Global Portfolio Diversification for Long-Horizon Investors

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Abstract

This paper conducts a theoretical and empirical investigation of the risk of globally diversified portfolios of stocks and bonds and of optimal intertemporal global portfolio choice for long horizon investors in the presence of permanent cash flow shocks and transitory discount rate shocks to asset values. 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 much more muted effect on portfolio risk at long horizons, suggesting that the benefits of global portfolio diversification to long-term investors do not recede when the source of increased global return correlations is correlated discount rates. Empirically, we document a secular increase in the cross-country correlations of both stock returns and government bond returns since the late 1990's. We identify increased correlations of discount rate shocks resulting from financial globalization as the main driver of the upward shift in stock return correlations. We also identify increased correlations of inflation shocks as an equally important source of the upward shift in bond correlations. By contrast, we don't find evidence of a secular shift in the cross-country correlations of stock market volatility shocks, which have remained fairly low through time except during the financial crisis of 2009.

JEL classification: G12.

1 Introduction

The traditional argument for holding globally diversified equity portfolios relies on the fact that historically stock markets have exhibited low return correlations. Given the magnitude of these correlations, French and Poterba (1991) argue that investors would need implausibly large return expectations on their own domestic markets to justify holding a domestically biased equity portfolio.[2] These beliefs of course cannot be mutually consistent. Campbell, Serfaty-de-Medeiros, and Viceira (2010) document that the historical cross-country correlations of currency-hedged long-term government bond returns are even lower than those of stock returns, suggesting that the case for holding a globally diversified bond portfolio is also strong.

The gains from global portfolio diversification have been questioned recently under the argument that the trend towards trade and financial globalization has increased the degree of co-movement of global capital markets, making international portfolio diversification less valuable (Quinn and Voth, 2008). Figure 1 documents this empirical phenomenon. It plots the cross-country average 3-year moving 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. Figure 1 shows a secular increase in the cross-country correlations of stock and bond returns, and a further temporary significant increase in global stock return correlations during the global financial crisis of 2008-2009.[3]

Complementing Figure 1, Figure 2 plots the average 3-year moving stock-bond correlation both within countries and across countries. This figure shows a strong decline in the stock-bond correlation over the same period, including a reversal of its sign from positive to negative since the turn of the century. Figure 2 shows that this phenomenon, which has been well documented for the U.S. and the U.K.,[4] extends to a wide cross-section of developed economies. It suggests that while the benefits of international portfolio diversification within stock and bond portfolios appear to have declined over time, the benefits of diversification across stocks and equities appear to have increased.

[2]See also Odier and Solnik (1993), Erb et al. (1994, 1995), Longin and Solnik (1995), Karolyi and Stulz (1996), De Santis and Gerard (1997), and Bekaert et al. (1998).

[3]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 2000, Longin and Solnik 2001, Hartmann et al. 2004, Chua et al. 2009, Leibovitz and Bova 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. 2008). 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)

[4]See Campbell, Shiller, and Viceira 2009 and Campbell, Sunderam, and Viceira, 2007.

In an environment with constant investment opportunities, the increase in cross-country return correlations shown in Figure 1 implies a reduction of the benefits of international portfolio diversification for all investors, regardless of their investment horizon, unless there is a compensating increase in expected returns.[5] However, the assumption of constant investment opportunities has been challenged in recent decades by a large body of empirical research documenting predictable variation in discount rates.[6]

The main contribution of our work is to examine global portfolio diversification in the presence of time variation in discount rates, both real interest rates and risk premia, and volatility. We show that both the risk of globally diversified portfolios and optimal international portfolio diversification are a function of investment horizon when investment opportunities are time varying. In such environment, an increase in short-horizon return correlations does not necessarily imply a reduction in the benefits of global portfolio diversification, even without a compensating increase in expected returns.

When discount rates are time varying, asset values and returns vary over time in response to both shocks to cash flows or fundamentals, and shocks to discount rates. Empirically, the effect of the former appears to be permanent, while the effect of the latter appears to be transitory (Campbell and Shiller, 1988, Campbell 1991, Campbell and Vuolteenaho 2004). Therefore, asset returns can be correlated because either cash flows are correlated, or discount rates are correlated.[7]

We show that the impact of correlated transitory discount rate shocks on portfolio risk is a decreasing function of investment horizon, while the impact of correlated persistent cash flow shocks is independent of investment horizon. Moreover, long-horizon investors optimally hold riskier portfolios in the presence of correlated discount rate news than in the presence of correlated cash flow news. Correlated persistent volatility shocks increase portfolio risk at all horizons.

Our theoretical results are intuitive. Long-term investors care primarily about diversifying permanent cash flow risk, while short-term investors care about diversifying both transitory discount rate risk and permanent cash flow risk. If cash flows become more correlated across markets, the scope for global portfolio diversification declines for all investors regardless of their investment horizon. If discount rates become more correlated, the scope

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

[6]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).

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

for global portfolio diversification declines for short-term investors, but less so for long-term investors.

We next explore the implications of these insights for global portfolio diversification in equities and sovereign bonds in the period 1986-2016.[8] 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. Our estimates are based on the return decomposition and news estimation framework of Campbell (1991). We do not account explicitly for estimation uncertainty in our analysis, although we use simultaneously the whole cross-section of countries in our estimation to increase power.[9]

Following Ammer and Mei (1996), we interpret an increase in the cross-country correlations of discount rate news across subperiods as an indicator of increased financial market integration, and an increase in the cross-country correlations of stock cash flow news as an indicator of increased real economic integration. For nominal bonds, an increase in the cross-country correlations of cash flow news reflects an increase in the cross-country correlation of inflation news, since their real cash flows vary inversely with inflation.

Our empirical analysis reveals 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. We also find a significant increase in the average cross-country correlation of nominal bond cash flow news, or inflation news, but not in the correlation of cash flow news for stocks. These results are robust to using the alternative measure of market integration of Pukthuanthong and Roll (2009), which we extend to accommodate cash flow and discount rate news.

We also estimate volatility news for the cross-section of stock markets included in our sample following the methodology of Campbell, Giglio, Polk, and Turley (2017). 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 estimates suggest that a stronger degree of financial integration of global markets in the most recent period explains the increment in one-period stock return correlations shown in Figure 1. Arguably the freedom of capital to flow across borders has drastically reduced capital market segmentation: Today the marginal investor in most developed markets is more likely to be a global investor, and investor sentiment and risk aversion in developed markets tend to move together more strongly than in the past. In the case of nominal bonds, 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.

[8]Our start date is constrained by data availability for the seven countries included in Figure 1.

[9]There is disagreement in the literature about how precisely one can estimate time variation in expected returns: See Campbell and Yogo (2006), Campbell and Thompson (2008), Goyal and Welch (2008), and Pastor and Stambaugh (2009 and 2012).

Our research adds to a nascent but growing body of research that explores the sources and effects of globalization on capital markets. 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 work also adds to a body of research that documents a large increase in the average cross-country correlation of inflation which has not been corresponded by an increase in the cross-country correlations of real ouput, and provides evidence of 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 has reduced country-specific variation in inflation expectations (Cecchetti and Schoenholtz, 2014, 2015).

We explore the implications of our empirical findings for global portfolio diversification in two different but related ways. First, following the methodology in Campbell and Viceira (2005), we compute the risk of global portfolios of stocks and bonds as function of investment horizon for each subperiod implied by our estimates of return dynamics and news. We find that the long-run risk of internationally diversified stock portfolios has declined in the 2000-2016 period relative to the 1986-1999, despite a significant increase in one-period return correlations.

We show that the reduction in the long-run risk of global equity portfolios in the second subperiod is the result of two effects. First, long-run return correlations have not increased in this subperiod. This is a direct consequence of our finding that increased discount rate news correlations account for most of the increase in short-run return correlations. Second, the average long-run volatility of stock market returns at the country level has declined. This finding is a direct consequence of our estimates of return dynamics, which imply an increase in the degree of stock return predictability in this subperiod relative to the 1986-1999 period. 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, our estimate that bond cash flow news correlations have increased in the second subperiod implies that bond return correlations have increased at all horizons. The increase in bond return correlations implies in turn an upward shift in the risk of global bond portfolios at all horizons that is detrimental to long-only bond investors. However, it also implies that global bond portfolio diversification is 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).

Second, we compute optimal intertemporal global equity portfolio allocations and expected utility implied by our estimates across periods under different assumptions about investor preferences. We consider two types of investors: An investor with power utility defined over terminal wealth at a finite horizon as in Jurek and Viceira (2011), and an investors with Epstein-Zin utility over instantaneous consumption and an infinite horizon as in Campbell and Viceira (1999) and Campbell, Chan, and Viceira (2003). We find 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 in the most recent period as measured by expected utility, even after we control for the increase in within-country stock return predictability. 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 returns 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 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:

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

where r_t denotes the natural log of the gross total return on the asset and Δd_{t+1} the change in the log dividend (or cash flow). The constant $\rho \equiv 1/\left(1+\exp\left(\overline{d-p}\right)\right)$ is a log-linearization

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

parameter, where $\overline{d-p}$ denotes the unconditional mean of the log dividend-price ratio.

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, and to the latter as discount rate shocks or discount rate news, and write more succinctly

$$r_{t+1} - \mathbb{E}_t\left[r_{t+1}\right] \equiv N_{CF,t+1} - N_{DR,t+1}. \tag{2}$$

We can further decompose $N_{DR,t+1}$ into news about excess log returns—or risk premia—, and news about the return on the reference asset used to compute excess returns:

$$N_{DR,t+1} = N_{RR,t+1} + N_{RP,t+1}, \tag{3}$$

with

$$N_{RR,s,t+1} \equiv \left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\left[\sum_{j=1}^{\infty} \rho^j r_{f,t+1+j}\right],$$

$$N_{RP,s,t+1} \equiv \left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\left[\sum_{j=1}^{\infty} \rho^j xr_{t+1+j}\right],$$

where $xr_{t+1+j} = r_{t+1+j} - r_{f,t+1+j}$ denotes log excess returns with respect to the log return on the benchmark asset $r_{f,t+1+j}$. In our empirical analysis we use cash (i.e., a short-term nominal bond like a T-bill in the US) as the reference asset, and measure returns in real terms. For example, $r_{f,t+1} = y^N_{1,t} - \pi_{t+1}$, where $y^N_{1,t}$ denotes the yield on a one-period nominal bond at t, which is also its nominal return at $t+1$, and π_{t+1} denotes log inflation.

The preceding expressions assume the asset is a perpetual claim on cash flows, such as equities or a consol bond. In our empirical analysis we also consider nominal bonds, whose cash flows (i.e., coupons) are fixed in nominal terms—and thus in real terms they vary inversely with the price level—and have a fixed maturity. The Appendix shows that for a \$1-coupon nominal bond with maturity n,

$$r_{n,t+1} - \mathbb{E}_t\left[r_{n,t+1}\right] = N_{CF,n,t+1} - N_{RR,n,t+1} - N_{RP,n,t+1}, \tag{4}$$

with

$$N_{CF,n,t+1} = -N_{INFL,n,t+1} \equiv -\left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\left[\sum_{j=1}^{n-1} \rho_b^j \pi_{t+1+j}\right],$$

$$N_{RR,n,t+1} \equiv \left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\left[\sum_{j=1}^{n-1} \rho_b^j r_{f,t+1+j}\right],$$

$$N_{RP,n,t+1} \equiv \left(\mathbb{E}_{t+1} - \mathbb{E}_t\right)\left[\sum_{j=1}^{n-1} \rho_b^j xr_{n-j,t+1+j}\right],$$

and $\rho_b = 1/\left(1 + \exp\left(-\bar{p_n}\right)\right)$.

The news components defined above 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:

$$\tilde{\mathbf{z}}_{t+1} = \mathbf{a} + \mathbf{A}\tilde{\mathbf{z}}_t + \mathbf{u}_{t+1}, \tag{5}$$

where $\tilde{\mathbf{z}}_{t+1}$ is a state vector whose first elements are the excess log returns on the assets under consideration, and the rest are state variables that predict excess returns and variables that capture the dynamics of inflation and the short-term interest rate. The vector of innovations $\mathbf{u}_{t+1}$ is uncorrelated over time with conditional variance-covariance matrix $\mathbb{V}_t\left[\mathbf{u}_{t+1}\right]$. Given a specification for $\tilde{\mathbf{z}}_{t+1}$, it is straightforward to derive the components of the return decomposition as a function of the vector $\mathbf{u}_{t+1}$ of innovations to $\tilde{\mathbf{z}}_{t+1}$ and the parameters of the VAR(1). We perform this derivation in both Section 3 and Section 4.

Three observations about this VAR specification are in order. First, it is well known that a VAR(1) specification can easily acommodate 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 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. Third, our main empirical analysis considers a homoskedastic version of the VAR, but we also consider a hetersokedastic specification along the lines of Campbell, Giglio, Polk, and Turley (2017) in Section 6.

3 Long-Run Portfolio Risk and Optimal Global Portfolio Diversification with Time-Varying Discount Rates

The return decomposition (2) implies that asset values and returns move over time in response to either changes in expected future cash flows or changes in discount rates. Therefore if asset returns are conditionally cross-sectionally correlated, it must be because either their cash flows, their discount rates, or both, are conditionally cross-sectionally correlated. This section shows that the cross-sectional correlation of each component has a different impact on portfolio risk, portfolio choice, and the benefits of portfolio diversification at investment horizons beyond one period.

To illustrate this point and help fix ideas for our empirical analysis, we consider in this section a symmetrical model of investment opportunities with N markets or assets ("countries") that have identical return generating processes. This model is a direct extension to a multi-marekt 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 because it allows to cleanly disentangle the effects of different types of cross-country news correlations on portfolio risk and portfolio choice at long horizons. Please refer to the Appendix for derivations of all expressions in this section.

3.1 Model

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

$$r_{i,t+1} = \mu_1 + \beta s_{i,t} + u_{i,t+1} \tag{6}$$

$$s_{i,t+1} = \mu_2 + \phi s_{i,t} + u_{si,t+1}, \tag{7}$$

where $r_{i,t+1}$ denotes the log return on country i, and $s_{i,t+1}$ denotes the single state variable that drives the time variation in the conditional expected return on country i: $\mathbb{E}_t[r_{i,t+1}] = \mu_1 + \beta s_{i,t}$. Without loss of generality we normalize $\beta > 0$.

The parameters μ_1, μ_2, β, and ϕ are identical across countries, and $|\phi| < 1$ to preserve stationarity. The conditional within-country variance-covariance matrix of the shocks to the VAR is also identical across countries and constant over time:

$$V_t\left[\mathbf{u}_{i,t+1}\right] = \begin{bmatrix} \sigma_{uu}^{wc} & \sigma_{us}^{wc} \\ \sigma_{us}^{wc} & \sigma_{ss}^{wc} \end{bmatrix}. \tag{8}$$

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 shocks between any pair of countries is also identical across country pairs and constant over time:

$$C_t\left[\mathbf{u}_{i,t+1}, \mathbf{u}_{j,t+1}\right] = \begin{bmatrix} \sigma_{uu}^{xc} & \sigma_{us}^{xc} \\ \sigma_{us}^{xc} & \sigma_{ss}^{xc} \end{bmatrix} \tag{9}$$

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

The stylized model of country returns defined by equations (6)-(9) 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 (2) to the VAR(1) model (6)-(9) shows that the shocks to the model (6)-(7) are related to structural cash flow and discount rate shocks as follows:

$$N_{DR,i,t+1} = \lambda u_{si,t+1}, \tag{10}$$

$$N_{CF,i,t+1} = u_{i,t+1} + \lambda u_{si,t+1}, \tag{11}$$

with

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

Therefore discount rate news are proportional to shocks 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 (8)-(9), together with equations (10) and (11), 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

$$C_t[N_{CF,i,t+l}, N_{CF,j,t+l}] \equiv \sigma^m_{CF,CF}, \tag{12}$$

$$C_t[N_{CF,i,t+l}, N_{DR,j,t+l}] \equiv \sigma^m_{CF,DR}, \tag{13}$$

$$C_t[N_{DR,i,t+l}, N_{DR,j,t+l}] \equiv \sigma^m_{DR,DR}, \tag{14}$$

where $m \equiv wc$ when $i = j$, and $m \equiv xc$ when $i \neq j$. For example, $\sigma^{xc}_{CF,CF}$ denotes both 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. This is the mean-variance optimal portfolio for these N markets. The risk per period 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 cross-country covariance of k-horizon returns:

$$\frac{1}{k}V_t[r^{(k)}_{p,t+k}] = \frac{1}{N}\frac{1}{k}V_t[r^{(k)}_{i,t+k}] + (1-\frac{1}{N})\frac{1}{k}C_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}]. \tag{15}$$

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

$$C_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}] = \sum_{l=1}^{k} C_t[r_{i,t+l}, r_{j,t+l}] + 2\sum_{l=1}^{k-1}\sum_{m=1}^{k-l} C_t[r_{i,t+l}, r_{j,t+l+m}]. \tag{16}$$

The expression for the within-country conditional return variance $V_t[r^{(k)}_{i,t+k}]$ follows immediately from (16) by noting that $V_t[r^{(k)}_{i,t+k}] = C_t[r^{(k)}_{i,t+k}, r^{(k)}_{i,t+k}]$. [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 (15) 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 (6)-(7) shows that future one-period realized returns are given by

$$r_{i,t+l} - E_t[r_{i,t+l}] = N_{CF,i,t+l} - N_{DR,i,t+l} + \frac{\beta}{\lambda}\sum_{m=1}^{l-1}\phi^{m-1}N_{DR,i,t+l-m}, \tag{17}$$

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 (10) and (11). Note that $\beta/\lambda > 0$.

Equation (17) 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 is a function only of the contemporaneous cash flow shock. But it depends on the entire history of discount rate shocks between $t+1$ and $t+l$, such that a positive discount rate shock drives realized returns down contemporaneously, but this effect reverses over time at a speed determined by the autoregressive coefficient ϕ.

Using expression (17) it is straightforward to write the conditional moments of one-period returns as a function of the conditional moments of return news and the cross-country component (16) of portfolio risk at horizon k as:

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

with coefficients $a(k) \equiv a(k;\beta,\phi,\rho)$ and $b(k) \equiv b(k;\beta,\phi,\rho)$ given in the Appendix. For $k = 1$, equation (18) reduces to

$$C_t[r_{i,t+1}, r_{j,t+1}] = \sigma^{xc}_{CF,CF} + \sigma^{xc}_{DR,DR} - 2\sigma^{xc}_{CF,DR}. \tag{19}$$

Equations (18) and (19) clarify how correlated cash flow news and correlated discount rate news impact portfolio risk across investment horizons. At a horizon of one period, equation (19) shows that 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, equation (18) shows that each type of return news cross-country covariance has a different effect on portfolio risk as the horizon lengthens ($k > 1$). 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 invevstment horizon. In the limit, the cross-country component of portfolio risk per period (18) converges to

$$lim_{k\to+\infty}\frac{1}{k}C_t[r^{(k)}_{i,t+k}, r^{(k)}_{j,t+k}] = \sigma^{xc}_{CF,CF} + \left(1 - \frac{1-\rho\phi}{\rho-\rho\phi}\right)^2 \times \sigma^{xc}_{DR,DR} - 2 \times \left(1 - \frac{1-\rho\phi}{\rho-\rho\phi}\right)^2 \times \sigma^{xc}_{CF,DR} \tag{20}$$

where the coefficient on $\sigma^{xc}_{DR,DR}$ is positive, 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.

Equation (20) shows that at long horizons an increase in the cross-country covariance of cash flow news has a larger impact on portfolio risk than a similar increase in the cross-country covariance of discount rate news, unless discount rate shocks are extremely persistent. Figure 3 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 grows larger 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 at long horizons than correlated cash flow news.

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

$$\frac{1}{k}V_t[r^{(k)}_{i,t+k}] = \sigma^{wc}_{CF,CF} + \left[a(\mathrm{k})^2 + b(\mathrm{k})\right] \times \sigma^{wc}_{DR,DR} - 2 \times a(\mathrm{k}) \times \sigma^{wc}_{CF,DR}. \tag{21}$$

Of course, the within-country k-return portfolio variance (21) 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 $V_t[r^{(k)}_{i,t+k}]/k$ as a function of the moments of the shocks to the VAR(1). Equation (21) writes single-country portfolio risk as a function of the moments of cash flow news and discount rate news. This derivation helps us gain intuition into why empirically portfolio risk per unit of time appears to decline 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 (18) and (21) 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

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

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 (6)-(7) to US excess stock returns, with the log

[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 $\rho \to 1$ essentially say that in the limit correlated discount rate news do not matter for long-run portfolio risk if they are not sufficiently persistent.

dividend-price ratio as the state variable. We use these estimates to compute portfolio risk per period $\sqrt{V_t[r^{(k)}_{p,t+k}]/k}$ for on an equally-weighted portfolio of U.S. stock market clones under three different scenarios for the cross-country correlations of return news.

The first scenario, or baseline case, sets all cross-country news correlations to zero. The second scenario and the third scenario both set the cross-country correlation of one-period returns to the same positive value, but each generates this correlation from a different type of cross-country news correlation. The second scenario generates positive cross-country return correlations from correlated cash flow news while setting all other news correlations to zero.[13] The third scenario generates positive cross-country return correlations from correlated cash flow news exclusively.[14] All scenarios assume that discount rate news and cash flow news are uncorrelated, both within countries and across countries.[15]

Figure 4 plots annualized portfolio risk $\sqrt{V_t[r^{(k)}_{p,t+k}]/k}$ as a function of investment horizon for each of the three scenarios. Panel A plots portfolio risk for a portfolio of two countries, and Panel B for a portfolio of seven countries—the number of countries we consider in our empirical analysis. Consistent with our results in Section 3.2, the figure shows that portfolio risk per period declines as investment horizon increases in each of the three scenarios. This results from return predictability. In the absence of return predictability, the lines in each plot would be horizontal.

In the baseline scenario, the decline in portfolio risk per period comes exclusively from the impact of return predictability on within-country return volatility, the effect analyzed in Campbell and Viceira (2005). Figure 4 shows that portfolio risk increases at any given horizon relative to the baseline scenario when returns become positively cross-sectionally correlated, as one would expect.

However, the magnitude of the increase in portfolio risk at long horizons depends critically on the source of the increase in cross-country return correlations. Correlated cash flow news generate a much larger increase in long-horizon portfolio risk than correlated discount rate news, even though both generate the same level of portfolio risk at short horizons. Panel A and Panel B in the figure show that this differential effect on long-run portfolio risk increases with the number of countries in the portfolio.

[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 cother 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 cross-county correlation of one-period returns as in the second scenario is 0.09. 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.

[15]In terms of the correlation structure to the innovations to the VAR, the first scenario implies zero cross-country correlations of unexpected returns and shocks to the state variables (see equations 10 and 11). The second scenario implies a positive cross-country correlation of unexpected stock returns and zero cross-country correlations of dividend-price ratio shocks. The Appendix provides the values of the coefficients.

Figure 4 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. 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 in return correlations is capital market integration (or correlated discount rates) than when it is real markets integration (or correlated cash flows).

3.4 Optimal Global Portfolio Diversification Across Investment Horizons

Our stylized symmetrical model is also helpful to understand the impact of financial and real market integration on optimal international portfolio diversification across investment horizons. We illustrate these effects using the model of optimal intertemporal portfolio choice of Jurek and Viceira (2011) in which an investor with power utility preferences over terminal wealth at a finite horizon faces a time-varying investment opportunity set described by a VAR(1) model for returns and state variables.

Formally, an investor with investment horizon k chooses the sequence of portfolio weights $\left\{\boldsymbol{\alpha}^{\boldsymbol{\tau}}_{\boldsymbol{t+k-\tau}}\right\}_{\tau=k}^{\tau=1}$ between time t and $(t+k-1)$ such that

$$\left\{\boldsymbol{\alpha}^{\boldsymbol{\tau}}_{\boldsymbol{t+k-\tau}}\right\}_{\tau=k}^{\tau=1} = argmax\; E_t\left[\frac{W_{t+k}^{1-\gamma}}{1-\gamma}\right] \tag{22}$$

subject to the intertemporal budget constraint

$$W_{t+1} = W_t\left(1 + R_{p,t+1}\right), \tag{23}$$

$$R_{p,t+1} = \sum_{j=1}^{N} \alpha_{i,t}\left(R_{i,t+1} - R_{f,}\right) + R_{f,}, \tag{24}$$

where γ is the coefficient of relative risk aversion, $\boldsymbol{\alpha_t} = (\alpha_{1,t}, \ldots, \alpha_{N,t})'$, $R_{i,t} = \exp\{r_{i,t}\} - 1$, and R_f is the risk-free rate, which we assume is constant. The dynamics of excess log returns in each market i follow the VAR(1) model (6)-(7), identical across markets.

This intertemporal portfolio optimization problem has an exact recursive solution up to a log-linear approximation to the log return on wealth (23)-(24). The recursive solution is an affine function of the vector of states variables with coefficients that vary with investment horizon. The solution has two components. The first component is equal to the optimal 1-period horizon allocation, which is the instantaneous mean-variance or “myopic” optimal portfolio. The second component, which is horizon dependent, reflects intertemporal hedging motives in optimal portfolio choice that arise only when investment opportunities are time varying. Therefore horizon effects enter portfolio choice exclusively through the optimal desire of the investor to hedge changes in investment opportunities.

Figure 5 plots the mean optimal portfolio allocation to risky assets as a function of investment horizon for each of the scenarios we consider in Section 3.3. We add a risk free asset ("cash") to the menu of identical stock markets with returns calibrated to the U.S. stock market, and set the investor's coefficient of relative risk aversion to 5. Panel A presents results for two countries, and Panel B for seven. Note that the optimal portfolio allocation to risky assets is an equal weighted portfolio because all markets have identical return generating processes and cross-country correlations are identical across country pairs. Therefore we need to report only one mean optimal portfolio allocation for each scenario.

The intercepts in the figure reflect the one-period or instantaneously mean-variance efficient allocation to risky assets. 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 of zero cross-country return correlations. This implies a positive optimal allocation to cash, or equivalently a smaller optimal allocation to stocks, in the other two scenarios where the cross-country correlation of one-period stock returns is positive.[16] The difference between each point in a curve and the intercept reflects intertemproal hedging demand.

Figure 5 shows that total portfolio demand for stocks is increasing in investment horizon in all three scenarios. This result is familiar from the literature that examines the optimal allocation to stocks at long horizons. Intertemporal portfolio choice is entirely driven by intertemporal hedging demand, which is positive in our calibration because shocks to the state variable—or equivalently expected excess returns—are negatively correlated with realized stock excess returns. That is, realized returns tend to be positive when expected excess returns fall, implying that a long position in the risky asset helps hedge against a fall in expected returns.

Figure 5 also shows that optimal portfolio demand increases less strongly with investment horizon when returns are cross-sectionally correlated, implying that the intertemporal hedging demand for stocks is smaller in the scenarios with correlated returns across countries than in the benchmark case with uncorrelated returns. Moreover, the extent to which this horizon effect is smaller depends crucially on the source of the cross-correlation of returns. Intertemporal hedging demands are significantly smaller, and total portfolio demand flatter as a function of investment horizon, when correlated cash flow news is the driver of cross-country return correlation than when correlated discount rate news is the driver.

This result is consistent with our results for portfolio risk across investment horizons. When discount rate shocks are correlated across markets but cash flow shocks are not, the scope for global diversification declines much less at long horizons than at short horizons.

[16] It is also the same in both scenarios because recall that we set the cross-correlations of cash flow news and discount rate news in each scenario such that they imply identical one-period return cross-correlations.

Long-horizon investors can still take advantage of global portfolios to diversify cash flow risk, which is the most important risk at long horizons. At the same time, they can use global stocks and not just their local market to hedge against adverse changes in expected returns. By contrast, if cash flow shocks become correlated across markets, the scope for reducing long-run risk through global diversification declines for all investors regardless of their investment horizon.

Figure 5 is also helpful to understand optimal intertemporal portfolio demand as the number of markets available for investing increases. The figure shows that. in the baseline case of uncorrelated markets, total optimal portfolio demand for stocks is independent of the number of markets available for investing at all horizons. To see this, note that total portfolio demand obtains by multiplying by a factor of two the allocations in Panel A and by a factor of seven those in Panel B. As the number of markets increases, the investor distributes the total portfolio demand for stocks across more markets but the portfolio demand for stocks, both myopic and intertemporal hedging, remains unchanged. The scope for diversification of both discount rate risk and cash flow risk increases in the number of uncorrelated markets available for investing, as well as the ability to hedge adverse changes in expected returns.

If returns are correlated across markets, the total optimal portfolio demand for stocks is a decreasing function of the number of markets available for investing at all horizons. The reduction in total portfolio demand is much larger when the source of cross-country return correlations is correlated cash flow news than when it is correlated discount rate news. The differential effect of each type of news comes through the intertemporal hedging demand, because the reduction in myopic demand is the same in both scenarios. It is straightforward to see from Figure 5 that total intertemporal hedging demand at the longest horizon in the plot declines from about 230% to about 210% in the correlated discount rate news scenario as we go from two to seven markets, and from about 175% to 65% in the correlated cash flow news scenario. The investor still distributes the total portfolio demand for stocks across more markets, but he does not see the increase in the number of markets as an opportunity to take on more overall portfolio risk as he is just adding more correlated—or less diversifiable—long run risk. But if the added risk is discount rate risk, the long-horizon investor understands this correlated risk has only a transitory impact on portfolio risk and he optimally reduces his overall risk exposure by much less than when the added risk is cash flow risk, which has a permanent impact on portfolio risk.

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

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 bond returns of seven major developed economies for the period January 1986 through December 2016. This is the longest period for which we have complete data on returns and state variables for all the countries included in our sample: Australia, Canada, France, Germany, Japan, the U.K., and the U.S. These countries account for at least 80% of total global stock market capitalization throughout our sample period.

4.1 VAR Specification and Estimates

We estimate the VAR(1) model (5) for the seven countries using monthly data over the entire sample period 1986.01-2016.12. This is the period for which we have observations for all the variables included in our empirical specification of our VAR (1) across the seven countries. Our specification includes the log return on equities and bonds in excess of the return on their domestic T-bill,[17] variables known to predict excess returns on stocks and bonds—dividend-price ratios and yield spreads—, and variables that help capture the dynamics of real interest rates and inflation—nominal short-term interest rates and inflation (Campbell, Chan, and Viceira, 2003, Campbell and Viceira, 2005).

Specifically, we estimate a pooled VAR(1) model for the seven countries in our sample:

$$\tilde{\mathbf{z}}_{i,t+1} = \mathbf{a_i} + \mathbf{A}\tilde{\mathbf{z}}_{i,t} + \mathbf{u}_{i,t+1}, \tag{25}$$

where

$$\tilde{\mathbf{z}}_{i,t+1} = \left[xr_{s,i,t+1}, xr_{10,i,t+1}, d_{i,t+1} - p_{i,t+1}, \pi_{i,t+1}, y^N_{1,i,t+1}, y^N_{10,i,t+1} - y^N_{1,i,t+1}\right], \tag{26}$$

i denotes country, and $\mathbf{a_i}$ is a 6×1 vector of intercepts and $\mathbf{A}$ is a 6×6 slope coefficient matrix which is identical for all countries. We estimate a pooled VAR(1) model in an attempt to use as much cross-country information as possible to estimate the process for expected returns, since our sample is relatively short in the time series dimension. 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.

In (26), $xr_{s,i,t+1}$ denotes the excess log return on equities in country i, $xr_{10,i,t+1}$ the excess log return on the 10-maturity nominal government bond, $d_{i,t+1}-p_{i,t+1}$ the log of the dividend-price ratio, $\pi_{i,t+1}$ log inflation, $y^N_{1,i,t+1}$ the short-term nominal log interest rate, and $y^N_{10,i,t+1}$ the log yield on the 10-year nominal government bond. We measure excess log returns in each country as

$$xr_{i,t+1} = r^{\$}_{i,t+1} - y^N_{1,i,t} = \left(r^{\$}_{i,t+1} - \pi_{i,t+1}\right) - \left(y^N_{1,i,t} - \pi_{i,t+1}\right) \equiv r_{i,t+1} - r_{f,i,t+1}.$$

We obtain monthly data for the state variables in all seven countries from a variety of sources. The Appendix provides a detailed description of the data and its sources.

Finally, $\mathbf{u}_{i,t+1}$ is an i.i.d. 6×1 vector of shocks with within-country variance-covariance matrix $\sum_i^{wc}$ and cross-country covariance matrix $\sum_{i,j}^{xc}$, $i, j = 1, ..., 7$. We consider a heteroskedastic version of this VAR in Section 6.

[17]This ensures that the return decomposition is currency independent (Campbell, Sefarty de Medeiros, and Viceira, 2010).

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 for two subperiods of similar length, 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 performance of bonds reflects a common downward trend in nominal interest rates that has pushed bond prices higher throughout the entire period in all countries; by contrast, equity valuations have gone through periods of expansion and contraction, including the run-up in valuations in the 1990's, the decline in valuations in the early 2000's and during the financial crisis of 2008 and 2009, and the subsequent recovery.

Across subsamples, the cross-country average bond excess return remained stable at about 3.2% per annum, while the average stock excess return declined from 5.1% to 1.9% p.a. between the first and the second half of the sample period. Excess return volatility in each market and in each country has experienced a small decline between the first and second subperiod, but 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.[18] This table complements Figure 1 and Figure 2. It shows that cross-country return correlations have increased significantly from the early to the late subperiod for both stocks and bonds, and that the stock-bond correlation has switched sign from positive to negative.

Section E of the Appendix reports the 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 monthly 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 equations for excess log returns exhibit the lowest R^2, which demonstrates the difficulty of predicting 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) process. Log inflation follows a less persistent process. As we will see, this has important implications for the benefits of global diversification of bond portfolios.

[18] Section E of the Appendix reports the full correlation matrices.

The correlation matrix of residuals shows a large negative cross-country average correlation between unexpected stock excess returns and shocks to the dividend-price ratio, 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.[19] 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, thus providing investors with a hedge against deterioration in investment opportunities.

4.3 Estimates of News Components of Stock and Bond Excess Returns

We obtain estimates of the news components of stock and bond excess returns for each country implied by the estimates of the VAR(1) system (25)-(26).

Following standard practice in this literature, we have specified the state vector (26) such that we can explicitly identify unexpected stock excess returns and discount rate news from equations in the VAR, and obtain cash flow news as the sum of unexpected excess returns and discount rate news. Specifically, Section A in the Appendix shows that the news components for stock excess returns given in (2)-(3) obtain from the VAR system as follows:

$$\begin{aligned}
xr_{s,t+1} - \mathbb{E}_t\left[xr_{s,t+1}\right] &= \mathbf{e1}'\mathbf{u}_{t+1}, \\
N_{RP,s,t+1} &= \mathbf{e1}'\left(\sum_{j=1}^{\infty}\rho_s^j\mathbf{A}^j\right)\mathbf{u}_{t+1}, \\
N_{RR,s,t+1} &= \mathbf{e5}'\left(\sum_{j=1}^{\infty}\rho_s^j\mathbf{A}^{j-1}\right)\mathbf{u}_{t+1} - \mathbf{e4}'\left(\sum_{j=0}^{\infty}\rho_s^j\mathbf{A}^j\right)\mathbf{u}_{t+1}, \\
N_{CF,s,t+1} &= \left(xr_{s,t+1} - \mathbb{E}_t\left[xr_{s,t+1}\right]\right) + N_{RR,s,t+1} + N_{RP,s,t+1},
\end{aligned}$$

where we omit the country subscript i for simplicity, and where $\mathbf{eL}$ denotes a column vector with a 1 in the $\mathbf{L}$ position and 0's in the rest.

We follow a different identification strategy for estimating the news components of bond excess returns. We explicitly identify bond cash flow news from the inflation equation in the VAR and obtain the risk premium—or future expected excess returns—component as the residual. The Appendix shows that the news components for bond excess returns given in (4) obtains from the VAR system as follows:

[19] 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.

$$
\begin{aligned}
xr_{n,t+1} - \mathbb{E}_t\left[xr_{n,t+1}\right] = \mathbf{e2}'\mathbf{u}_{t+1}, \\
N_{CF,n,t+1} &= -\,\mathbf{e4}'\left(\sum_{j=1}^{n-1}\rho_b^j\mathbf{A}^j\right)\mathbf{u}_{t+1}, \\
N_{RR,n,t+1} &= \mathbf{e5}'\left(\sum_{j=1}^{n-1}\rho_b^j\mathbf{A}^{j-1}\right)\mathbf{u}_{t+1} - \mathbf{e4}'\left(\sum_{j=1}^{n-1}\rho_b^j\mathbf{A}^j\right)\mathbf{u}_{t+1}, \\
N_{RP,n,t+1} &= N_{CF,n,t+1} - N_{RR,n,t+1} - \left(xr_{n,t+1} - \mathbb{E}_t\left[xr_{n,t+1}\right]\right).
\end{aligned}
$$

We extract the news components of stock and bond excess returns for the entire sample period as well as for the subperiods 1986-1999 and 2000-2013. To compute news components for each subperiod, we use the full sample coefficient estimates $\mathbf{A}$ and split the residuals $\mathbf{u}_{t+1}$ into two subsamples.

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. Accordingly, we use our entire sample period to estimate the slope coefficients.

4.4 Empirical News Decomposition of Cross-Country Correlations of Global Stock and Bond Excess Returns

Following Ammer and Mei (1996), we use our estimates of the news components of returns to explore the sources of cross-country correlations of returns and their changes between the 1986-1999 subperiod and the 2000-2016 subperiod. We adopt their terminology and refer to cross-country cash flow news correlations as a measure of real economic integration, and to cross-country discount rate news—excess return news and real rate news—correlations as a measure of financial or capital markets integration.

Before we present our empirical results, it is helpful to get economic intuition about the implications of each type of integration for cross-country return news correlations. First, 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 in that world. Alternatively, we can also think of a world with integrated capital markets as a world in which shocks to investor risk aversion or investor 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.

Now consider a world with a high degree of economic integration. In that case we expect to see common aggregate shocks affecting all economies. To the extent that national stock markets are large enough to reflect their national economies and to largely allow for the diversification of stock-specific idiosyncratic shocks, we expect a high degree of cash flow news correlation across countries, particularly in a sample like ours with very large economies and markets.

Finally, we also expect country-level local inflation to react in similar ways to global demand shocks in a world with a high degree of real economic integration, particularly if central banks react to those shocks in a similar manner. In that case we expect a high degree of cross-country correlation of inflation news and consequently in nominal bond cash flow news.

Table 3 reports the average cross-country correlations of the news components of excess stock returns for each subperiod in the upper panel, and p-values of the differences based on bootstrap and Fisher transformation methods in the lower panel. Figure 6 plots the proportional contribution of each component to the average cross-country return covariance. Table 4 reports similar figures for bond excess returns. (See Appendix G for a description of the statistical tests and the calculation of the contribution of each component to total correlation.)

Table 3 shows that capital market integration is the 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 stayed fairly stable from one subperiod to another. Figure 6 shows that the the risk-premium component of stock returns is the main contributor to cross-country stock return covariance in both subperiods, with a large increase of its relative importance in the second subperiod, from 58% to 84%. Cash flow news covariation is the second most important component, and its contribution to total covariance has declined slightly in the second subperiod. This figure also shows that covariance across different types of news explain a small fraction of the total cross-country stock return covariance.

Figure 7 provides visual confirmation of the results in Table 3. It plots the time series of the 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. Panel A shows the upward trend in the average cross-country correlation of realized stock excess returns, with the exception of a temporary decline in 2014-2015.[20] Panel B shows that the average cross-country correlation of cash flow news exhibits no time series trend, while the cross-country correlation of both real interest rate news and risk premium news exhibits a clear updward trend..

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

Table 4 presents results for bond excess returns. This table shows that, in contrast to stock returns, the cross-country correlation of cash flow news—i.e., the negative of inflation news–has also been a significant contributor to the increase in cross-country bond return correlations from the early subperiod to the late subperiod. The increase in cross-country inflation news is significant both economically and statistically, from 0.34 to 0.64. Our results on cash flow news for both stocks and bonds add to a body of research that documents a large increase in the average cross-country correlation of inflation which has not been corresponded by an increase in the cross-country correlations of real ouput, 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 an it has reduced country-specific variation in inflation expectations (Cecchetti and Schoenholtz, 2014, 2015).

Table 4 shows that, consistent with our estimates for discount rate news for stock returns, the average cross-country correlation of real rate news for bonds has also risen significantly across subperiods, from 0.35 to 0.63.[21] The cross-country correlation of bond risk premium news has also increased significantly from 0.20 to 0.42, although at 0.42 it is significantly lower than the correlation of bond cash flow news and real rate news, suggesting that bond markets are less well integrated globally than stock markets. Figure 6 shows that the covariance of discount rate news, especially the real interest rate news component, explains a very large fraction of total cross-country bond excess return covariance, at 66% and 75% in the first and second subperiod respectively. The covariance of inflation news explains a smaller but still significant fraction of the total covariance in both periods.

Figure 8, whose structure is identical to that of Figure 7, presents time series of realized bond excess returns and bond return news components. This figure provides visual confirmation of the results shown in Table 4. It shows that all news components of bond excess returns help explain the upward trend in the average cross-country correlation of realized bond excess returns in our sample, with cross-country correlations of bond cash flow news and real rates being the main contributors to this trend.

Overall, Tables 3 and 4 and Figures 7 and 9 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 2000-2013. In the case of bonds, cash flow (or inflation) news has also been an important contributor to the increase in cross-country return correlations. Our results add to a small but 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

[21] Note that the two measures of real rate news differ in the horizon at which they are computed, since we treat stocks as infinitely lived securities and bonds as securities with finite maturity.

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 also highlight the importance of accounting for time variation in discount rates to understand the second moments of returns, both within markets and across markets. They also add to the evidence on time variation in expected returns, since in a world with constant discount rates, cash flow news is the only source of cross-country return correlations and the only factor that can explain a change in them.

We also explore the sources of the stock-bond correlation within countries and across countries in Table 5 and Table 6, respectively. Both tables show a switch from positive to negative in the sign of the stock-bond cash flow news correlation from the early period to the late period. This is one of the main drivers of the switch in the sign of the stock-bond return correlation shown in Figure 2 and Table 2. Since bond cash flow news is the negative of inflation news, this switch in correlation implies that inflation news has switched from behaving countercyclically in the early period to behaving procyclically in the late subperiod in our sample of countries.

The tables also show a significant increase in the correlation of bond risk premium news with stock cash flow news in the most recent subperiod, which is the second main driver of the switch in the sign of the stock-bond correlation. It suggests that investors demand lower risk premia on bonds in recessions—when stock cash flow news are negative—, consistent with bonds being considered by investors as safe assets in the most recent period. Both sets of results are consistent with the evidence shown in Viceira (2012) and Campbell, Sunderam and Viceira (2013) for U.S. stocks and bonds, and the economic drivers of bond risk explored in Campbell, Pflueger and Viceira (2015) for the U.S.

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 and real integration. Pukthuanthong and Roll (2009) argue that small cross-country correlations do not necessarily imply a lack of integration. For example, they argue that cross-country return correlations can be small even when countries are highly integrated if returns are explained by a global multifactor model and each country return loadings on these global factors differ. They propose using an alternative metric of integration: the R^2 from regressing returns on global factors estimated from a principal component analysis. A larger R^2 then corresponds to greater integration.

We apply the Pukthuanthong-Roll methodology to realized returns and the news components of returns. For a given return or news series, we find the first three principal components every year and the R^2 from a simple least squares regression. This methodology is particularly helpful to determine if the relatively low degree of cross-country correlations of cash flow news of stocks could be the result of a multifactor structure underlying these shocks instead of evidence of lack of integration in stock cash flows. For all other news components in stocks and bonds, the pair-wise correlations are already large in both subperiods and have increased significantly from the early to the late subperiod, suggesting that pair-wise correlations help capture integration for these components.

Table 7 reports average R^2 over the two subperiods for each series. Panel A corresponds to stocks, and Panel B corresponds to bonds. When excess returns $xr_{s,t+1}$ and $xr_{n,t+1}$ are the return series of interest, the R^2 increases from 0.60 to 0.73 and 0.59 to 0.74, respectively. This result suggests that the overall level of integration has risen between the two subperiods. Not surprisingly, a similar result holds when conducting the analysis using innovations in excess returns. The results for news terms lead to the same conclusions we have a achieved from the cross-country 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. This suggests a significant increase in the level of financial integration in the stock market and in the bond market from the early subperiod to the late subperiod.

5.2 Direct Measures of Cash Flow Correlations

The empirical stock return decomposition performed in Section 5 is based on a direct estimation of discount rate news, and it identifies stock cash flow news as the difference between realized excess stock returns and discount rate news. Therefore, our estimates of cash flow news and discount rate news rely on an appropriate identification of the drivers of time variation in real interest rates and equity risk premia.

Although our estimates are based on variables widely used in the literature as return predictors, there is nonetheless disagreement about how precisely one can estimate time variation in expected returns (Campbell and Yogo 2006, Campbell and Thompson 2008, Goyal and Welch 2008, Pastor and Stambaugh, 2009 and 2012). Chen and Zhao (2009) note that if discount rate news cannot be accurately measured, then estimates of cash flow news will inherit the mispecification of the return prediction model. They suggest modeling cash flow news directly. We follow their suggestion in this section.

In our analysis, estimation error in the discount rate news component of returns could potentially lead us to erroneously attribute the secular increase in the correlation of global stock returns to changes in the correlation of discount rate news. To attenuate this concern, we have collected four proxies of aggregate country equity cash flows, estimated univariate models for each one of them, and computed rolling cross-country correlations of the innovations of each proxy measure of equity cash flows. Specifically, we compute correlations of innovations to real GDP growth, real consumption growth, real industrial production growth, and real earnings growth. Section E of the Appendix reports full details of the data and the estimation procedure.

Figure 9 reports the results of this analysis. None of the four 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%-25%. 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. The plots in Figure 9 suggest that it is hard to attribute the observed increase in the correlation of global stock returns to increased correlations of cash flow fundamentals. Therefore, if it is not the result of increased correlation of fundamentals, the increased correlation of global stock returns 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. The literature on optimal intertemporal portfolio choice with stochastic volatility (Chacko and Viceira, 2005, Liu, 2007, Moreira and Muir, 2017a and 2017b[33]) 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. However, empirical calibrations of these models based on univariate models of stochastic volatility find that volatility shocks are not persistent enough to generate significant horizon effects in portfolio choice.

This view has been challenged recently by Campbell, Giglio, Polk, and Turley (2017, CGPT henceforth). CGPT estimate a heteroskedastic multivariate VAR that includes realized volatility in the state vector and document the existence of persistent shocks to U.S. stock market volatility tied to shocks to the default spread in corporate bonds. They show evidence that volatility news is an independent source of risk that helps explain the cross-section of expected stock returns in the U.S., in addition to cash flow shocks and discount rate risk.

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. smaller at long horizons when volatility shocks are transitory. We examine next whether volatility shocks are correlated across markets, and whether this correlation has changed over time.

We estimate volatility news for the stock markets included in our sample following CGPT two-stage heteroskedastic-VAR methodology. We expand our baseline specification of the state vector (26) to include the default spread and stock market return variance for each of the countries included in our sample. The default spread is the yield spread of low-rated corporate bonds over high-rated corporate bonds. We construct our international sample of default spreads building on the work of Kang and Pflueger (2015). A caveat to keep in mind is that unfortunately the corporate bond market is not nearly as developed and deep in many countries as it is in the U.S., and consequently high-quality data on yields on corporate bonds of different credit quality is not as readily available in other countries as it is in the U.S. The Appendix describes in detail our data sources and data construction procedures.

Following CGPT, we start our estimation of volatility news with individual country regressions of realized stock market return variance on its own lagged value and the lagged value of the other state variables included in the VAR. Monthly realized stock market variance is based on within-month daily stock market returns denominated in U.S. dollars. We use the fitted value of variance from this regression as a proxy for the stock market return variance component of the state vector. We then estimate a heteroskedastic VAR for each country. The heteroskedastic component of the VAR is specified such that the volatility of stock returns drives time-variation in the volatility of all innovations. We use Weighted Least Squares with shrinkage to estimate both the first stage regression and the VAR. The Appendix shows the estimation results.

Our estimates show that both realized and expected stock market return variance and the default spread are persistent variables in each country. As expected, the default spread forecasts stock market return variance with a positive and statistically significant coefficient in Australia, Germany, the U.K., and the U.S. However, it forecasts variance with a negative and statistically significant coefficient in Japan, and it is not a statistically significant predictor of variance in France and Canada. Our caveat about data availability and quality might play a role in these estimation results.

The VAR estimates allow us to extract estimates of cash flow news, discount rate news, and volatility news for each country. CGPT show that volatility news is a scaled version of news about risk implied by the stochastic discount factor of an investor with Epstein-Zin preferences, where risk is defined a the change in the expected variance of future log returns plus the log stochastic discount factor. Therefore, volatility news correlations also describe correlations of news about risk. Of course, each news component exhibits the common time-varying volatility component of the innovations to the VAR.

Figure 10 plots the time series of the 3-year moving average of average cross-country correlations of volatility news for expected variance (Panel A) and the average cross-country correlations of innovations to realized stock return variance from the first stage regression (Panel B). 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.

Panel A in Figure 10 shows that the cross-country correlation of volatility news has been very low on average and fairly stable over time. There are two exceptions to this pattern: The correlation raised to about 50% around 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.

To understand the implications of the results in Figure 10 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. (The Appendix describes in detail how we have extended the model and calibrated it.) Figure 11 plots the annualized global portfolio risk generated by the model as a function of investment horizon under different scenarios: Different degrees of persistence in volatility (Panel A and Panel B) and uncorrelated (left plots) or correlated volatility (right plots) across countries.[22] Each panel in the figure considers a different degree of persistence in volatility, 0.90 (Panel A) and 0.99 (Panel B).

The left column of each panel in Figure 11 shows the impact on portfolio risk of adding stochastic volatility to a model with constant volatility in a scenario in which volatility shocks are uncorrelated across countries. The solid lines in the plots correspond to the model with constant volatility. These are the lines shown on Panel B of Figure 4. This column shows that stochastic volatility increases portfolio risk at all horizons, especially at short horizons. The increase in market risk is more pronounced as volatility becomes more persistent.

The right column of each panel in Figure 11 shows the impact of correlated stochastic volatility shocks. The solid lines in the plots correspond to the case with stochastic volatility with uncorrelated volatility shocks. These are the dashed lines on the left column. These plots show that correlated volatility further increases portfolio risk, especially at long horizons. However, this increase is significant only when volatility shocks are highly persistent and correlated cash flow news is the source of correlated returns across countries. In that case, correlated volatility shocks amplify the effect of cash flow news correlation on portfolio risk at long horizons.

These results suggest that stochastic volatility shocks increase portfolio risk at all horizons when they are highly persistent. However, allowing for correlated volatility shocks has only a small added impact on portfolio risk, except if returns are also correlated across countries, and the source of this correlation is correlated cash flow news. This scenario is not empirically plausible, because the main source of correlation in returns is correlated discount rate news, not correlated cash flow news. Therefore, these results suggest that while stochastic volatility increases portfolio risk at all horizons, this risk doesn't necessarily increase more during periods in which risk becomes more correlated across markets, as in the two episodes documented in Figure 10. In light of this last consideration, we proceed with our empirical analysis assuming away time variation in volatility. That is, we present results based on the homoskedastic VAR model of Section 4.

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

Section 4 presents robust empirical evidence of an economically and statistically significant increase in the cross-country correlations of stock and bond excess returns between 1986-1999

[22]Since there is no analytical expression $\sqrt{V_t[r^{(k)}_{p,t+k}]/k}$, we evaluate it through simulation. See Appendix for details.

and 2000-2016, driven primarily by an increase in the cross-country correlations of discount rate news in both markets. It also documents a substantive increase in the cross-country correlation of inflation innovations that determine cash flow news of nominal bonds.

We have shown in Section 3 that an increase in cross-country return correlations affects portfolio risk and portfolio choice at long horizons differently depending on the source of such increase—correlated cash flow news or correlated discount rate news. Accordingly, we now explore the implications of our empirical results for portfolio risk and optimal global portfolio diversification at long horizons.

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

We start with an analysis of portfolio risk across investment horizons of all-equity and all-bond portfolios. We consider both equal-weighted (EW) and value-weighted (VW) portfolios of the seven markets in our sample. We set the weights for both the all-equity and the all-bond value-weighted portfolios equal to the relative stock market capitalization values at the inception of our sample in January 1986: 1.51% (Australia), 2.83% (Canada), 5.22% (France), 5.07% (Germany), 16.09% (Japan), 10.38% (U.K.), and 58.88% (U.S.). This choice of weights implies that the results for the value-weighted portfolios are largely dominated by the U.S. market experience. This is a reason why we also consider an equal-weighted portfolio. We compute portfolio risk for two subperiods: 1986.01-1999.12, and 2000.01-2016.12

Figure 12 presents results for stock portfolios. Panel A plots the percent annualized standard deviation of portfolio excess returns, $100 \times \sqrt{(12/k)\, V_t[xr^{(k)}_{p,t+k}]}$, implied by our VAR estimates for each subperiod as a function of investment horizon k. The panel shows that the risk of a globally diversified equity portfolio is about the same at short horizons in both subperiods, but it is significantly lower at longer horizons in the second subperiod. For example, at a 1-month horizon, the risk of the VW portfolio is similar in both samples at about 14% p.a.; at a 25-year horizon (300 months), the risk of the portfolio is 9.3% p.a. in the early sample and 7.6% p.a. in the late sample. This is an economically significant difference, especially when compounded over 25 years.

The portfolio risk decomposition (15) is helpful to understand the sources of this change in long-run portfolio risk across subperiods. This decomposition shows that changes in portfolio risk result from either changes in cross-country return correlations or changes in return volatility (or both). Panel B and Panel C report the results from performing this decomposition.

Panel B in Figure 12 plots the cross-country average of conditional k-horizon excess return volatility implied by our VAR estimates, in percent annual terms:

$$100 \times \sum_{i=1}^{N} \left(\frac{w_i}{\sum_{i=1}^{N} w_i} \right) \sqrt{\frac{12}{k} V_t[xr^{(k)}_{i,t+k}]},$$

where w_i equals either market i capitalization weight (VW portfolio) or 1/7 (EW portfolio).

The panel shows a declining pattern in average excess return volatility as a function of investment horizon in both samples. This reflects the well-known dampening effect of return predictability on long-horizon return volatility at the individual market level. The panel also shows that the average excess return volatility is lower in the late sample than in the early sample at all investment horizons.

This fall in excess return volatility at all horizons in the late period is to large extent the result of a significant increase in the degree of stock return predictability in this period.[23] The early period includes the second half of the 1990's, a period of a sharp rise in valuations relative to fundamentals that weakened the empirical evidence on return predictability, while the late period includes the subsequent correction that strengthened the empirical evidence on stock return predictability (Cochrane, 2008). It also reflects, to a lesser extent, a small decline in one-period return volatility in some stock markets in the late period (see Table 1).

Panel C in Figure 12 plots the percent cross-country average of pairwise conditional correlations of k-horizon excess returns:

$$100 \times \sum_{i=1}^{N} \sum_{j=i}^{N} \left(\frac{w_i w_j}{\sum_{i=1}^{N} \sum_{j=i}^{N} w_i w_j} \right) Corr_t[xr_{i,t+k}^{(k)}, xr_{j,t+k}^{(k)}],$$

where w_i equals either market i capitalization weight (VW portfolio) or 1/7 (EW portfolio).

The panel shows that cross-country return correlations decline as investment horizon increases in both subperiods, and that this decline is significantly more pronounced in the late subperiod. At long horizons, there is no increase in return correlations in the late period relative to the early period. The declining pattern in both samples is a direct result of the fact that discount rate news explains a large fraction of the correlation of returns, as show in Table 3. Section 3 shows that the impact of correlated transitory discount rate news on return correlations declines at long horizons. Table 3 also shows that discount rate news has become more correlated in the second subsample but cash flow news has not. This explains why return correlations are significantly larger at shorter horizons in the late period relative to the early period (72% versus 52%), but not different at long horizons (35%).

In summary, two factors explain the pattern of change in the risk of global equity portfolios at different horizons from the 1986-1999 period to the 2000-2016 period. First, return predictability appears to be stronger in the second subperiod, and this implies reduced long-term stock market return volatility at all horizons. Second, financial globalization has resulted in increased cross-country correlations of discount rate news, which increase risk at short horizons but not at long horizons.

[23]Note that we keep the slope coefficients of the VAR the same across samples. Therefore this effect on within-country return volatility is essentially the result of the correlation of unexpected excess stock returns and shocks to expected excess stock returns becoming more strongly negative in the late sample.

To isolate the effect of cross-country correlations on global portfolio risk, we have re-estimated the overall variance-covariance matrix of VAR innovations across all countries in the late subperiod subject to the constraint that its block diagonal—i.e., the variance-covariance matrix of innovations for each country—remains at the same values as in the early subperiod.[24] This ensures that we hold constant the conditional variance of k-period excess returns across periods, while we allow cross-country correlations to vary.

Figure 13, whose structure is similar to that of Figure 11, shows the results of this counterfactual exercise. Panel A in the figure shows that, holding constant country k-horizon excess return volatility, global equity portfolios are riskier in the late period relative to the early period at horizons up to 12 years, but less risky at longer horizons. Panel B confirms that we are indeed holding return volatility constant across periods. Panel C shows the constrained estimate of the average cross-country return correlation as a function of investment horizon. Estimated short-term cross-country return correlations are about the same as in the unconstrained estimation case, but long-term correlations are signficantly lower. This is consistent with the fact we have documented in Table 3 that the increase in global equity return correlations in the second subperiod is the result of increased correlation of transitory discount rate news, whose impact on return correlations abates as horizon increases.

Figure 14 presents results for global bond portfolios. Panel A in the figure shows that, similar to equities, the risk of internationally diversified bond portfolios is decreasing as a function of investment horizon in both sample periods. However, unlike equities, portfolio risk has gone up in the second subperiod for all investment horizons. Panel B shows that volatility effects cannot explain this increase, as the average country volatility of k-horizon bond excess returns has declined in the second period relative to the first for all investment horizons. Thus the effect has to be entirely the result of increases in cross-country correlations of bond excess returns. Indeed Panel C shows that the average cross-country correlation of k-horizon bond excess returns is substantially larger in the late sample than in the early sample at every horizon (60% vs 20% at long horizons).

Once again, the symmetric model in Section 3 and the empirical results in Table 4 help understand the patterns shown in Figure 14 as a result of the increase in the cross-country correlation of inflation shocks. The model in Section 3 shows that cross-country correlations of persistent cash flow shocks impact k-horizon return correlations at all horizons similarly. For bonds, cash flow shocks are inflation shocks, and Table 5 shows that the cross-country correlations of bond cash flow news—i.e., inflation—have experienced a significant increase in the late subperiod.

[24]It is important to note that direct substitution of the within-country covariance matrices of VAR innovations in the late sample with those in the early sample does not guarantee that the resulting overall variance-covariance matrix is properly defined in the sense that it is a positive-definite matrix. To ensure this basic property of variance-covariance matrices we use semidefinite programming methods to re-estimate the cross-country components of the overall variance-covariance matrix subject to the constraint the within-country components take values equal those of the early sample. See Appendix G for a description of the semidefinite programming method we use.

Therefore, the increase in the cross-country correlation of inflation shocks has exacerbated the risk of internationally diversified bond portfolios at all horizons in the late period, reducing the benefits of global portfolio diversification in bonds for long only investors. However, arguably the opposite is true for investors with long dated liabilities, which are equivalent to a short position in bonds, such as pension funds. The change in cross-country correlations of bond returns implies that these investors can use global bonds to hedge their liabilities. This can be particularly beneficial for investors whose local bond market is relatively small.

6.2 Optimal Global Equity Portfolio Diversification at Long Horizons

Section 6.1 shows that the long-run risk of globally diversified equity portfolios has not increased in the 2000-2016 period relative to the earlier 1986-1999 period, despite a significant increase in the cross-country correlations of one-period excess stock returns. This result holds even after controlling for the effects on long-run portfolio risk of declining long-run return variances. By contrast, the long-run risk of globally diversified bond portfolios has increased.

These results suggest that the secular increase in the correlations of global equity and bond markets has not diminished the benefits of global portfolio diversification for long-horizon equity investors, although they have diminished the benefits of global bond portfolio diversification. We now explore this insight in the context of models of intertemporal portfolio choice.

We compute optimal intertemporal portfolio allocations to cash and global equities as well as expected utility implied by our estimates of return dynamics in each subperiod. We do so for two types of investors. The first one is the investor we consider in Section 3.4, that is, an investor with power utility preferences over terminal wealth at a finite horizon (Jurek and Viceira, 2011). We refer to this investor as the "JV investor." For calibration purposes we set the investment horizon of the JV investor to 20 years and the value of the coefficient of relative risk aversion to 5.

The second investor is the infinitely lived investor with Epstein-Zin utility over intermediate consumption considered in Campbell and Viceira (1999) and Campbell, Chan, and Viceira (2003). We refer to this investor as the "CCV investor." We set the elasticity of intertemporal substitution of consumption of this investor to one, the coefficient of relative risk aversion to 5, and the time discount factor to 0.92. This choice of parameters implies that the investor optimally consumes each period a constant fraction of his wealth equivalent to an annual 8% rate.[25]

[25]We solve for the optimal intertemporal portfolio allocation of this investor building on the approximate solution methods of Campbell and Viceira (1999) and Campbell, Chan, and Viceira (2003). They show that the optimal intertemporal portfolio policy for this investor is an affine function of the vector of state variables similar to the solution in Jurek and Viceira (2011) that has two componets, a myopic or one-period component and an intertemporal hedging component.

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 (left panel) or the VW global equity portfolio (right panel), 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.

Table 8 and Table 9 report optimal global equity portfolio allocations and expected utility respectively for the two investors in each subperiod. The first numerical column in each panel of Table 8 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 the JV investor and the CCV investor, respectively. Table 9 reports expected utility expressed as a certainty equivalent of wealth for a JV investor at horizons of 5, 10, 15, and 20 years, and expected utility per unit of wealth for the CCV investor. Each panel in Table 9 has two rows. The first row reports certainty equivalent of wealth and expected utility for each investor under the constrain that the investor can invest only in U.S. equities. The second reports these metrics when the investor has access to all seven equity markets.

Panel A in Table 8 reports portfolio allocation results for the early sample. By construction, the myopic allocation is 100% invested in either the EW equity portfolio or the VW 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. The intertemporal hedging demand of the CCV investor is smaller than that for the JV investor because, although the CCV investor is infinitely lived, his investment horizon is effectively shorter. To see this, note that the CCV investor consumes every period, while 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.

The relative composition of the intertemporal hedging allocation across markets is qualitatively similar for both investors. Their optimal intertemporal portfolio demands tilt total portfolio demand toward U.S. equities, and to a smaller but still significant degree, toward German and Japanese equities.

Panel A in Table 9 shows very large gains in expected utility for long-horizon investors from the ability to invest globally. 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 a similar investor able to invest only in the U.S. stock market. Moreover, for the JV investor, welfare gains increase exponentially with investment horizon: The gain from having access to seven markets is proportionally much larger at at 20-year horizon than at a 10-year horizon.[26]

Panel B in Table 8 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. The increase in the cross-country correlations of one-period returns generates a one-period myopic allocation with long and short positions. For example, the VW portfolio shows a significant increase of the myopic allocation to U.K. and Australian equities, funded by a short position in German equities and cash. Investors optimally choose levered equity portfolios, illustrating the fact that increased correlations do not necessarily imply less willingness to hold risky assets in a portfolio in the absence of borrowing and short-selling constraints. Panel B also shows a significant increase in intertemporal hedging demands for stocks in the late sample, at 166% for the JV investor and 106% for the CCV investor in the VW case. The corresponding panel in Table 9 shows that expected utility also increases dramatically for both investors relative to the early sample.

The portfolio risk decomposition of Section 6.1 is helpful to understand the changes in intertemporal hedging demand and the welfare gains in the late period with respect to the early period. We have shown that the late sample is characterized by both a significant increase in cross-country correlations of one-period stock excess returns and a significant decrease in country volatility of stock excess returns at all horizons resulting from increased mean reversion. The first factor can be welfare increasing for an unconstrained investor. The second factor implies more willingness to hold risky assets in a portfolio for intertemporal hedging reasons and, as shown in Campbell and Viceira (1999), it also implies large increases in expected utility. Therefore, within-country effects could explain the changes in intertemporal hedging demands and in expected utility across periods.

Panel C in Table 8 reports optimal equity portfolio allocations in the late sample holding constant within-country stock return predictability across samples as Section 6.1. 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.

Panel C in Table 8 shows that, under this constrained estimation, optimal myopic portfolio demand is somewhat smaller in the late sample than in the early sample, but intertemporal hedging demands stay at about the same level. The investor still holds optimally long and short positions as in the unconstrained estimation case. The corresponding panel in Table 9 shows that expected utility still increases significantly in the late sample relative to the early sample. Since we are holding within-country mean-reversion constant across samples, this welfare gain is a result of the change in the correlation structure. In fact, when comparing

[26]These large benefits of diversification are consistent with those reported in Jarek 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 can invest only in U.S. equities and cash.

Panel C to Panel B, we see that the welfare gain is even larger in the late sample is even larger in the constrained estimation case except at very long investment horizons. This is so because, although we are keeping constant within country-mean reversion, the constrained estimates of cross-country correlations approach zero at long horizons (see Panel C in Figure 12).

These results suggest again 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 substantive secular increase in the cross-country return correlation of global stock and bond markets since the turn of the 21st century, and explored its implications for portfolio risk, optimal intertemporal global portfolio choice, and the benefits of global portfolio diversification as a function of investment horizon. Our analysis builds from a framework with time-varying, mean-reverting discount rates—real interest rates and risk premia—in which asset valuations vary over time in response to cash flow news and to discount rate news, both of which can be correlated across markets.

We show empirically 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. By contrast, we don't find empirical evidence that the globalization of trade has resulted in an increase of the cross-country correlations of the second component of realized returns, cash flow shocks. We also find no evidence of an increase in the cross-country correlation of long-term volatility and risk shocks in the period of globalization. We estimate the average cross-country correlation of volatility or risk shocks to be close to zero throughout the 1986-2016 period, except for brief but significant spikes in late 1987 and during the financial crisis and its immediate aftermath.

We find that, although the increase in global stock return correlations has reduced the benefits of global portfolio diversification for short-horizon investors, long-horizon equity investors still benefit from holding internationally diversified equity portfolios in the 2000-2016 period as much as they did in the preceding 1986-1999 period, when global return correlations were much lower. 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 in fact increased.

We have shown that these results on global portfolio diversification follow from 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 the impact of an increase in the cross-country correlation of discount rate news on return correlations declines as investment horizon increases.

This differential impact derives from the permanence 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 shocks that affect valuations and returns at all horizons, while discount rate shocks are transitory shocks whose impact on valuations and returns dissipates at long horizons. Therefore, cash flow news are more relevant to long-term investors than discount rate news. 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 have also documented that the empirical evidence of 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 country return volatility effect has also contributed 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.

With respect to bond markets, we find that the significant increase in the cross-country correlation of bond returns has been driven by both increased correlation of discount rate news resulting from global capital markets integration, and increased correlation of nominal bond cash flow news resulting from increased correlation of inflation across monetary areas. Long-run cross-country bond return correlations have increased as much as short-run correlations, implying that the benefits of international bond portfolio diversification have declined as much for long-horizon long-only bond investors as for short-horizon investors. However, the increased correlation of global bond markets at short and long horizons is beneficial to investors with long-dated liabilities such as pension funds. The scope for hedging liabilities using global bonds has increased. This can be particularly beneficial to investors with large long-dated liabilities whose own domestic bond markets are small.

Finally, we have shown that the well documented negative stock-bond correlation in the U.S. since the turn of the century is a global phenomenon. We have shown that this correlation is negative not only within countries but also across countries, suggesting that the benefits of stock-bond diversification have increased in all developed markets in recent times.

Our research could expand in different directions. First, it would be interesting to document why trade globalization does not appear to have led to an increase in the global correlation of cash flow news identified from equity returns. 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 in detail that the negative stock-bond correlation is a persistent global phenomenon. Understanding the economic drivers of this phenomenon at a global scale is another potential venue of future research.

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Table 1: **Summary Statistics**

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

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.

Table 2: **Correlation Summary Statistics**

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

This table summarizes the individual country-pair correlations found in Tables 2.A, 2.B, and 2.C. Overall average correlations are computed within and across countries for the full period as well as for each subperiod.

Table 3: **Return Correlation Decomposition (Stocks Across Countries)**

		Component Correlations		
		CF (s)	RR (s)	ER (s)
Subperiod 1	CF (s)	0.41		
	RR (s)	0.03	0.39	
	ER (s)	-0.30	-0.33	0.49
Subperiod 2	CF (s)	0.47		
	RR (s)	0.28	0.63	
	ER (s)	-0.39	-0.59	0.63
Difference	CF (s)	0.06		
	RR (s)	0.25	0.25	
	ER (s)	-0.09	-0.26	0.14
		CF (s)	RR (s)	ER (s)
p-values	CF (s)	0.18		
(bootstrap)	RR (s)	0.00	0.00	
	ER (s)	0.18	0.00	0.02
p-values	CF (s)	0.25		
(Fisher r-to-z)	RR (s)	0.01	0.00	
	ER (s)	0.18	0.00	0.03

This table decomposes the sources of global stock return correlations. Correlations among individual stock return components (i.e., cash-flow, real-rate, and expected-return 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.

Table 4: **Return Correlation Decomposition (Stocks Across Countries)**

		Component Correlations		
		CF (b)	RR (b)	ER (b)
Subperiod 1	CF (b)	0.34		
	RR (b)	-0.34	0.35	
	ER (b)	0.02	-0.01	0.20
Subperiod 2	CF (b)	0.64		
	RR (b)	-0.63	0.63	
	ER (b)	0.10	-0.08	0.42
Difference	CF (b)	0.30		
	RR (b)	-0.28	0.28	
	ER (b)	0.08	-0.07	0.22
		CF (s)	RR (s)	ER (s)
p-values	CF (b)	0.00		
(bootstrap)	RR (b)	0.00	0.00	
	ER (b)	0.20	0.24	0.00
p-values	CF (b)	0.00		
(Fisher r-to-z)	RR (b)	0.00	0.00	
	ER (b)	0.22	0.25	0.01

This table decomposes the sources of global bond return correlations. Correlations among individual bond return components (i.e., cash-flow, real-rate, and expected-return 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.

Table 5: **Return Correlation Decomposition (Bonds vs. Stocks Within Countries)**

		Component Correlations		
		CF(s)	RR(s)	ER(s)
Subperiod 1	CF (b)	0.10	-0.13	-0.46
	RR (b)	-0.94	0.98	-0.21
	ER (b)	0.66	-0.65	0.46
Subperiod 2	CF (b)	-0.27	0.24	-0.50
	RR (b)	-0.91	0.98	-0.17
	ER (b)	0.84	-0.86	0.42
Difference	CF (b)	-0.37	0.37	-0.04
	RR (b)	0.03	0.00	0.04
	ER (b)	0.18	-0.21	-0.04
		CF(s)	RR(s)	ER(s)
p-values	CF (b)	0.00	0.00	0.33
(bootstrap)	RR (b)	0.01	0.37	0.36
	ER (b)	0.00	0.00	0.37
p-values	CF (b)	0.00	0.00	0.33
(Fisher r-to-z)	RR (b)	0.05	0.41	0.35
	ER (b)	0.00	0.00	0.32

This table decomposes the sources of global bond-stock return correlations within countries. Correlations among individual return components (i.e., cash-flow, real-rate, and expected-return news) within 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.

Table 6: **Return Correlation Decomposition (Bonds vs. Stocks Across Countries)**

		Component Correlations		
		CF(s)	RR(s)	ER(s)
Subperiod 1	CF (b)	0.00	-0.01	-0.26
	RR (b)	-0.36	0.36	-0.03
	ER (b)	0.28	-0.28	0.20
Subperiod 2	CF (b)	-0.28	0.27	-0.38
	RR (b)	-0.61	0.63	-0.09
	ER (b)	0.57	-0.57	0.23
Difference	CF (b)	-0.28	0.28	-0.12
	RR (b)	-0.26	0.26	-0.06
	ER (b)	0.29	-0.29	0.03
		CF(s)	RR(s)	ER(s)
p-values	CF (b)	0.00	0.00	0.05
(bootstrap)	RR (b)	0.00	0.00	0.34
	ER (b)	0.00	0.00	0.46
p-values	CF (b)	0.00	0.00	0.11
(Fisher r-to-z)	RR (b)	0.00	0.00	0.29
	ER (b)	0.00	0.00	0.39

This table decomposes the sources of global bond-stock return correlations across countries. Correlations among individual return components (i.e., cash-flow, real-rate, and expected-return 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.

Table 7: **Average R^2 using PCs as global factors**

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

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.

Table 8: **Optimal global equity portfolio allocations**

		Value Weight Portfolio			Equal Weight Portfolio		
	Country	Myopic demand	JV hedging demand at 20 yr	CCV hedging demand	Myopic demand	JV hedging demand at 20 yr	CCV hedging demand
Panel A: Early Sample	AUS	1.51%	13.62%	6.61%	14.29%	23.12%	12.99%
	CAN	2.83%	12.50%	8.02%	14.29%	16.63%	10.96%
	FRA	5.22%	-7.25%	-3.94%	14.29%	-7.05%	-4.29%
	GER	5.07%	22.15%	13.59%	14.29%	31.66%	19.42%
	JPN	16.09%	18.62%	12.04%	14.29%	18.84%	12.04%
	UKI	10.38%	0.25%	0.66%	14.29%	-1.31%	0.60%
	USA	58.88%	52.20%	33.67%	14.29%	28.80%	18.26%
	Total	100.00%	112.09%	70.64%	100.00%	110.69%	69.98%
Panel B: Late Sample	AUS	23.09%	25.04%	18.53%	82.76%	78.37%	55.07%
	CAN	10.04%	34.31%	20.77%	23.59%	55.21%	35.26%
	FRA	12.06%	27.13%	19.72%	29.67%	29.95%	22.34%
	GER	-39.79%	-20.41%	-16.56%	-12.73%	-2.71%	-3.17%
	JPN	5.17%	22.73%	12.34%	-1.82%	18.81%	9.09%
	UKI	50.51%	4.61%	3.61%	52.44%	14.73%	8.80%
	USA	62.40%	72.43%	47.62%	-41.32%	-8.29%	-8.72%
	Total	123.47%	165.85%	106.03%	132.58%	186.07%	118.67%
Panel C: Late Sample (Hypothetical Covariance Matrix)	AUS	-9.05%	6.92%	4.02%	11.52%	5.87%	3.46%
	CAN	25.97%	2.42%	2.90%	28.37%	3.66%	1.50%
	FRA	-2.32%	17.46%	9.26%	14.67%	15.23%	8.50%
	GER	-18.95%	22.21%	10.86%	7.28%	23.30%	12.84%
	JPN	-1.51%	12.20%	7.09%	-0.35%	8.99%	6.11%
	UKI	19.72%	3.45%	1.80%	16.98%	0.44%	1.43%
	USA	82.91%	50.24%	35.50%	6.18%	59.10%	44.63%
	Total	96.77%	114.89%	71.43%	84.64%	116.59%	78.47%

The table reports optimal global equity portfolio allocations by "JV" investor and "CCV" investor. 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 (Panel A), late sample (Panel B) and late sample with hypothetical covariance matrix that controls for within-country correlation (Panel C). To make it comparable, we fix the monthly implied excess returns across these 3 scenarios. We set implied excess returns for value weight portfolio such that investor hold the myopic demand equal to market cap weight, and 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.

Table 9: **Expected Utility**

		Value Weight Portfolio					Equal Weight Portfolio				
	Number of Countries	JV W_{CE} K=60	K=120	K=180	K=240	CCV $E[V_t]$	JV W_{CE} K=60	K=120	K=180	K=240	CCV $E[V_t]$
Panel A: Early Sample	7	3.31	158.81	259.44	30296.59	0.1021	2.86	223.86	384.79	31334.84	0.1089
	1	1.85	4.01	5.33	22.91	0.0099	1.74	3.27	4.16	15.48	0.0079
Panel B: Late Sample	7	4.13	104.61	750.64	1917218.32	0.1693	3.91	137.15	799.21	3272444.57	0.2209
	1	1.83	3.98	4.91	27.45	0.0135	1.73	3.09	3.75	16.25	0.0099
Panel C: Late Sample (Hypothetical Covaricnce Matrix)	7	11.74	316.62	3005.15	690898.73	0.217	8.41	497.63	3590.55	974716.37	0.2273
	1	1.85	4.01	5.33	22.91	0.010	1.74	3.27	4.16	15.48	0.0079

The table reports the expected utility by "JV" investor and "CCV" investor, with the same optimal portfolio allocation as reported in Table 9 (across the 3 scenarios). The CCV investor has Epstein-Zin preference and the expected value function defined as $E[V_t] \equiv \frac{U_t}{W_t} = (1-\delta)^{-\psi/(1-\psi)} \left(\frac{C_t}{W_t}\right)^{1/(1-\psi)}$. We report the expected value function for CCV investor in the Table across the 3 scenarios (with EIS $\psi \to 1$ and RRA$\gamma = 5$). The JV investor's utility is power utility defined on terminal wealth $E_t[\frac{1}{1-\gamma} W_{t+K}^{1-\gamma}]$. We assume investor has initial wealth of one dollar and look at investment horizons 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, $W_{CE} = u^{-1}\left(E[u(\widetilde{W_{t+K}})]\right)$.

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.

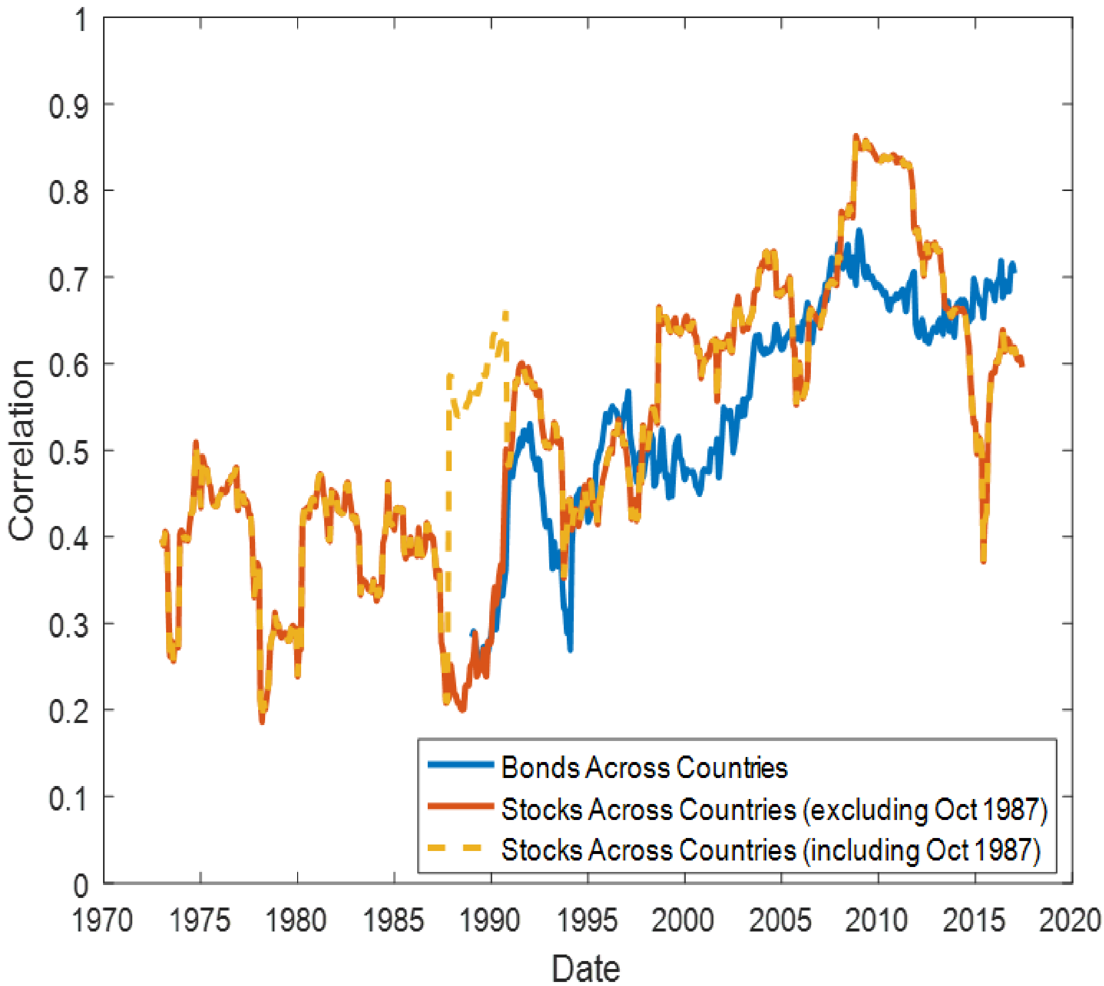


Figure 2: Stock-bond correlations across and within countries

This figure plots average stock-bond correlations across countries and within countries. Monthly averages are computed using pairwise return correlations within and 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.

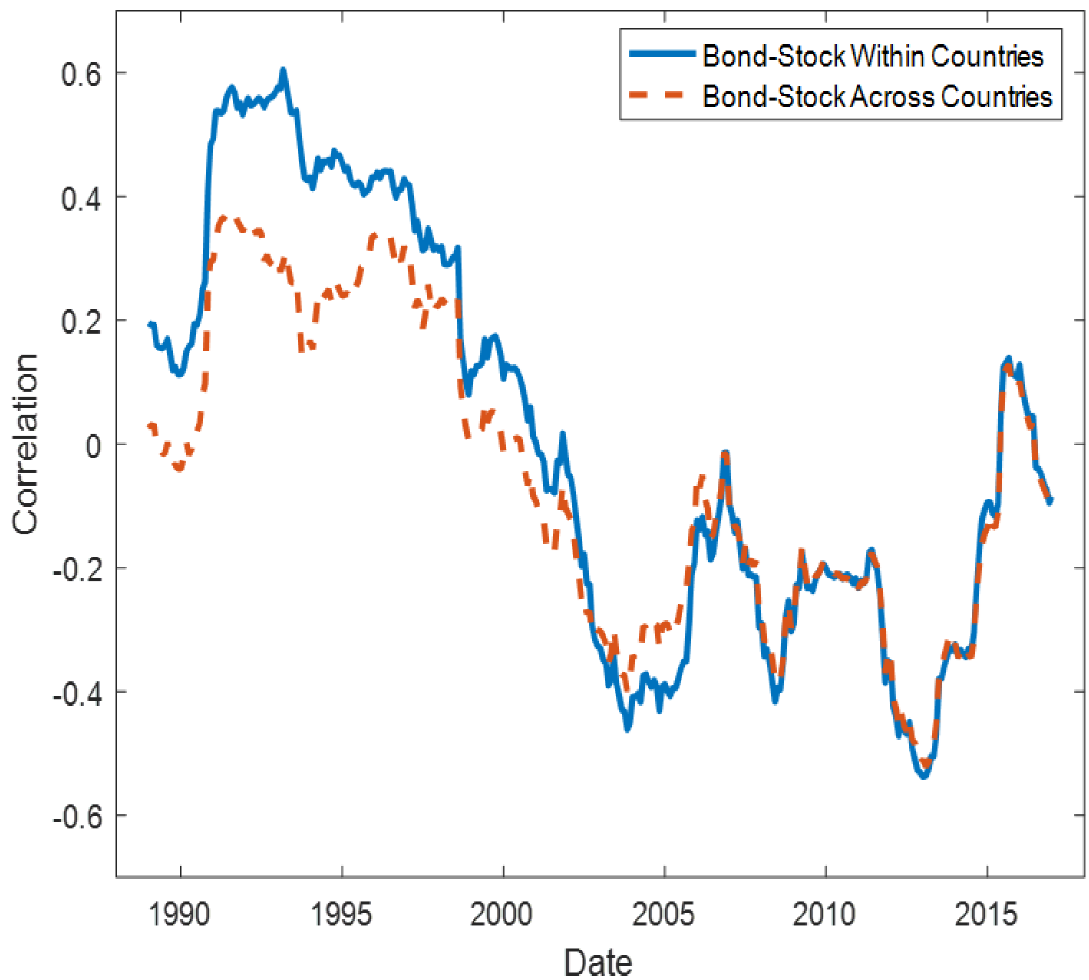


Figure 3: Coefficient on $\sigma^{xc}_{DR,DR}$ as a function of investment horizon k

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.

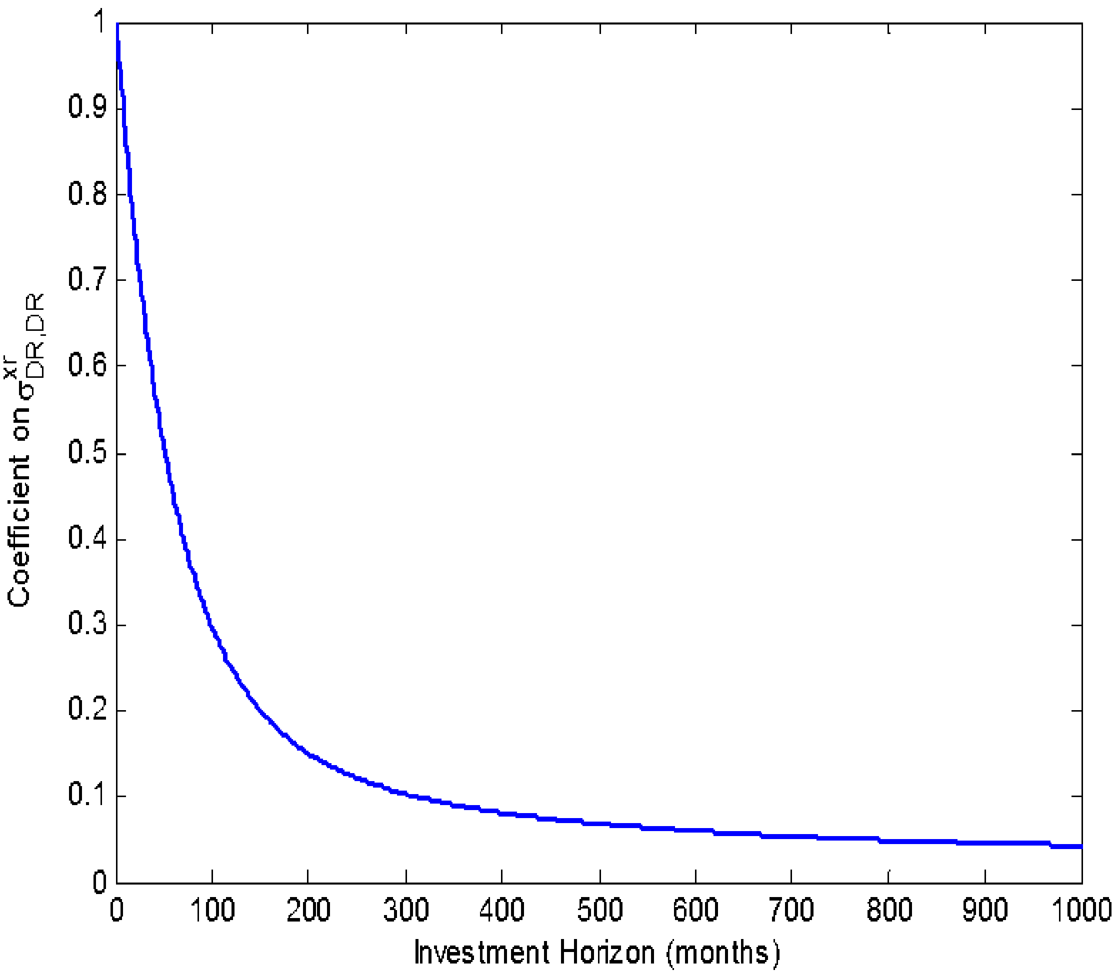
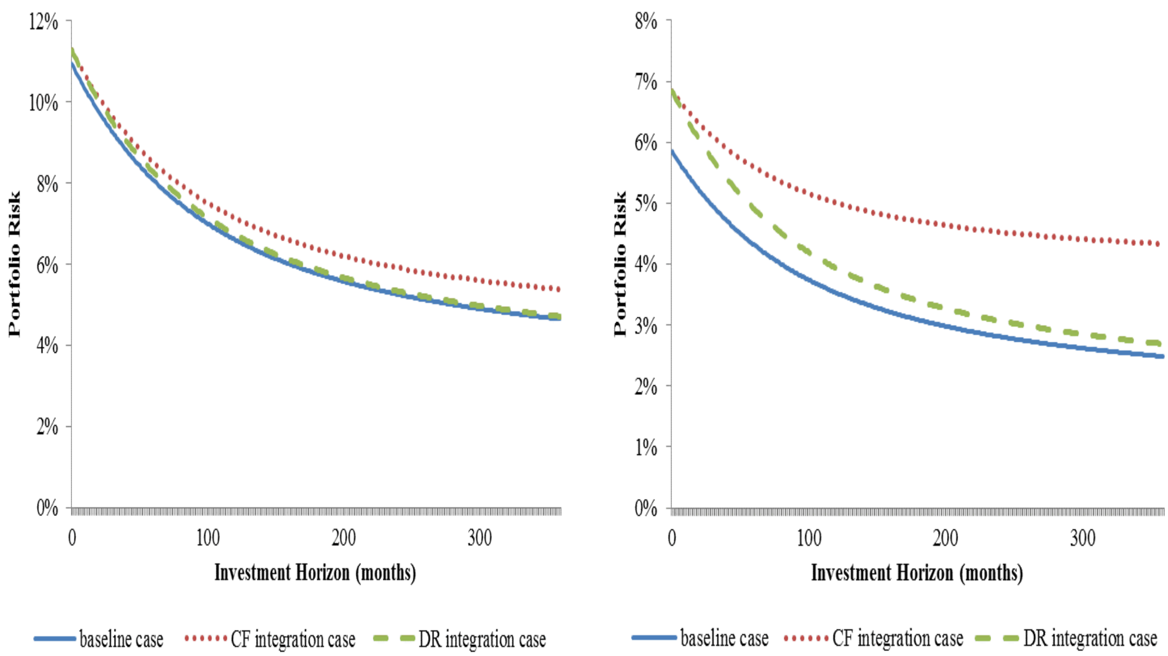


Figure 4: Annualized portfolio risk as a function of investment horizon

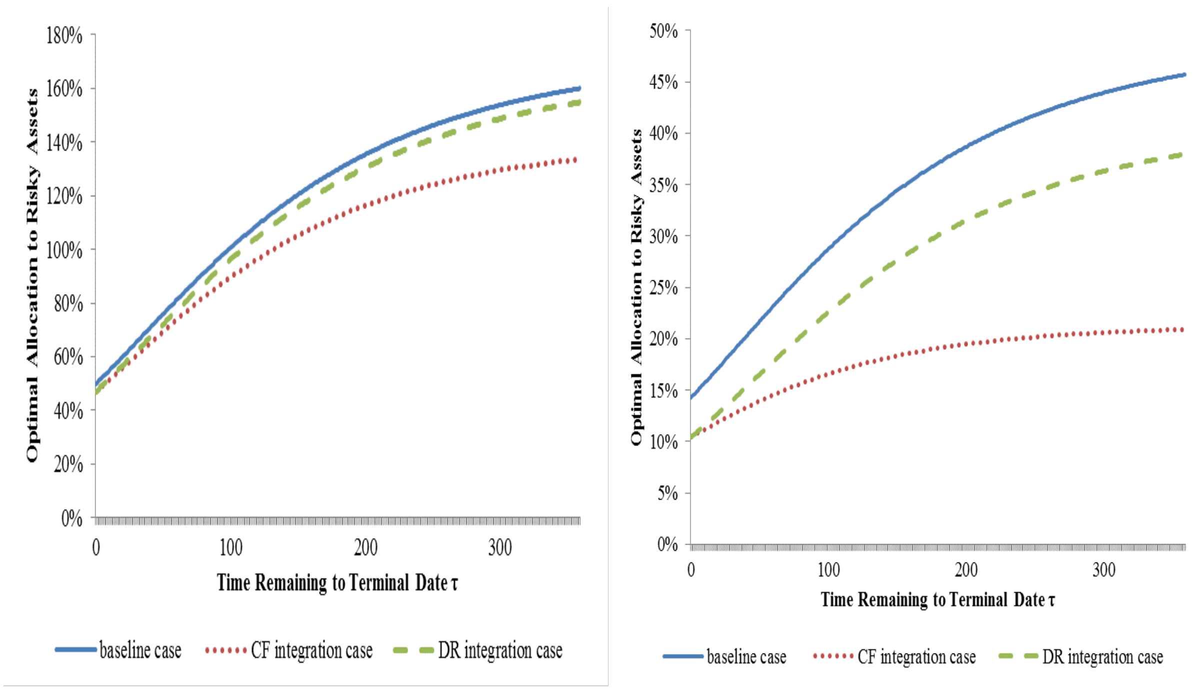
The figure plots $\sqrt{V_t(r^{(k)}_{p,t+k})/k}$ as a function of investment horizon k (months). We compare the term structure of this conditional standard deviation for 3 scenarios: (1) Baseline case with zero cross-country return news correlations, both for CF news and DR news. (2) CF news integration 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 two symmetric countries, and Panel B for a portfolio of seven countries.



Panel A (left): two symmetric countries
Panel B (right): seven symmetric countries

Figure 5: Optimal allocation to risky assets as a function of time remaining to terminal date

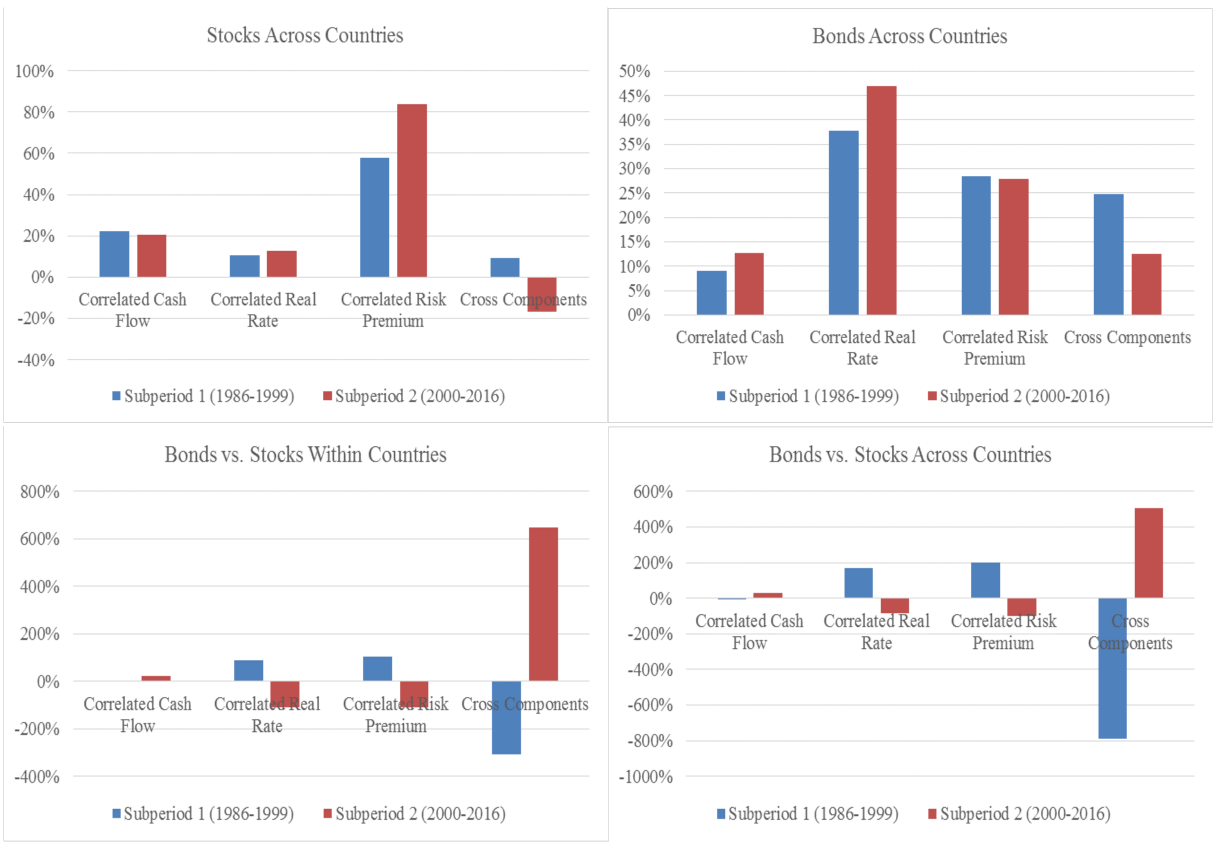
The figure plots optimal allocation to risky assets as a function of time remaining to terminal date. The total optimal allocation is the sum of two parts: myopic allocation (equals the intercept at $\tau = 1$) and hedging allocation. The investor has horizon of $k = 800$ and rebalance his allocation 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 in Figure 4. We set the expected excess returns so that in the benchmark case, the myopic investor ($\tau = 1$) allocate $1/N$ to each risky asset (50% for $N = 2$ and 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. Panel A plots optimal allocation in each case for a portfolio of two symmetric countries, and Panel B for a portfolio of seven countries.



Panel A: two symmetric countries
Panel B: seven symmetric countries

Figure 6: Relative Contribution of Covariances of Return Components to Overall Return Covariance

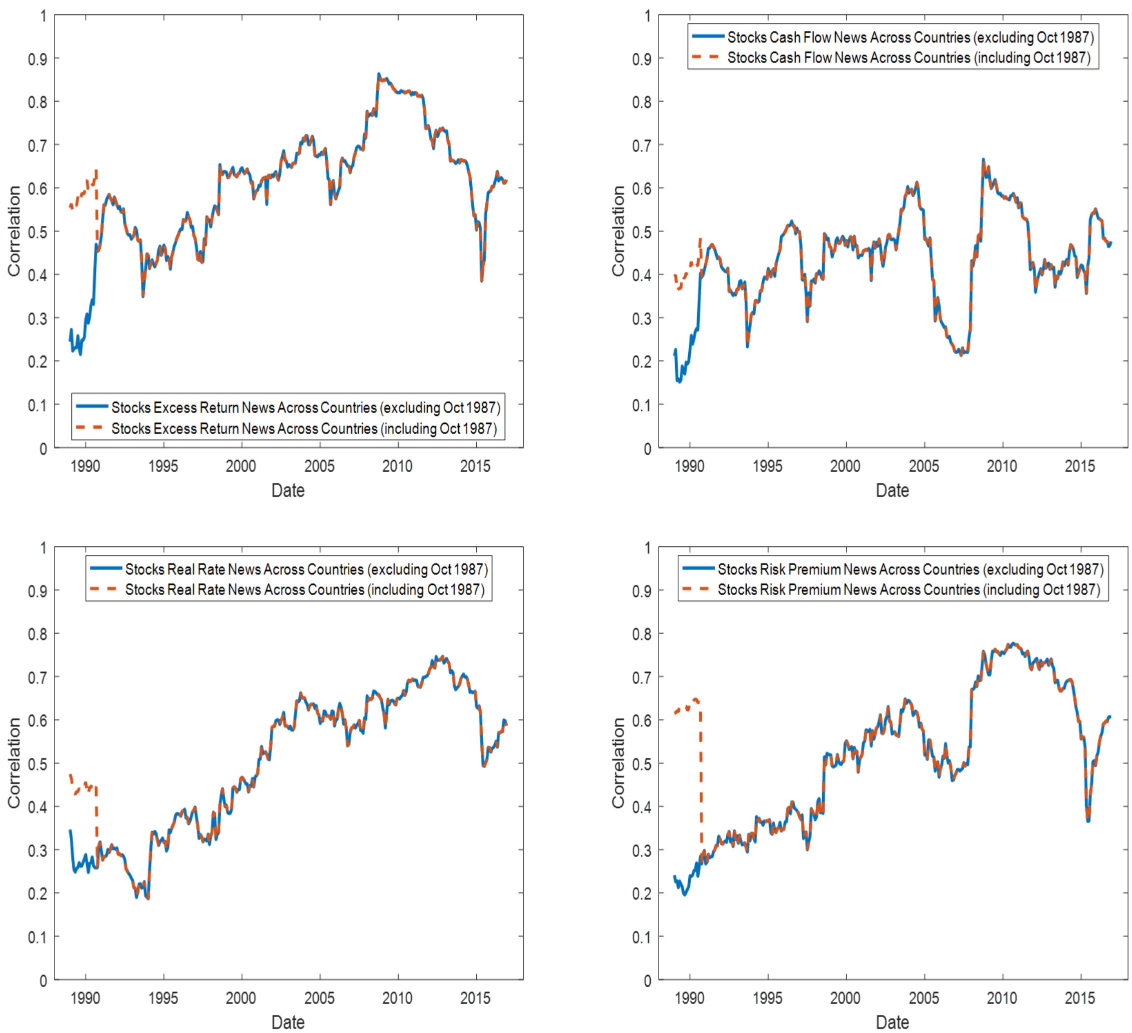
Contributions of news components to unexpected stock return correlations across countries (Panel A), unexpected bond return correlations across countries (Panel B), unexpected bond v.s. return correlations within countries (Panel C) and bond v.s. stock return correlations across countries (Panel D) are broken down in the rightmost columns. In Panel A (stocks across countries), the cash flow conponent 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 conponent 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 component contribution is calculated as $\frac{1}{N(N-1)/2}\sum_i \sum_{j\neq i} \frac{Cov(N_{ER,i},N_{ER,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}$, and the cross components is calculated as $\frac{1}{N(N-1)/2}\sum_i \sum_{j\neq i} \left(\frac{Cov(N_{CF,i},-N_{RR,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)} + \frac{Cov(N_{CF,i},-N_{ER,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)} + \frac{Cov(-N_{RR,i},-N_{ER,j})}{Cov(\tilde{xs}_i,\tilde{xs}_j)}\right)$. The component contributions in the other panels are calculated similarly. Note that by definition, values in the component contributions sum up to 1.



Panel A (upper left): Contributions of news components to overall cross-country unexpected stock return covariance
Panel B (upper right): Contributions of news components to overall cross-country unexpected bond return covariance
Panel C (lower left): Contributions of news components to overall within-country unexpected bond v.s. stock return covariance
Panel D (lower right): Contributions of news components to overall cross-country unexpected bond v.s. stock return covariance

Figure 7: 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.



Panel A (upper left): Average cross-country correlations of stock excess return news
Panel B (upper right): Average cross-country correlations of stock cash flow news
Panel C (lower left): Average cross-country correlations of stock real rate news
Panel D (lower right): Average cross-country correlations of stock risk premium news

Figure 8: 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).

Panel A (upper left): Average cross-country correlations of bond excess return news
Panel B (upper right): Average cross-country correlations of bond cash flow news
Panel C (lower left): Average cross-country correlations of bond real rate news
Panel D (lower right): Average cross-country correlations of bond risk premium news

Figure 9: 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). For GDP, IP and consumption, we include Australia, Canada, France, Germany, Japan, UK and USA in our sample. For corporate earnings, our sample covers the same set of countries excluding France, which we didn't find data.

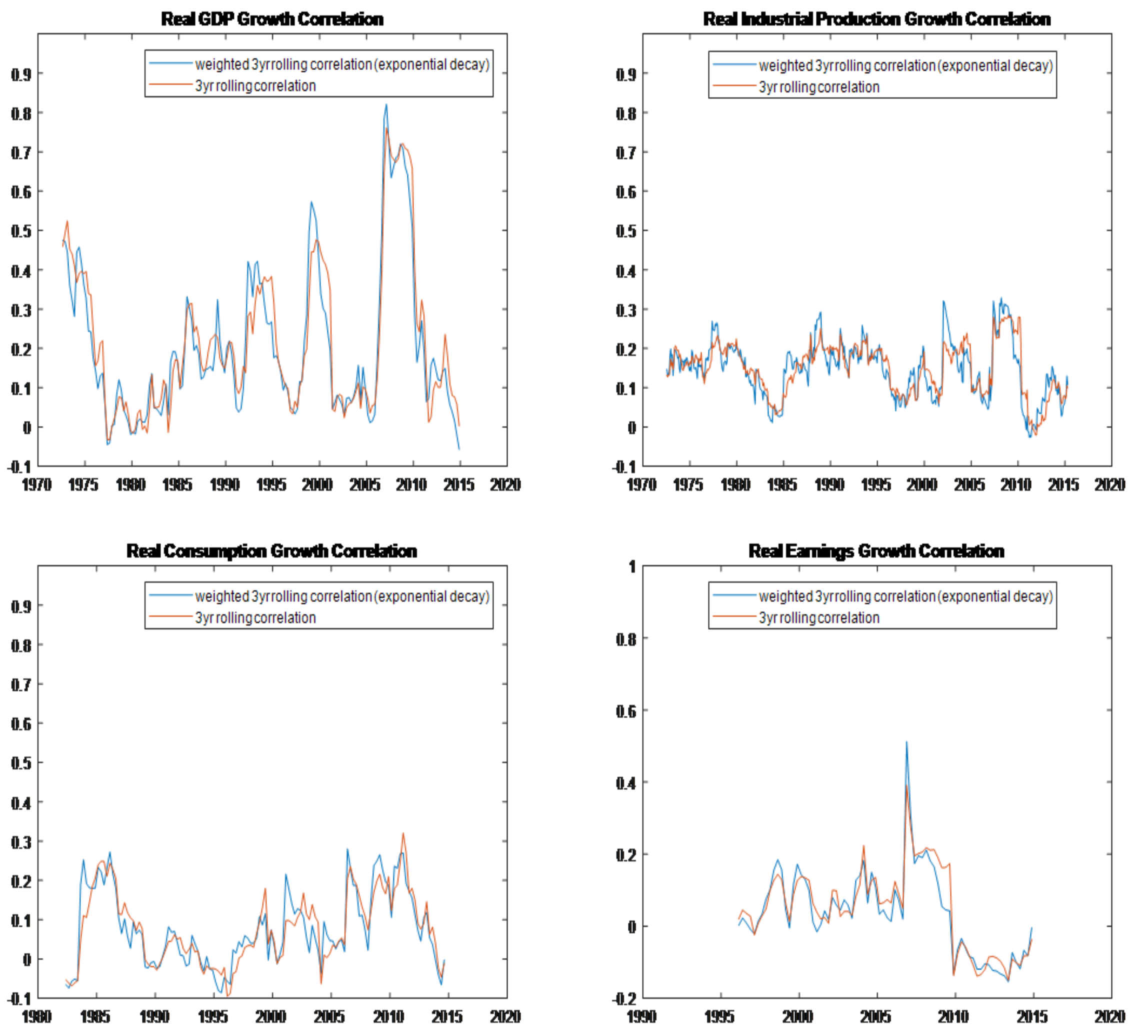
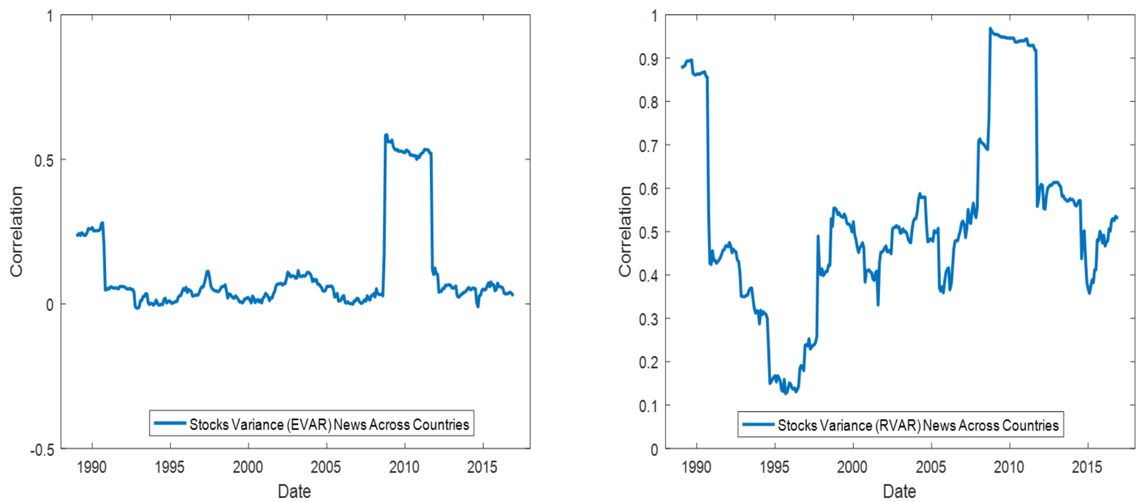


Figure 10. Cross country correlations of stock volatility news

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).



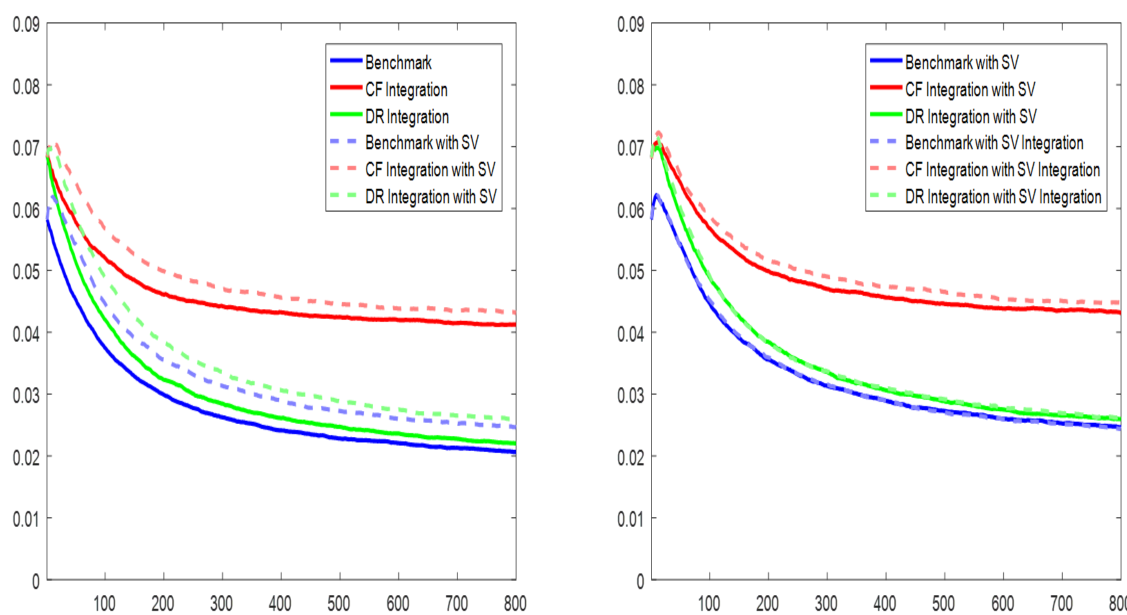
Panel A (left): Cross-country correlations of volatility news for expected variance (EVAR)
Panel B (right): Cross-country correlations of volatility news for realized stock return variance (RVAR)

Figure 11. Impact of stochastic volatility news on equity portfolio risk

This figure plots the equity portfolio risk $\sqrt{V_t[r^{(k)}_{p,t+k}]/k}$ as a function of investment horizon k. As there's no analytical expression, we evaluate it by simulating our symmetrical model with stochastic volatility (see appendix for details). The left column of each panel plots the portfolio risk in a homoskedastic symmetrical model (solid line) and in a heteroskedastic version of the symmetrical model with stochastic volatility news uncorrelated across countries (dashed line). In each version of the model, we compare the term structure of portfolio risk across 3 scenarios (as described in Figure 4). The right column of each panel plots the portfolio risk in a heteroskedastic version of the symmetrical model of Section 3 with stochastic volatility news uncorrelated across countries (solid line) and with volatility news correlated across countries (dashed line). In this version of the model, volatility follows a AR(1) process with persistence parameter ψ. Panel A is simulated with volatility persistence $\psi = 0.9$ and Panel B is simulated with $\psi = 0.99$.

Panel A: Impact of stochastic volatility news on equity portfolio risk

(volatility persistence $\psi = 0.9$)



Panel B: Impact of stochastic volatility news on equity portfolio risk

(volatility persistence $\psi = 0.99$)

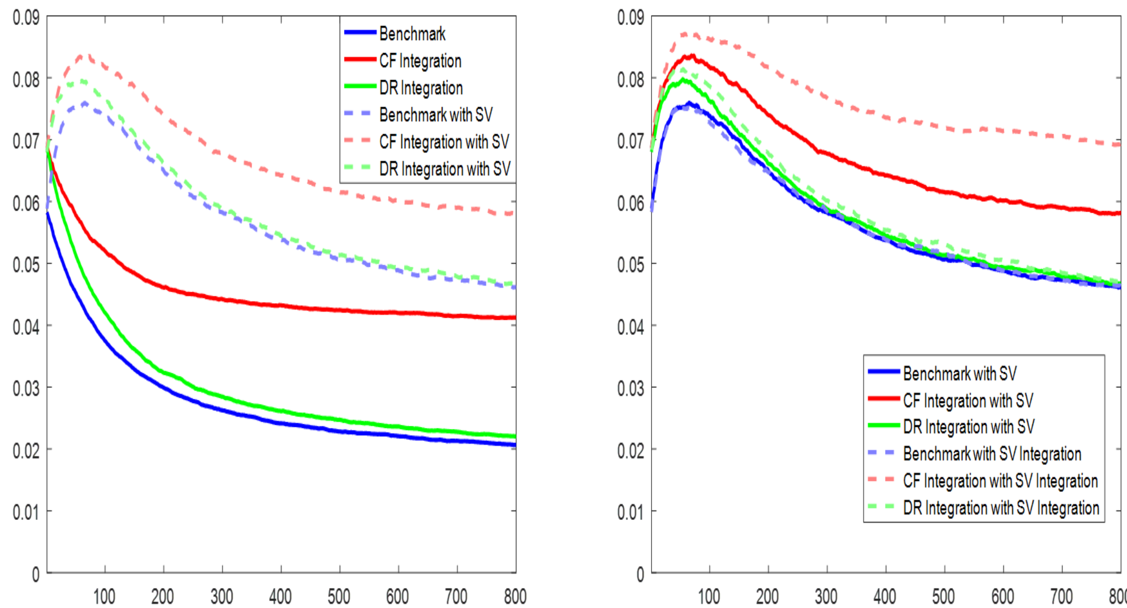
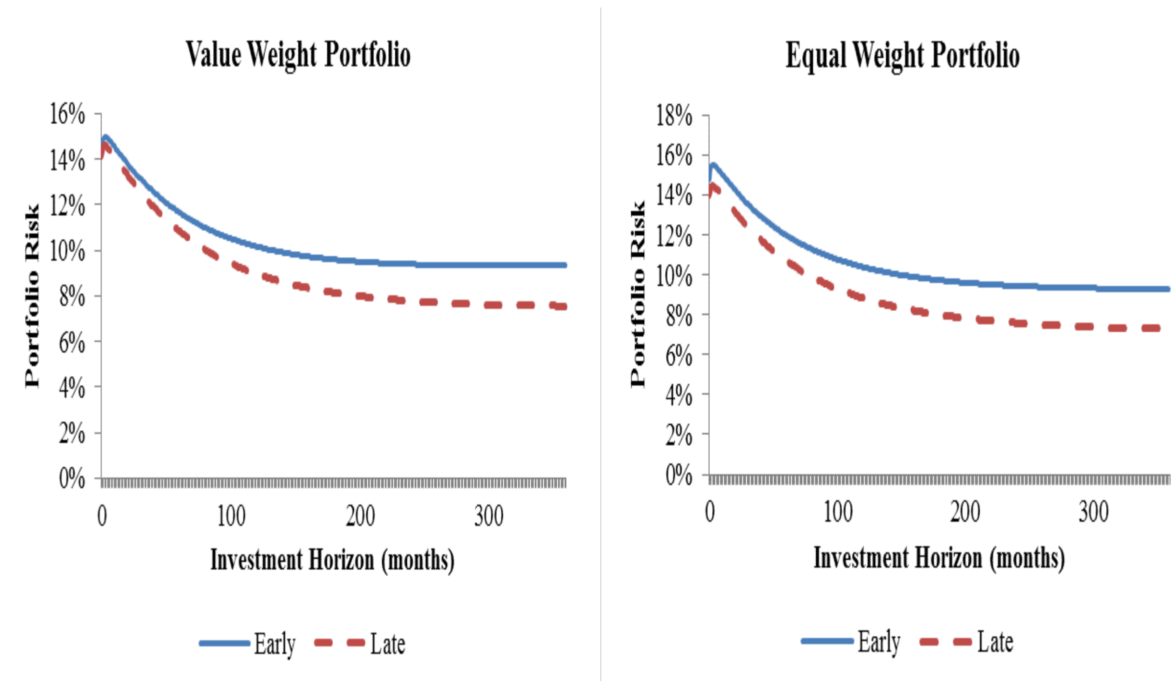


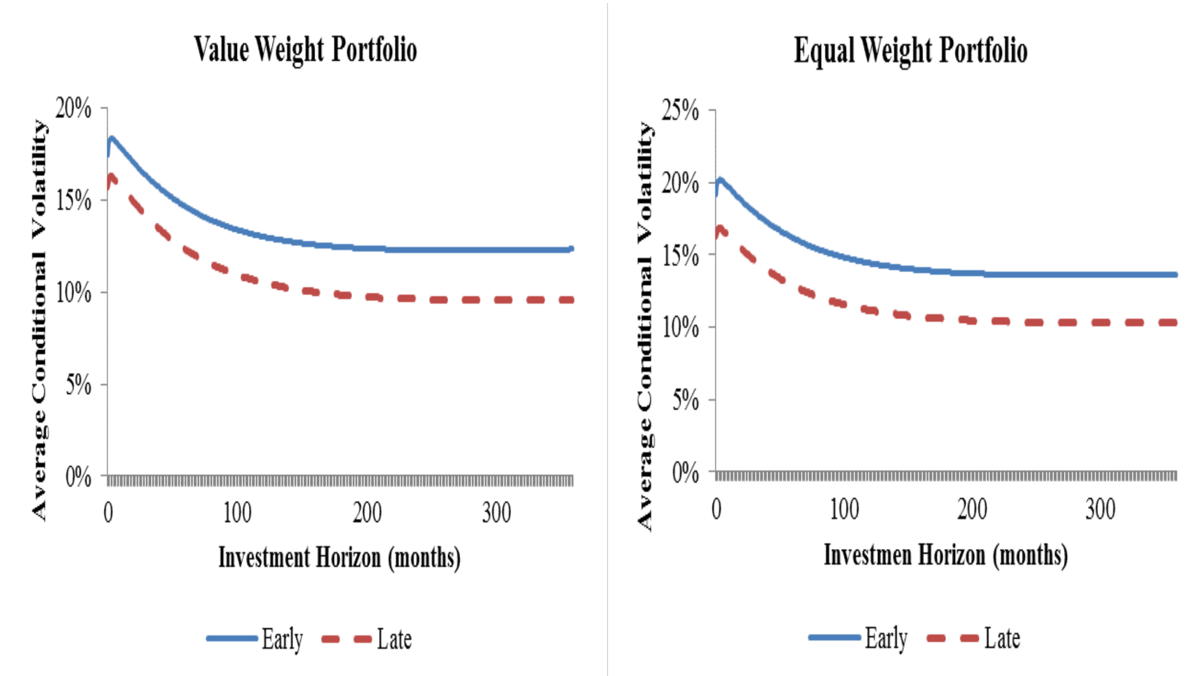
Figure 12: All-equity portfolio risk as a function of investment horizon

The figure compares the early sample (1986.01-1999.12) and late sample (2000.01-2016.12) all-equity portfolio risk across investment horizons. Panel A plots the annualized conditional standard deviation of portfolio excess returns. Panel B plots the average (across N countries) annualized k-period conditional volatility of excess returns. Panel C plots the pairwise average of cross-country k-period excess returns conditional correlation. Each panel includes the results for value-weighted and equal-weighted portfolios.

Panel A: Annualized conditional standard deviation of portfolio excess returns



Panel B: Average annualized k-period conditional volatility of excess returns



Panel C: Pairwise average of cross-country k-period excess returns conditional correlation

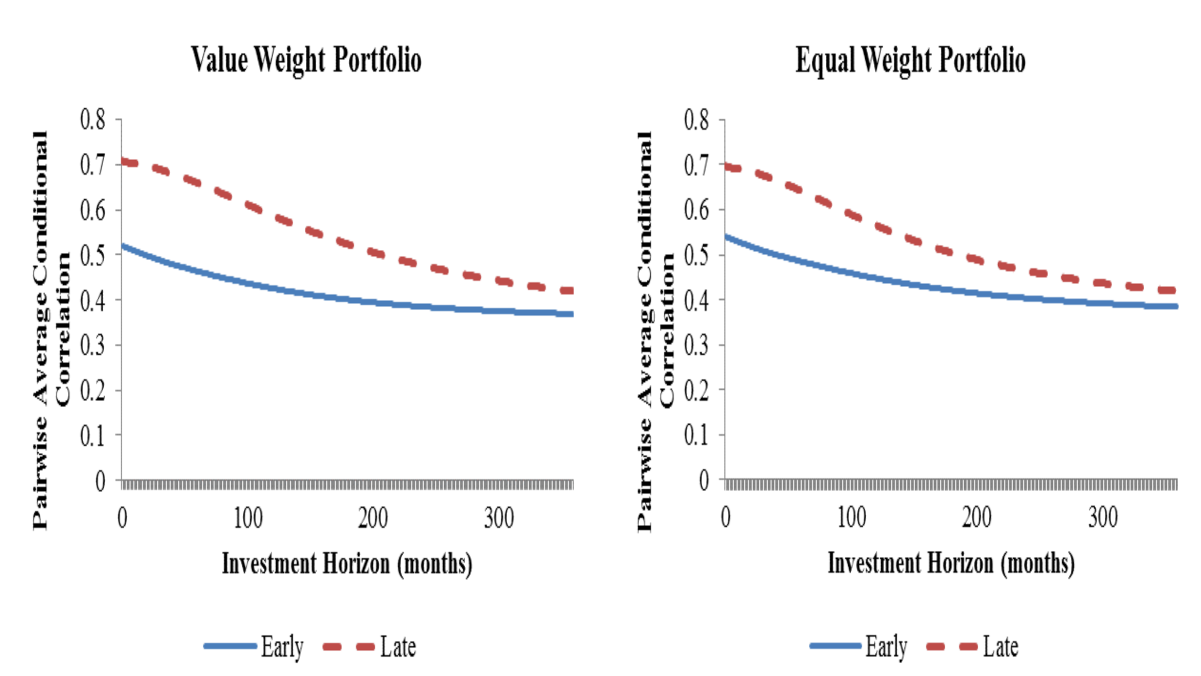
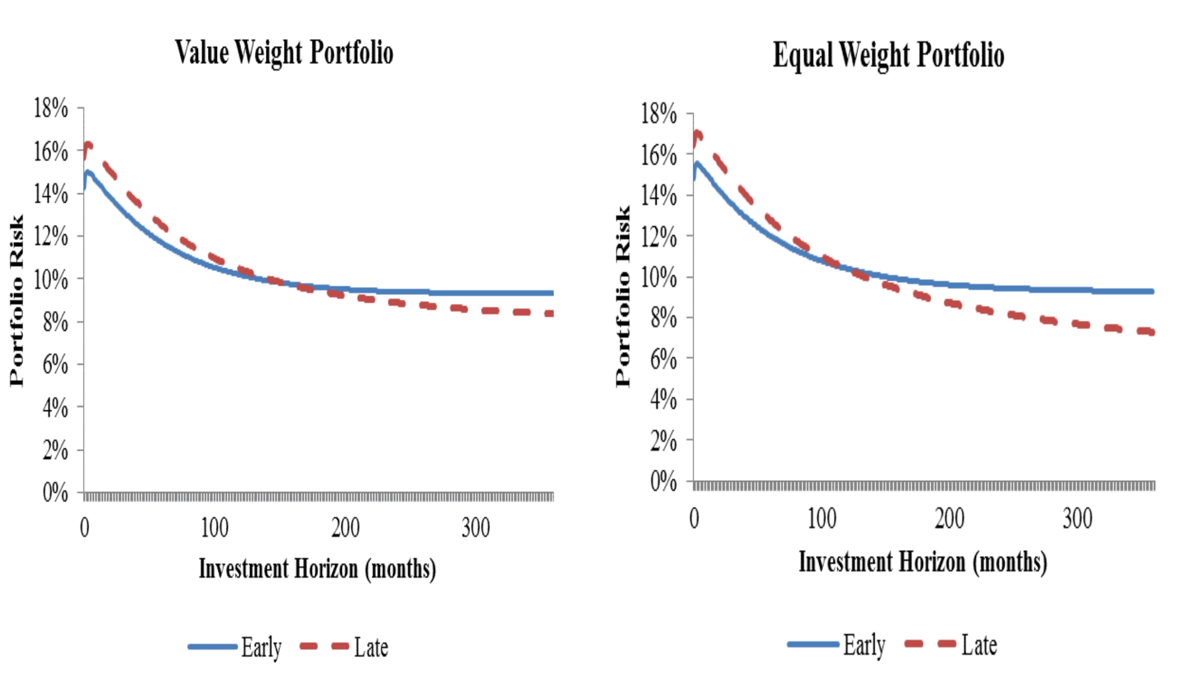


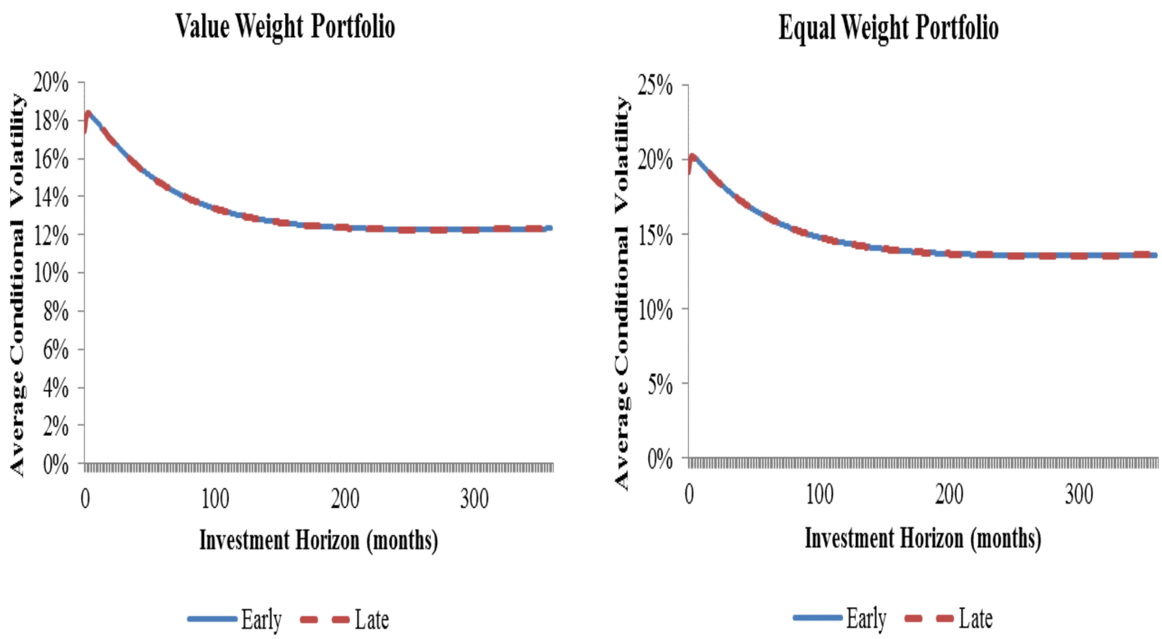
Figure 13: All-equity portfolio risk as a function of investment horizon, controlling for within-country volatility

The figure compares the early sample (1986.01-1999.12) and late sample (2000.01-2016.12) all-equity portfolio risk across investment horizons. It differs from Figure 10 in that it estimates a hypothetical late sample covariance matrix to study the effect of an increase in cross-country return correlations controlling for within-country effects. The estimation imposes two constraints: (a) all state variables have the same volatility in the early and late samples; and (b) within-country correlations are the same in the early and late samples. Given these two constraints, we estimate the cross-country correlations in the late sample covariance matrix, by minimizing the distance between late sample hypothetical covariance matrix and actual covariance matrix. To guarantee the estimated hypothetical covariance matrix is well behaved, we use the semidefinite programming (SDP) methodology. Panel A plots the annualized conditional standard deviation of portfolio excess returns. Panel B plots the average (across N countries) annualized k-period conditional volatility of excess returns. Panel C plots the pairwise average of cross-country k-period excess returns conditional correlation. Each panel includes the results for value weighted and equal weighted portfolios.

Panel A: Annualized conditional standard deviation of portfolio excess returns



Panel B: Average annualized k-period conditional volatility of excess returns



Panel C: Pairwise average of cross-country k-period excess returns conditional correlation

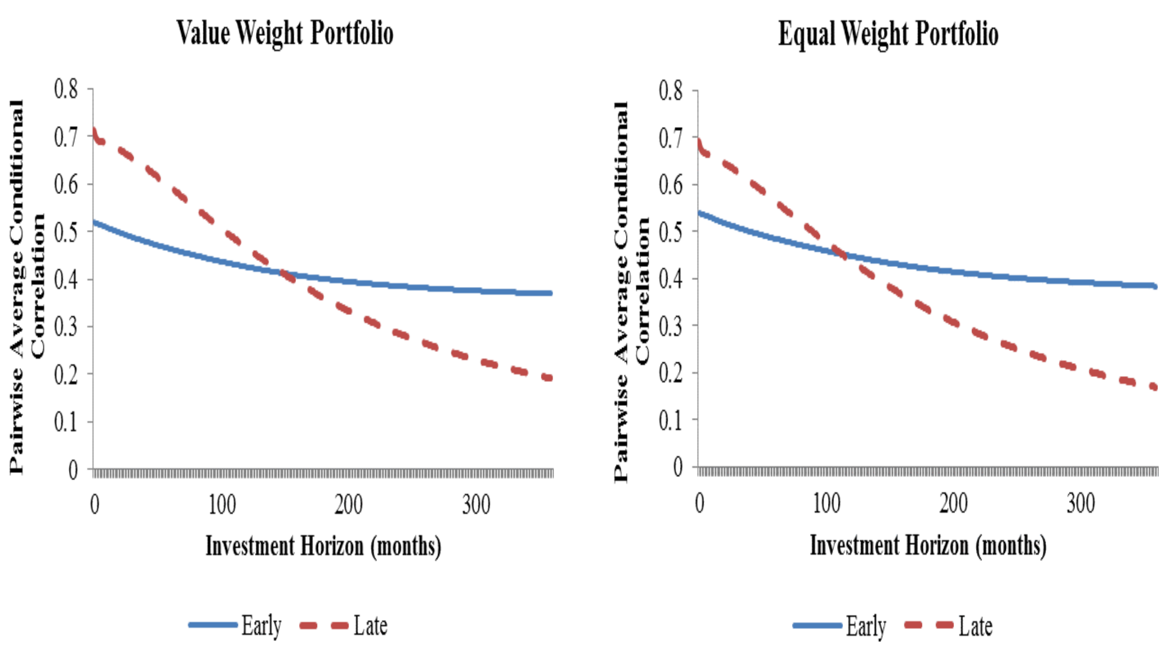
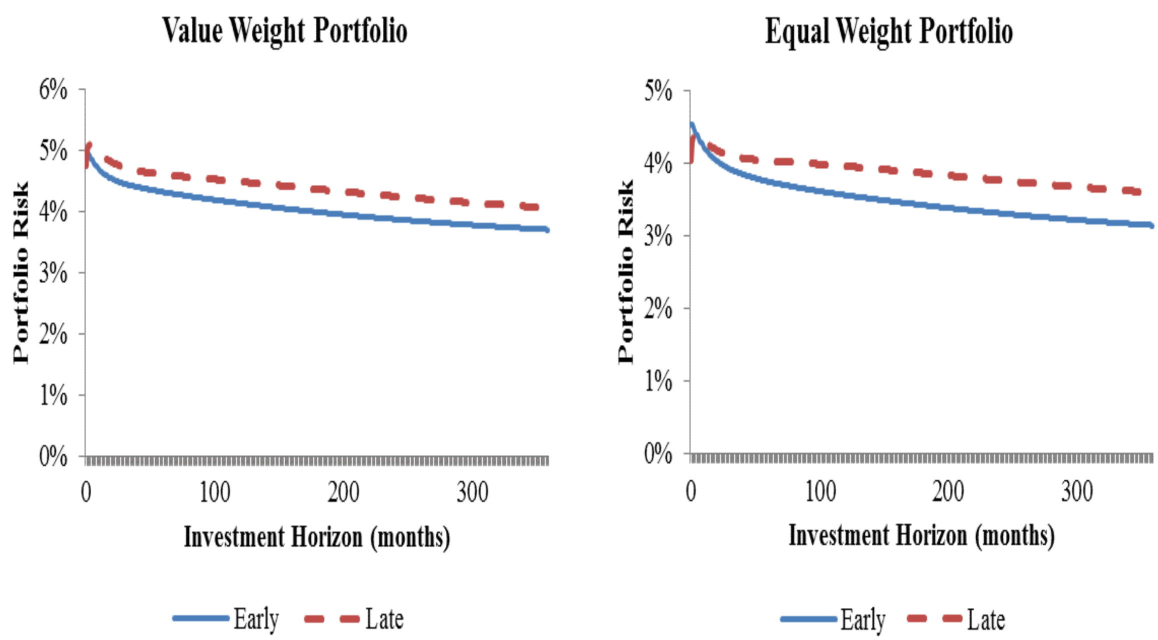


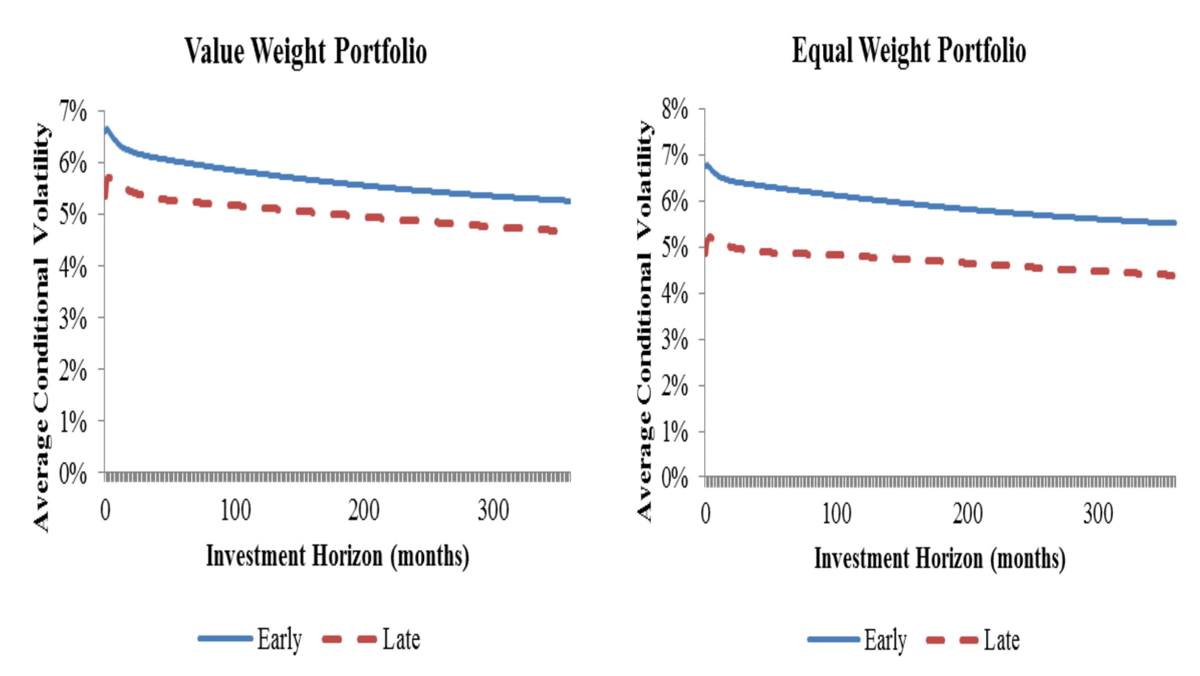
Figure 14: Bond portfolio risk as a function of investment horizon

The figure compares the early sample (1986.01-1999.12) and late sample (2000.01-2016.12) all-bond portfolio risk across investment horizons. Panel A plots the annualized conditional standard deviation of portfolio excess returns. Panel B plots the average (across N countries) annualized k-period conditional volatility of excess returns. Panel C plots the pairwise average of cross-country k-period excess returns conditional correlation. Each panel includes the results for value weighted and equal weighted portfolios.

Panel A: annualized conditional standard deviation of portfolio excess returns



Panel B: Average annualized k-period conditional volatility of excess returns



Panel C: Pairwise average of cross-country k-period excess returns conditional correlation