expect discount rates to move synchronously. Alternatively, we can also think of a world with integrated capital markets as a world in which shocks to investor risk aversion or investor

[16]By contrast, Campbell, Chan, and Viceira (2003) and Campbell and Viceira (2005) report a positive estimate of this correlation for the U.S. in the postwar period up to the early 2000's.

sentiment propagate rapidly across markets. In either case, we expect discount rate news to be highly correlated across markets. By contrast, cash flows need not be perfectly correlated in such world, just like we don't expect the cash flows on two individual stocks in the same stock market to be perfectly correlated, as they can be subject to idiosyncratic shocks in addition to common aggregate shocks.

Table 3 shows that capital market integration is the main source of the significant increase in global cross-country correlations of stock excess returns from the early subperiod to the late subperiod: The cross-country correlations of both the real rate news component and the risk premium component of discount rate news have experienced increases which are economically and statistically significant, from 0.39 to 0.63 and from 0.49 to 0.63 respectively. By contrast, the cross-country correlations of cash flow news have experienced a much smaller increase, from 0.41 to 0.47 from the early to the late subperiod.

Figure 4 shows that the the risk-premium component of stock returns is the most important contributor to cross-country return covariance in each subperiod, and that its contribution has become even more important in the late subperiod at 84% from 54%. The cash flow news covariance is the second largest contributor, but its contribution is much smaller at about 20% in both subperiods. This figure also shows that cross-news covariances explain a very small fraction of the total cross-country stock return covariance.

Figure 5 plots the time series of the 3-year moving average of average cross-country correlations of shocks to excess stock returns (Panel A), stock cash flow news (Panel B), real rate news (Panel C), and stock risk premium news (Panel D), both including the October 1987 crash and excluding it. Panel A shows an upward trend in the average cross-country correlation of realized stock excess returns, with the exception of a temporary decline in 2014-2015.[17] Panel B shows that the average cross-country correlation of cash flow news exhibits no time series trend, while the cross-country correlations of both real interest rate news and risk premium news exhibit a clear updward trend.

Table 3 shows interesting contrasting results for bonds relative to equities. First, all components of bond news have experienced a significant increase in their average cross-country correlations from the early period to the late period, a point that Figure 6 confirms visually. In particular, the average correlation of bond cash flow news, i.e., inflation news, has almost doubled from 0.34 to 0.64, similar to the real rate news component. Second,

[17]This decline is not attributable to a specific time observation or country pair.

the cross-country correlation of risk premium news is considerable smaller for bonds than for stocks in each subperiod, suggesting that bond markets are less globally integrated than stock markets.

Figure 4 shows that real rate news covariance is the most important contributor to cross-country bond return covariance and that risk premium news covariance comes second. The cash flow or inflation news covariance explains only a small fraction of total bond return cross-country covariance.

Our estimates of the increase in the cross-country correlations of bond cash flow news add to a body of research in Economics that documents a large increase in the average cross-country correlation of inflation and suggests the presence of a global factor in inflation (Wang and Wen 2007, Mumtaz, Simonelli and Surico 2011, Neely and Rapach 2011, and Henriksen, Kydland and Sustek 2013). This increased correlation in inflation could be the result of successful inflation targeting by central banks, which has operated as an implicit mechanism of coordination in monetary policy and it has reduced country-specific variation in inflation expectations (Cecchetti and Schoenholtz, 2014, 2015).

Overall, our empirical results present strong evidence that financial integration has been a powerful driver of the increase in the cross-country correlation of stock and bond returns between 1986-1999 and 2000-2016. There is a growing literature exploring global financial integration. Davis and van Wincoop (2017) document a large increase in the global correlation between capital inflows and outflows from 1970-1990 to 1990-2011, which they attribute to an increase in financial globalization. Lustig, Stathopoulus, and Verdelhan (2016) estimate stochastic discount factors (SDF) for G10 countries using bond data, and show that permanent shocks to each SDF are highly correlated and exhibit very similar volatility in the 1985-2012 period. Our results highlight the importance of accounting for time variation in discount rates to understand financial globalization.

5 Robustness Checks

5.1 Alternative Measure of Market Integration

Thus far we have used only cross-country correlations of returns and their news components as our metric for financial integration. Pukthuanthong and Roll (2009) propose using the R^2

from regressing returns on global factors estimated from a principal component analysis as an alternative metric of integration. This methodology is particularly helpful to determine if a relatively low degree of cross-country correlations could be the result of a multifactor structure instead of evidence of lack of integration.

We apply the Pukthuanthong-Roll methodology to realized returns and the news components of returns. For each return and news component series and for each subsample, we find the first three principal components every year and the R^2 from a simple least squares regression.

Table 4 reports average R^2 over the two subperiods for each series. The results from this exercise confirm the conclusions from the correlation analysis: We find a substantial increase in R^2 in each case except for stocks cash flow news, for which the increase in R^2 is negligible.

5.2 Direct Measures of Cash Flow Correlations

The empirical stock return news decomposition performed in Section 4 identifies stock cash flow news as the difference between realized excess stock returns and discount rate news. This implies that estimates of cash flow news will inherit any mispecification of the return prediction model (Chen and Zhao 2009). Estimation error in the discount rate news component of returns could potentially lead us to underestimate the contribution of cash flow news to the secular increase in the correlation of global stock returns. Moreover, the use of full-sample, pooled estimates of the slope coefficients of the VAR model to estimate news components could also introduce bias in our results.[18]

To attenuate these concerns, we follow Chen and Zhao (2009) and model cash flow news directly from five proxies of aggregate equity cash flows: real dividend growth, real corporate earnings growth, real GDP growth, real consumption growth, and real industrial production growth. (See Section D.3 in the Appendix for full details of the data source for these variables). We estimate univariate models for each one of them to extract shocks, and compute rolling cross-country correlations of the innovations.

[18] For example, suppose that in the late sample cash flow news gets more volatile and more correlated across countries; and assume the process for discount rate news is the exact same as in the early period. This means that the dividend-price ratio will be more correlated across countries because growth has become more correlated across countries. If we re-estimated the VAR in the late period, we would properly recover that the increased return correlation is due to cash flow news.

Table 5 and Figure 7 report the results of this analysis. Table 5 shows a small but not statistically significant increase in the cross-country correlations of all these cash flow measures except for real industrial production growth. Figure 7 confirms visually these results. None of the variables under consideration exhibit any upward trend in cross-country correlations. Correlations exhibit variation over time but overall they oscillate around a constant average around 15%-30%. The average magnitude of the correlations is somewhat lower than the average correlation level exhibited by our estimates of cash flow news, suggesting that, if anything, our approach overestimates the correlation of cash flow news.

These empirical results strongly suggest that the observed large increase in the correlation of global stock returns is not caused by increased correlations of cash flow fundamentals. Therefore, if the increase in the correlation of global stock returns is not the result of increased correlation of fundamentals, it must be the result of increased correlation of discount rates.

5.3 Correlated Stock Market Volatility News

Our analysis so far has not considered the well-known empirical regularity that stock market volatility—and return volatility more generally—is time varying and subject to persistent shocks (Campbell, Giglio, Polk, and Turley 2017, CGPT henceforth). If persistent volatility shocks are a feature of capital markets, it is important to understand whether they are correlated across markets and what this means for global portfolio diversification.[19]

We estimate volatility news for our cross-section of country stock markets following CGPT two-stage heteroskedastic-VAR methodology. This requires expanding our baseline specification of the state vector to include the default spread and stock market return variance for each country. We construct our international sample of default spreads building on the work of Kang and Pflueger (2015). Monthly realized stock market variance is based on within-month daily stock market returns denominated in U.S. dollars. Section D in the Appendix provides full detail of our data sources and data construction procedures, and Section H shows the estimation results.

Figure 8 plots the time series of the 3-year moving average of average cross-country

[19]Chacko and Viceira (2005) shows that it is optimal for investors to time market volatility, and for long-term investors to tilt their portfolios away from stocks when volatility shocks are persistent and negatively correlated with realized stock returns. See also Liu (2007). Moreira and Muir (2017a and 2017b) show the profitability of market volatility timing.

correlations of volatility news to expected variance (Panel A) and to realized stock return variance from the first stage regression (Panel B).[20] Panel A in the figure shows that the cross-country correlation of volatility news has been very low on average and fairly stable over time except for short-lived sharp increases during the crash of October 1987 and during the 2008-2009 financial crisis. (Because we plot rolling 3-year correlations, correlation appears to be high during the subsequent period. In reality, only a few observations in late 2008 and early 2009 are responsible for this increase). Panel B shows that the cross-country correlation of shocks to realized volatility is a noisy version of the the cross-country correlation of volatility news shown in Panel A, although with a larger average level.

To understand the implications of the results in Figure 8 for portfolio risk at long horizons, we have extended the symmetric model of Section 3 to allow for time-varying return and expected return volatility as in CGPT. This analysis shows that persistent stochastic volatility shocks increase portfolio risk at all horizons relative to the case of constant volatility. However, cross-country correlated volatility shocks have a small added impact on portfolio risk relative to the case of uncorrelated volatility shocks. Section H in the Appendix describes in detail how we have extended the calibrated model and shows the results from our calibration based on U.S data.

6 The Impact of Real and Financial Integration on Long-Run Global Portfolio Diversification

Section 3 shows that the impact of an increase in cross-country return correlations on portfolio risk and portfolio choice at long horizons depends on the source of the increase—correlated cash flow news or correlated discount rate news. Section 4 has documented empirically an economically and statistically significant increase in the cross-country correlations of stock and bond excess returns between 1986-1999 and 2000-2016 driven by an increase in the cross-country correlations of discount rates. We now explore the implications of our empirical results for portfolio risk and optimal global portfolio diversification at long horizons.

[20] Section H in the Appendix reports similar plots for stock excess returns, stock cash flow news, real rate news, and risk premium news. We omit those in the main text as they are very similar to the ones we obtain in the homoskedastic case.

6.1 The Risk of Globally Diversified Stock and Bond Portfolios Across Investment Horizons

We start with an analysis of portfolio risk of all-equity and all-bond portfolios across investment horizons and across subperiods. We consider both equal-weighted (EW) and value-weighted (VW) portfolios of the seven markets in our sample and present results for the EW portfolios, which are more representative of the average country experience, as the VW portfolios are largely dominated by the U.S. market experience. Section I in the Appendix presents results for the VW portfolios, which are very similar to those for the EW portfolios.

Figure 9 presents our main portfolio risk results. The first row in Panel A and Panel B shows plots of the percent annualized standard deviation of portfolio excess returns implied by our VAR estimates for each subperiod as a function of investment horizon.[21] The plotsl show a declining pattern in the risk of globally diversified portfolios of both equities and bonds as a function of investment horizon in both subperiods. This pattern is much more pronounced for global equity portfolios than for global bond portfolios.

The upper plot in Panel A also shows a reduction in the risk of global equity portfolios in the second subperiod, particularly at long horizons. At a 25-year horizon (300 months), portfolio risk is about 10% p.a. in the early sample and 8% p.a. in the late sample. This is an economically significant difference, especially when compounded over 25 years. By contrast, the risk of global bond portfolios has grown from the early to the late subperiod.

The portfolio risk decomposition (12) is helpful to understand the drivers of this change in long-run portfolio risk across subperiods: changes in country return volatilities or changes in cross-country return correlations (or both). The second adn third rows in Panel A and Panel B report the results from performing this decomposition.

The second row in Panel A and Panel B of Figure 9 shows plots of the cross-country average of conditional k-horizon excess return volatility implied by our VAR estimates, in percent annual terms.[22] The plots show a declining pattern for both equities and bonds that reflects the well-known dampening effect of return predictability on long-horizon return volatility at the individual market level. The plots also show that the average excess return

[21]That is, $100 \times \sqrt{(12/k)\,\mathbb{V}_t[xr^{(k)}_{p,t+k}]}$.

[22]That is, $100 \times \sum_{i=1}^{N} \left(w_i / \sum_{i=1}^{N} w_i \right) \sqrt{(12/k)\,\mathbb{V}_t[xr^{(k)}_{i,t+k}]}$, where w_i equals either market i capitalization weight (VW portfolio) or 1/7 (EW portfolio).

volatility of both equities and bonds is lower in the late subperiod than in the early subperiod at all investment horizons. Therefore changes in country return volatility help explain the decline in global equity portfolio risk in the late subperiod, but cannot explain the increase in bond portfolio risk.

The reduction in stock return volatility at all horizons in the late period reflects the restoration of stock return predictability after the run up in valuations relative to fundamentals of the second half of the 1990's that weakened the empirical evidence on return predictability (Cochrane, 2008).

The third row in Panel A and Panel B of Figure 9 shows plots of the percent cross-country average of pairwise conditional correlations of k-horizon excess returns.[23] These plots show that cross-country return correlations for both stocks and bonds are a declining function of investment horizon in both periods, although the pattern is much more pronounced for equities than for bonds. This pattern reflects the presence of correlated transitory components in returns: In the case of equities, Section 4 shows that the main contributor to return cross-country covariances is transitory equity risk premium news; in the case of bonds, it is real rate news, which is also transitory.

The third row of Figure 9 also shows an increase in cross-country return correlations for both equities and bonds at all horizons in the late period relative to the early period. In the case of equities, this increase is very small at long horizons, reflecting that the main driver of the increase in stock return correlations is a large increase in the correlations of the transitory components of returns, particularly risk premia news. Therefore, the estimated significant increase in short-run cross-country return correlation has not contributed to an increase in global portfolio risk at long horizons in the late subperiod.[24]

For bonds the increase is highly significant at all horizons, which explains the increase in the risk of global bond portfolios in the late period. Section 4 shows that the main drivers of the increase in bond correlations are large increases in the cross-country correlations of

[23]That is, $100 \times \sum_{i=1}^{N} \sum_{j=i}^{N} \left(w_i w_j / \sum_{i=1}^{N} \sum_{j=i}^{N} w_i w_j \right) Corr_t[xr_{i,t+k}^{(k)}, xr_{j,t+k}^{(k)}]$, where w_i equals either market i capitalization weight (VW portfolio) or 1/7 (EW portfolio).

[24]We use semidefinite programming methods to re-estimate the overall variance-covariance matrix of VAR innovations across all countries in the late subperiod subject to the constraint that the elements of the within-country variance-covariance matrix of innovations for each country remain at the same values as in the early subperiod. This excercise shows that indeed global equity portfolio risk would have not increased in the late subperiod despite a substantive increase in short-run cross-country return correlations. See Section G in the Appendix

real rate news and cash flow or inflation news, and that the real rate is a highly persistent component of bond returns.

6.2 Optimal Global Equity Portfolio Diversification at Long Horizons

Portfolio optimization is another way to evaluate the significance of the secular increase in global asset return correlations for long-term investors. We compute optimal intertemporal portfolio allocations and expected utility implied by our estimates of return dynamics in each subperiod.

We consider two types of equity long-horizon investors. The first one is an investor with power utility preferences over terminal wealth at a finite horizon (Jurek and Viceira, 2011). This is the investor we consider in our calibration exercise of Section 3.3. We refer to this investor as the "JV investor." The second investor is an infinitely lived investor with Epstein-Zin utility over intermediate consumption (Campbell and Viceira 1999, Campbell, Chan, and Viceira (2003). We refer to this investor as the "CCV investor." For calibration purposes, we set the time discount factor of both investors to 0.92 and their coefficient of relative risk aversion to 5. We also set the elasticity of intertemporal substitution of consumption of the CCV investor to one.[25]

In order to compute optimal portfolio allocations we need to take a stand on unconditional expected returns and the risk free rate. In the spirit of the approach pioneered by Black and Litterman (1992), we set the vector of unconditional expected excess returns and the risk free rate such that the myopic or one-period mean-variance optimal portfolio allocation in the early sample equals either the EW global equity portfolio or the VW global equity portfolio, given the estimated variance-covariance of one-period returns. This assumption allows us to understand how optimal portfolio allocations change across investment horizons within each period, and across periods, for reasons related exclusively to changes in risk across investment horizons.

[25]We solve for the optimal intertemporal portfolio allocation of these investors using the approximate solution methods of Campbell and Viceira (1999), Campbell, Chan, and Viceira (2003), and Jurek and Viceira (2011). They show that the optimal intertemporal portfolio policy for each type of investor is the sume of two affine functions of the vector of state variables. The first function is the myopic or one-period mean-variance portfolio. The second function is intertemporal hedging demand. The coefficients of this component are a function of investment horizon.

Table 6 report optimal global equity portfolio allocations in Panel A and expected utility in Panel B for the two investors in each subperiod in EW case. Section I in the Appendix reports results for the VW case. The first numerical column in Panel A reports the mean optimal one-period (or mean-variance) allocation to stocks, which is the same for both investors. The second column and the third column report the vector of mean intertemporal hedging demands for a JV investor with a 20-year horizon and the CCV investor, respectively. Panel B reports expected utility expressed as a certainty equivalent of wealth for JV investors with horizons of 5, 10, 15, and 20 years, and expected utility per unit of wealth for the CCV investor. We compute expected utility for two cases: When the investor can invest only in U.S. equities, and when the investor has access to global markets.

The first block of rows of Panel A in Table 6 reports portfolio allocation results for the early sample. By construction, the myopic allocation is 100% invested in the EW equity portfolio. The total intertemporal hedging demand for stocks is positive and large for both investors, at about 110% for the JV investor and 70% for the CCV investor.Total intertemporal hedging demand of the CCV investor is smaller than the one of the JV investor because, although the CCV investor is infinitely lived, his effective investment horizon is shorter because he consumes a fraction of his wealth every period.[26] Although different in size, the composition of the intertemporal hedging allocation is qualitatively similar for both investors. Optimal intertemporal portfolio demands are distributed across markets, with the exception of the French and U.K. stock markets.

The corresponding block in Panel B shows very large expected utility gains for long-horizon investors from the ability to invest globally in this early sample, and also in the late sample. The certainty equivalent of wealth for the JV investor and the expected utility of consumption per unit for the CCV investor are both an order of magnitude larger for a long-horizon investor with access to global equity markets than for an identical investor able to invest only in the U.S. stock market. Moreover, for the JV investor, welfare gains increase exponentially with investment horizon. These large benefits of portfolio diversification are consistent with those reported in Jurek and Viceira (2011, Tables VI and VIII) and Campbell, Chan, and Viceira (2003, Table 5) for U.S. investors who gain access to bonds when they

[26]While the CCV investor consumes every period, the JV investor delays consumption till the end of his long horizon of 20 years. Given our parametric assumptions, the duration of the consumption liabilities the CCV investor is funding out of his wealth is about 13.5 years, significantly shorter than that of the JV investor, which is 20 years.

can invest only in U.S. equities and cash.

The second block of rows in Table 6 reports optimal equity portfolio allocations and expected utility implied by our estimates of the return generating process in the late sample, holding unconditional expected excess returns and the risk free rate at the same values as in the early sample. Panel A shows that the increase in the cross-country correlations of one-period returns generates a one-period myopic allocation with long and short positions and an overall levered position in equities, illustrating the fact that increased correlations do not necessarily imply less investor's willingness to hold risky assets in the absence of borrowing and short-selling constraints. The panel also shows a significant increase in intertemporal hedging demands for stocks in the late sample, at 186% for the JV investor and 119% for the CCV investor.

The corresponding block in Panel B shows that expected utility from investing globally increases significantly for both types of investors in the second subperiod relative to the first subperiod, despite the increase in correlations, while the expected utility from investing solely in the U.S. stock market stays about the same. As we have noted in Section 6.1, the changes in intertemporal hedging demand and the welfare gains in the late period with respect to the early period could be the result of either changes in within-country stock return predictability, or changes in cross-country correlations.

To isolate the effect of the second, the bottom block of rows of each panel in Table 6 reports optimal equity portfolio allocations and expected utility in the late sample holding within-country stock return predictability constant across samples using semidefinite programming methods (see Section G in the Appendix). This excercise shows that, under this constrained estimation, total optimal myopic portfolio demand is somewhat smaller in the late sample than in the early sample, but total intertemporal hedging demand is larger. Moreover, there are still significant utility gains from investing globally relative to the early period even though we are holding within-country mean-reversion constant across periods. These welfare gains are the result of the change in the correlation structure of returns at long horizons.

Overall, these results suggest that the increase in short-term correlations of stock excess returns resulting from financial globalization have not diminished the benefits of international portfolio diversification for long-horizon investors. This is so because the most relevant risk to these investors is cash flow risk, and cash flow shocks have not become significantly more correlated across countries in the late sample. Therefore, long-horizon investors still have ample room to diversify cash flow risk through global diversification. Moreover, if anything, the benefits have increased for unconstrained investors, who can take advantage of the increase in short-term correlations to build long-short myopic portfolios with lower overall risk.

7 Conclusions

We have documented a significant secular increase in the cross-country return correlation of global stock and bond markets in the 1986-2016 period, particularly since the turn of the 21st century. We have explored the implications of this phenomenon for portfolio risk, optimal intertemporal global portfolio choice, and the benefits of global portfolio diversification as a function of investment horizon. Our analysis builds upon a framework with time-varying discount rates—real interest rates and risk premia—in which asset valuations vary over time in response to persistent cash flow shocks and to transitory discount rate shocks, both of which can be correlated across markets.

We show empirical evidence that the main source of the increase in global return correlations has been financial globalization, which has made discount rate shocks significantly more correlated across markets. We also find evidence of increased correlation of nominal bond cash flow news resulting from increased correlation of inflation news across monetary areas. By contrast, we don't find evidence of an increase of the cross-country correlations of cash flow shocks to equities. We do not find evidence either of a secular increase in the cross-country correlation of shocks to stock market volatility in the period of globalization, although we estimate a sharp temporary increase in this correlation at the unleash of the financial crisis of 2008-2009.

We find that the increase in global stock return correlations has increased the short-run risk of globally diversified equity portfolios in the 2000-2016 period relative to the preceding 1986-1999 period. However, long-run global equity portfolio risk has not increased, optimal long-horizon portfolios are as globally diversified and invest in equities as much as in the preceding period, and the expected utility of long-horizon investors from holding global equity portfolios has if anything increased.

Our framework of analysis explains these these findings as the result of the differential impact that correlated discount rate news and correlated cash flow news have on long-run return correlations, global portfolio risk, and optimal global intertemporal portfolio choice. We show that an increase in the cross-country correlation of cash flow news leads to a one-to-one increase in cross-country return correlations at all horizons, while an increase in the cross-country correlation of discount rate news increases return correlations significantly more at short horizons than at long horizons.

This differential impact derives from the persistence of each type of shock. Cash-flow news correlations have a much larger impact on long-horizon return correlations than discount rate news correlations because cash flow shocks are highly persistent and affect valuations and returns at all horizons, while discount rate shocks are transitory shocks whose impact on valuations and returns dissipates at long horizons. This implies in turn that the ability to diversify cash flow shocks is more relvant to long-horizon investors than the ability to diversify discount rate shocks. Because empirically cash flow news exhibit low cross-country correlations and these correlations do not appear to have increased over time, long-horizon investors still have ample margin to reduce equity cash flow risk through international equity portfolio diversification. By contrast, short-horizon investors care equally about both discount rate risk and cash flow risk, and discount rate risk has become strongly more correlated across markets over time.

We also find evidence that stock return predictability appears to have strengthened in the 2000-2016 period relative to the 1986-1999 period, resulting in a decline in stock return volatility at all horizons. This within-country return volatility effect has also contributed both to reduce the risk of globally diversified equity portfolios at long horizons and to increase the utility benefits of holding globally diversified portfolios for long-horizon investors.

The increase of cross-country correlations of cash flow news and discount rate news for bonds implies that cross-country correlations of bond returns have increased at all horizons. Consequently, the benefits of holding internationally diversified bond portfolios have declined as much for long-horizon investors as for short-horizon investors. Interestingly though, the increased cross-country correlation of bond returns at all horizons is beneficial to investors with long-dated liabilities such as pension funds, since it implies in increase in the scope for hedging liabilities using global bonds. This can be particularly beneficial to investors with large long-dated liabilities facing small domestic bond markets.

Our research could expand in several directions. First, it would be interesting to document why trade globalization does not appear to have led to a significant increase in the global correlation of cash flows. Although our results about stock and bond cash flow news correlations are consistent with a body of literature in empirical macroeconomics documenting a large increase in cross-country correlations of inflation but no increase cross-country correlations of real output, it would be interesting to explore this phenomenon more systematically at a more granular level. Second, although we have shown that persistent volatility shocks do not appear to have become more correlated over time, their correlation appears to increase significantly at times of sharp market declines. These are times in which expected returns also increase, suggesting that the increase in risk is compensated by a corresponding increase in expected returns. It would be interesting to explore the implications for intertemporal portfolio choice and for global portfolio diversification at long horizons of the joint comovement of discount rate news and risk news. Finally, we have documented but not explored an additional phenomenon: that the negative stock-bond correlation since the turn of the century documented for the U.S. and U.K. appears to be a global phenomenon.[27] Understanding the economic drivers of this phenomenon at a global scale is another potential venue of future research.

8 References

References

[1] Ammer, J. and Mei, J. (1996). Measuring international economic linkages with stock market data. *The Journal of Finance*, 51(5):1743–1763.

[2] Andersen, T. G. and Bollerslev, T. (1998). Answering the skeptics: Yes, standard volatility models do provide accurate forecasts. *International economic review*, pages 885–905.

[3] Ang, A. and Bekaert, G. (2002). International asset allocation with regime shifts. *The Review of Financial Studies*, 15(4):1137–1187.

[4] Asness, C. S., Israelov, R., and Liew, J. M. (2011). International diversification works (eventually). *Financial Analysts Journal*, 67(3):24–38.

[27] See Campbell, Shiller, and Viceira 2009, Viceira 2012, David and Veronesi 2013, and Campbell, Sunderam, and Viceira, 2017.

[5] Baele, L. (2005). Volatility spillover effects in european equity markets. *Journal of Financial and Quantitative Analysis*, 40(2):373–401.

[6] Barberis, N. (2000). Investing for the long run when returns are predictable. *The Journal of Finance*, 55(1):225–264.

[7] Bekaert, G., Harvey, C. R., Lundblad, C. T., and Siegel, S. (2011). What segments equity markets? *The Review of Financial Studies*, 24(12):3841–3890.

[8] Bekaert, G., Harvey, C. R., Lundblad, C. T., and Siegel, S. (2013). The european union, the euro, and equity market integration. *Journal of Financial Economics*, 109(3):583–603.

[9] Bekaert, G. and Hodrick, R. (2017). *International financial management*. Cambridge University Press.

[10] Bekaert, G., Hodrick, R. J., and Zhang, X. (2009). International stock return comovements. *The Journal of Finance*, 64(6):2591–2626.

[11] Black, F. and Litterman, R. (1992). Global portfolio optimization. *Financial analysts journal*, 48(5):28–43.

[12] Bollerslev, T. (1986). Generalized autoregressive conditional heteroskedasticity. *Journal of econometrics*, 31(3):307–327.

[13] Campa, J. M. and Fernandes, N. (2006). Sources of gains from international portfolio diversification. *Journal of Empirical Finance*, 13(4-5):417–443.

[14] Campbell, J. Y. (1991). A variance decomposition for stock returns. *The Economic Journal*, 101(405):157–179.

[15] Campbell, J. Y., Chan, Y. L., and Viceira, L. M. (2003). A multivariate model of strategic asset allocation. *Journal of financial economics*, 67(1):41–80.

[16] Campbell, J. Y., Giglio, S., Polk, C., and Turley, R. (2017). An intertemporal capm with stochastic volatility. *Journal of Financial Economics*.

[17] Campbell, J. Y. and Hentschel, L. (1992). No news is good news: An asymmetric model of changing volatility in stock returns. *Journal of financial Economics*, 31(3):281–318.

[18] Campbell, J. Y., Serfaty-De Medeiros, K., and Viceira, L. M. (2010). Global currency hedging. *The Journal of Finance*, 65(1):87–121.

[19] Campbell, J. Y. and Shiller, R. J. (1988). The dividend-price ratio and expectations of future dividends and discount factors. *Review of financial studies*, 1(3):195–228.

[20] Campbell, J. Y., Shiller, R. J., Viceira, L. M., Mishkin, F. S., and Wright, J. H. (2009). Understanding inflation-indexed bond markets/comments and discussion. *Brookings Papers on Economic Activity*, (1):79.

[21] Campbell, J. Y., Sunderam, A., and Viceira, L. M. (forthcoming). Inflation bets or deflation hedges? the changing risks of nominal bonds. *Critical Finance Review*.

[22] Campbell, J. Y. and Thompson, S. B. (2007). Predicting excess stock returns out of sample: Can anything beat the historical average? *The Review of Financial Studies*, 21(4):1509–1531.

[23] Campbell, J. Y. and Viceira, L. M. (1999). Consumption and portfolio decisions when expected returns are time varying. *The Quarterly Journal of Economics*, 114(2):433–495.

[24] Campbell, J. Y. and Viceira, L. M. (2002). *Strategic asset allocation: portfolio choice for long-term investors*. Oxford University Press, USA.

[25] Campbell, J. Y. and Viceira, L. M. (2005). The term structure of the risk–return trade-off. *Financial Analysts Journal*, 61(1):34–44.

[26] Campbell, J. Y. and Vuolteenaho, T. (2004). Bad beta, good beta. *The American Economic Review*, 94(5):1249–1275.

[27] Campbell, J. Y. and Yogo, M. (2006). Efficient tests of stock return predictability. *Journal of financial economics*, 81(1):27–60.

[28] Carrieri, F., Errunza, V., and Hogan, K. (2007). Characterizing world market integration through time. *Journal of Financial and Quantitative Analysis*, 42(4):915–940.

[29] Carrieri, F., Errunza, V., and Sarkissian, S. (2012). The dynamics of geographic versus sectoral diversification: Is there a link to the real economy? *The Quarterly Journal of Finance*, 2(04):1250019.

[30] Cecchetti, S. G. and Schoenholtz, K. L. (2014). Inflation targeting: Better than bretton woods. *Money, Banking, and Financial Markets Blog.*

[31] Cecchetti, S. G. and Schoenholtz, K. L. (2015). Is international diversification dead? *Money, Banking, and Financial Markets Blog.*

[32] Chacko, G. and Viceira, L. M. (2005). Dynamic consumption and portfolio choice with stochastic volatility in incomplete markets. *The Review of Financial Studies*, 18(4):1369–1402.

[33] Chen, L. and Zhao, X. (2009). Return decomposition. *Review of Financial Studies*, 22(12):5213–5249.

[34] Chua, D. B., Kritzman, M., and Page, S. (2009). The myth of diversification. *Journal of Portfolio Management*, 36(1):26.

[35] Cochrane, J. H. (2008). The dog that did not bark: A defense of return predictability. *Review of Financial Studies*, 21(4):1533–1575.

[36] Cochrane, J. H. (2011). Presidential address: Discount rates. *The Journal of Finance*, 66(4):1047–1108.

[37] Davis, J. S. and van Wincoop, E. (2017). Globalization and the increasing correlation between capital inflows and outflows. *NBER Working Paper No. 23671.*

[38] De Santis, R. A. and Gerard, B. (2009). International portfolio reallocation: Diversification benefits and european monetary union. *European Economic Review*, 53(8):1010–1027.

[39] Engle, R. F. (1982). Autoregressive conditional heteroscedasticity with estimates of the variance of united kingdom inflation. *Econometrica: Journal of the Econometric Society*, pages 987–1007.

[40] Engle, R. F., Ghysels, E., and Sohn, B. (2013). Stock market volatility and macroeconomic fundamentals. *Review of Economics and Statistics*, 95(3):776–797.

[41] Erb, C. B., Harvey, C. R., and Viskanta, T. E. (1994). Forecasting international equity correlations. *Financial analysts journal*, 50(6):32–45.

[42] Erb, C. B., Harvey, C. R., and Viskanta, T. E. (1995). Country risk and global equity selection. *Journal of Portfolio Management*, 21(2):74–83.

[43] Errunza, V., Hogan, K., and Hung, M.-W. (1999). Can the gains from international diversification be achieved without trading abroad? *The Journal of Finance*, 54(6):2075–2107.

[44] Eun, C. S., Lai, S., Roon, F. A. d., and Zhang, Z. (2010). International diversification with factor funds. *Management Science*, 56(9):1500–1518.

[45] French, K. R. and Poterba, J. M. (1991). Investor diversification and international equity markets. *American Economic Review*, 81.2:222–226.

[46] French, K. R., Schwert, G. W., and Stambaugh, R. F. (1987). Expected stock returns and volatility. *Journal of financial Economics*, 19(1):3–29.

[47] Goetzmann, W. N., Li, L., and Rouwenhorst, K. G. (2005). Long-term global market correlations. *Journal of Business*, 78(1).

[48] Greenwood, R. and Vayanos, D. (2014). Bond supply and excess bond returns. *Review of Financial Studies*, 27(3):663–713.

[49] Grubel, H. G. (1968). Internationally diversified portfolios: welfare gains and capital flows. *The American Economic Review*, 58(5):1299–1314.

[50] Hamilton, J. D. and Wu, J. C. (2012). The effectiveness of alternative monetary policy tools in a zero lower bound environment. *Journal of Money, Credit and Banking*, 44(s1):3–46.

[51] Hartmann, P., Straetmans, S., and Vries, C. d. (2004). Asset market linkages in crisis periods. *Review of Economics and Statistics*, 86(1):313–326.

[52] Henriksen, E., Kydland, F. E., and Šustek, R. (2013). Globally correlated nominal fluctuations. *Journal of Monetary Economics*, 60(6):613–631.

[53] Heston, S. L. and Rouwenhorst, K. G. (1994). Does industrial structure explain the benefits of international diversification? *Journal of Financial Economics*, 36(1):3–27.

[54] Jurek, J. W. and Viceira, L. M. (2011). Optimal value and growth tilts in long-horizon portfolios. *Review of Finance*, 15(1):29–74.

[55] Kang, J. and Pflueger, C. E. (2015). Inflation risk in corporate bonds. *The Journal of Finance*, 70(1):115–162.

[56] Karolyi, G. A. and Stulz, R. M. (1996). Why do markets move together? an investigation of us-japan stock return comovements. *The Journal of Finance*, 51(3):951–986.

[57] Karolyi, G. A. and Stulz, R. M. (2003). Are financial assets priced locally or globally? *Handbook of the Economics of Finance*, 1:975–1020.

[58] Leibowitz, M. L. and Bova, A. (2009). Diversification performance and stress-betas. *Journal of Portfolio Management*, 35(3):41.

[59] Levy, H. and Sarnat, M. (1970). International diversification of investment portfolios. *The American Economic Review*, 60(4):668–675.

[60] Liu, J. (2006). Portfolio selection in stochastic environments. *The Review of Financial Studies*, 20(1):1–39.

[61] Longin, F. and Solnik, B. (1995). Is the correlation in international equity returns constant: 1960–1990? *Journal of international money and finance*, 14(1):3–26.

[62] Longin, F. and Solnik, B. (2001). Extreme correlation of international equity markets. *The journal of finance*, 56(2):649–676.

[63] Lustig, H. N., Stathopoulos, A., and Verdelhan, A. (2016). Nominal exchange rate stationarity and long-term bond returns.

[64] Merton, R. C. (1969). Lifetime portfolio selection under uncertainty: The continuous-time case. *The review of Economics and Statistics*, pages 247–257.

[65] Moreira, A. and Muir, T. (2017a). Should long-term investors time volatility? *Working Paper*.

[66] Moreira, A. and Muir, T. (2017b). Volatility-managed portfolios. *The Journal of Finance*, 72(4):1611–1644.

[67] Mumtaz, H., Simonelli, S., and Surico, P. (2011). International comovements, business cycle and inflation: A historical perspective. *Review of Economic Dynamics*, 14(1):176–198.

[68] Neely, C. J. and Rapach, D. E. (2011). International comovements in inflation rates and country characteristics. *Journal of International Money and Finance*, 30(7):1471–1490.

[69] Odier, P. and Solnik, B. (1993). Lessons for international asset allocation. *Financial Analysts Journal*, 49(2):63–77.

[70] Pástor, L. and Stambaugh, R. F. (2009). Predictive systems: Living with imperfect predictors. *The Journal of Finance*, 64(4):1583–1628.

[71] Pástor, L. and Stambaugh, R. F. (2012). Are stocks really less volatile in the long run? *The Journal of Finance*, 67(2):431–478.

[72] Pukthuanthong, K. and Roll, R. (2009). Global market integration: An alternative measure and its application. *Journal of Financial Economics*, 94(2):214–232.

[73] Quinn, D. P. and Voth, H.-J. (2008). A century of global equity market correlations. *The American Economic Review*, 98(2):535–540.

[74] Reinhart, C. M. and Rogoff, K. S. (2014). *Financial and Sovereign Debt Crises: Some Lessons Learned and Those Forgotten*. Presented September 14, 2012, at IMF conference on financial crises, Washington, DC., edited by s. claessens, m.a. kose, l. laeven, and f. valencia edition.

[75] Santis, G. and Gerard, B. (1997). International asset pricing and portfolio diversification with time-varying risk. *The Journal of Finance*, 52(5):1881–1912.

[76] Schwert, G. W. (1989). Why does stock market volatility change over time? *The journal of finance*, 44(5):1115–1153.

[77] Solnik, B. H. (1974). An equilibrium model of the international capital market. *Journal of economic theory*, 8(4):500–524.

[78] Solnik, B. H. and McLeavey, D. W. (2009). *Global investments*.

[79] Viceira, L. M. (2012). Bond risk, bond return volatility, and the term structure of interest rates. *International Journal of Forecasting*, 28(1):97–117.

[80] Vuolteenaho, T. (2002). What drives firm-level stock returns? *The Journal of Finance*, 57(1):233–264.

[81] Wang, P. and Wen, Y. (2007). Inflation dynamics: A cross-country investigation. *Journal of Monetary Economics*, 54(7):2004–2031.

[82] Welch, I. and Goyal, A. (2008). A comprehensive look at the empirical performance of equity premium prediction. *The Review of Financial Studies*, 21(4).

Table 1: **Summary Statistics**

This table reports summary statistics of monthly bond and stock returns for the whole sample (January 1986 to December 2016), early sample (January 1986 to December 1999) and late sample (January 2000 to December 2016). Estimates of means, volatilities, and Sharpe Ratios are all scaled to annualized units. Returns are in U.S. Dollar currency-hedged terms in excess of the three-month U.S. Treasury bill rate.

Whole Sample: January 1986 to December 2016							
Stocks							
	AUS	CAN	FRA	GER	JPN	UKI	USA
Mean	2.8%	3.2%	3.8%	3.0%	1.2%	3.4%	6.0%
Volatility	17.3%	15.3%	19.4%	21.7%	20.1%	15.6%	15.3%
Sharpe Ratio	0.16	0.21	0.19	0.14	0.06	0.22	0.39
Bonds							
	AUS	CAN	FRA	GER	JPN	UKI	USA
Mean	2.8%	3.2%	3.7%	3.1%	3.3%	2.8%	3.8%
Volatility	6.5%	6.0%	5.2%	4.9%	5.2%	7.5%	6.4%
Sharpe Ratio	0.44	0.53	0.70	0.64	0.64	0.38	0.59
Early Sample: January 1986 to December 1999							
Stocks							
	AUS	CAN	FRA	GER	JPN	UKI	USA
Mean	2.5%	2.8%	7.8%	4.8%	1.5%	5.8%	10.5%
Volatility	21.2%	15.6%	21.1%	21.4%	22.0%	17.4%	15.3%
Sharpe Ratio	0.12	0.18	0.37	0.23	0.07	0.34	0.69
Bonds							
	AUS	CAN	FRA	GER	JPN	UKI	USA
Mean	3.6%	2.9%	3.1%	2.1%	4.4%	2.4%	3.5%
Volatility	7.6%	7.1%	5.7%	5.0%	6.9%	9.4%	6.5%
Sharpe Ratio	0.47	0.40	0.55	0.42	0.65	0.25	0.54
Late Sample: January 2000 to December 2016							
Stocks							
	AUS	CAN	FRA	GER	JPN	UKI	USA
Mean	3.0%	3.6%	0.5%	1.5%	0.9%	1.4%	2.4%
Volatility	13.5%	15.0%	18.0%	22.0%	18.4%	14.1%	15.2%
Sharpe Ratio	0.22	0.24	0.03	0.07	0.05	0.10	0.16
Bonds							
	AUS	CAN	FRA	GER	JPN	UKI	USA
Mean	2.3%	3.5%	4.1%	3.9%	2.4%	3.2%	4.0%
Volatility	5.5%	5.0%	4.9%	4.8%	3.2%	5.4%	6.4%
Sharpe Ratio	0.41	0.70	0.85	0.82	0.74	0.59	0.63

Table 2: **Correlation Summary Statistics**

The table reports the overall average correlations within and across countries for the full period (January 1986 to December 2016) as well as for each subperiod (January 1986 to December 1999, January 2000 to December 2016), based on individual country-pair stock and bond return correlations. Returns are in U.S. Dollar currency-hedged terms in excess of the three-month U.S. Treasury bill rate. The individual country-pair correlations are reported Appendix D.4.

	Within Countries			Across Countries		
		Bonds	Stocks		Bonds	Stocks
Full Period	Bonds	1.00		Bonds	0.49	
	Stocks	0.06	1.00	Stocks	-0.03	0.62
		Bonds	Stocks		Bonds	Stocks
Early Sample	Bonds	1.00		Bonds	0.40	
	Stocks	0.30	1.00	Stocks	0.13	0.54
		Bonds	Stocks		Bonds	Stocks
Late Sample	Bonds	1.00		Bonds	0.64	
	Stocks	-0.25	1.00	Stocks	-0.23	0.71
		Bonds	Stocks		Bonds	Stocks
Difference	Bonds	0.00		Bonds	0.25	
	Stocks	-0.54	0.00	Stocks	-0.37	0.17

Table 3: **Cross-Country Return Correlation Decomposition**

This table decomposes the sources of global stock return correlations and bond return correlations. Correlations among individual stock/bond return components (i.e., cash-flow, real-rate, and risk premium news) across countries are shown in the table. Estimates are reported for each subperiod as well as the difference between the two subperiods. Tests for significant correlation differences between subperiods are based on bootstrap and Fisher r-to-z methods for calculating p-values.

		Stocks				**Bonds**		
		CF (s)	RR (s)	RP (s)		CF (b)	RR (b)	RP (b)
	CF (s)	0.41			CF (b)	0.34		
Subperiod 1	RR (s)	0.03	0.39		RR (b)	-0.34	0.35	
	RP (s)	-0.30	-0.33	0.49	RP (b)	0.02	-0.01	0.20
	CF (s)	0.47			CF (b)	0.64		
Subperiod 2	RR (s)	0.28	0.63		RR (b)	-0.63	0.63	
	RP (s)	-0.39	-0.59	0.63	RP (b)	0.10	-0.08	0.42
	CF (s)	0.06			CF (b)	0.30		
Difference	RR (s)	0.25	0.25		RR (b)	-0.28	0.28	
	RP (s)	-0.09	-0.26	0.14	RP (b)	0.08	-0.07	0.22
		CF (s)	RR (s)	RP (s)		CF (b)	RR (b)	RP (b)
p-values	CF (s)	0.18			CF (b)	0.00		
(bootstrap)	RR (s)	0.00	0.00		RR (b)	0.00	0.00	
	RP (s)	0.18	0.00	0.02	RP (b)	0.20	0.24	0.00
p-values	CF (s)	0.25			CF (b)	0.00		
(Fisher r-to-z)	RR (s)	0.01	0.00		RR (b)	0.00	0.00	
	RP (s)	0.18	0.00	0.03	RP (b)	0.22	0.25	0.01

Table 4: **Average R^2 Using Principal Components as Global Factors**

This table applies the Pukthuanthong-Roll methodology to realized returns, unexpected returns and the three news components of returns. For a given return or news component series, we find the first three principal components every year and obtain the R^2 from a simple least squares regression using PCs as global factors. The table reports average R^2. Panel A corresponds to stocks, and Panel B corresponds to bonds.

Panel A: Stocks				
	All	Sub-period 1	Sub-period 2	Difference
Currency Hedged Stock Returns	0.68	0.60	0.73	0.13
Unexpected Stock Returns	0.67	0.59	0.74	0.15
CF News (Stocks)	0.53	0.51	0.54	0.03
RR News (Stocks)	0.58	0.42	0.71	0.28
RP News (Stocks)	0.59	0.48	0.68	0.19

Panel B: Bonds				
	All	Sub-period 1	Sub-period 2	Difference
Currency Hedged Bond Returns	0.68	0.59	0.74	0.15
Unexpected Bond Returns	0.64	0.55	0.71	0.17
CF News (Bonds)	0.56	0.39	0.70	0.31
RR News (Bonds)	0.57	0.40	0.71	0.31
RP News (Bonds)	0.46	0.38	0.52	0.13

Table 5: **Direct Measure of Cash Flow Correlations**

The table reports cross-country correlation of real GDP growth, real consumption growth, real industrial production growth, real dividend growth and real corporate earnings growth over early sample and late samples. The correlations are computed using the AR(1) residual of each variable. Specifically, we first run a AR(1) regression for growth in each macro variable $\Delta X_{t+1} = \alpha + \beta \Delta X_t + \varepsilon_{t+1}$, and then compute the average pairwise cross-country correlations of the residuals. The GDP, consumption and corporate earnings correlations are constructed using quarterly observations, and industrial production growth and dividend growth correlations are constructed using monthly observations. We also report correlation in late sample excluding crisis (2007Q4-2009Q4 for quarterly data and 2007.12-2009.12 for monthly data), and the difference in correlation between late sample and early sample. Data for corporate earnings are only available starting from 1994, thus we redefine early sample as 1994-2005 and late sample as 2006-2016. p-values calculated using Fisher's transformation are reported.

	Early Sample	Late Sample	
	1986-1999	2000-2016	2000-2016 (excluding crisis)
Real GDP Growth (quarterly)	0.120	0.365	0.136
Difference (late - early)		0.246	0.016
p-values		[0.078]	[0.466]
Real Consumption Growth (quarterly)	0.016	0.134	0.092
Difference (late - early)		0.119	0.076
p-values		[0.259]	[0.345]
Real Industrial Production Growth (monthly)	0.171	0.131	0.079
Difference (late - early)		-0.040	-0.092
p-values		[0.348]	[0.193]
Real Dividend Growth (monthly)	0.075	0.145	0.061
Difference (late - early)		0.070	-0.014
p-values		[0.249]	[0.448]
	Early Sample	Late Sample	
	1994-2005	2006-2016	2006-2016 (excluding crisis)
Real Corporate Earnings Growth (quarterly)	0.028	0.082	-0.058
Difference (late - early)		0.054	-0.085
p-values		[0.402]	[0.357]

Table 6: **Optimal Global Equity Portfolio Allocations and Expected Utility**

Panel A reports optimal global equity portfolio allocations by "JV" investor and "CCV" investor. The CCV investor has Epstein-Zin preference and the expected value function defined as $E[V_t] \equiv \frac{U_t}{W_t} = (1-\delta)^{-\psi/(1-\psi)} \left(\frac{C_t}{W_t}\right)^{1/(1-\psi)}$. The JV investor's utility is power utility defined on terminal wealth $E_t[\frac{1}{1-\gamma} W_{t+K}^{1-\gamma}]$. The myopic demand is the allocation of those two investors at investment horizon 1. An investor's allocation is the sum of myopic demand and hedging demand. We report the JV hedging demand for an investor at horizon of 20 years (240 months). We compare across 3 scenarios: optimal allocation in early sample, late sample and late sample with hypothetical covariance matrix that controls for within-country correlation. To make it comparable, we fix the monthly implied excess returns across these 3 scenarios. We set implied excess returns for equal weight portfolio such that investor hold the myopic demand equal to 1/N in each country. "Total" allocation is the sum of the allocations to each country. Panel B reports the expected utility by "JV" investor (with RRA$\gamma = 5$) and "CCV" investor (with EIS $\psi \to 1$ and RRA$\gamma = 5$), assuming they allocate optimally to the 7 countries investment space as reported in Panel A. We also report investor's expected utility by constraining the investment space to USA only. We assume investor has initial wealth of one dollar and look at investment horizons K of 5 years (60 months), 10 years (120 months), 15 years (180 months) and 20 years (240 months). We report the certainty equivalent for the JV investor (with RRA$\gamma = 5$). The results are obtained by Monte Carlo simulation using 2,000 VAR paths sampled using the method of antithetic variates. The certainty equivalent of wealth is computed by evaluating the mean utility realized across the simulated paths and computing, $W_{CE} = u^{-1}\left(E[u(\widetilde{W_{t+K}})]\right)$.

	Panel A: Optimal Global Equity Portfolio Allocations				**Panel B: Expected Utility**					
	Country	Myopic demand	JV hedging demand at 20 yr	CCV hedging demand		JV W_{CE} K=60	K=120	K=180	K=240	CCV $E[V_t]$
Early Sample	AUS	14.29%	23.12%	12.99%						
	CAN	14.29%	16.63%	10.96%	7 countries	2.86	223.86	384.79	31334.84	0.1089
	FRA	14.29%	-7.05%	-4.29%						
	GER	14.29%	31.66%	19.42%						
	JPN	14.29%	18.84%	12.04%	USA only	1.74	3.27	4.16	15.48	0.0079
	UKI	14.29%	-1.31%	0.60%						
	USA	14.29%	28.80%	18.26%						
	Total	100.00%	110.69%	69.98%						
Late Sample	AUS	82.76%	78.37%	55.07%						
	CAN	23.59%	55.21%	35.26%						
	FRA	29.67%	29.95%	22.34%	7 countries	3.91	137.15	799.21	3272444.57	0.2209
	GER	-12.73%	-2.71%	-3.17%						
	JPN	-1.82%	18.81%	9.09%						
	UKI	52.44%	14.73%	8.80%	USA only	1.73	3.09	3.75	16.25	0.0099
	USA	-41.32%	-8.29%	-8.72%						
	Total	132.58%	186.07%	118.67%						
Late Sample (Hypothetical Covariance Matrix)	AUS	11.52%	5.87%	3.46%						
	CAN	28.37%	3.66%	1.50%						
	FRA	14.67%	15.23%	8.50%	7 countries	8.41	497.63	3590.55	974716.37	0.2273
	GER	7.28%	23.30%	12.84%						
	JPN	-0.35%	8.99%	6.11%						
	UKI	16.98%	0.44%	1.43%	USA only	1.74	3.27	4.16	15.48	0.0079
	USA	6.18%	59.10%	44.63%						
	Total	84.64%	116.59%	78.47%						

Figure 1: **Stock and Bond Correlations Across Countries**

This figure plots average correlations of stock returns across countries and bond returns across countries. Monthly averages are computed using pairwise return correlations across seven different countries over 3-year rolling windows (Australia, Canada, France, Germany, Japan, United Kingdom, and United States). Returns are in U.S. Dollar currency-hedged terms in excess of the three-month U.S. Treasury bill rate. The sample is from Jan 1986 to Dec 2016.

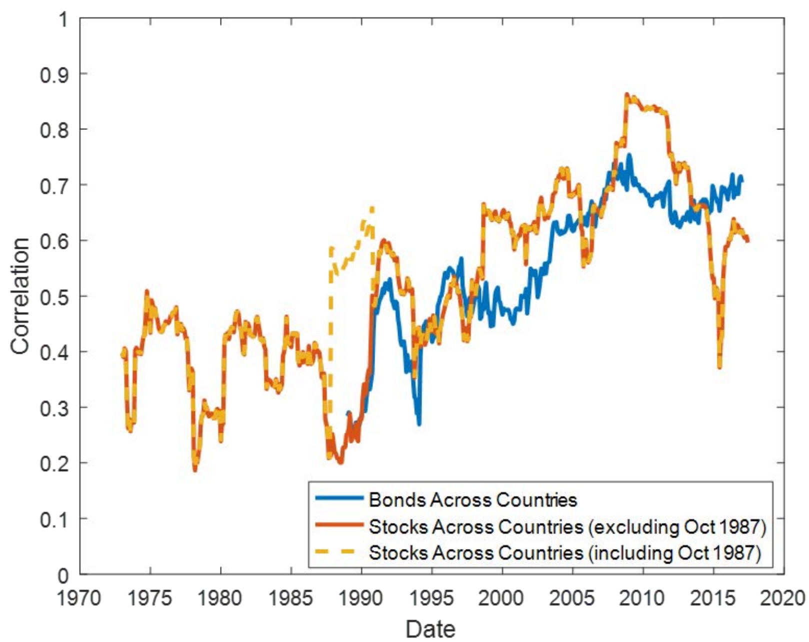


Figure 2: **Coefficient on $\sigma^{xc}_{DR,DR}$ as a Function of Investment Horizon k**

The figures plots the coefficient on $\sigma^{xc}_{DR,DR} = a(k; \beta, \phi, \rho)^2 + b(k; \beta, \phi, \rho)$ as a function of investment horizon k. We use parameters estimated from U.S. data for calibration: $\beta = 0.0121$, $\phi = 0.9864$, $\rho = 0.9982$. The expressions for $a(k; \beta, \phi, \rho)$ and $b(k; \beta, \phi, \rho)$ are given in the Appendix.

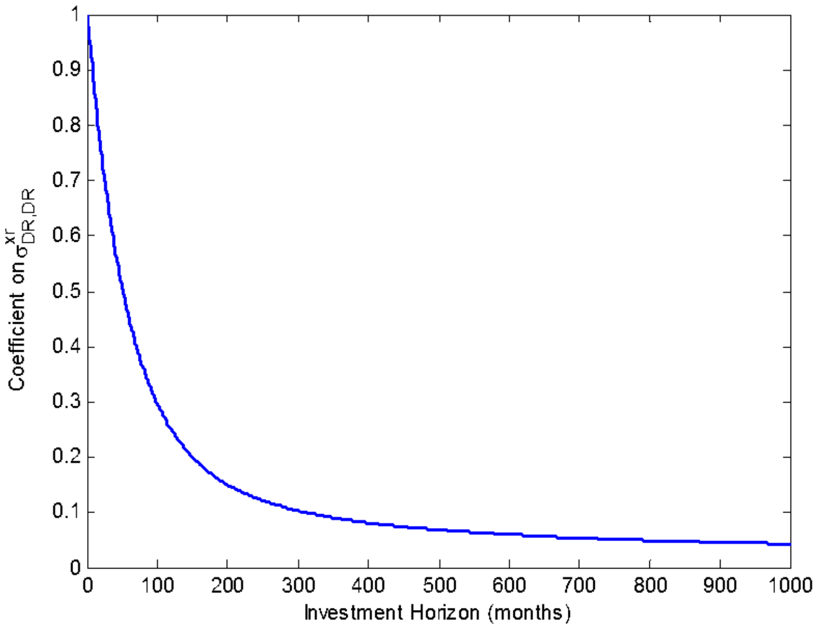


Figure 3: **Annualized Portfolio Risk and Optimal Allocation to Risky Assets as a Function of Investment Horizon**

The figure plots annualized portfolio risk $\sqrt{\mathbb{V}_t(r_{p,t+k}^{(k)})/k}$ (panel A) and optimal allocation to risky assets (panel B) as a function of investment horizon k (months). We compare the term structure of portfolio risk and optimal allocation for 3 scenarios: (1) Baseline case with zero cross-country return news correlations, both for CF news and DR news. (2) CF news integration case, where cross-country return correlations come from positive cross-country CF news correlations; cross-country correlations of DR news are zero. (3) DR integration case, where cross-country return correlations come from positive cross-country DR news correlation; cross-country correlations of CF news are zero. To make Scenarios 2 and 3 comparable, we set the cross-country correlation of one-period returns at the same value (0.07). Panel A plots portfolio risk in each scenario for a portfolio of seven symmetric countries. Panel B plots optimal allocation to risky assets (for a portfolio of seven countries) as a function of time remaining to terminal date. The total optimal allocation is the sum of two parts: myopic allocation (equals the intercept at $\tau = 1$) and hedging allocation. The investor has horizon of $K = 360$ (30 years) and rebalance his allocation each period. The x-axis τ is the time remaining to the terminal date. We compare the term structure of optimal allocation to risky assets across the same 3 scenarios described above. We set the expected excess returns so that in the benchmark case, the myopic investor ($\tau = 1$) allocate $1/N$ to each risky asset (14.3% for $N = 7$) and zero to cash. The expected excess returns are kept the same across the three cases to make them comparable.

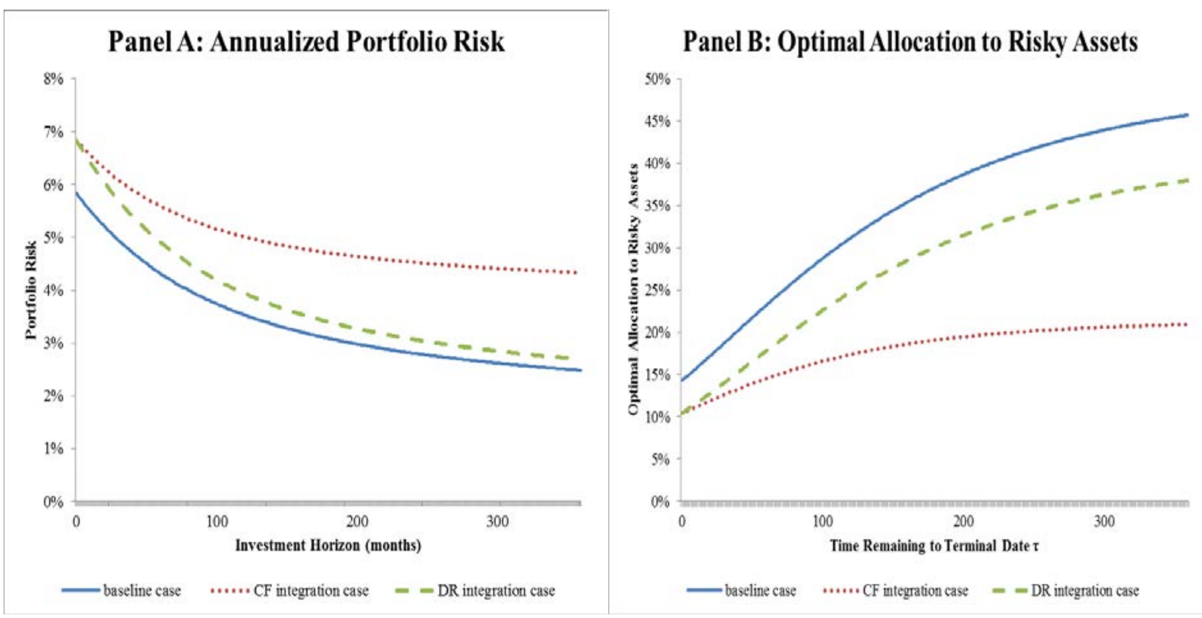


Figure 4: **Contributions of News Components to Overall Cross-Country Unexpected Return Covariance**

The figure plots breakdown of contributions of different news components to unexpected stock return correlations across countries (Panel A) and unexpected bond return correlations across countries (Panel B). In Panel A (stocks across countries), the cash flow news component contribution is calculated as $\frac{1}{N(N-1)/2}\sum_i \sum_{j\neq i} \frac{Cov(N_{CF,i},N_{CF,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}$, the real rate news component contribution is calculated as $\frac{1}{N(N-1)/2}\sum_i \sum_{j\neq i} \frac{Cov(N_{RR,i},N_{RR,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}$, the risk premium news component contribution is calculated as $\frac{1}{N(N-1)/2}\sum_i \sum_{j\neq i} \frac{Cov(N_{RP,i},N_{RP,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}$, and the cross components is calculated as

$$\frac{1}{N(N-1)/2}\sum_i \sum_{j\neq i}\left(\frac{Cov(N_{CF,i},-N_{RR,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}+\frac{Cov(N_{CF,i},-N_{RP,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}+\frac{Cov(-N_{RR,i},-N_{RP,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}\right).$$

The component contributions in panel B are calculated similarly. Note that by definition, values in the component contributions sum up to 1.

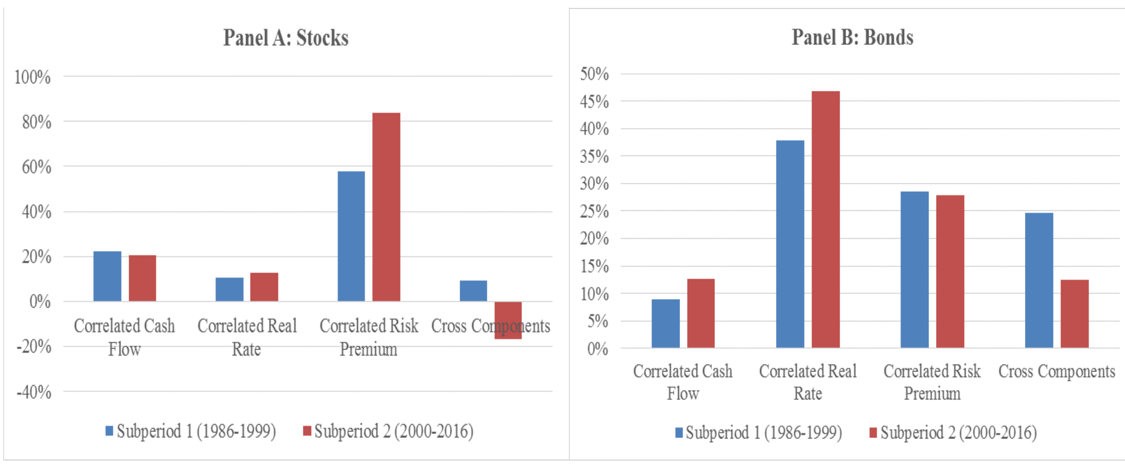
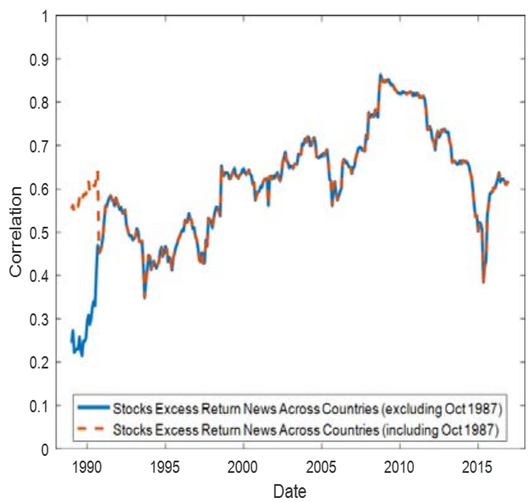


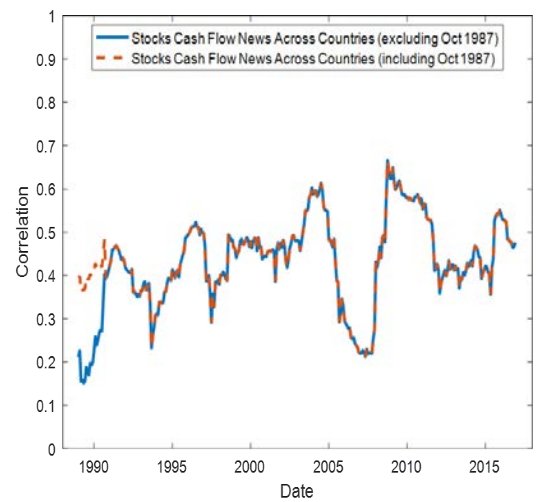
Figure 5: **Average Cross-Country Correlations of VAR News (Stocks)**

This figure plots the three year 3-year moving average of average cross-country correlations of shocks to stock excess returns (Panel A), cash flow news (Panel B), real rate news (Panel C), and risk premium news (Panel D), both including the October 1987 observation and excluding it.

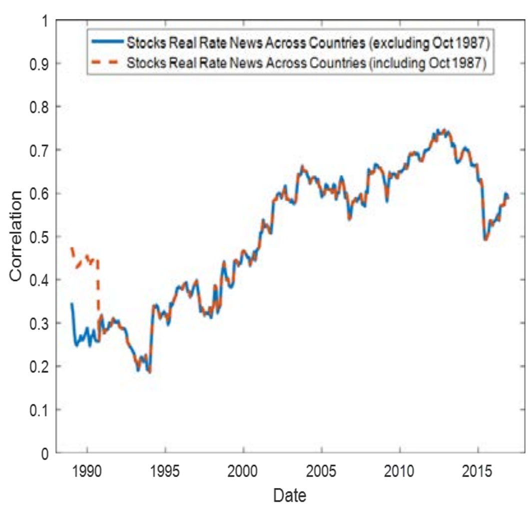
(a) **Panel A: Stock Excess Return News**



(b) **Panel B: Stock Cash Flow News**



(c) **Panel C: Stock Real Rate News**



(d) **Panel D: Stock Risk Premium News**

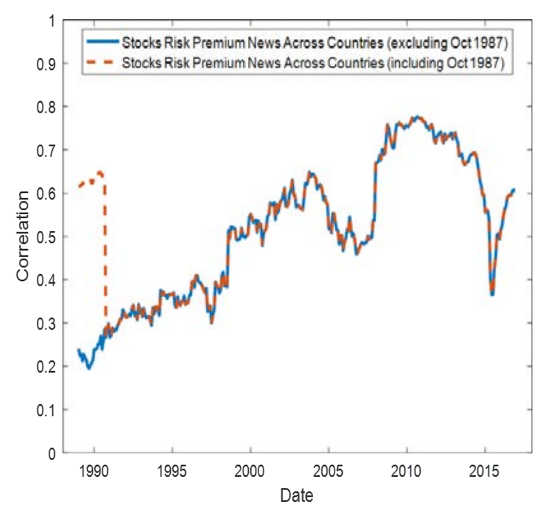
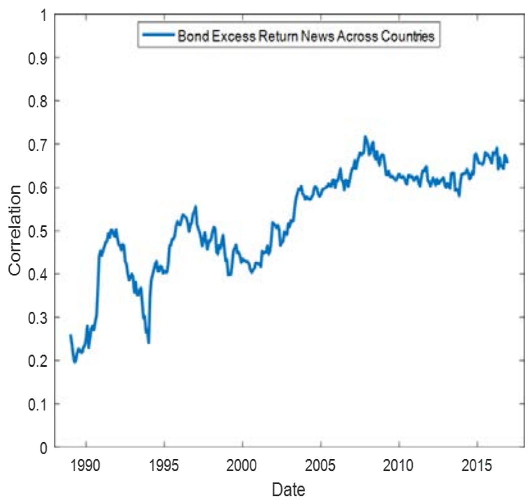


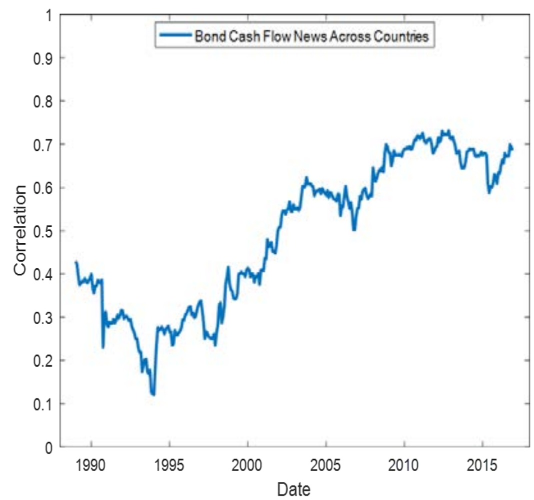
Figure 6: **Average Cross-Country Correlations of VAR News (Bonds)**

This figure plots the three year 3-year moving average of average cross-country correlations of shocks to bond excess returns (Panel A), cash flow news (Panel B), real rate news (Panel C), and risk premium news (Panel D).

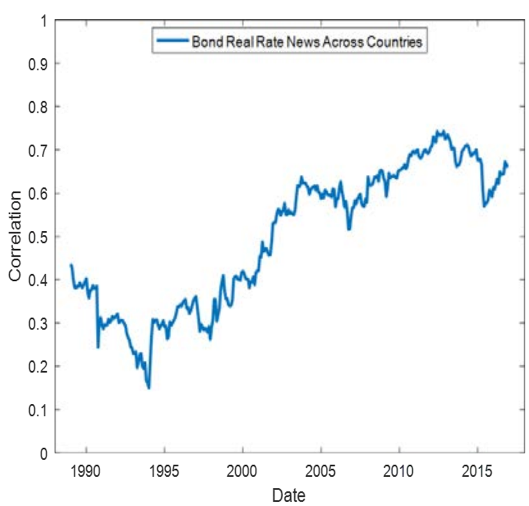
(a) **Panel A: Bond Excess Return News**



(b) **Panel B: Bond Cash Flow News**



(c) **Panel C: Bond Real Rate News**



(d) **Panel D: Bond Risk Premium News**

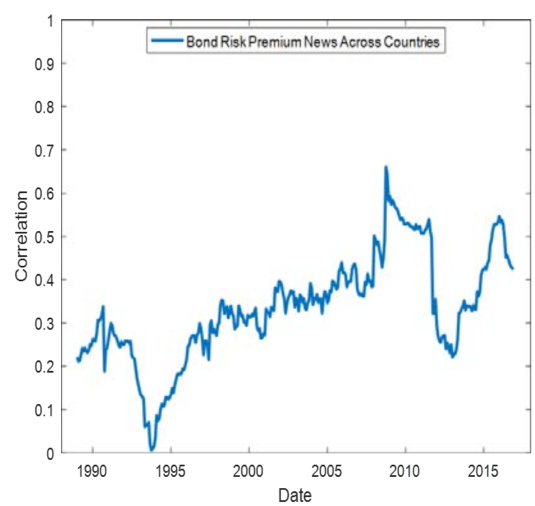
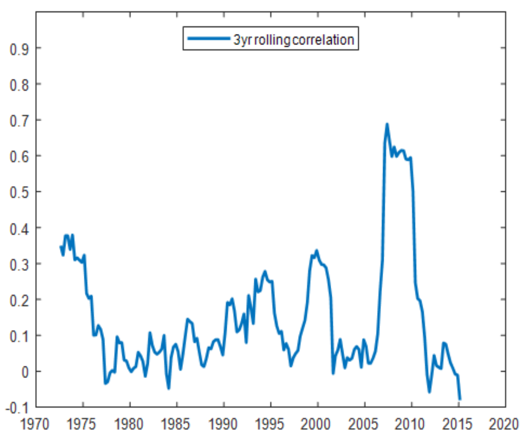


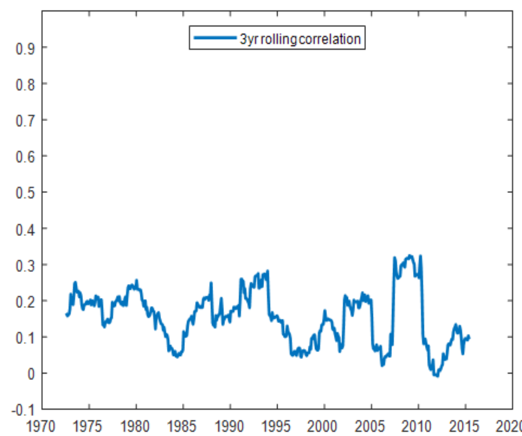
Figure 7: **Cross-Country Correlations of Proxies for Equity Cash Flow Fundamentals**

This figure plots the three year 3-year moving average of average cross-country correlations of shocks to GDP growth (Panel A), industrial production growth (Panel B), consumption growth (Panel C) and corporate earnings (Panel D). Quarterly GDP, monthly industrial production index and quarterly consumption are in real terms and in local currency. Quarterly corporate sector earnings are in nominal terms and in local currency, and we adjust for inflation to convert them into real terms. We run a AR(1) regression $\Delta X_{t+1} = \alpha + \beta \Delta X_t + \varepsilon_{t+1}$ for the log growth of real GDP, real industrial production, real consumption and real corporate earnings at country level. And then we compute the average pairwise correlation of residual from the AR(1) regression over a 3 year rolling window (36 months for IP, 12 quarters for GDP, consumption and earnings). Corporate earnings in our sample starts from 1994 due to data availability. GDP, IP is plotted starting from 1970 and consumption from 1980.

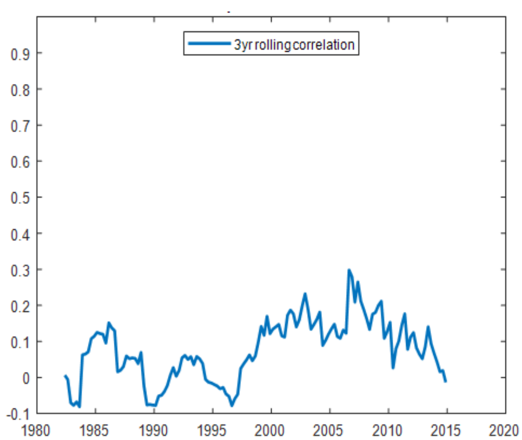
(a) **Panel A: Real GDP Growth**



(b) **Panel B: Real Industrial Production Growth**



(c) **Panel C: Real Consumption Growth**



(d) **Panel D: Real Corporate Earnings Growth**

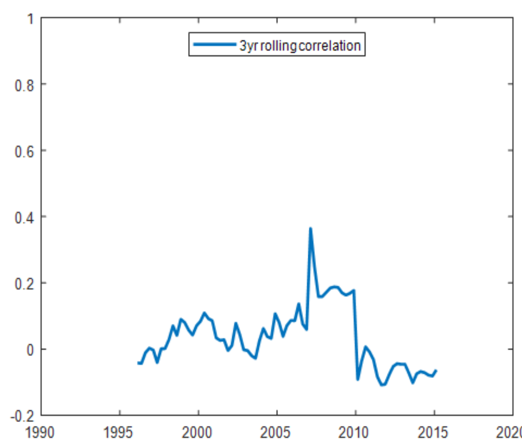
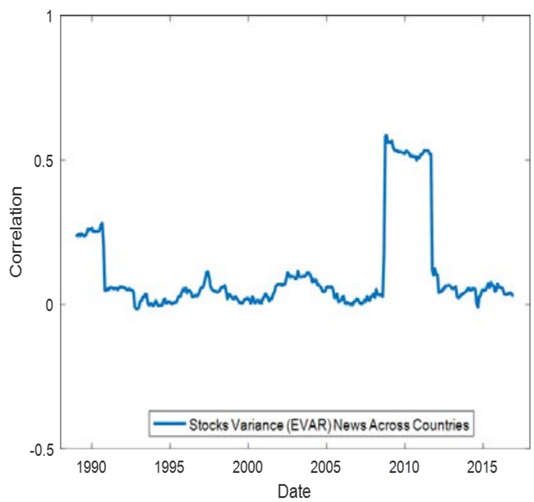


Figure 8: **Cross Country Correlations of Stock Volatility News**

This figure plots the time series of the 3-year moving average of average cross-country correlations of volatility news for expected variance (EVAR, Panel A) and the average cross-country correlations of innovations to realized stock return variance from the first stage regression (RVAR, Panel B).

(a) **Panel A: Expected Variance (EVAR)**



(b) **Panel B: Realized Variance (RVAR)**

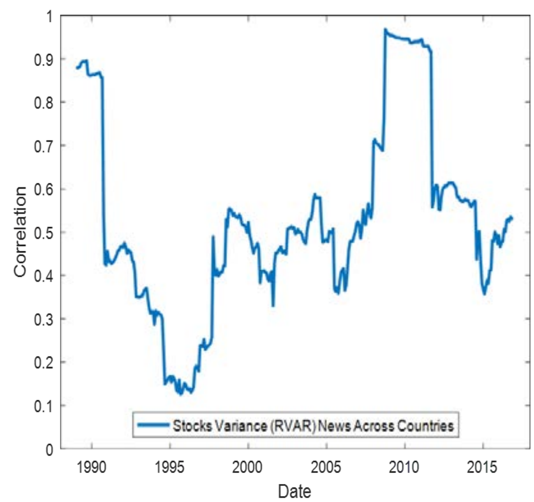


Figure 9: **Equal Weighted Portfolio Risk as a Function of Investment Horizon (Equities and Bonds)**

The figure compares the early sample (1986.01-1999.12) and late sample (2000.01-2016.12) equal weighted portfolio risk across investment horizons for equities (Panel A) and bonds (Panel B). For each panel, we plot the annualized conditional standard deviation of portfolio excess returns, annualized average conditional volatility (across N countries) of excess returns , and pairwise average conditional correlation of cross-country excess returns. Portfolios are equal-weighted.