The Variance Risk Premium around the World†

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* JEL Classification: E44, F36, G12, G13, G15.

Keywords: variance risk premium, economic uncertainty, interdependence, international integration, return predictability.

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1 Introduction

Traditional asset pricing models have mainly focused on characterizing the reward for equity risk. However, such models typically fail to capture the reward for bearing variance risk. The variance risk premium is formally defined as the difference between the risk neutral and the physical expectation of the total stock return variation. This premium can be estimated using model-free measures as the difference between the option implied and the expected realized variance. At least for the US, the documented evidence suggests that the variance premium is large, varies significantly over time and has predictive power for future stock returns. This evidence challenges standard asset pricing models and therefore the way we understand the sources of the variance risk premium.

To generate a time-varying variance premium, standard asset pricing models have been adjusted in different ways classifiable into two general strands of the literature. One strand of the literature, and the one I follow in this paper, links the variance risk premium to macroeconomic uncertainty. This strand follows the intuition behind the long-run risk model in Bansal and Yaron (2004) (BY hereafter), and the idea that agents have a preference for an early resolution of uncertainty in Bansal et al. (2005). Extending BY’s model, Bollerslev, Tauchen and Zhou (2009) (BTZ hereafter) propose a model where the variance premium predicts stock returns – an implication for which they find empirical evidence for the US. An alternative strand of the literature relates the variance premium to agents’ attitudes towards non-normalities in the distribution of stock returns. In Bakshi and Madam (2006), for example, the variance risk premium is explained by the desire of risk averse agents to buy protection against extreme events. In a similar vein, Bekaert and Engstrom (2010), Todorov (2010), and Gabaix (2009), using different methodologies, focus on the interplay between stock returns, risk aversion and extreme events to explain many asset pricing regularities including the variance risk premium.

Existing work, both theoretical and empirical, has mainly focused on the US market. This paper adds to the literature by extending the variance premium analysis to an international setting. My contribution is threefold. First, I provide new evidence on the basic stylized facts related to the variance premium for a total of eight countries. I show that while the variance premiums are on average positive and display significant time variation in all countries analyzed, the local return predictability pattern does not hold internationally. Then, I extend the domestic model in Bollerslev, Tauchen and Zhou (2009) to an international setting. My model links the variance premium to local and aggregate macroeconomic uncertainty and yields a qualitative explanation for the local predictability puzzle. Finally, I provide new empirical evidence to investigate the main qualitative implications of my model. This new empirical evidence suggests that the US variance premium predicts stock returns in the US and in any other country in the sample. In addition,
the evidence also suggests that the US variance premium plays a key role in predicting variance premium and stock return correlations across countries. The different parts and contributions of the paper are discussed in more detail below.

In the first part of this paper, I investigate the main stylized facts related to the variance premium, and largely documented for the US, in an international setting. In particular, I investigate whether the time-varying and positive nature of the variance premium as well as its capacity to predict stock returns holds internationally. To do so, I collect data for the US, Germany, UK, Japan, Switzerland, The Netherlands, Belgium, and France for the sample period between 2000 and 2009. For each country, as has become standard in the literature, I estimate the variance premium using model-free measures of the expected variance of returns under the risk-neutral and the physical measure. Thus, I approximate the expectation of the total return variation under the risk-neutral measure by the (square of the) model-free implied volatility (IV) index for each equity market (Carr and Madan, (1998), and Britten-Jones and Neuberger, (2000)), and the expectation under the physical measure by a conditional forecast of the actual realized variance.

The single-country evidence shows that the variance premiums are, on average, positive and display significant time variation for all countries in the sample. This international evidence is in line with previous findings for the US.\(^1\) I also show that the local variance premium can predict local stock returns only in the US and Belgium. For any other country in my sample, the evidence suggests that the local variance premium cannot predict local stock returns. This finding is puzzling from the point of view of the existing domestic models where the variance premium implicitly explains part of the variation in the local stock returns.\(^2\)

Motivated by the strictly domestic nature of the existing models, in the second part of the paper I propose a model to investigate the role of the variance premium in explaining the interactions across international equity and option markets. My model is a two-country extension of that in BTZ and takes the intuition that agents have a preference for an early resolution of uncertainty to an international setting. In my model, the macroeconomic uncertainty is characterized by the dynamics of the consumption growth volatility of each country. The most innovative feature of my model is to allow for this uncertainty to be transmitted across countries given a unique representative agent endowed with recursive preferences. Although this uncertainty-transmission mechanism can be in principle bidirectional, I only present a version of the model that explicitly assumes an uncertainty-transmission in one direction. Thus, the consumption process of the uncertainty-driver country, labeled as country 1, is assumed to be entirely driven by local shocks. But the shocks

\(^1\)See for instance Britten-Jones and Neuberger (2000), Jiang and Tian (2005), Bakshi and Madan (2006), Carr and Wu (2009), Bollerslev, Gibson and Zhou (2011), and BTZ.

\(^2\)BTZ, Zhou (2010), and Drechsler and Yaron (2011) find empirical evidence for their respective model-implied return predictability. However, Bekaert and Engstrom (2010) find weak evidence of return predictability.
of the uncertainty-driver consumption process can be partially transmitted to a second country, country 2. This setting yields several implications that, to the best of my knowledge, are new to the literature.

The first main qualitative implication of my model comes from the fact that shocks to macro-economic uncertainty in any country play a role in characterizing the variance premium in the two countries. More specifically, each country’s variance premium loads on the volatility of volatility of consumption (VoV hereafter) generated in both countries. The variance premium load on each country’s VoV increases with the relative size of this country’s economy and the degree of economic dependence between countries. As a consequence of having common components, the model-implied variance premiums are highly correlated. Moreover, in a one-direction uncertainty-transmission setting, the cross-country variance premium correlation is mainly driven by the VoV generated in the uncertainty-driver country, country 1. So country 1’s variance premium plays the key role in predicting the cross-country variance premium correlation.

The second main implication of my model follows from the fact that changes in VoV also explain a portion of the expected stock returns in any country. Similar to the implication for the variance premiums, the expected-stock-return load on each country’s VoV increases with the relative size of each economy and the implied correlation of the two countries’ consumption processes. Together with the model’s first implication, this mechanism links the variance premium to all countries’ expected stock returns. More importantly, this mechanism provides the intuition for the potential role of any country’s variance premium in predicting local and foreign stock returns. In particular, my model explains the possibility that the uncertainty-driver’s variance premium predicts other countries’ stock returns as well as the pairwise cross-country stock return correlations.

The third contribution of this paper is to provide new empirical evidence on the two main qualitative implications of my model. So, in the third part, I investigate the fundamental linkages between the variance premiums across countries as well as the interplay between the variance premiums and international stock returns. To do so, I provide evidence that (a) the variance premiums are highly correlated for all countries investigated as suggested by the model-implied common variance premiums loads on all countries’ VoV; (b) the US variance premium predicts stock returns for all countries in the sample except perhaps for Japan and outperforms all other countries’ variance premiums in predicting local and foreign stock returns;\(^3\)\(^4\) and (c) international stock

\(^3\)Rapach, Strauss and Zhou (2012) find evidence suggesting a leading role of the US stock returns in predicting stock returns in several countries, including all countries in my sample but Belgium. Their paper provides a good literature review on the leading role of the US stock market including explanations related to size and economic dependence.

\(^4\)In independent concurrent work, Bollerslev, et al. (2012) also find that the US variance outperforms all other countries’ variance premium in predicting stock returns. But their explanation, unlike mine, uses the US variance premium as a proxy for the global variance premium.
returns tend to comove more intensely following episodes of increasing US variance premium. The predictive power of the variance premium for stock returns and cross-country return correlations holds for horizons between 3 and 6 months and is additional to that of traditional (local or US) variables such as the term spread and the dividend yield. This predictive power is in line with my model’s second main implication according to which one country’s variance premium, that of the uncertainty-driver, might play the key role in predicting local and foreign stock returns.

The remainder of the paper is organized as follows: Section 2 introduces the main definitions and data used throughout the paper. Section 3 provides international single-country evidence on the regularities related to the variance premium. Section 4 introduces the international consumption-based general equilibrium model and summarizes its qualitative implications. Section 5 investigates the empirical evidence in light of the implications of my model. Section 6 concludes.

2 Data and Definitions

In this section, I introduce the data used to estimate the monthly variance premiums for the following countries: US, Germany, Japan, UK, Switzerland, The Netherlands, Belgium and France. The variance premium is defined as the difference between the risk neutral and the physical expectation of the market stock return variation between months \( t \) and \( t + 1 \). I estimate this premium, as has become standard in the related literature, using model-free measures for the expectations of the total return variation.

I approximate the risk neutral expectation of the market return variation as (the square of) the model-free options implied volatility (IV) index for each market. The methodology for the IV index was initially proposed by Carr and Madan (1998) and Britten-Jones and Neuberger (2000). The IV index has shown to provide a much better approximation to the expected risk neutral return variation than previous Black-Scholes based measures (Bollerslev, Gibson and Zhou, (2011)). The IV indices are constructed from a portfolio of European calls where the underlying is a representative market index for each country as in

\[
iv_{j,t} = 2 \int_0^\infty C_{j,t}(t + 1, \frac{K}{B_j(t,t+1)}) - C_{j,t}(t, K) \frac{dK}{K^2},
\]

where \( C_{j,t} \) are the prices of calls with strikes from zero to infinity, and \( B_j(t,t + 1) \) are the local prices of zero-coupon bonds with one-month ahead maturity.

The availability of the IV index for the countries analyzed is limited by the recent development of their option markets. The index was first reported for the US by the Chicago Board Options Exchange (CBOE), the VIX, in 1993 (with data from 1990). The VIX was adapted to the model-
free methodology in 2003, and was then called the New-VIX. A year later, in 1994, the German Stock Exchange (Deutsche Beurse and Goldman Sachs) released an index for the German market, the VDAX (with data from 1992). The Center for the Study of Finance and Insurance (CSFI) at Osaka University then launched an index for Japan, the VXJ, with data from 1995. In 2005, the Swiss Exchange introduced the index for Switzerland, the VSMI.5 In 2007, Euronext announced IV indices for France (VCAC), Belgium (VBEL), the UK (VFTSE, in partnership with FTSE), and The Netherlands (VAEX) with data from 2000.6 Considering the data restrictions for the European markets, the empirical analysis in this paper is centered on the sample period between 2000 and 2009.

As for the expectation of the total stock return variation under the physical measure, I estimate a benchmark measure based on the first order autoregressive forecast of the total realized return variation or realized variance from the following equation:

$$rv_{j,t+1} = \gamma_0 + \gamma_1 rv_{j,t} + \epsilon_t,$$

where the realized variance is calculated summing the squared daily stock returns for each market as in

$$rv_{j,t} = \sum_{i=1}^{N_t} (r_{j,t_i})^2,$$

where $r_{j,t_i}$ are daily local stock returns within month $t$. I rely on daily returns since data at a higher frequency are not available for all countries in my sample.7

To make the results comparable to those in the literature, and as a preventive solution to the possible underperformance of my benchmark measure, I verify the robustness of the main results in this paper using three alternative approximations of the expected realized variance. In the first alternative measure, I rely on the martingale assumption where the expected realized variance is approximated by the current realized variance (That is, $E_t(rv_{t+1}) = rv_t$). In the second one, I estimate a forecast of the realized variance that includes the local IV index as in the following equation:8

$$rv_{j,t+1} = \gamma_0 + \gamma_1 rv_{j,t} + \gamma_2 iv_{j,t} + \epsilon_t.$$

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5 Currently, Eurex estimates and reports both VDAX and VSMI following a unified New-VIX methodology.
6 Both, the UK (FTSE) and France (French March des Options Negociables de Paris) have previously introduced IV indices separately.
7 Andersen et al., (2001), Barndorff-Nielsen and Shephard, (2002); and Meddahi, (2002), have shown that the use of intradaily returns outperforms lower frequency data in the estimation of the realized variance.
8 In unreported results, I show that the US IV does a worse job in predicting other countries’ RVs than their local IVs. In other words, in the pure sense of Jiang and Tian (2005), local IVs seem to be more informative for the forecast of realized variances.
Finally, in the third one, I estimate a forecast of the realized variance that includes the range-based variance for each country as in

$$rv_{j,t+1} = \gamma_0 + \gamma_1 rv_{j,t} + \gamma_2 \text{RangeV}_{j,t} + \epsilon_t,$$

where $\text{RangeV}_{j,t}$ is the range-based variance calculated as

$$\text{RangeV}_{j,t} = \frac{1}{4 \ln 2} \sum_{t_i=1}^{N_t} \text{range}_{i,t},$$

where $\text{range}_{i,t}$ is the daily difference between the highest and the lowest price of the index.\(^9\)\(^10\)

The data for the IV and the underlying index returns for all countries are obtained from Datastream. All returns are expressed in local currencies although I also check for the robustness of the results when all returns are expressed in a common currency. To obtain the local excess returns used to investigate the stock return predictability, I consider the 3-months T-bill rates for each country. Finally, I also control for two variables traditionally used to predict excess returns, the dividend yield and the term spread, calculated as the difference between the 1 year T-bill and the 3-months T-bill rate for each country. The T-bill rates and the dividend yields for all countries are also obtained from Datastream.

### 3 Variance Premium: Single-Country Evidence

In this section, I investigate whether the stylized facts observed for the US variance premium also hold internationally. In a first step, I investigate the positive and time-varying nature of the variance premium. Then, I investigate the ability of the local variance premium to predict stock returns in each country separately.

To get an idea of the magnitude and the time-varying nature of the variance premiums, Figure 1 displays the (benchmark) time series for all countries considered. The main statistics of these series are summarized in Table 1. This table also displays the IV and its underlying stock index for each country. Finally, I also include the volatility premiums, $\text{volp}_{j,t} = iv_t - \sqrt{rv_{j,t+1}}$, in the table to visualize the magnitude of the premiums in annual percentages. The average volatility premium ranges from 1.7% for Belgium to 3.8% for Japan. To get an intuitive idea of the economic

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\(^9\) Martens and van Dijk (2007) provide a description of the range-based volatility. Jacob and Vipul (2008) investigate the role of the range-based measure to forecast the variance.

\(^10\) As an alternative preventive measure to reduce the noise implicit in country-specific variance premiums, I also check the robustness of my results to considering a proxy for the world VP (with and without the US) similar to that in Bollerslev, et al. (2011).
significance of these magnitudes, the 3.8% volatility premium in Japan translates into a (one-month) at-the-money put price difference of 18% in a Black Scholes world. This means that one month at-the-money put options priced at 26.75% implied volatility -the average IV index for Japan- are 18% more expensive than the same options priced at 22.87% implied volatility -the average realized volatility for this country in the same period.

[Insert Figure 1 here.]

[Insert Table 1 here.]

The information in Table 1 and Figure 1 suggests that the variance premiums display significant time variation. Their volatility ranges from 257.5 for the US to 485.4 for Japan. Interestingly, the variance premiums show several periods of high volatility and notorious spikes around the same episodes. The first high-variance-premiums episode occurs around the end of the technological boom in 2000. A second episode occurs at the end of 2002. This second episode coincides with the high macroeconomic uncertainty reported in the second semester of 2002 in the US (first semester of 2003 for Germany) –an episode also related to the corporate accounting scandals around those years. Finally, the most notorious variance premium spikes occur around the beginning of the 2008 subprime crisis. Not surprisingly, the minimum and maximum values for all series, except for Germany, occur in the last quarter of 2008. For Japan, for example, the variance premium reaches 3,398.2 (annual square percentage) in October 2008. As a consequence of this dynamics, the series display important deviations from the normal distribution with Kurtosis ranging from 7.7 for Switzerland to 21.6 for Japan and Skewness ranging from −0.72 for Belgium to 3.9 for Japan.

To assess the positive nature of the average variance premiums, Figure 2 summarizes the results for a test on the significance of the mean variance premium for all countries. This figure displays the average variance premiums and their respective confidence intervals for the four alternative measures introduced in Section 2. The evidence suggests that the average variance premium is positive and significant for all countries and all alternative measures considered, except perhaps when the martingale measure is used. These results extend the evidence found for the US by Britten-Jones and Neuberger (2000), Jiang and Tian (2005), Bakshi and Madan (2006), Carr and Wu (2009), Todorov (2010), Bollerslev, Gibson and Zhou (2011), Bekaert and Engstrom (2010),

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11See Bollerslev, Gibson and Zhou (2011), and Corradi, et al. (2009) for a more detailed analysis of the relation between the variance premium and the business cycle in the US.
and BTZ, among others.\textsuperscript{12} This paper is then, to the best of my knowledge, the first to show that these stylized facts also hold in other developed markets.\textsuperscript{13}

[Insert Figure 2 here.]

In the rest of this section, I test another US-based stylized fact, namely that the local variance premium predicts local stocks returns.\textsuperscript{14} Motivated by the new evidence on the significance of the variance premiums, I investigate the role of the local variance premium in predicting stock returns for all countries in the sample. To do so, Figure 3 reports the estimation results for the following regressions:

\[
(r - r_f)_{j,t,t+h} = \gamma_0_{j,h} + \gamma_1_{j,h} v p_{j,t} + \gamma_2_{j,h} d y_{j,t} + \gamma_3_{j,h} t s_{j,t} + \epsilon_{j,h,t},
\]

where \((r - r_f)_{j,t,t+h}\) represents \(h\)-months ahead compounded annualized excess returns, \(d y_{j,t}\) is the local dividend yield, and \(t s_{j,t}\) is the local term spread.

[Insert Figure 3 here.]

The evidence in Panel A of Figure 3 confirms most of the results previously found in the literature for the US. That is, the US variance premium predicts stock returns specially for horizons between 3 to 6 months. In fact, the evidence shows that the US variance premium explains up to 15\% of the total variation in future stock returns at the quarterly frequency. The predictive power and the coefficient of the variance premium in these regressions follow a hump-shaped pattern and become irrelevant for horizons around one year.

In contrast to the evidence for the US, the results in Panels B through H suggest that the local variance premiums play a modest or insignificant role in predicting stock returns in any other

\textsuperscript{12}A group of papers have also provided preliminary evidence of this regularity using Black-Scholes-based implied volatility. See, for instance, Bakshi, Cao and Chen (2000), Christoffersen, Heston and Jacobs (2006), and Bollerslev and Zhou (2006).

\textsuperscript{13}This paper is certainly not the first one to investigate the informational content of option markets internationally. Some preliminary evidence that volatility risk is priced in an international setting can be found in Mo and Wu (2007) and Driessen and Maenhout (2006). Implied volatility in international markets has also been analyzed in Konstantinidi, Skiadopoulos, and Tzagkaraki (2008), Siriopoulos and Fassas (2009), and Jiang, Konstantinidi and Skiadopoulos (2010).

\textsuperscript{14}See for instance BTZ, Zhou (2010) and Drechsler and Yaron (2011).
country except perhaps for Belgium. For example, the results show that for Germany, Japan, the UK and the Netherlands, the $R^2$ is modest and hardly ever above 1%. Not surprisingly, for these countries, the variance premium does not predict stock returns for any of the horizons considered. In contrast, the $R^2$ for Belgium (Panel G) is as high as 10% for the one-month horizon; and the local predictive power of the Belgian variance premium follows a decreasing pattern as the horizon increases.\footnote{It is worth pointing out that the Belgian variance premium shows the lowest Sharpe ratio (almost half that for the rest of the countries). This could preliminary suggest that the variance premium is particularly volatile in Belgium which in turn implies a somehow noisier measure in this country, potentially driven by the liquidity of its option market.} Finally, for France, although the $R^2$ is also modest, the predictability follows a pattern similar to that for the US. In the case of France, however, both the $R^2$ and the variance premium coefficient are only significant at the 2-months horizon.\footnote{The empirical evidence on the inability of the local VP to predict local excess returns for all countries in our sample except for Belgium and the Netherlands has also been obtained in independent concurrent work by Bollerslev, et al. (2012).}

In sum, although this is, to the best of my knowledge, the first paper to present evidence on the role of the variance premium in predicting stock returns for countries other than the US, the single-country evidence is puzzling. My findings are on the one hand consistent with the existence of significant and time-varying variance premiums for a large sample of countries. On the other hand, my results suggest that the variance premium cannot predict stock returns in countries other than the US. The concurrence of these two findings cannot be explained by the existing domestic models where the variance premium implicitly explains the variation in the local expected stock returns. This puzzling evidence is nonetheless the motivation for the international general equilibrium model introduced in the following section. My model is able to qualitatively explain the poor evidence for the role of the local variance premium in predicting returns outside the US. In particular, my model suggests that the variance premium of one country might play a dominant role in predicting stock returns in other countries—a key implication for which I provide empirical evidence in the subsequent section.

4 A Two-Country Model for the role of the Variance Premium in International Equity Markets

In this section, I propose an international consumption-based general equilibrium (GE) model where the variance risk is priced in the global and in the local portfolios. My model yields several qualitative implications for the role of the variance premium in international stock and option markets that, to the best of my knowledge, are new to the literature. The most relevant implication
of my model is that the variance premium of one economy might play a dominant role in predicting stock returns in foreign countries. In addition, the variance premium from this country might also play the key role in explaining stock and option markets correlations across countries.

In the first part of the section, I present the basic setup of the model and its main implications.\textsuperscript{17} I do not attempt to estimate nor to test my model but rather to use its qualitative implications to investigate the inability of the variance premium to predict local stock returns in countries other than the US. Nevertheless, I do propose a set of numerical simulations to understand the model’s implications and illustrate the mechanism behind it. These numerical simulations provide the link between the single-country evidence, the implications of my model and the empirical evidence presented in the following section.

4.1 Model Setup and Assumptions

The model presented here preserves the two key ingredients in BTZ’s model: recursive preferences, and time-varying macroeconomic uncertainty. However, my model adds to the literature by extending the intuition that financial markets dislike macroeconomic uncertainty (BY and Bansal, et al., (2005)) to a two-country setting. This uncertainty is characterized by the time-varying volatility and the volatility of volatility (VoV) of each country’s consumption growth process.\textsuperscript{18} The most innovative feature of my model is to allow for this uncertainty to be transmitted across countries. Although this uncertainty-transmission mechanism can be bidirectional, I only present a version of the model that explicitly assumes the transmission of uncertainty in one direction. Thus, the consumption process of the uncertainty-driver country, country 1, is assumed to be entirely driven by local shocks. But the shocks of the uncertainty-driver consumption process can be partially transmitted to a second country, country 2. I also assume fully integrated stock markets. That is, there is a unique representative agent holding a global portfolio with positions in the two stock markets. The assumptions of fully integrated stock markets and potentially integrated economies seem adequate given the particular characteristics of the sample considered in this paper. In particular, given the level of development of stock and option markets in the countries and the sample period used considered.

The consumption process in each country is modeled similar to BTZ. Country 1’s log consumption growth follows the process

\[ g_{1,t+1} = \mu_{1,g} + \sigma_{1,t}z_{g_{1,t+1}}, \]  

\textsuperscript{17}In order to save space, the detailed solution of my model is presented in Appendix A

\textsuperscript{18}Bekaert, Engstrom and Xing (2009) survey the evidence on time-varying volatility of consumption for the US. Bansal, et al. (2005) provide empirical evidence of time-varying macroeconomic uncertainty for the US, Germany, Japan, and the UK. BTZ also find preliminary empirical evidence on the existence of time-varying VoV for the US.
\[ \sigma_{1,t+1}^2 = a_\sigma + \rho \sigma_{1,t}^2 + \sqrt{q_{1,t}^2} \sigma_{1,t+1}, \]

\[ q_{1,t+1} = a_q + \rho q_{1,t} + \varphi_q \sqrt{q_{1,t}} z_{q_{1,t+1}}, \]

whereas country 2’s consumption process follows

\[ g_{2,t+1} = \mu_{2,g} + \phi_g \mu_{1,g} + \phi_g \sigma_{1,t} z_{g_{1,t+1}} + \sigma_{2,t} z_{g_{2,t+1}}, \]

(2)

\[ \sigma_{2,t+1}^2 = a_\sigma + \rho \sigma_{2,t}^2 + \sqrt{q_{2,t}^2} \sigma_{2,t+1}, \]

\[ q_{2,t+1} = a_q + \rho q_{2,t} + \varphi_q \sqrt{q_{2,t}} z_{q_{2,t+1}}. \]

The global consumption growth is a weighted average of the two countries’ consumption processes,

\[ g_{w,t} = \omega g_{1,t} + (1 - \omega) g_{2,t}, \]

where \( \omega \) is the weight of country 1 in the global economy.

To simplify the model, the parameters in the volatility and VoV processes in Eqs. (1) and (2) are assumed to be homogeneous across countries. I also assume that there are neither within nor cross-country statistical correlations in the shocks. So the only correlations in my model are those implied by the parameters \( \phi_g \) (level) and \( \phi_\sigma \) (volatility) in Eq. (2). These two parameters control the extent to which country 2 is affected by the shocks generated in country 1. In particular, \( \phi_g \) implies that the consumption process of country 2 is affected not only by the local macroeconomic uncertainty, but also by that generated in the foreign economy, country 1. More importantly, the fact that both economies are exposed to the same sources of macroeconomic uncertainty yields the systemic component in both countries’ variance premiums.\(^{19}\)

The unique world representative agent is endowed with Epstein Zin Weil preferences (Epstein and Zin, 1989; and Weil, 1989). Her life-time utility function is given by the following equation:

\[ U_t = [(1 - \delta)C_t^{1-\eta} + \delta(E_t[U_{t+1}^{1-\gamma}])^\frac{1}{1-\gamma}]^{1-\eta}, \]

(3)

\(^{19}\)The parameters \( \phi_g \) and \( \phi_\sigma \) can of course be set to 0—a case that I will also analyze in the numerical simulation of the model. Although \( \phi_g \) turns out to have an insignificant effect on the role of the variance premium, I have decided to keep this parameter to maintain the possibility of a common level component in the countries’ consumption processes.
where $0 < \delta < 1$ is the time discount rate, $\gamma \geq 0$ is the risk aversion parameter, and $\theta = \frac{1-\gamma}{1-\nu}$ for $\psi \geq 1$ is the intertemporal elasticity of substitution (IES). These preferences have the property of assigning non-zero market prices to shocks not directly related to aggregate consumption. This property is crucial to investigate other risk factors such as news related to volatility which is the main objective of this paper.

### 4.2 Model-Implied Variance Premiums

It can be shown that the two countries’ VoV uniquely characterize the variance premium in the global and the local portfolios. The expression for the global portfolio’s variance premium is given by

$$VP_{w,t} = E_t^Q[Var_{r_j,t+1}] - E_t^P[Var_{r_j,t+1}],$$

where $Var_{r_j,t}$ is the conditional variation of returns between time $t$ and $t+1$ for portfolio $j$ $(j = 1, 2, w)$ (see appendix A). The variance premium can be approximated as

$$VP_{w,t} \approx (\theta - 1)\kappa_{w,1}(V_{w,1}q_{1,t} + V_{w,2}q_{2,t}),$$

where $(\theta - 1)\kappa_{w,1}V_{j,k}$ represents the $VP_{j,k}$ load on $q_{k,t}$. For the global portfolio, these loads are characterized by the following expressions:

$$V_{w,1} = (\omega + (1 - \omega)\phi_0)^2 A_{w,1} + (A_{w,1}^2 + A_{w,2}^2\varphi_q^2)\kappa_1^2\varphi_q^2 A_{w,2},$$

$$V_{w,2} = (1 - \omega)^2 A_{w,3} + (A_{w,3}^2 + A_{w,4}^2\varphi_q^2)\kappa_1^2\varphi_q^2 A_{w,4},$$

where $A_{j,1}, A_{j,2}, A_{j,3}$ and $A_{j,4}$ are portfolio $j$’s wealth-consumption loads on the risk factors $\sigma_{1,t+1}, \sigma_{2,t+1}, \sigma_{3,t+1}, \sigma_{4,t+1}$ respectively.

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20. To be coherent with the idea of agents that fear an increase in macroeconomic uncertainty, $\psi$ is assumed to be higher than 1. This assumption accomodates some empirical asset pricing regularities, among them: (i) a positive variance premium; (ii) the feedback effect between PD ratios and consumption volatility; and (iii) a low risk-free rate (BY and BTZ). See also Mehra and Prescott (1985) for reasonable values of $\gamma$.

21. This is actually the drift difference of the conditional variance between the two measures. Drechsler and Yaron, (2011) show that in a Gaussian-shocks framework, the level difference $(Var^Q(r_{t+1}) - Var^P(r_{t+1}))$ is null. Yet, I assume a Gaussian-shocks framework to maintain the simplicity of the expressions and to be able to explicitly solve the model and center the attention on its qualitative implications.

22. The risk neutral probability is replaced by its log-linear approximation:

$$E_t^Q(\sigma_{1,t+1}^2) \approx \log [e^{-\gamma r_t} E_t(e^{m_{t+1} + \sigma_{1,t+1}^2}) - \frac{1}{2}Var_t(\sigma_{1,t+1}^2)].$$

Bear in mind that a closed-form solution to the risk neutral variance cannot be obtained in this setting.
The variance premium for country 1 is given by

\[ VP_{1,t} = E_Q^t[Var_{r_{1,t+1}}] - E_P^t[Var_{r_{1,t+1}}] \approx (\theta - 1)\kappa_w,1(V_{1,1}q_{1,t} + V_{1,2}q_{2,t}), \]

\[ V_{1,1} = A_{w,1} + (A_{1,1}^2 + A_{1,2}^2\varphi_q^2)\kappa_{1,1,1}\varphi_q^2 A_2, \]

\[ V_{1,2} = A_{1,3}^2 + (A_{1,4}^2\varphi_q^2)\kappa_{1,1,1}\varphi_q^2 A_{w,4}, \]

while for country 2,

\[ VP_{2,t} = E_Q^t[Var_{r_{2,t+1}}] - E_P^t[Var_{r_{2,t+1}}] \approx (\theta - 1)\kappa_w,1(V_{2,1}q_{1,t} + V_{2,2}q_{2,t}), \]

\[ V_{2,1} = \phi_{\sigma}^2 A_{w,1} + (A_{2,1}^2 + A_{2,2}^2\varphi_q^2)\kappa_{2,1,1}\varphi_q^2 A_{w,2}, \]

\[ V_{2,2} = A_{w,3} + (A_{2,3}^2 + A_{2,4}^2\varphi_q^2)\kappa_{2,1,1}\varphi_q^2 A_{w,4}. \]

Eqs. (4) to (6) imply that the VoV of both countries are the unique sources of the variance premiums in all portfolios. Actually, for \( \theta < 1 \), the two countries’ variance premiums load positively on VoV. That is, \( V_{j,k} \leq 0 \) for \( j, k = 1, 2, w \) (see appendix A). Consequently, the global and local variance premiums are positive if \( \theta < 1 \). Note that country 1’s variance premium load on the foreign VoV is explained only by the recursive nature of the utility function given fully integrated equity markets. But country 2’s variance premium load on country 1’s VoV comes from two channels: the recursive nature of the preferences, and the implied sensitivity of country 2’s consumption process to country 1’s macroeconomic uncertainty (See Eq. (2)).

As an immediate consequence of the common components in the variance premium of all portfolios, the cross-country variance premium covariance is also uniquely characterized by the two countries’ VoV. The expression for the variance premium covariance derived from Eqs. (5) and (6) can be written as follows:

\[ Cov_t(VP_{1,t+1}, VP_{2,t+1}) = (\theta - 1)^2k_{w,1,1}\varphi_q^2(V_{1,1}V_{2,1}q_{1,t} + V_{1,2}V_{2,2}q_{2,t}), \]

where the variance premium covariance loads positively on both countries’ VoV as long as \( \theta < 1 \).
4.3 Model-Implied Equity Premiums

To understand the model-implied relation between the variance premiums and the dynamics of stock returns, in this section, I find the expressions for each portfolio’s expected stock returns or equity premium.

The global equity premium is characterized by the following expression:

\[ EP_{w,t} = E_t(r_{w,t+1} - r_{f,t}) \]

\[ = \gamma \sigma^2_{w,t} - \frac{1}{2} \sigma^2_{w,t} + (1 - \theta) k_{w,1}(P_{w,1q_1,t} + P_{w,2q_2,t}), \]

where \( r_{j,t+1} \) is the (log) gross return for portfolio \( j \) (\( j = 1, 2, w \)), \( r_{f,t} \) is the global risk-free rate, \( \sigma^2_{w,t} = \omega \sigma^2_{1,t} + (1 - \omega) \sigma^2_{2,t} \) is the volatility of the world consumption, \( -\frac{1}{2} \sigma^2_{r_{w,t}} \) is the geometric adjustment term, and \( (1 - \theta)k_{w,j}P_{j,k} \) represents the \( EP_{j,t} \) load on \( q_{k,t} \). For the global portfolio these loads are given by

\[ P_{w,1} = k_{w,1}(A^2_{w,1} + A^2_{w,2}\varphi^2_q), \]

\[ P_{w,2} = k_{w,1}(A^2_{w,3} + A^2_{w,4}\varphi^2_q). \]

Equation (8) shows the three model-implied components of the global expected stock returns. The first component is the classic risk-return trade-off \( \gamma \sigma^2_{w,t} \) — a component that is also present when agents are endowed with CRRA preferences. The two additional components correspond to the VoV generated in each country. These VoV components of the expected stock returns represent the true premium for variance risk since they are driven by the shocks to the volatility and the VoV of consumption in both countries. In the particular case of the global portfolio, the expected stock return loads positively on both countries’ VoV as long as \( \theta < 1 \). That is, \( (1 - \theta)k_{w,1}P_{w,j} \geq 0 \), for \( j = 1, 2 \) (see Appendix A). These positive loads are in line with the concept that, at least for the global portfolio, agents are positively compensated for the risk generated by the time-varying nature of the VoV.

The expressions for the expected stock returns for each country are given by

\[ EP_{1,t} = E_t(r_{1,t+1} - r_{f,t}) \]

\[ = \gamma(\omega + (1 - \omega)\phi_\sigma)\sigma^2_{1,t} - \frac{1}{2} \sigma^2_{r_{1,t}} + (1 - \theta)k_{w,1}(P_{1,1q_1,t} + P_{1,2q_2,t}), \]
and

\[ EP_{2,t} = E_t(r_{2,t+1} - r_{f,t}) \]
\[ = \gamma \phi_\sigma (\omega + (1 - \omega)\phi_\sigma)\sigma_{1,t}^2 + \gamma (1 - \omega)\sigma_{2,t}^2 - \frac{1}{2}\sigma_{r_{2,t}}^2 \]
\[ + (1 - \theta)k_{w,1}(P_{2,1}q_{1,t} + P_{2,2}q_{2,t}) \]

respectively, where

\[ P_{j,1} = k_{j,1}(A_{w,1}A_{j,1} + A_{w,2}A_{j,2}\varphi_q^2), \]
\[ P_{j,2} = k_{j,1}(A_{w,3}A_{j,3} + A_{w,4}A_{j,4}\varphi_q^2), \quad \text{for } j = 1, 2. \]

As for the global portfolio, the expected stock returns in each country are characterized by a volatility of consumption component, and two VoV components, one for each country. In particular, the VoV components in Eqs. (9) and (10) represent the true premium for local and foreign variance risk.

Comparing the expressions for the variance premiums (Eqs. (5) and (6)) with those for the expected stock returns (Eqs. (9) and (10)) yields the basic intuition for the role of the local and foreign variance premiums in predicting stock returns in any country. The intuition is as follows: the VPs reveal the VoV in both countries which in turn drives (in part) the time variation in the expected stock returns.\(^\text{23}\)

It seems natural from Eqs. (8) to (10) to expect the VoV to also explain the time variation in the cross-country covariance of returns. The expression for the covariance of returns is given by

\[ Cov_t(r_{1,t+1}, r_{2,t+1}) = \phi_\sigma \sigma_{1,t}^2 + CO_{1}q_{1,t} + CO_{2}q_{2,t}, \]

where \( CO_j \) is the the covariance of returns load on \( q_{j,t} \),

\[ CO_1 = \kappa_{1,1}\kappa_{2,1}(A_{1,1}A_{2,1} + A_{1,2}A_{2,2}\varphi_q^2), \]
\[ CO_2 = \kappa_{1,1}\kappa_{2,1}(A_{1,3}A_{2,3} + A_{1,4}A_{2,4}\varphi_q^2). \]

4.4 Numerical Simulations: Implications of the Two-Country Model

In this section, I present some numerical simulations of my model to investigate the mechanism of transmission of VoV shocks between two countries. The purpose of these simulations is to inves-

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\(^{23}\) Keep in mind that although the VoV is not a necessary condition to generate a variance risk premium, introducing the VoV isolates the risk premium on volatility and differentiates it from the consumption risk premium (see BTZ).
tigate the qualitative implications of my model for the variance premiums and for the interaction between the variance premiums and the expected stock returns. Understanding these qualitative implications provides a natural step between the model and the empirical evidence presented in the next section.

The base scenario for the numerical simulations is displayed in Table 2. In this scenario, the parameters in the preference function are calibrated as in BTZ. In order to simplify the interpretation of results, I consider the hypothetical case where the world is composed of only two countries: the US, and Germany. Just for the purpose of illustrating the mechanism behind the model, the US is considered as country 1 while Germany is considered as country 2. For these two countries, I calibrate the parameters in Eqs. (1) and (2) as follows: $μ_{j,\bar{g}}$ is estimated as the average industrial production (IP hereafter) growth in each country during the period 1973-2009; $μ_{j,\sigma}$ is estimated as the IP growth unconditional variance for the same period. The rest of the parameters are taken from BTZ (homogeneous parameters for the two countries). I estimate the Campbell and Shiller constants, $k_0$ and $k_1$, using data for the Price-Dividend (PD) ratio for each country as well as for the Datastream world portfolio. Thus, these constants are estimated as $k_1 = \frac{e^{E(PD)}}{1 + e^{E(PD)}}$, where $E(PD)$ is the unconditional mean of the (log) PD ratio, and $k_0 = -k_1 \ln(1 - k_1) - (1 - k_1) \ln(1 - k_1)$ (Campbell and Cochrane, 1999). This particular calibration of $k_0$ and $k_1$ allows me to make these two parameters independent from the set of parameters considered in each simulation. Nevertheless, $k_0$ and $k_1$ should actually be made dependent on the model-implied wealth-consumption ratio (see Appendix A).

24 Although one could mention several arguments similar to those in Rapach, Strauss and Zhou (2012) and papers cited therein to label the US as the uncertainty-driver economy, I prefer to leave the identification of this economy to the empirical evidence. Thus, I leave the door open for any country in my sample to behave as country 1 and any other country or countries to behave as country 2 in my model.

25 A full calibration of my model is out of the scope of this paper and is being considered for further research. My attention is rather centered in my model’s qualitative implications. These implications explain in turn the main empirical findings of this paper such as the local predictability puzzle and the ability of the US variance premium to predict all other countries stock returns.

4.4.1 Variance Premium Dynamics

According to the first main implication of my model, all portfolios’ variance premiums load positively on both countries’ VoV (see Eqs. (4) to (6)). Figure 4 displays all portfolios’ variance

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premiums (unconditionally expected) VoV loads. The figure shows the components of the variance premiums for alternative values of the risk aversion ($\gamma$), the weight of country 1 in the global economy ($\omega$), and the correlation of consumption ($\phi_\alpha$). The simulations show that the model-implied size of country 1’s VoV component dominates that of country 2 in all cases considered. The dominance of country 1’s VoV increases with the relative size of its economy ($\omega$), and with the relative dependence of country 2 to the uncertainty generated in country 1 ($\phi_\alpha$). In contrast, the contribution of country 2’s VoV in the variance premiums is almost insignificant irrespective of the size or the independence of the consumption process in this economy.

[Insert Figure 4 here.]

The simulations also suggest that the magnitude of the model-implied (unconditional) variance premiums increases with the risk aversion, and decreases with the relative size of the riskiest market, which is assumed, for coherence, to be country 2.\textsuperscript{26} Nevertheless, for all cases considered, the model-implied variance premium is quantitatively far from that empirically observed for these two countries (see Table 1).\textsuperscript{27}

In unreported results, I show that the model-implied variance premium correlation between the two countries is above 0.98 for all simulations. This result is to be expected given the high common component of the country 1’s VoV component in all variance premiums. Actually, for all cases considered, my model implies that country 1’s VoV accounts for more than 99% of the total cross-country variance premium covariance. Surprisingly, the result on the dominant role of country 1’s VoV holds no matter the relative size of its economy - at least as long as $(1 - \omega) < 0.5$-
or the implied correlation between economies 1 and 2.

In sum, the numerical simulations show that the VoV generated in country 1 accounts for most of the systemic component of the variance premiums. Therefore, the VoV generated in country 1 plays the key role in explaining the variance premium for all portfolios. This in turn implies that country 1’s VoV is also the key driver of the expected variance premium correlation between the two countries.

\textsuperscript{26}It is easy to show that a relation in the same direction holds for the IES parameter $\psi$. Results for the relation between $\psi$ and the model implications are available upon request.

\textsuperscript{27}In a single-country setting, Drechsler and Yaron (2011) have documented the limitation to quantitatively reflect the observed premium in models with recursive preferences.
4.4.2 Stock Return Dynamics

According to the second main implication of my model, the two countries’ VoV that uniquely characterize the variance premiums also drive the time variation in expected stock returns. Figure 5 displays the model-implied components of the expected stock returns for the global and the local portfolios for alternative sets of parameters. In sum, the simulations show that country 1’s VoV component dominates that of country 2 in all portfolios’ expected stock returns for all cases considered.

My simulations also reveal that only when economies are assumed to be poorly correlated, country 2’s expected stock returns load negatively on country 1’s VoV (Panels J and K). In contrast, country 1’s expected stock returns load on country 2’s VoV is negative for all cases considered (Panels C,F,I, and L), except of course for the extreme case where the size of economy 2 is insignificant.

The possibility of the expected stock returns loading negatively on VoV can be explained by the mechanism of transmission of shocks to VoV implied by my model. According to this mechanism, a positive shock to VoV in country 2 has a negative impact on country 1’s expected stock returns. This effect can be interpreted as an uncertainty-induced flight-to-safety from country 2 to country 1. The possibility of an uncertainty flight-to-safety in this direction is actually generated by the fact that the country 1’s consumption process is, by construction, not affected by the shocks generated in country 2 (Eq. (1)). Thus, stocks in country 1 become more attractive with respect to this foreign source of risk. That is, when all other sources of risk remain unchanged. In contrast, an uncertainty-driven flight-to-safety in the other direction (country 1 to country 2) is not always possible since country 2’s consumption process is affected by the shocks generated in country 1 (Eq. (2)). Therefore, according to my model, a flight-to-safety in this direction would only be possible if the economies are assumed to be independent or almost independent from each other. For instance, in the case of totally independent economies in Panel J, any country’s stock market is free from the uncertainty risk generated in the foreign economy. Thus, in this extreme case, any country’s expected stock returns load on the VoV of the foreign country will always be negative.

As a consequence of the second main implication of my model, both countries’ VoV also play a role in explaining the stock returns covariance between the two countries. In unreported simulations, I show that even if country 2’s economy is assumed to be relatively large ((1 − ω) < 0.5), country
1' VoV component dominates the stock returns correlation. The dominance of country 1’s VoV component increases with the relative size of its economy ($\omega$), and the degree of dependence between the two economies ($\phi$). Moreover, in line with the simulations in Figure 5, the cross-country return covariance may even load negatively on country 2’s VoV. Actually, in the case of totally independent or poorly correlated economies, the simulations confirm that the cross-country return covariance may even load negatively on country 1’s VoV.

Finally, the simulations in Figure 6 show the relation between the degree of economic correlation and the model-implied correlation between the two stock markets. These simulations aim to reflect the documented disparity between the correlation of stock markets and the correlation of consumption growth processes. The figure reveals that cross-country stock return correlation is in some cases higher than the implied correlation of consumption. In particular, the simulations suggest that for moderately risk averse agents ($\gamma > 2$) and moderately correlated economies, the implied correlation between the two stock markets is larger than that implied by the correlation of their consumption processes. This result arrives as a direct consequence of the recursive nature of the representative agent’s preferences.

[Insert Figure 6 here.]

In sum, the numerical simulations show that, for a particular set of assumptions, the uncertainty-driver country’s VoV plays the key role in explaining the time variation in the expected stock returns of all portfolios. As a consequence of this implication, the uncertainty-driver country’s VoV also plays a dominant role in explaining the time variation in cross-country stock return correlations.

5 The Variance Premium and International Equity and Option Markets: Empirical Evidence

In this section, I present empirical evidence for the role of the variance premium in explaining the interactions across international stock and option markets. I also contrast this evidence with the qualitative implications of the GE model proposed in Section 4. Using the variance premiums for all countries in the sample, I investigate their role in (i) explaining the time variation in foreign variance premiums, (ii) predicting the cross-country variance premium correlations, (iii) predicting local and foreign future stock returns, and (iv) predicting the cross-country stock return correlation.
5.1 Cross-country Variance Premium Correlations

A first implication of my model is that the variance premiums are highly correlated across countries. The high model-implied variance premium correlations are due to the variance premiums common load on country 1’s, the uncertainty-driver country, VoV. This in turn implies that country 1’s variance premium plays a key role in predicting the future cross-country variance premium correlation. To analyze this implication, I first provide evidence for the variance premium correlations across countries. Then, I investigate the role of each country’s variance premium in predicting the variance premium correlations with any other country.

Table 3 displays the variance premium correlations between all pairs of countries in the sample. All pairwise correlations, except for those including Japan, are above 0.5. In particular, the US and the UK show a high correlation coefficient of 0.73. Among European markets, France and The Netherlands show the highest correlation coefficient in the sample, 0.89. In contrast, Japan’s variance premium shows a relatively low, or even negative, correlation with the variance premium of any other country excepts perhaps with Switzerland, 0.61. The evidence for Japan stands in sharp contrast to the implications of my model. In fact, my model can only accommodate positive (unconditional) variance premium correlations as long as \( \theta < 1 \).

The results on the high cross-country variance premium correlations has been previously documented in the literature for a shorter sample of countries. For example, Bekaert, Hoerova and Scheicher (2009) find evidence of high risk aversion and uncertainty correlation between Germany and the US. Although their measures are not directly the variance premiums, their empirical methodology uncovers the risk aversion and uncertainty time series using the observed IV and realized volatilities for these two countries. Sugihara (2010) also finds evidence of strong linkages in volatility premiums between the US, Germany and Japan. He actually finds empirical evidence that the correlation between these three markets is stronger around certain episodes; in particular, after the subprime crisis. However, in this paper, I not only extend the evidence for a larger sample of countries but also provide a fundamental explanation for the dynamics of the cross-country variance premium correlations. In particular, my model relates the high variance premium correlations to a common component in all countries’ variance premiums.

\[28\] The highly idiosyncratic dynamic of the variance premium in Japan has been previously documented in the literature (see, for instance, Driessen and Maenhout, (2006)).
A direct consequence of the common component in all variance premiums is that the variance premium should also be a useful predictor of cross-country variance premium correlations. To test this consequence, Table 4 reports the estimated coefficients $\gamma_{1,jk}$ for the following regressions:

$$\rho_t(vp_{j,t:t+1},vp_{k,t:t+1}) = \gamma_{0,jk} + \gamma_{1,jk}vp_{k,t} + \epsilon_{jk,t},$$

where $\rho_t(vp_{j,t:t+1},vp_{k,t:t+1})$ represents the correlation coefficient, and is calculated using daily data for the variance premiums of the two countries for the month starting immediately after the realization of $vp_{k,t}.^{29,30}$ The evidence suggests that the US variance premium predicts the one-month-ahead variance premium correlation between the US, Germany, and Japan (first horizontal block of results). The results also show that the US variance premium does not necessarily outperform all other countries’ variance premium. For example, the first vertical block of results in the table suggests that the variance premiums in Germany, Japan, the UK, Switzerland and The Netherlands can also forecast the variance premium correlation between these countries and the US.\(^32\)

[Insert Table 4 here.]

In sum, the evidence in this section suggests that the cross-country variance premium correlations increase following episodes of increasing variance premiums. The evidence also suggests that the model-implied dominant role of one of the country’s variance premium might restrict the interpretation of the potential ability of other countries in predicting one-month ahead variance premium correlations—a limitation derived from the simplicity of a two-country model with a one-directional uncertainty transmission mechanism.

### 5.2 Cross-Country Stock Return Correlations

The second main implication of my model is that the variance premiums covary with the expected stock returns (Eqs. (9) and (10)). This is due to the fact that both countries’ expected stock

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\(^{29}\)The following month, $(t, t + 1)$, is assumed to be the period 22 days after the realization of $vp_{k,t}.$

\(^{30}\)Equation (7) actually has an implication on the variance premium covariance. To avoid a potential scale problem, and make results easier to interpret, I report cross-country correlations instead of covariances. An expression for the variance premium correlation from Eq. (7) is direct, although not necessarily linear in VoV.

\(^{31}\)In unreported results, I actually show that, except for the variance premium measure based on the martingale assumption, the predictive role of the US variance premium over its correlation with Germany and Japan holds for all alternative variance premium specifications considered.

\(^{32}\)Given the high correlation in $vp_t$ across countries, it would be hard to disentangle the simultaneous role of $vp_{US,t}$ with any other $vp_{j,t}$ as multiple regressions will be highly affected by multicollinearity.
returns load on the VoV that uniquely characterize the variance premiums. More specifically, my model implies that one of the country’s VoV component, that of the uncertainty-driver, dominates in all countries’ expected stock returns. As a consequence, the variance premium of the uncertainty-driver country should outperform that of any other country in predicting local and foreign stock returns. In this section, I provide evidence for the role of foreign variance premiums in predicting future stock returns for all countries in the sample.

Table 5 reports the estimation results for the following regressions:

\[(r - r_f)_{j,t,t+3} = \gamma_0_{j,k} + \gamma_{1,j,k}V_{p,k,t} + \gamma_{1,j,k}dy_{j,t} + \gamma_{1,j,k}ts_{j,t} + \epsilon_{j,k,t},\]

where \((r - r_f)_{j,t,t+3}\) represents 3-months ahead compounded annualized excess stock returns, \(dy_{j,t}\) is the local dividend yield, and \(ts_{j,t}\) is the local term spread.\(^{33}\) The main result in this table is that only the US variance premium plays a significant role in predicting stock returns for all other countries in the sample. Nevertheless, for other pairs of countries, the predictive power of the foreign variance premium over international stock returns is also significant. This is the case for the significant predictive power of the Japanese variance premium over Belgium and France’s stock returns. It is also the case for the (often borderline) predictive power of the variance premium of all countries, except for Switzerland and Japan, over the US stock returns.\(^{34}\)

[Insert Table 5 here.]

To investigate more in depth the predictive power of the US variance premium over international stock returns, Figure 7 reports the estimation results for the following regressions:

\[(r - r_f)_{j,t,t+h} = \gamma_{0,j,h} + \gamma_{1,j,h}V_{US,t} + \gamma_{1,j,h}dy_{j,t} + \gamma_{1,j,h}ts_{j,t} + \epsilon_{j,h,t},\]

where \((r - r_f)_{j,t,t+h}\) represents \(h\)-months ahead annualized excess returns. The results suggest that the predictive power of the US variance premium for all countries, except perhaps for Japan, resembles the hump-shaped pattern found by BTZ for the US (local return predictability). This

\(^{33}\)The evidence for the US in BTZ suggests that the predictive power of the variance premium is stronger at the quarterly horizon.

\(^{34}\)In fact, in unreported results, I show that not even a proxy for the world variance premium (with and without the US) is able to significantly predict stock returns for all other countries in the sample. This evidence is in contrast with that in Bollerslev, et al. (2012). They find a value weighted VP - where the VP is measured using the Martingale assumption as in BTZ - to have predictive power over future stock returns for all countries in our sample except for Belgium and the Netherlands for a sample period between 2000 and 2010.
pattern reflects the fact that the variance premium should be a dominant predictor for horizons where the VoV is the main source of variation in stock returns. In light of the implications of my model, the extension of this evidence to other countries suggests that the US VoV is the dominant source of variation in all countries’ stock returns for horizons between 3 and 6 months. The figure also suggests that the predictive power of the US variance premium is complementary to that of local term spreads and dividend yields. More important, comparing the evidence in Figure 7 with that in Figure 3 yields that the US variance premium outperforms the local variance premiums in predicting stock returns for all countries considered.

As additional robustness tests, in unreported results, I show that the ability of the US variance premium to predict one-quarter ahead foreign stock returns holds even if a large noise signal is added to the original variance premium measure. The results from this stress test suggest that for all countries’ stock returns, except perhaps for the Netherlands and Japan, the standard deviation of the noise signal has to be at least 50% that of the original US variance premium before its predictive power disappears. Moreover, the predictive power of the US variance premium over international stock returns holds for all alternative variance premium specifications considered, except perhaps for the range-based estimation.

According to my model, as a consequence of the common component in all countries’ expected stock returns, the US variance premium should also be a useful predictor of cross-country stock return correlations (Eq. (11)). To test this consequence, Figure 8 reports the estimation results for the following regressions:

$$\rho_t(r_{j,t+h}, r_{US,t+h}) = \gamma_{0,jk} + \gamma_{1,j,US}v_{US,t} + \epsilon_{jk,t},$$

where $$\rho_t(r_{j,t+h}, r_{US,t+h})$$ is the $$h$$-months ahead equity return correlation between any country
and the US. The results suggest that the US variance premium predicts stock return correlations between the US and any other country in the sample except for Japan and Belgium. The ability of the US variance premium to predict stock return correlations holds for horizons between 3 and 6 months for most of the countries. Actually, for the correlation between the US and Germany's stock returns, the US variance premium has predictive power for horizons up to 12 months.\(^{39}\)

[Insert Figure 8 here.]

In sum, the evidence in this section supports the qualitative implications of my model for the role of the variance premium in predicting international stock returns. In particular, this evidence confirms the predominant role of the US variance premium in predicting foreign stock returns and cross-country stock return correlations. Thus, this evidence supports my model’s implied solution to the local return predictability puzzle in Section 3 and suggests that the local variance premium cannot predict stock returns in countries other than the US because the role of the local variance premium is dominated by that of the US.

6 Conclusions

This paper presents several new findings related to the variance risk premium for a total of eight countries. First, I provide new evidence that the variance premiums display significant time variation and are, on average, positive for all countries in my sample. However, I also provide evidence that except for the US and Belgium, the local variance premiums do not predict local stock returns. This evidence stands in sharp contrast to the existing single-country models where the variance premium implicitly explains the time variation in expected stock returns.

Motivated by the puzzling single-country evidence, I propose an international model to understand the role of the variance premium in explaining the interactions across international stock and option markets. My model yields several relevant qualitative implications that explain the inability of the variance premium in predicting local stock returns in countries other than the US. In particular, my model implies that the variance premium of a country whose uncertainty affects the consumption process in a foreign country plays a key role in explaining the time variation in local and foreign stock returns. Therefore, this uncertainty-driver country’s variance premium

\(^{39}\)In unreported results, I repeat this exercise for all other pairwise correlations and show that the US variance premium outperforms all other countries in the sample in predicting stock return correlations.
outperforms that of any foreign country in predicting future stock returns and cross-country stock return correlations.

Finally, I provide new empirical evidence for the role of the variance premium in explaining international stock and derivative markets. I show that the US variance premium has predictive power for future stock returns for all countries in the sample. The predictive power of the US variance premium over international stock returns is (i) stronger for horizons between 3 and 6 months, (ii) additional to that of traditional local (or US) variables, and (iii) clearly outperforms the local variance premium themselves. Finally, I also show that the US variance premium predicts the cross-country stock return correlation between the US and any other country in the sample, except for Japan and Belgium.
APPENDIX

A Detailed Solution of the Two-country Model

This appendix explains in detail the solution to the model in Section 4.

Each country return process is assumed to be a claim on the local consumption growth, while
the global portfolio return is a claim on the weighted global consumption, $g^w_t = \omega g^1_t + (1 - \omega)g^2_t$, where \( \omega \) is the weight of country 1. Following Campbell and Shiller (1988), the returns are linearized as

\[
    r_{j,t+1} = \kappa_j,0 + \kappa_j,1 z_{j,t+1} - z_{j,t} + g_{j,t+1}, \quad \text{for } j = 1, 2, w, \tag{12}
\]

where $z_{j,t}$ denotes the log of the wealth-consumption ratio of the asset that pays the consumption endowment $\{C_{j,t+i}\}_{i=1}^{\infty}$. As it is standard in the asset pricing literature, I conjecture a solution for $z_{j,t}$ as a function of the state variables of both countries as follows:

\[
    z_{j,t+1} = A_{j,0} + A_{j,1} \sigma_{1,t+1}^2 + A_{j,2} q_{1,t+1} + A_{j,3} \sigma_{2,t+1}^2 + A_{j,4} q_{2,t+1}. \tag{13}
\]

Based on this solution, the basic asset pricing equation is imposed in order to determine the components of $z_{j,t+1}$. The basic asset pricing equation is the first order condition from the agent maximization problem given by

\[
    E_t[(\exp(m_{t+1} + r_{j,t+1}))] = 1,
\]

where $m_{t+1}$ is the (log of) intertemporal marginal rate of substitution. For the case of Epstein-Zin-Weil preferences, and given that markets are assumed to be perfectly integrated, the unique marginal rate of substitution is given by

\[
    m_{t+1} = \theta \log \delta - \frac{\theta}{\psi} g_{t+1} + (\theta - 1)r_{t+1} = b_{m0} + b_{mg} g_{w,t+1} + b_{mr} r_{w,t+1},
\]

where $0 < \delta < 1$ is the time discount rate, $\gamma \geq 0$ is the risk aversion parameter, and $\theta = \frac{1 - \gamma}{1 - \psi}$ for $\psi \geq 1$ is the intertemporal elasticity of substitution (IES).
Solving for the world portfolio yields the following expressions for the components of $z_{j,t+1}$:

$$A_{w,0} = \theta \log \delta + (1 - \gamma)(\omega \mu_{1,g} + (1 - \omega)(\mu_{2,g} + \phi_g \mu_{1,g})) \frac{\theta(1 - \kappa_{w,1})}{\theta(1 - \kappa_{w,1})} + \frac{\kappa_{w,0} + \kappa_{w,1}A_{w,1}a_\sigma + \kappa_{w,1}A_{w,2}a_q + \kappa_{w,1}A_{w,3}a_\sigma + \kappa_{w,1}A_{w,4}a_q}{(1 - \kappa_{w,1})},$$

$$A_1 = \frac{(1 - \gamma)^2(\omega + (1 - \omega)\phi_g)^2}{2\theta(1 - \kappa_{w,1} \rho_\sigma)},$$

$$A_{w,2} = \frac{(1 - \kappa_{w,1} \rho_q) \pm \sqrt{(1 - \kappa_{w,1} \rho_q)^2 - \theta^2 \kappa_{w,1} \rho_q^2 \varphi_q^2 A_{w,1}}}{\theta \kappa_{w,1} \rho_q},$$

$$A_{w,3} = \frac{(1 - \gamma)^2(1 - \omega)^2}{2\theta(1 - \kappa_{w,1} \rho_\sigma)},$$

and

$$A_{w,4} = \frac{(1 - \kappa_{w,1} \rho_q) \pm \sqrt{(1 - \kappa_{w,1} \rho_q)^2 - \theta^2 \kappa_{w,1} \rho_q^2 \varphi_q^2 A_{w,3}}}{\theta \kappa_{w,1} \rho_q \varphi_q^2}.$$

To avoid the load of time-varying volatilities $\sigma_{1,t}$ and $\sigma_{2,t}$ from growing without bounds, I only keep $A_{w,2}$ ($A_{w,4}$). The positive root discarded is explosive in $\varphi_q$, i.e., $\lim_{\varphi_q \to 0} A_{w,2}^{+} \varphi_q \neq 0$ ($\lim_{\varphi_q \to 0} A_{w,4}^{+} \varphi_q \neq 0$). $A_{w,2}$ ($A_{w,4}$) will be a solution to the model as long as $(1 - \kappa_{w,1} \rho_q)^2 \geq \theta^2 \kappa_{w,1} \rho_q^2 \varphi_q^2 A_{w,1}$ ($1 - \kappa_{w,1} \rho_q)^2 \geq \theta^2 \kappa_{w,1} \rho_q^2 \varphi_q^2 A_{w,3}$). It is easy to show from these expressions that the global wealth-consumption ratio loads negatively on all state variables. That is, $A_{w,1}$, $A_{w,2}$, $A_{w,3}$, $A_{w,4} \leq 0$ as long as $\theta < 1$.

Solving for country 1 yields the following expressions:

$$A_{1,0} = \frac{\kappa_{1,0} + \kappa_{1,1}A_{1,1}a_\sigma + \kappa_{1,1}A_{1,2}a_q + \kappa_{1,1}A_{1,3}a_\sigma^2 + \kappa_{1,1}A_{1,4}a_q + \mu_{1,g}}{(1 - \kappa_{1,1})} + \frac{\kappa_{w,0} + (\kappa_{w,1} - 1)A_{w,0} + \kappa_{w,1}A_{w,1}a_\sigma + \kappa_{w,1}A_{w,2}a_q + \kappa_{w,1}A_{w,3}a_\sigma + \kappa_{w,1}A_{w,4}a_q + \omega \mu_{1,g} + (1 - \omega)(\mu_{2,g} + \phi_g \mu_{1,g})}{(1 - \kappa_{1,1})},$$

$$A_{1,1} = \frac{(1 - \theta)(1 - \gamma)^2(\omega + (1 - \omega)\phi_g)^2 + \theta(1 - \gamma)(\omega + (1 - \omega)\phi_g)^2)}{2\theta(1 - \kappa_{1,1} \rho_\sigma)}.$$
Finally, for country 2, solving the basic asset pricing equation yields

\[ A_{1,2} = \frac{(1 - \kappa_{1,1} \rho_q) + (1 - \theta) \kappa_{1,1} \kappa_{w,1} A_{w,2} \varphi_q^2}{\kappa_{1,1}^2 \varphi_q^2} \]

\[ \pm \sqrt{\frac{((1 - \kappa_{1,1} \rho_q) + (1 - \theta) \kappa_{1,1} \kappa_{w,1} A_{w,2} \varphi_q^2)^2 - \kappa_{1,1}^2 \varphi_q^2((\theta - 1)^2 \kappa_{w,2}^2 A_{w,2} \varphi_q^2 + 2(\kappa_{w,1} \rho_q - 1)(\theta - 1) A_{w,2} + (\kappa_{1,1} A_{1,1} + (\theta - 1) \kappa_{w,1} A_{w,1})^2)}{\kappa_{1,1}^2 \varphi_q^2}}, \]

\[ A_{1,3} = \frac{(1 - \theta)(1 - \kappa_{w,1} \rho_q) A_{w,3} + \frac{1}{2} \gamma^2 (1 - \omega)^2}{(1 - \kappa_{1,1} \rho_q)}, \]

and

\[ A_{1,4} = \frac{(1 - \kappa_{1,1} \rho_q) + (1 - \theta) \kappa_{1,1} \kappa_{w,1} A_{w,4} \varphi_q^2}{\kappa_{1,1}^2 \varphi_q^2} \]

\[ \pm \sqrt{\frac{((1 - \kappa_{1,1} \rho_q) + (1 - \theta) \kappa_{1,1} \kappa_{w,1} A_{w,4} \varphi_q^2)^2 - \kappa_{1,1}^2 \varphi_q^2((\theta - 1)^2 \kappa_{w,2}^2 A_{w,4}^2 + 2(\kappa_{w,1} \rho_q - 1)(\theta - 1) A_{w,4} + (\kappa_{1,1} A_{1,3} + (\theta - 1) \kappa_{w,1} A_{w,3})^2)}{\kappa_{1,1}^2 \varphi_q^2}}. \]

Finally, for country 2, solving the basic asset pricing equation yields

\[ A_{2,0} = \frac{\kappa_{2,0} + \kappa_{2,1} A_{2,1} a_\sigma + \kappa_{2,1} A_{2,2} a_q + \kappa_{2,1} A_{2,3} a_\sigma + \kappa_{2,1} A_{2,4} a_q + \mu_{2,1} + \phi_{2,1} \mu_{1,1}}{(1 - \kappa_{2,1})} \]

\[ \frac{\kappa_{w,0} + \kappa_{w,1} A_{w,0} + \kappa_{w,1} A_{w,1} a_\sigma + \kappa_{w,1} A_{w,2} a_q + \kappa_{w,1} A_{w,3} a_\sigma + \kappa_{w,1} A_{w,4} a_q - A_{w,0} + \omega \mu_{1,1} + (1 - \omega)(\mu_{2,1} + \phi_{2,1} \mu_{1,1})}{(1 - \kappa_{2,1})}, \]

\[ A_{2,1} = \frac{(1 - \theta)(1 - \gamma)^2 (\omega + (1 - \omega) \phi_\sigma)^2 + \theta (\phi_\sigma - \gamma (\omega + (1 - \omega) \phi_\sigma))^2}{2 \theta (1 - \kappa_{2,1} \rho_\sigma)}, \]

28
\[ A_{2,2}^{\pm} = \frac{(1 - \kappa_{2,1}\rho_q) + (1 - \theta)\kappa_{w,1}\kappa_{2,1}A_{w,2}\varphi_q^2}{\kappa_{2,1}^2\varphi_q^2} \]

\[ \pm \sqrt{\frac{((1 - \kappa_{2,1}\rho_q) + (1 - \theta)\kappa_{w,1}\kappa_{2,1}A_{w,2}\varphi_q^2)^2 - 2\varphi_q^2\kappa_{2,1}^2((\theta - 1)(\kappa_{w,1}\rho_q - 1)A_{w,2} + \frac{1}{2}((\theta - 1)\kappa_{w,1}A_{w,1} + \kappa_{2,1}A_{2,1})^2 + \frac{1}{2}\varphi_q^2(\theta - 1)^2\kappa_{w,1}^2A_{w,2}^2)}{(\kappa_{1}^2)^2\varphi_q^2}}, \]

\[ A_{2,3} = \frac{(1 - \theta)(1 - \kappa_{w,1}\rho_q^2)A_{w,3} + \frac{1}{2}(1 - \gamma(1 - \omega))^2}{(1 - \kappa_{2,1}\rho_q^2)}, \]

and

\[ A_{2,4}^{\pm} = \frac{(1 - \kappa_{2,1}\rho_q) + (1 - \theta)\kappa_{w,1}\kappa_{2,1}A_{w,4}\varphi_q^2}{\kappa_{2,1}^2\varphi_q^2} \]

\[ \pm \sqrt{\frac{((1 - \kappa_{2,1}\rho_q) + (1 - \theta)\kappa_{w,1}\kappa_{2,1}A_{w,4}\varphi_q^2)^2 - 2\varphi_q^2\kappa_{2,1}^2[2(\kappa_{w,1}\rho_q - 1)(\theta - 1)A_{w,4} + ((\theta - 1)\kappa_{w,1}A_{w,3} + \kappa_{2,1}A_{2,3})^2 + \varphi_q^2(\theta - 1)^2\kappa_{w,1}^2A_{w,4}^2)]}{(\kappa_{2,1}^2)^2\varphi_q^2}}, \]

Again, following the reasoning for the world portfolio, it only makes sense to keep \( A_{j,2} \) and \( A_{j,4} \).
References


The table reports the average volatility premiums (in annual percentages) calculated monthly as $\text{volp}_{j,t} = iv_{j,t} - E_t(rv_{j,t+1})$ for the eight countries considered and the sample period running from 2000 to 2009. I also report the summary statistics for the variance premiums (in annual square percentages). The variance premium in each country is estimated as $\text{vp}_{j,t} = iv_{j,t}^2 - (\hat{rv}_{j,t+1})^2$, where the benchmark specification for the expected realized variance is its first order autoregressive forecast. AR(1) is the estimated first-order autoregressive coefficient of the variance premium. *,**, and *** represent significance at the standard 1, 5 and 10% confidence levels, both for the significance of the mean and the AR(1) coefficient. For the average volatility and variance premium, I perform a standard mean test and correct the standard deviations using Newey-West with 12 lags (given the evidence on the significance of the autoregressive coefficient). The standard errors to assess the significance of the AR(1) coefficient are also corrected using the Newey-West HAC (Heteroskedasticity and autocorrelation correction) standard deviations with 12 monthly lags (Newey and West, 1987).

<table>
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<tr>
<th>Country</th>
<th>IV Index</th>
<th>Index</th>
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<th>Variance Premium</th>
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</thead>
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<td></td>
<td></td>
<td></td>
<td>Mean (%)</td>
<td>Mean (sq. %)</td>
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<td>124.32***</td>
</tr>
<tr>
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<td>VDAX</td>
<td>DAX 30</td>
<td>2.42***</td>
<td>142.25***</td>
</tr>
<tr>
<td>JAP</td>
<td>VXI</td>
<td>NIKKEI 225</td>
<td>3.87***</td>
<td>257.35***</td>
</tr>
<tr>
<td>UK</td>
<td>VFTSE</td>
<td>FTSE 100</td>
<td>3.40***</td>
<td>152.68***</td>
</tr>
<tr>
<td>SWI</td>
<td>VSMI</td>
<td>SMI</td>
<td>2.72***</td>
<td>140.48***</td>
</tr>
<tr>
<td>NL</td>
<td>VAEX</td>
<td>AEX 25</td>
<td>3.24***</td>
<td>164.95***</td>
</tr>
<tr>
<td>BE</td>
<td>VBEL</td>
<td>BEL 20</td>
<td>1.71***</td>
<td>67.84**</td>
</tr>
<tr>
<td>FR</td>
<td>VCAC</td>
<td>CAC 100</td>
<td>2.31***</td>
<td>115.87**</td>
</tr>
</tbody>
</table>
Table 2: Base Scenario for the Numerical Implications of the Two-Country Model
The table reports the values for the two-country model parameters considered as the base scenario to test its numerical implications. In this scenario, all parameters in the preference function (Eq. (3)) are taken from BTZ. The country-specific parameters in Eqs. (1) and (2) are estimated as follows: $\mu_{j,g}$ is estimated as the average IP growth for the sample 1973-2009; $\mu_{j,g}$ is estimated as the average IP growth for the sample 1973-2009; $\mu_{j,g}$ is estimated as the IP growth unconditional variance for the sample 1973-2009. Finally, the parameters $k_0$ and $k_1$ in the log-linearization of returns (Eq. (12)) are estimated using data for the Price-Dividend (PD) ratio for each country as well as for the Datastream world portfolio. The log-linearization constants are estimated as $k_1 = \frac{E(PD)}{1+e^{k_2 \eta}}$, where $E(PD)$ is the unconditional mean of the (log) PD ratio, and $k_0 = -k_1 \ln(1 - k_1) - (1 - k_1) \ln(1 - k_1)$ (Campbell and Cochrane, 1999).

<table>
<thead>
<tr>
<th>Param.</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu_g$</td>
<td>Mean consumption growth</td>
<td>Global: $1.6 \times 10^{-5}$, Country 1: $8.3 \times 10^{-4}$, Country 2: $6.6 \times 10^{-6}$</td>
</tr>
<tr>
<td>$a_\sigma$</td>
<td>Long-run consumption volatility</td>
<td>$1.2 \times 10^{-6}$, $6.6 \times 10^{-6}$</td>
</tr>
<tr>
<td>$\rho_\sigma$</td>
<td>Speed of reversion consumption volatility</td>
<td>$0.98$, $0.98$</td>
</tr>
<tr>
<td>$a_q$</td>
<td>Long-run VoV</td>
<td>$2.0 \times 10^{-7}$, $2.0 \times 10^{-7}$</td>
</tr>
<tr>
<td>$\rho_q$</td>
<td>Speed of reversion VoV</td>
<td>$0.80$, $0.80$</td>
</tr>
<tr>
<td>$k_0$</td>
<td>Campbell-Shiller $k_0$</td>
<td>$0.12$, $0.13$, $0.12$</td>
</tr>
<tr>
<td>$k_1$</td>
<td>Campbell-Shiller $k_1$</td>
<td>$0.97$, $0.97$, $0.97$</td>
</tr>
<tr>
<td>$\psi$</td>
<td>Intertemporal elasticity of substitution</td>
<td>$2.50$</td>
</tr>
<tr>
<td>log $\delta$</td>
<td>Discount factor</td>
<td>$1.00$</td>
</tr>
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Table 3: Pairwise Variance Premium Correlations
The table reports the pairwise variance premium correlation coefficients for all countries in my sample for the period running from 2000 to 2009.

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>GER</th>
<th>JAP</th>
<th>UK</th>
<th>SWI</th>
<th>NL</th>
<th>BE</th>
<th>FR</th>
</tr>
</thead>
<tbody>
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<td>0.74</td>
<td>0.37</td>
<td>0.76</td>
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<td>0.42</td>
<td>0.78</td>
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<td>0.07</td>
<td>-0.14</td>
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<td></td>
</tr>
<tr>
<td>UK</td>
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<td>0.64</td>
<td>0.77</td>
<td></td>
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<tr>
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<td>1.00</td>
<td>0.67</td>
<td>0.48</td>
<td>0.51</td>
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<td></td>
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</tr>
<tr>
<td>NL</td>
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</tr>
</tbody>
</table>
Table 4: Predicting Cross-country Variance Premium Correlations

The table reports the estimated coefficients $\gamma_{1,j,k}$ in the following regression:

$$ \rho_t(v_{p,j,t+1}, v_{p,k,t+1}) = \gamma_{0,j,k} + \gamma_{1,j,k} v_{p,k,t-1} + \epsilon_{j,k,t}, $$

where $j$ are the countries in the columns and $k$, the countries in the rows. For example, the information under the column JAP shows how the variance premium correlation between Japan ($j$) and any other country in the rows ($k$) is forecasted by country $k$'s variance premium. The correlation coefficient, $\rho_t(.)$, is calculated using daily data for the variance premiums of the two countries for the month, roughly 22 days, starting immediately after the realization of $v_{p,k,t-1}$. The standard errors in all regressions are corrected by Newey-West with 12 lags. To make the coefficients easier to interpret, the variance premiums are taken in monthly percentages square.

<table>
<thead>
<tr>
<th>$v_{p,k,t-1}$</th>
<th>US</th>
<th>GER</th>
<th>JAP</th>
<th>UK</th>
<th>SWI</th>
<th>NL</th>
<th>BE</th>
<th>FR</th>
<th>Avg. R$^2$</th>
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<tr>
<td>US</td>
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<td>45.53**</td>
<td>28.62</td>
<td>26.54</td>
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<td>46.40</td>
<td>8.22</td>
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<td></td>
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<tr>
<td></td>
<td>(2.05)</td>
<td>(2.03)</td>
<td>(1.58)</td>
<td>(1.42)</td>
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<tr>
<td>$R^2$</td>
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<td></td>
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<td>(2.58)</td>
<td>(0.62)</td>
<td>(1.84)</td>
<td>(1.07)</td>
<td>(0.89)</td>
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<td>(2.77)</td>
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Table 5: Predicting International Stock Returns

The Table reports the estimated coefficient $\gamma_{1,j,k}$ in the following regressions:

$$(r - r_f)_{j,t,t+3} = \gamma_{0,j,k} + \gamma_{1,j,k} v_{p,t} + \gamma_{1,j,k} d_{y,j,t} + \gamma_{1,j,k} t_{s,j,t} + \epsilon_{j,k,t},$$

where $(r - r_f)_{j,t,t+3}$ are 3-months ahead (compounded annualized) excess stock returns, $d_{y,j,t}$ are the (local) dividend yields and $t_{s,j,t}$ the (local) term spreads calculated as the difference between the 1 year T-bill and the 3 months t-bill rate. The standard errors are corrected by Newey-West with a number of lags $l = 12$. The table also reports the average $R^2$ for the predictive power of each country’s variance premium.

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<th>UK</th>
<th>SWI</th>
<th>NL</th>
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Figure 1: (model-free) Variance Premiums

The figure shows the Variance Premiums $vp_t$ in annual percentages square for the eight countries in my sample (see Table 1) for the sample period between 2000 and 2009. The variance premium in each country is calculated as $vp_{jt} = \hat{v}_{j,t}^2 - E_t(\hat{v}_{j,t+1})^2$, where the benchmark specification for the expected realized variance, $E_t(\hat{v}_{j,t+1})^2$, is its first order autoregressive forecast. The shaded areas represent NBER recession episodes for the US.
The figure reports the average variance premiums for each country for 4 alternative specifications (in bold squares) for the sample period from 2000 to 2009. For each measure and each country, I also report the 95% confidence intervals for the significance of the average variance premium. Measure 1 is the benchmark measure (AR(1)) where the expected realized variance is estimated as its first order autoregressive forecast. Measure 2 assumes that the expectation of the volatility under the physical measure is well-proxyed by \( rv_t \) or martingale assumption. In measure 3, the expected realized variance is estimated from a regression that includes the IV indices as in \( rv_{j,t+1} = \gamma_0 + \gamma_1 rv_{j,t} + \gamma_2 iv_{j,t} + \epsilon_t \). Finally, in measure 4, the expected realized variance is estimated from a regression that includes the monthly range-based variance for each country as in \( rv_{j,t+1} = \gamma_0 + \gamma_1 rv_{j,t} + \gamma_2 RangeV_{j,t} + \epsilon_t \), where \( RangeV_{j,t} \) is the range based variance calculated as \( RangeV_{j,t} = \frac{1}{4ln2} \sum_{t=1}^{N_t} range_{t_i}^2 \), where \( range_{t_i} \) is the daily difference between the highest and the lowest price of the index.
The Figure reports the estimated coefficients $\gamma_{1,j,h}$ in the following regressions:

$$(r - r_f)_{j,t,t+h} = \gamma_{0,j,h} + \gamma_{1,j,h}vp_{j,t} + \gamma_{2,j,h}dy_{j,t} + \gamma_{3,j,h}ts_{j,t} + \epsilon_{j,h,t},$$

where $(r - r_f)_{j,t,t+h}$ are $h$-months ahead (compounded annualized) excess stock returns, $dy_{j,t}$ are the local dividend yields and $ts_{j,t}$ are the local term spreads calculated as the difference between the 1 year T-bill and the 3 months t-bill rate. I consider monthly forecasting horizons up to 12 months. The shaded areas represent the 95% confidence intervals for the Newey-West corrected standard errors with a number of lags $l = \max\{2h, 12\}$. The figure also reports, in the secondary axis, the $R^2$ for each regression. To identify the predictive power of the variance premium, the $R^2$ are reported for regressions in which only the variance premiums are considered as in $(r - r_f)_{j,t,t+h} = \gamma_{0,j,h} + \gamma_{1,j,h}vp_{j,t} + \epsilon_{j,h,t}$. 

Figure 3: The role of the Local Variance Premiums in Predicting Local Stock Returns
Figure 3: The role of the Local Variance Premiums in Predicting Local Stock Returns. Continued
Figure 4: Simulations: Variance Premiums loads on the VoV. Alternative Parameters

The figure reports each portfolio’s variance premium total unconditional loads on the two countries’ volatility of volatility (VoV) as implied by Eqs. (4) to (6) for alternative values of parameters $\gamma$, $\omega$, and $\phi_\gamma$. The unconditional loads are calculated as $(\theta - 1)\kappa_{w',1}V_j,kE(q_{US,t})$ and $(\theta - 1)\kappa_{w',1}V_j,kE(q_{GER,t})$ for $k = US, GER$, and $j$ each one of the three possible portfolios: Country 1 (US), Country 2 (GER), and the global portfolio. Given the parameters in the base scenario (Table 2), the average VoV is given by $E(q_{US,t}) = E(q_{GER,t}) = \frac{\sigma_q}{1-\rho_q} = 1.0 \times 10^{-6}$. 
Figure 4: Simulations: Variance Premiums loads on the VoV. Alternative Parameters. Continued
Figure 5: Consumption Volatility and Expected Stock Returns loads on the VoV. Alternative Parameters

The figure reports the total unconditional components of all possible portfolio’s expected stock returns as implied by Eqs. (8) to (10) for alternative values of parameters $\gamma$, $\omega$, and $\phi_{p}$. To facilitate the interpretation, the exponential adjustment term $(-\frac{1}{2}\sigma_{r,t}^2)$ is excluded from the figure. Given the parameters in the base scenario in Table 2, the loads on the volatility of consumption are calculated by assuming that (the average volatility of consumption) $E(\sigma_{US,t}) = E(\sigma_{GER,t}) = \frac{\sigma_{US}}{1-\rho_{\sigma}} = 6.0 \times 10^{-5}$. The loads on VoV are calculated by assuming that (the average VoV) $E(q_{US,t}) = E(q_{GER,t}) = \frac{q_{US}}{1-\rho_{q}} = 1.0 \times 10^{-6}$.
Figure 5: Consumption Volatility and Expected Stock Returns loads on the VoV. Alternative Parameters. Continued
Figure 6: Cross-Country Return Correlations and Model-implied Consumption Growth Correlations
The figure shows the model-implied unconditional correlation of consumption growth ($\rho(g_{US,t}, g_{GER,t})$) and the model-implied stock return correlation ($\rho(r_{US,t}, r_{GER,t})$) between Country 1 (US) and Country 2 (Germany) for several alternative values of parameters $\gamma$, $\omega$, and $\phi_\sigma$. 
Figure 7: The role of the US Variance Premium in Predicting International Stock Returns

The Figure reports the estimated coefficient $\gamma_{1,j,h}$ in the following regressions:

$$(r - rf)_{j,t,t+h} = \gamma_{0,j} + \gamma_{1,j,h}vp_{US,t} + \gamma_{1,j,h}dy_{j,t} + \gamma_{1,j,h}ts_{j,t} + \epsilon_{j,h,t},$$

where $(r - rf)_{j,t,t+h}$ are $h$-months ahead (compounded annualized) excess returns, $dy_{j,t}$ are the local dividend yields and $ts_{j,t}$ are the local term spreads calculated as the difference between the 1 year T-bill and the 3 months t-bill rate. I consider monthly forecasting horizons up to 12 months. The shaded areas represent the 95% confidence intervals for the Newey-West corrected standard errors with a number of lags $l = max \{2h, 12\}$. The figure also reports, in the secondary axis, the $R^2$ for each regression. To separately identify the predictive power of the variance premium, the $R^2$ are reported for regressions in which only the US variance premium is considered as in $(r - rf)_{j,t,t+h} = \gamma_{0,j,h} + \gamma_{1,j,h}vp_{j,US} + \epsilon_{j,h,t}$. 

The Figure also reports, in the secondary axis, the $R^2$ for each regression. To separately identify the predictive power of the variance premium, the $R^2$ are reported for regressions in which only the US variance premium is considered as in $(r - rf)_{j,t,t+h} = \gamma_{0,j,h} + \gamma_{1,j,h}vp_{j,US} + \epsilon_{j,h,t}$.
Figure 7: The role of the US Variance Premium in Predicting International Stock Returns. Continued
Figure 8: The role of the US Variance Premium in Predicting Cross-country Stock Return Correlations

The table shows the estimated coefficients $\gamma_{1,j,US}$ in the following regression:

$$\rho_t(r_{j,t,t+h}, r_{US,t,t+h}) = \gamma_{0,jk} + \gamma_{1,j,US} v_{US,t-1} + \epsilon_{jk,t},$$

where $\rho_t(r_{j,t,t+h}, r_{US,t,t+h})$ is the $h$-months ahead stock return correlation between any country and the US. The correlation coefficient for the period $t$ to $t + 1$ is calculated using daily stock returns for the two countries for the month starting immediately after the realization of $v_{p_k,t-1}$. The shaded areas represent the 95% confidence intervals for the Newey-West corrected standard errors with a number of lags $l = \max\{2h, 12\}$. The figure also reports in the secondary axis the $R^2$ for each regression.
Figure 8: The role of the US Variance Premium in Predicting Cross-country Stock Return Correlations. Continued