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Evaluating international consumption risk sharing gains: An asset return view[☆]

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ABSTRACT

International consumption risk sharing studies often generate counterfactual implications for asset return behavior with potentially misleading results. We address this contradiction using data moments of consumption and asset returns to fit a canonical international consumption risk sharing framework. Introducing persistent consumption risk, we find that its correlation across countries is more important for risk sharing than that of transitory risk. To identify these risk components, we jointly exploit the comovement of equity returns and consumption. This identification implies high correlations in persistent consumption risk, suggesting a strong degree of existing risk sharing despite low consumption correlations in the data.

1. Introduction

International consumption risk sharing studies often ignore asset return implications. Indeed, their assumptions about risk and intertemporal substitution in consumption usually generate counterfactual implications for the behavior of asset returns.[1] This contradiction is important because risk sharing gains depend directly upon how agents value consumption risk, a value inherently observable through asset prices. Therefore, ignoring asset return implications may lead to incorrect assessments of international risk sharing gains.

The counterfactual asset return behavior in risk sharing studies originates from different approaches toward risk in the macroeconomic and finance literatures. On the one hand, many international risk sharing studies are based upon macroeconomic models that implicitly treat shocks to consumption as temporary deviations from a deterministic trend. These shocks are insufficiently volatile to explain equity returns and the resulting gains implied from risk sharing tend to be small. On the other hand, the gains from risk sharing in the empirical finance literature are measured from equity returns that are much more volatile, suggesting much higher risk sharing gains. However, these financial studies tend to focus on equity returns alone and ignore the connection to consumption behavior.

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[1] Surveys that discuss the literature on international risk sharing welfare gains include van Wincoop (1994), Tesar (1995), Lewis (2011), and Coeurdacier and Rey (2013). On the counterfactual implications of asset returns in this literature, see Obstfeld (1994b) and Lewis (2000).

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In this paper, we begin to bridge the gap between these two approaches using a canonical international consumption risk sharing framework calibrated to match features of asset returns. For this purpose, we draw from research that generates asset return implications that are closer to the data by allowing for persistence in the marginal utility of consumption.[2]

Specifically, we incorporate persistent consumption risk by introducing a small autoregressive component in consumption growth following Bansal and Yaron (2004), hereafter BY.[3] Given this consumption process, our approach in this paper proceeds in the following steps. First, use a Simulated Method of Moments (SMM) analysis to find the parameters that best fit the model to consumption and asset return data moments. Then calculate the world consumption allocation that would implement full risk sharing. Finally, measure the potential welfare gains of moving to this optimally diversified economy.

While persistent consumption risk improves the ability for the consumption-based model to match asset returns, its behavior also carries significant implications for risk sharing. Indeed, our results below show that the magnitude of risk sharing gains depends critically upon how much persistent risk can be diversified. Therefore, understanding risk sharing requires identifying the international correlation in the transitory versus persistent components separately, rather than the simple consumption correlations typically studied. To decompose each of these two types of risk, our analysis develops an identification strategy using the relationship between international equity return and consumption correlations. This relationship implies that the persistent risk correlations are very high and near one across our sample of advanced economies. The intuition behind this result is straightforward. In the data, international correlations of equity returns are higher than those of consumption. In the model, equity returns are more sensitive to persistent shocks than are consumption variations. As disciplined by the data, therefore, the model implies that this persistent risk is strongly correlated.

This result highlights a key finding of our paper. Since the persistent risk component of consumption is already highly diversified, the potential for international risk sharing gains arises primarily from diversifying the transitory shocks. As a result, these gains are quantitatively closer to macro-based studies that ignore asset pricing considerations. Importantly, this result stands in contrast to a conventional view that disciplining consumption-based models to match the equity premium will necessarily generate very high welfare gains, at times exceeding 100% of permanent consumption.[4]

Our finding that important consumption risk is already diversified is reminiscent of a related theme in exchange rate-based studies. Brandt et al. (2006) show that the lower volatility of exchange rates compared to equity returns implies a high degree of risk sharing. They pose this observation as a puzzle because low consumption correlations in the data suggest the opposite. By contrast, we show that high risk sharing and low consumption correlations are mutually consistent and need not present a puzzle in a one good economy with identical preferences. Similarly, in a two good economy with differing preferences across countries, Colacito and Croce (2011) and Stathopoulos (2012) generate low consumption correlations under full risk sharing. However, these papers assume complete markets, while we do not.[5]

The structure of the paper is as follows. Section 2 describes the basic risk sharing framework and identification of the benchmark economy assuming equity pays out realizations from the consumption process. Section 3 develops the full risk sharing economy and reports the implied risk sharing gains. Consistent with the literature, we find that this version of the equity model cannot adequately fit asset return moments. Consequently, Section 4 considers the BY model based upon dividend data, providing a better fit. Section 5 extends the analysis to include differing means, population sizes and a wider set of countries. Section 6 gives concluding remarks. On-line appendices provide details for all of the analysis and empirical methods.

2. The consumption asset benchmark

We begin by describing a canonical framework for evaluating international risk sharing gains. For this purpose, define C_t^B and W_t^B, respectively, as consumption and wealth at time t under our "benchmark economy," or the current level of risk sharing implied by data, and C_t^* and W_t^* as their counterparts in the fully diversified economy. Relationships for variables without the superscript B and $*$ throughout the paper hold in either equilibrium. Further, we specify the lifetime utility, or value function, in the benchmark economy and fully diversified economy to be given by $V(C_t^B, W_t^B)$ and $V(C_t^*, W_t^*)$, respectively. The welfare gain, Δ, is then the percentage increase to the benchmark consumption and wealth that achieves the lifetime utility of the full risk sharing economy at some initial time 0:

$$V((1+\Delta)C_0^B, (1+\Delta)W_0^B) = V(C_0^*, W_0^*). \tag{1}$$

These value functions depend crucially upon the utility function of investors. The time-additive constant relative risk aversion (CRRA) preferences often assumed in risk sharing studies create two significant problems for our purposes, however. First, they imply counterfactual asset pricing behavior. In particular, the equity premium is too low (Mehra and

[2] For example, Campbell and Cochrane (1999) employ habit persistent preferences, Bansal and Yaron (2004) assume that consumption growth has a persistent "long run risk" component, and Barro (2006) considers disaster risk.

[3] Our analysis is based upon this approach because it both matches important asset features and naturally nests the transitory-only risk case, as discussed below.

[4] For example, see the discussions in Obstfeld (1994b), Lewis (2000), and, more recently, Coeurdacier and Rey (2013).

[5] As another important difference, we consider a general multiple country world economy with differing income processes, while these papers restrict their analysis to a two country world with identically symmetric stochastic processes.

Prescott, 1985), the risk-free rate is too high (Weil, 1989), and the volatility of asset returns is too low (Campbell and Shiller, 1988). Second, as shown by Obstfeld (1994a), CRRA preferences cannot be used to accurately evaluate welfare gains in the presence of consumption growth because risk aversion and the intertemporal elasticity of substitution (IES) have opposing effects but are governed by the same parameter.[6]

For these reasons, we assume that consumers in each country have recursive preferences with distinct IES and risk-aversion parameters following Epstein and Zin (1989) and Weil (1990):

$$U(C_t, U_{t+1}) = \left\{ C_t^{((1-\gamma)/\theta)} + \beta E_t\left[(U_{t+1})^{1-\gamma} \right]^{1/\theta} \right\}^{\theta/(1-\gamma)}, \tag{2}$$

where C_t is the consumption at time t, U_{t+1} is the utility function at $t+1$; $0<\beta<1$ is the time discount rate; $\gamma \geq 0$ is the risk-aversion parameter; $\theta \equiv (1-\gamma)/(1-1/\psi)$ for $\psi \geq 0$, the intertemporal elasticity of substitution; and where $E_t(\cdot)$ is the expectation operator conditional on the information set at time t.

Since the utility function is homogeneous in consumption and wealth, we can write the value function following Campbell (1993) as $V(C_t, W_t) = \left(W_t/C_t\right)^{1/(1-(1/\psi))} C_t$. Moreover, defining P_t as the price of a "consumption asset," or an asset that pays out the consumption process in all future periods, wealth can be expressed as the identity: $W_t \equiv P_t + C_t$. Substituting this identity into the value function at time $t=0$, we rewrite welfare gains in Eq. (1) as

$$(1+\Delta) = \left\{ \frac{W_0^*/C_0^*}{W_0^B/C_0^B} \right\}^{(1/(1-(1/(\psi)))} \left(\frac{C_0^*}{C_0^B} \right) = \left\{ \frac{Z_0^*+1}{Z_0^B+1} \right\}^{(1/(1-(1/\psi)))} \left(\frac{C_0^*}{C_0^B} \right), \tag{3}$$

where $Z_t^* = (P_t^*/C_t^*)$ and $Z_t^B = (P_t^B/C_t^B)$ are the time t price–consumption ratios for the consumption asset prices under the full risk sharing and the benchmark economies, respectively. Therefore, as Eq. (3) shows, welfare gains can be computed given initial consumption levels, C_0^* and C_0^B, and price-to-consumption ratios in the benchmark and risk sharing economies, Z_0^B and Z_0^*.

To solve for these values, we use the first-order Euler equation condition for asset returns. Specifically, with the preferences in Eq. (2), Epstein and Zin (1989) show that the gross return on any asset ℓ, defined as R_ℓ, must satisfy the first-order Euler condition:

$$E_t\left\{ \beta^\theta (C_{t+1}/C_t)^{(-\theta/\psi)} (R_{P,t+1})^{(\theta-1)} R_{\ell,t+1} \right\} = 1, \tag{4}$$

where $R_{P,t+1}$ is the gross return on the consumption asset. That is, using our definition of the consumption asset price, $R_{P,t+1} \equiv (P_{t+1}+C_{t+1})/P_t$.

In this paper, we consider the potential international risk sharing gains for an individual country and therefore signify the country with an additional superscript j. Then, measuring the welfare gain in Eq. (3) requires the price-to-consumption and consumption levels for representative agents in each country: a set for the benchmark economy, Z_0^{jB} and C_0^{jB}; and a set for the risk sharing economy, Z_0^{j*} and C_0^{j*}. This section outlines the solutions for asset prices, including the consumption asset price, in the benchmark economy. Section 3 describes the counterparts in the risk sharing economy.

2.1. Asset prices and consumption in the benchmark economy

As shown above, measuring welfare gains depends critically on valuing the consumption asset price. Using our benchmark economy notation, the return on the consumption asset for country j is $R_{P,t+1}^j \equiv (C_{t+1}^{jB} + P_{t+1}^{jB})/P_t^{jB}$, determined in the benchmark equilibrium by substituting $R_{\ell,t+1} = R_{P,t+1} = R_{P,t+1}^j$ and $C_t = C_t^{jB}$ into Eq. (4) yielding

$$E_t\left\{ \beta^\theta (C_{t+1}^{jB}/C_t^{jB})^{(-\theta/\psi)} (R_{P,t+1}^j)^\theta \right\} = 1. \tag{5}$$

This benchmark Euler equation will be evaluated with observed consumption and asset data below, a standard approach in the asset pricing literature.

Although we aim to match the Euler equation to data on asset return and consumption moments, an extensive literature beginning with Mehra and Prescott (1985) has shown the difficulties of doing so. More recent research has demonstrated that low frequency, persistent consumption risk is necessary to better approximate asset return behavior. Among these, the "long run risk" approach of BY is the only model that uses both recursive preferences and targets asset return variability, like our framework. Following this approach, we define the benchmark consumption growth rate for each country j as $g_{c,t+1}^j \equiv \ln(C_{t+1}^{jB}/C_t^{jB})$ and incorporate a persistent stochastic component $x_t{}^j$ given by

$$\begin{aligned} g_{c,t+1}^j &= \mu^j + x_t^j + \sigma^j \eta_{t+1}^j \\ x_{t+1}^j &= \rho^j x_t^j + \varphi_e^j \sigma^j e_{t+1}^j, \end{aligned} \tag{6}$$

[6] Intuitively, as the IES rises, the gains to future certainty equivalent consumption become more important. But under CRRA preferences, higher IES simultaneously means lower risk aversion, thereby dampening the value of reduced volatility.

where $\eta^j_{t+1}, e^j_{t+1} \backsim N(0,1)$ and are mutually independent. We adopt the more parsimonious notation that $\sigma^j_e \equiv \varphi^j_e \sigma^j$ wherever possible. Since annual consumption growth shocks appear to be transitory in the data, the persistent component in consumption must be small, as found below.

2.2. Asset returns and consumption

Our empirical approach disciplines the consumption parameters for each country by targeting the observed stock return and risk-free rate with simulated moments from the model. Two different identifying assumptions for equity are considered, following the literature. That is, equity owners receive realizations of either the consumption process, equivalent to the "consumption asset," or, alternatively, the dividend process in the data, an asset hereafter called the "dividend asset." This section analyzes equity as the consumption asset, while the dividend asset case is postponed until Section 4.

When equity pays out the consumption process, equity returns are equivalent to the consumption asset returns so that its Euler equation is simply given by Eq. (5). To specify consumption asset returns in the benchmark economy, we combine the consumption process (6) and the Campbell and Shiller (1988) approximation for returns, resulting in the equity return solution for country j:

$$R^j_{P,t+1} = a^j_0 + a^j_1 x^j_t + a^j_2 \sigma^j_e e^j_{t+1} + \sigma^j \eta^j_{t+1}, \tag{7}$$

where a^j_0, a^j_1, a^j_2 are constants. Further substituting Eq. (7) into the Euler equation determines these constants as functions of the model parameters.

Similarly, the Euler equation (4) determines the risk-free rate in this economy. To see how, define $R^j_{f,t}$ as the return on a pure discount bond that pays out one unit of consumption for sure at $t+1$. Then substituting $R_{\ell,t+1} = R^j_{f,t}$ and this known future payment into the Euler equation (4) provides the risk-free rate solution as a function of the underlying shocks to consumption and the model parameters.

2.3. Identifying persistent risk correlation with consumption

The potential for international diversification depends critically upon the consumption correlation across countries. However, the consumption growth process in Eq. (6) depends upon both a transitory and a persistent shock, η and e, respectively. Moreover, Eq. (7) shows that these components have different implications for equity returns, requiring that we identify the correlation in the consumption components separately.

Fortunately, the benchmark model framework together with asset return and consumption data provides a straightforward identification for these correlations. The identification follows naturally from covariances in consumption and equity returns. First, note that the covariance in consumption growth across countries using Eq. (6) can be written as

$$Cov\left(g^i_c, g^j_c\right) = \sigma^i \sigma^j Corr\left(\eta^i, \eta^j\right) + \frac{\sigma^i_e \sigma^j_e}{1-\rho^2} Corr\left(e^i, e^j\right), \tag{8}$$

where $Corr(,)$ is the correlation operator. This covariance contains two sources of correlation: the component due to the temporary shock, η, and to the persistent shock, e, where $1-\rho^2$ adjusts for the autocorrelation.

Calculating the covariance of equity returns across countries using the consumption asset Eq. (7) provides a second observable variable that also depends upon both temporary and persistent shock correlations:

$$Cov\left(R^i_P, R^j_P\right) = \sigma^i \sigma^j Corr\left(\eta^i, \eta^j\right) + \left[\frac{a^i_1 a^j_1}{1-\rho^2} + a^i_2 a^j_2\right] \sigma^i_e \sigma^j_e Corr\left(e^i, e^j\right). \tag{9}$$

Note that equity covariances and consumption covariances depend upon the transitory correlation, $Corr(\eta^i, \eta^j)$, in the same way, but differ in how they respond to the persistent correlation, $Corr(e^i, e^j)$.[7]

Combining the two data covariances in consumption growth from Eq. (8) with the equity return covariance from Eq. (9), we can solve for the correlation in the persistent shocks as

$$Corr\left(e^i, e^j\right) = D_o \frac{\sigma^i_R \sigma^j_R}{\sigma^i_e \sigma^j_e} \left[Corr\left(R^i_P, R^j_P\right) - \frac{\sigma^i_c \sigma^j_c}{\sigma^i_R \sigma^j_R} Corr\left(g^i_c, g^j_c\right)\right], \tag{10}$$

where $D_o \equiv \left[(a^i_1 a^j_1 - 1)/(1-\rho^2) + a^i_2 a^j_2\right]^{-1} > 0$ and where σ^i_R, σ^i_c, and σ^i_e are the standard deviations of R^i_P, g^j_c, and e^i, respectively.

Eq. (10) highlights the implications of consumption and equity covariances for the correlation on persistent risk. The implied correlation of persistent shocks will be high if the correlation in stock returns, $Corr(R^i_P, R^j_P)$, is large relative to the correlation in consumption, $Corr(g^i_c, g^j_c)$. We show below that the data correlation of equity returns is indeed higher than the

[7] In particular, they differ by two terms in the equity covariance equation: (1) the current level of persistent risk, x_t, measured by the autoregressive effect $a^i_1 a^j_1/(1-\rho^2)$; and (2) the current innovation in persistent risk through $a^i_2 a^j_2$.

Table 1
Consumption asset model: parameters and target moments.

Type	*Identification*	*Parameters*
Panel A: Parameters identification		
Preference parameters	Assumed	γ, ψ, β
Country consumption parameter	Calibrated	μ^j
Country consumption parameters	SMM	$\sigma^j, \varphi_e^j, \rho^j$
International correlation	Calculated[a]	$Corr(e^i, e^j)$
Panel B: Target moments for SMM[b]		
Equity excess return – Mean		$E(R^j_{P,t+1} - R^j_{f,t})$
Equity return – Standard deviation		$Var(R^j_{P,t+1})^{1/2}$
Risk-free rate – Mean		$E(R^j_{f,t})$
Risk-free rate – Standard deviation		$Var(R^j_{f,t})^{1/2}$
Consumption growth – Standard deviation		$Var(g^j_{c,t+1})^{1/2}$
Consumption growth – Autocorrelation		$AC(g^j_{c,t+1})$

This table summarizes model parameters, identification methods, and targeted data moments, when equity is assumed to be the consumption asset. Panel A reports the model parameters and method of identification. Panel B lists the targeted data moments for SMM.

[a] Using Eq. (10) with preference and country consumption parameters.

[b] Calculated for $R^j_{P,t+1}$ using equity return Eq. (7); for $R^j_{f,t}$, using the Euler Eq. (4) where $R^j_{\ell,t+1} = R^j_{f,t}$ is the return on an asset paying out one unit of consumption for sure at time $t+1$; and for $g^j_{c,t+1}$ using consumption equation (6).

correlation of consumption, thereby implying a high correlation in persistent shocks. Furthermore, this effect is exacerbated since the variability in equity returns as measured by σ^i_R significantly exceeds that of consumption, σ^i_c, in the data.

2.4. Fitting parameters: equity as a consumption asset

We now describe our data and empirical approach for finding the consumption parameters that best match observed asset returns and consumption data. With common international preferences, we require a measure of consumption that incorporates potential risk in purchasing power variations across countries. For this purpose, we follow Obstfeld (1994b) in analyzing annual consumption adjusted for purchasing power parity deviations from the Penn World Tables. For dividend and equity return data, we use quarterly data through 2009 from the Total Market Indices in Datastream-Thomson Financial while our risk-free rates are from the IMF's International Financial Statistics. We follow Colacito and Croce (2010) in restricting the asset return sample to begin in 1970. We deflate all asset returns using the common good deflator, thereby incorporating real exchange rate risk through PPP deviations.

The persistent component in consumption must be small since deviations from annual consumption growth look close to transitory. As pointed out by Colacito and Croce (2010), estimating long run risk in international data is difficult because most countries do not have sufficiently long time periods. Since we consider a multiple country approach and thereby are restricted to a shorter sample period, we calibrate, rather than estimate, our parameters. At the same time, we seek to discipline our framework to the extent possible by using a Simulated Method of Moments (SMM) approach.

Specifically, for each set of parameter values, we first solve the model using the analytical solutions for returns in the benchmark economy described in Section 2.3. We then simulate and compute the difference between moments implied by the model and targeted data moments. Following BY, the model is specified at the monthly frequency. Therefore, we parameterize the model at the monthly frequency, and then time-aggregate to arrive at the annualized moment that is comparable to the data. We weight these moments equally to give the same importance to consumption and returns. The values that minimize this difference are the SMM fitted parameters.

Table 1 summarizes the identification used in the reported analysis. Panel A lists the identification of each model parameter. The preference parameters ψ, γ, and β are assumed to correspond with those in BY, specifically, $\psi = 1.5$, $\gamma = 10$, and annual $\beta = 0.985$, while the mean of consumption growth rates μ^j is calibrated directly to fit the data means.[8] By contrast, we use SMM to obtain three parameters for each country: (a) the standard deviation of the transitory component of consumption, σ^j; (b) the incremental standard deviation of the persistent component, φ^j_e, and (c) the autocorrelation of the persistent risk component, ρ^j. In all our estimates, the autocorrelation parameters ρ^j are quite similar to each other so we set them equal in the reported results. Finally, to identify the international correlation of persistent consumption shocks, e, we substitute the parameter estimates and the data correlation of consumption and equity returns into Eq. (10).

[8] Lewis and Liu (2012) describe sensitivity analysis to various preference parameters under i.i.d. disturbances.

Table 2
Consumption asset model: parameters, data moments, simulated model moments.

Country	United States	United Kingdom	Canada
Panel A: Monthly parameters			
Mean (μ^j)	0.173	0.166	0.164
Transitory Std Dev (σ^j)	0.920	0.630	0.660
Persistence Std Dev Ratio (φ_e^j)	0.029	0.048	0.040
Persistence Std Dev ($\sigma_e^j \equiv \varphi_e^j \sigma^j$)	0.027	0.030	0.026
Cons Std Dev (σ_{gc}^j)	0.929	0.648	0.673
Panel B: Data and model moments[a]			
1. *Mean Equity Premium – Data*	*4.3*	*4.5*	*6.5*
Model with Persistent Risk	1.6	1.2	1.1
Model without Persistent Risk	0.3	0.2	0.3
2. *Std Dev of Equity Return – Data*	*17.6*	*23.5*	*17.6*
Model with Persistent Risk	3.6	2.8	2.7
Model without Persistent Risk	1.8	1.7	1.7
3. *Mean of Risk-free Rate – Data*	*1.5*	*3.9*	*2.5*
Model with Persistent Risk	1.8	2.2	2.2
Model without Persistent Risk	2.7	2.7	2.8
4. *Std Dev of Risk-free Rate – Data*	*2.2*	*2.8*	*6.0*
Model with Persistent Risk	0.5	0.5	0.4
Model without Persistent Risk	0	0	0
5. *Std Dev of Consn Growth – Data*	*1.8*	*1.7*	*1.7*
Model with Persistent Risk	2.9	2.3	2.2
Model without Persistent Risk	1.8	1.7	1.7
6. *Autocorrelation of Consn Growth – Data*	*0.3*	*0.4*	*0.4*
Model with Persistent Risk	0.3	0.5	0.4
Model without Persistent Risk	0	0	0

This table shows identified model parameters, data moments, and simulated model moments, when equity is assumed to be the consumption asset. Panel A reports consumption growth and persistent risk parameters using the identification listed in Table 1. Panel B compares data moments (in italics) against model moments with and without persistent risk. Standard deviations in Panel A are in monthly percent, and all variables in Panel B are in annual percent.

[a] Model moments assume common mean $\mu^* = 0.168$ and common preference parameters of $\rho = 0.979$, $\gamma = 10$, $\psi = 1.5$, and annual $\beta = 0.985$.

Panel B lists the moments used in the SMM analysis to match the model to the data. We target six data moments for each country: the standard deviation and autocorrelation of annual consumption growth, the mean equity premium, the mean risk-free rate, and the standard deviations of the market return and the risk-free rate.

Table 2 Panel A shows the resulting SMM-generated parameters along with the monthly calibrated means of consumption. The monthly growth rates, μ^j, are near 0.17% for all three countries so we assume in our analysis that countries share a common mean equal to their average. The transitory risk standard deviation σ^j ranges from 0.63% for the U.K. to 0.92% for the U.S. As expected, persistent consumption measured by σ_e^j is only a small fraction of transitory volatility and is lowest for Canada at 0.026%. The table also reports the overall consumption volatility implied by the estimates: $\sigma_{gc}^2 = \sigma^2 + (\sigma_e^2/(1-\rho^2))$. Note that the U.S. has only marginally higher persistent risk variability than Canada but has the highest overall variability at 0.929% monthly.

Table 2 Panel B compares the targeted data moments for asset returns and consumption with model implied moments. Below each moment, we report those generated by our model simulations in the row labeled "Model with Persistent Risk," followed by those based upon transitory consumption risk alone in the row labeled "Model without Persistent Risk." Although standard asset pricing puzzles appear in our results, the moments improve relative to the transitory risk version common in much of the literature. For example, the equity premium ranges between 1.1% and 1.6% in the persistent risk model, still lower than in the data, but substantially higher than the 20–30 basis points without persistent risk. Similarly, the risk-free rate is lower in the model with persistent risk than without it. With persistent risk, the means for the U.S. and Canada are close to their data counterparts, although the rate is now too low for the U.K. Also, the standard deviation of equity returns is higher in the persistent risk model but remains too low compared to the data. Finally, although the transitory risk only model implies a constant risk-free rate, the table shows that persistent risk generates some risk-free rate volatility. Overall, while the model falls short of fitting the asset data moments, adding persistent consumption risk improves the model by producing a higher equity premium, a lower risk-free rate, and more volatile asset returns. This fit will improve further when we treat equity as the dividend asset in Section 4.

The final two sets of rows report the model fit for consumption moments. The implied consumption volatility is higher than the data for all three countries. In the data, the standard deviation is about 1.7% per year, but the model generates higher volatility ranging from 2.9% for the U.S. to 2.2% for Canada. On the other hand, the implied consumption autocorrelations appear to match the data well for all three countries.

3. Risk sharing with equity as consumption asset

Measuring risk sharing gains requires values for consumption and wealth in both the benchmark and the risk sharing economies. While the section above described these values for the benchmark economy, this section discusses the corresponding solutions in the risk sharing equilibrium and the implied welfare gains.

3.1. Asset prices and consumption in the risk sharing economy

Determining the risk sharing economy requires solving for the international consumption allocation. With common Epstein–Zin–Weil preferences, the optimal allocation of consumption across countries is given by[9]

$$C_t^{j*} = \varpi^j C_t^w, \tag{11}$$

where $C_t^w \equiv \Sigma_{j=1}^J C_t^{Bj}$ is the pooled world consumption, and ϖ^j is the share of this consumption assigned to country j. Eq. (11) shows that consumption allocations in this economy have two components: a common world consumption level and the proportion of this world consumption owned by each country.

The first component follows because residents of all countries optimally choose to pool their endowments into an aggregate world consumption given their identical iso-elastic preferences. Clearly then, the risk sharing consumption asset is a mutual fund of all countries, thereby paying out realizations of the world consumption level each period, C_t^w. Defining the price of an asset that pays out this aggregate consumption process as P_t^{w*}, the price–consumption ratio for the total world economy is therefore $Z_t^* \equiv P_t^{w*}/C_t^w$.

The second component in the allocation, ϖ^j, captures how countries differ in their shares of this pooled consumption. To see how each country's share in the world consumption is determined, consider a representative investor in country j at some initial point in time 0.[10] This investor wishes to buy claims on current and future world consumption. To do so, he sells off both his initial benchmark level, C_0^{jB}, and his claims to future benchmark consumption priced in the fully diversified world economy at P_0^{j*}.[11] That is, the investor in country j buys claims on current and future world resources valued at $\left(C_0^w + P_0^{w*}\right)$ in exchange for selling his own resources valued at $(C_0^{jB} + P_0^{j*})$ implying that the maximal share is

$$\varpi^j = \frac{C_0^{jB} + P_0^{j*}}{C_0^w + P_0^{w*}}. \tag{12}$$

Computing the share of country j in the risk sharing economy, ϖ^j, then requires solving for world and country asset prices in the risk sharing economy, P^{w*} and P^{j*}. For this purpose, we return to the Euler equation (4). In the full risk sharing economy, the consumption asset return is given by $R_{P,t+1} = R_{t+1}^{w*} \equiv \left(P_{t+1}^{w*} + C_{t+1}^w\right)/P_t^{w*}$. We can first solve for the price of the consumption asset itself, P_t^{w*}, by substituting $R_{\ell,t+1} = R_{t+1}^{w*}$ and $C_t = C_t^w$ into the Euler equation yielding an expression comparable to Eq. (5). Next, the prices of the benchmark consumption stream for each country, P_t^{j*}, can be valued by setting $R_{\ell,t+1} = R_{t+1}^{j*}$, where $R_{t+1}^{j*} = (P_{t+1}^{j*} + C_{t+1}^{jB})/P_t^{j*}$. Substituting this return, the common world consumption growth rate, and the solution for R_{t+1}^{w*} into the Euler Eq. (4) implies

$$E_t\left\{\beta^\theta (C_{t+1}^w/C_t^w)^{(-\theta/\psi)} (R_{t+1}^{w*})^{(\theta-1)} R_{t+1}^{j*}\right\} = 1. \tag{13}$$

Using this equation, we further solve for P_{t+1}^{j*} as a function of consumption shocks and the model parameters.

Finally, we use these prices and consumption allocations to calculate utility in the full risk sharing economy. As noted earlier, Eq. (3) shows that solving for welfare in this economy requires both the price-to-consumption ratio and the initial consumption, or $\{C_0^{j*}, Z_0^{j*}\}$. Note that since $Z_t^{j*} \equiv P_t^{j*}/C_t^{j*} = \left(\varpi^j P_t^{w*}\right)/\left(\varpi^j C_t^W\right) = Z_t^*$, $\forall j$, this price-to-consumption ratio is common across all countries. As a result, substituting the common and country-specific consumption allocations into the welfare gains in Eq. (3) implies

$$\left(1+\Delta^j\right) = \left\{\frac{W_0^*/C_0^*}{W_0^{jB}/C_0^{jB}}\right\}^{(1/(1-(1/\psi)))} \left(\frac{C_0^{j*}}{C_0^{jB}}\right) = \left\{\frac{Z_0^*+1}{Z_0^{jB}+1}\right\}^{(1/(1-(1/\psi)))} \left(\frac{\varpi^j C_0^W}{C_0^{jB}}\right). \tag{14}$$

Clearly the risk sharing gain depends directly on the share of the country in world consumption, ϖ^j, a value that is increasing in the price of a country's benchmark consumption stream. This price captures how well the claims to country j resources can hedge against shocks to the rest of the world as measured by its cross-country correlation. Therefore, the correlation structure is important for determining risk sharing gains below.

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[9] These allocations are solutions to a planner's problem as described in the on-line appendix.

[10] For now, we assume a single representative agent in each country. In Section 5, we relax this assumption.

[11] We could alternatively have assumed countries sell off claims to their output or factor resources. In the text, we evaluate the gains from sharing consumption measured by the data in order to condition on the standard consumption-based Euler equation.

Table 3
Consumption asset model: correlations and welfare gains.

Country	United States	United Kingdom	Canada
Panel A: Consumption growth correlation			
United States	1.00	0.49	0.63
United Kingdom	0.49	1.00	0.32
Canada	0.63	0.32	1.00
Panel B: Equity return correlation			
United States	1.00	0.75	0.72
United Kingdom	0.75	1.00	0.59
Canada	0.72	0.59	1.00
Panel C: Gains and persistent risk			
$Corr(e^i, e^w)$	*0.00*	*0.00*	*0.00*
Total gain	70.0	86.0	75.7
$Corr(e^i, e^w)$	*0.80*	*0.80*	*0.80*
Total gain	17.4	20.2	17.8
Panel D: Implied correlations[a]			
$Corr(e^i, e^w)$	1.00	1.00	1.00
$Corr(\eta^i, \eta^j)$			
United States	1.00	0.48	0.62
United Kingdom	0.48	1.00	0.29
Canada	0.62	0.29	1.00
Panel E: Welfare gains			
Total gain	7.9	9.4	7.8
Portfolio share ϖ^j	(30.9)	(31.7)	(37.4)
Gain from W^j/C^j	17	15	−4
Gain from C^{j*}/C^{jB}	−7	−5	1

This table shows data correlations, implied correlations on persistent risk, and percentage welfare gains, when equity is assumed to be the consumption asset. Panels A and B report pairwise country correlations for consumption growth and equity returns, respectively. Panel C compares welfare gains based on two different assumed correlations in persistent risk. Panel D provides implied correlations in persistent risk identified from the data. Panel E shows welfare gains based on the implied correlations in persistent risk in Panel D.

[a] "Implied correlations" are calculated from cross-country equity and consumption correlations in Panels A and B.

3.2. Implied consumption correlations and welfare gains

Table 3 reports the data correlations for consumption and equity returns in Panels A and B, respectively. The equity return correlations are generally high and above 0.5, while the consumption correlations are all lower.

To illustrate the sensitivity to persistent risk correlations, Panel C reports risk sharing gains for two assumed correlations of each country against the rest of the world, e^w, given by 0.0 and 0.8. When we set these correlations equal to zero in our benchmark model, moving to full risk sharing economy generates significant permanent gains in consumption and wealth ranging from 70% for the U.S. to 86% for the U.K. On the other hand, as we increase these correlations to 0.8, the gains drop significantly to around 20%.

Table 3 Panel D shows the implied correlations for persistent and transitory risk based upon actual consumption and equity correlations in the data. The high equity correlations compared to consumption correlations generate high correlations for the persistent consumption risk, $Corr(e^i, e^j)$. As expected, the combinations of consumption and equity covariances imply a very high degree of correlation in persistent risk, values that are all approximately one. The panel also reports the implied correlation between the transitory risk components. Higher correlations in persistent risk require slightly lower correlations on the transitory risk to match the overall consumption correlations in the data. For example, Panel A shows that the correlation between Canadian and U.K. total consumption is 0.32 but the correlation for η in Panel D is lower at 0.29.

Panel E of Table 3 reports the welfare gains based upon these implied consumption correlations. Since the identified correlations on the persistent component are essentially equal to one, persistent risk is already fully diversified and the welfare gains arise only from sharing transitory risk. The gains range from 7.8% for Canada to 9.4% for the U.K., far lower than the levels reported in Panel C.

The gains arise from two components in Eq. (14). The first component is the gain from the change in the wealth-to-consumption ratio: $\{(W_0^*/C_0^*)/(W_0^{jB}/C_0^{jB})\}^{1/(1-1/\psi)}$. We report these percentage gains in the rows labeled "Gain from W^j/C^j" for each country. Table 2 shows that the Canadian process has the lowest persistent consumption risk in the benchmark economy. Therefore, when this risk is pooled in the risk sharing economy, the wealth-to-consumption ratio for Canada declines and the "gain" registers as a loss of 4%. The second component, C_0^{j*}/C_0^{jB}, captures the compensation to countries such as Canada with better diversification potential. In this case, the consumption in Canada's benchmark economy is most

Table 4
Dividend asset model: parameters and target moments.

Type	*Identification*	*Parameters*
Panel A: Parameter identification		
Preference	Assumed	γ, ψ, β
Country consumption, dividends	Calibrated	μ^j, μ_d^j
Country consumption, dividends	SMM	$\sigma^j, \varphi_e^j, \rho^j, \phi^j, \varphi_d^j$
International correlation	Calculated[a]	$Corr(e^i, e^j)$
Panel B: Target moments for SMM[b]		
Equity excess return – Mean		$E(R^j_{m,t+1} - R^j_{f,t})$
Equity return – Standard deviation		$Var(R^j_{m,t+1})^{1/2}$
Risk-free rate – Mean		$E(R^j_{f,t})$
Risk-free rate – Standard deviation		$Var(R^j_{f,t})^{1/2}$
Consumption growth – Standard deviation		$Var(g^j_{c,t+1})^{1/2}$
Consumption growth – Autocorrelation		$AC(g^j_{c,t+1})$
Dividend growth – Standard deviation		$Var(g^j_{d,t+1})^{1/2}$
Dividend growth – Autocorrelation		$AC(g^j_{d,t+1})$

This table summarizes model parameters, identification methods, and targeted data moments, when equity is assumed to be the dividend asset. Panel A reports the model parameters and method of identification. Panel B lists the targeted data moments for SMM.

[a] Using Eq. (17) with preference and country parameters.

[b] Calculated for $R^j_{m,t+1}$ using equity return Eq. (16); for $R^j_{f,t}$, using the Euler equation (4) where $R^j_{\ell,t+1} = R^j_{f,t}$ is the return on an asset paying out one unit of consumption for sure at time $t+1$; for $g^j_{c,t+1}$ using consumption Eq. (6); for $g^j_{d,t+1}$ using dividend equation (15).

valuable and therefore the percent gain is positive at 12%. Since the correlation of persistent risk is close to one, the declining value of the wealth-to-consumption gains to Canada is offset by the price effect and the gains are net 7.8%. By contrast, both the U.S. and the U.K. gain from the world wealth-to-consumption ratio, but lose from risk sharing consumption relative to benchmark economy consumption at -7% and -5%, respectively. On net, the U.S. and the U.K. gain, respectively, 7.9% and 9.4% overall.

4. Risk sharing with equity as dividend asset

So far, we have assumed that equity returns pay out realizations of the consumption process. By contrast, BY have shown that U.S. returns are more consistent with the data when equity is identified as the "dividend asset" that pays out dividends in the data. This section reconsiders our analysis under this alternative equity identification.

4.1. Equity returns and dividends

To relate dividends and consumption, BY assume that the growth rate of dividends, $g_{d,t}$, depends upon the persistent component of consumption. Our analysis requires extending their approach across countries. Using a superscript to identify the country j for our purposes, the dividend process is

$$g^j_{d,t+1} = \mu^j_d + \phi^j x^j_t + \varphi^j_d \sigma^j u^j_{t+1}, \tag{15}$$

where μ^j_d is the mean growth rate, $u^j_{t+1} \sim N(0,1)$, and where u^j_{t+1}, η^j_{t+1} and e^j_{t+1} are mutually independent. Below we use the notation $\sigma^j_d \equiv \varphi^j_d \, \sigma^j$ wherever possible. Eq. (15) shows that dividends depend upon persistent consumption risk, x^j_t, through the "leverage" coefficient ϕ^j. Our analysis considers two identifying approaches for the leverage parameter: (a) setting $\phi^j = 3$ as in BY; and (b) fitting ϕ^j using SMM.

4.2. Identifying persistent risk correlation with dividends

We now amend our asset return framework to assume that equity pays the dividend process specified in Eq. (15). Defining R^j_m as equity returns for country j in this case, the Campbell and Shiller (1988) approximation together with the Euler equation implies that these returns can be written as

$$R^j_{m,t+1} = b^j_0 + b^j_1 x^j_t + b^j_2 \sigma^j_e e^j_{t+1} + \sigma^j_d u^j_{t+1}, \tag{16}$$

where b^j_0, b^j_1, b^j_2 are functions of the model parameters. In contrast to the consumption asset model, returns now depend upon the innovation to dividend growth, u, instead of the innovation to transitory consumption, η.

Table 5
Dividend asset model: parameters, data moments, simulated model moments.

Leverage identification	$\phi=3$ (BY 2004)			$\phi=$ SMM fit		
	U.S.	U.K.	Can	U.S.	U.K.	Can
Panel A: Monthly parameters						
Leverage ratio (ϕ)	3.000	3.000	3.000	3.599	3.598	2.711
Transitory Std Dev (σ^j)	0.604	0.469	0.454	0.670	0.550	0.610
Std Dev of persistent/transitory (φ_e^j)	0.073	0.086	0.097	0.066	0.072	0.079
Persistence Std Dev ($\sigma_e^j \equiv \varphi_e^j \sigma^j$)	0.044	0.040	0.044	0.044	0.039	0.048
Cons Std Dev (σ_{gc}^j)	0.641	0.509	0.499	0.704	0.583	0.654
Dividend SD (φ_d^j)	5.015	7.974	7.987	3.674	5.918	5.990
Panel B: Data and model moments[a]						
1. *Mean Equity Premium – Data*	*4.3*	*4.5*	*6.5*	*4.3*	*4.5*	*6.5*
Model with Persistent Risk	5.0	5.7	6.5	5.1	5.9	6.5
2. *Std Dev of Equity Return – Data*	*17.6*	*23.5*	*17.6*	*17.6*	*23.5*	*17.6*
Model with Persistent Risk	15.2	18.5	18.3	15.6	18.9	18.0
3. *Mean of Risk-free Rate – Data*	*1.5*	*3.9*	*2.5*	*1.5*	*3.9*	*2.5*
Model with Persistent Risk	2.0	2.0	1.9	2.1	2.0	1.7
4. *Std Dev of Risk-free Rate – Data*	*2.2*	*2.8*	*6.0*	*2.2*	*2.8*	*6.0*
Model with Persistent Risk	0.7	0.7	0.8	0.6	0.6	0.8
5. *Std Dev of Consn Growth – Data*	*1.8*	*1.7*	*1.7*	*1.8*	*1.7*	*1.7*
Model with Persistent Risk	2.6	2.4	2.6	2.5	2.4	2.9
6. *Autocorrelation of Consn Growth – Data*	*0.3*	*0.4*	*0.4*	*0.3*	*0.4*	*0.4*
Model with Persistent Risk	0.6	0.6	0.7	0.5	0.6	0.6
7. *Std Dev of Dividend Growth – Data*	*7.1*	*6.8*	*13.0*	*7.1*	*6.8*	*13.0*
Model with Persistent Risk	9.6	12.1	12.2	9.0	11.4	12.4
8. *Autocorrelation of Dividend Growth – Data*	*0.1*	*0.3*	*0.3*	*0.1*	*0.3*	*0.3*
Model with Persistent Risk	0.4	0.4	0.4	0.5	0.4	0.4

This table shows identified model parameters, data moments, and simulated model moments, when equity is assumed to be the dividend asset. Panel A reports consumption growth, dividend growth and persistent risk parameters using the identification listed in Table 4. Panel B compares data moments (in italics) against model moments with persistent risk. The first three columns report parameters and simulated model moments when the leverage parameter $\phi=3$, while the last three columns does the same using the SMM identified ϕ. Standard Deviations in Panel A are in monthly percent, and all variables in Panel B are in annual percent.

[a] Model moments assume common mean $\mu^*=0.168$ and common preference parameters of $\rho=0.979$, $\gamma=10$, $\psi=1.5$, and annual $\beta=0.985$.

Table 4 Panel A summarizes the parameters and target moments used in this version of the model. As before, the preference parameters are assumed from BY while the monthly growth rates are calibrated, in this case for both consumption, μ^j, and dividends, μ_d^j. SMM is then used to fit the five model parameters $\left[\sigma^j, \varphi_e^j, \rho^j, \phi^j, \varphi_d^j\right]$ to the eight data moments given in Panel B. These moments are the set of six consumption and asset return moments studied before, but now augmented by the standard deviation and autocorrelation of dividends. As before, fitted values for ρ^j are set to be equal since they are similar across countries.

The dividend asset model for equity requires a different approach to identify the international correlation of consumption components. Combining the new specification of equity returns in Eq. (16) together with the dividend process in Eq. (15), the correlation of persistent consumption risk is determined by

$$Corr\left(e^i, e^j\right) = B_o \frac{\sigma_R^i \sigma_R^j}{\sigma_e^i \sigma_e^j}\left[Corr\left(R_m^i, R_m^j\right) - \frac{\sigma_d^i \sigma_d^j}{\sigma_R^i \sigma_R^j} Corr\left(g_d^i, g_d^j\right)\right], \tag{17}$$

where $B_o \equiv \left[(b_1^i b_1^j - \phi^i \phi^j)/(1-\rho^2) + b_2^i b_2^j\right]^{-1} > 0$ and where σ_d^i is the standard deviation of g_d^j. The correlation of persistent risk now depends on the difference between the correlation of equity returns relative to that of dividends, instead of consumption. Therefore, $Corr(e^i, e^j)$ will be larger when the equity return correlation is high relative to the dividend growth correlation.

4.3. *Fitting parameters when equity pays out dividends*

Table 5 Panel A reports the parameter estimates based upon the two approaches for identifying the leverage ratio. The first set of columns considers the case when $\phi=3$ as in BY while the last three columns report results based upon fitting ϕ^j using SMM. In both versions of the model, the variability due to persistent risk, σ_e^j, for all three countries at around 0.04% is higher than the consumption asset model.

Table 5 Panel B shows the fit for the target data moments across both assumptions of the leverage parameter. Compared to the consumption asset model, the fitted equity premium is now close to the data at 5% for the U.S. and 6.5% for Canada, though the number for the U.K. is somewhat larger than in the data. Importantly, the standard deviation of equity in the model fits relatively well with implied estimates between 15% and 18.9%. The standard deviation of the risk-free rate is also

Table 6
Dividend asset model: correlations and welfare gains.

Panel A: Data correlations	Dividend growth			Equity return		
Country	U.S.	U.K.	Canada	U.S.	U.K.	Canada
United States	1.00	0.35	0.37	1.00	0.75	0.72
United Kingdom	0.35	1.00	0.12	0.75	1.00	0.59
Canada	0.37	0.12	1.00	0.72	0.59	1.00
Panel B: Model implications	$\phi=3$ (BY 2004)			ϕ=SMM fit		
	U.S.	U.K.	Canada	U.S.	U.K.	Canada
1. Implied correlations[a]						
Corr (e^i, e^w)	0.996	0.996	1.000	0.964	0.965	0.973
2. Welfare gains						
Total gain	2.7	4.2	2.7	2.1	11.5	2.9
Portfolio share ϖ^j	(30.2)	(38.3)	(31.4)	(30.3)	(44.5)	(25.2)
Gain from W^j/C^j	13	−9	9	12.3	−16.5	36.2
Gain from C^{j*}/C^{jB}	−9	15	−6	−9.1	33.6	−24.4

This table shows data correlations, implied correlations on persistent risk, and percentage welfare gains, when equity is assumed to be the dividend asset. Panel A reports the pairwise country correlations for dividend growth and equity returns. Panel B provides implied correlations in persistent risk identified from the data and the corresponding welfare gains.

[a] “Implied correlations” determined from cross-country equity and dividend correlations in Panel A.

higher, though still considerably lower than the data suggest.[12] The model also tends to predict a more volatile dividend process for the U.S. and U.K. as well as somewhat greater persistence. Nevertheless, compared to that model, the dividend-based model approximates the target asset moments more closely.

We now use the newly fitted parameters to re-evaluate international risk sharing gains. As noted earlier, the implied correlation of persistent risk will be higher if the correlation of equity returns is higher than that of dividends. Table 6 Panel A reports the data correlations for dividends and equity returns. Consistent with the pattern observed between equity returns and consumption, the correlations between equity returns are higher than dividends. Furthermore, dividends are less volatile in the data than equity returns. As a result, Panel B shows that the implied correlations on persistent consumption risk against the world are all close to one for both parameterizations of ϕ.

Panel B of Table 6 also gives the gains implied by this decomposition. When $\phi=3$, these gains range from 2.7% for the U.S. and Canada to 4.2% for the U.K. Notably, these levels are consistent with those found in the risk sharing literature ignoring asset returns (e.g., Tesar, 1995; van Wincoop, 1994). The implied standard deviation on persistent consumption, σ_e^j, is now lowest for the U.K. Thus, many of the features previously observed for Canada, as the lowest persistent risk country under the consumption asset case, hold here for the U.K. In particular, the U.K. has the highest share of world output at 38.3%. Furthermore, the percentage change from the wealth-to-consumption ratio worsens for the U.K. at −9% while both the U.S. and Canada gain at 13% and 9%, respectively. At the same time, the U.K. benefits from an improvement of initial consumption of 15% relative to the benchmark economy, while both the U.S. and Canada experience lower initial consumption levels. When ϕ^j is parameterized based upon SMM, these relationships are similar except that the U.K. gains more in the risk sharing equilibrium because its persistent risk volatility is lower.

Overall, when we treat equity as the dividend asset, the model provides a better fit for asset return and consumption moments. Nevertheless, we continue to find that persistent consumption risk is almost completely diversified, even without fully open markets.

5. Risk sharing gains and other considerations

In order to highlight the key features of international risk sharing with persistent consumption risk, we have focused upon a number of simplifying assumptions so far. First, all countries have the same mean growth rates. Second, all countries are of the same size. Third, the pooled risk sharing economy is composed of a small set of countries. In this section, we analyze the results of relaxing these three assumptions.[13]

[12] BY address this issue by assuming stochastic volatility. For parsimony, we do not include this risk in the present paper. Nevertheless, the high degree of correlation across countries in volatility measures suggests that this risk is also highly diversified.

[13] The online appendix also describes an alternative identification of the correlation in persistent risk using risk-free rates.

Table 7
Differing means, sizes and gains.

Country	United States	United Kingdom	Canada
Panel A: Differing means and gains			
1. Annual Mean Consumption Growth	2.08	1.99	1.96
2. Equity as Consumption Asset			
Welfare gains	8.3	9.5	7.5
Portfolio share ϖ^j	(32.6)	(31.4)	(36.0)
Gain from W^j/C^j	10.8	16.3	−0.6
Gain from C^{j*}/C^{jB}	−2.2	−5.9	8.1
3. Equity as Dividend Asset[a]			
Welfare gains	2.3	4.5	2.4
Portfolio share ϖ^j	(31.3)	(38.1)	(30.6)
Gain from W^j/C^j	8.9	−8.5	11.4
Gain from C^{j*}/C^{jB}	−6.1	14.2	−8.1
Panel B: Differing sizes and gains			
1. Population Weights	0.70	0.23	0.06
2. Equity as Consumption Asset			
Gain from W^j/C^j	8	6	−11
Maximum gains[b]	8.8	26.3	78.6
Portfolio share	(71)	(27)	(13)
Gain from C^{j*}/C^{jB}	1	19	101
Minimum portfolio share[c]	(65)	(22)	(7)
3. Equity as Dividend Asset[a]			
Gain from W^j/C^j	8	−14	4
Maximum gains[b]	3.0	7.2	31.0
Portfolio share	(67)	(29)	(8)
Gain from C^{j*}/C^{jB}	−5	24	26
Minimum portfolio share[c]	(65)	(27)	(6)

This table shows percentage welfare gains when countries vary in mean consumption growth and size. Panel A reports gains for both the consumption asset case and the dividend asset case when mean consumption growth differs across countries. Panel B reports gains for the consumption asset case and the dividend asset case when country population sizes differ. All variables are reported in percent.

[a] Assuming $\phi=3$.

[b] Results give bounds for efficient allocations, where $\Delta^j=0$ for all countries j except for column country.

[c] Shares that imply $\Delta=0$ for column country.

5.1. Differing means

We now consider the effects on welfare gains when growth rates are not the same across countries. The intuition is straightforward. The price of a country's resource in the risk sharing equilibrium, P^{j*}, is increasing in the growth rate. At the same time, a higher growth economy will experience a lower growth rate in the diversified economy as it pools with lower growth countries. Therefore, differing means creates a trade-off between these two effects.

Table 7 Panel A shows this intuition in our quantitative analysis. The top row repeats the mean annualized growth rates in Table 1 showing that the U.S. has the higher growth rate in the sample at 2.08%. Under the sections labeled “2. Equity as Consumption Asset” and “3. Equity as Dividend Asset”, the table reports the gains analysis with differing μ^i assuming equity is the consumption asset and the dividend asset, respectively. Compared to the earlier common means analysis, the U.S. receives a greater share of world output but also has a lower welfare gain than the other countries. For the dividend asset case, for example, when growth rates are common as in Table 6 (for $\phi=3$), the share of world output is 30.2% but this share increases to 31.3% with the higher U.S. mean in Table 7A. At the same time, the gains to the U.S. decline from 2.7% with common means to 2.3% with the differing means. Overall, allowing for differing means implies a higher world share for high growth countries, but also lower welfare gains as they share in a lower growth world economy.

5.2. Differing sizes

Above we assumed that the three countries were all the same size, though this premise is clearly counterfactual. We can easily consider differing sizes by multiplying our per capita consumption units by their populations to recover aggregate country consumption. When the social planner cares equally about each person, the country consumption allocations for country j are the same as above except that the shares of world consumption are now weighted by their world population shares, n^j. The first row of Table 7 Panel B reports the proportional country population sizes. The U.S. has the largest share of population n^j at 70%, followed by the U.K. and then Canada.

When we calculate the equilibrium using these parameters, the allocations used in the former analysis do not provide a unique decentralized equilibrium because one or more countries have unbounded utility.[14] Therefore, we instead characterize the range of Pareto efficient allocations. For this purpose, we calculate the upper bound in gains for each country j by finding the allocation when all other countries are indifferent to risk sharing and the surplus consumption is given to country j. That is, we set $\Delta^i = 0, \forall i \neq j$ in Eq. (14) and solve for the initial consumption allocation for country i residents that implies no gains for residents of these countries. This allocation is $\widehat{C}_0^{i*} = C_0^{iB}\left\{(W_0^{iB}/C_0^{iB})/(W_0^*/C_0^*)\right\}^{1/(1-1/\psi)}$, where W_0^{iB}/C_0^{iB} is determined in the benchmark economy as before. Substituting $\widehat{C}_0^{i*}$ for all other countries $i \neq j$ into the welfare gains Eq. (14) implies that the upper bounds on country j welfare gains are given by

$$\left(1+\Delta_{Max}^j\right) = \left(\frac{\widehat{C}_{0,Max}^{j*}}{C_0^{iB}}\right)\left\{\frac{W_0^*/C_0^*}{W_0^{jB}/C_0^{jB}}\right\}^{1/(1-1/\psi)} = \left(\frac{C_0^W - \sum_{i \neq j} n^j \widehat{C}_0^{i*}}{n^j C_0^{iB}}\right)\left\{\frac{W_0^*/C_0^*}{W_0^{jB}/C_0^{jB}}\right\}^{1/(1-1/\psi)} \tag{18}$$

The set of efficient allocations for residents in each country j is then bracketed by the minimum consumption, $\widehat{C}_0^{j*}$, that yields zero welfare gains and the maximum consumption, $\widehat{C}_{0,Max}^{j*}$, that gives them all the world consumption surplus.

Table 7 Panel B reports the results of these calculations under the sections labeled 2 and 3 assuming equity pays consumption and equity pays dividends, respectively. The first row shows the gains from the improvement in the wealth-to-consumption ratio. As before, these changes are positive for the U.S. and U.K., but negative for Canada in the consumption asset case under 2, while this pattern is reversed for the U.K. in the dividend asset case under 3. The remaining rows show the range in gains depending upon which country receives all the surplus. Under the consumption asset case, the U.S. receives as much as 71% of world output when Americans receive all the surplus, but that share declines to 65% when the U.S. receives no gains. By contrast, Canada loses on the wealth-to-consumption ratio but if compensated to the maximum share of 13% of world output, receives a large 78.6% gain. Similar patterns hold for the dividend asset case under Section 3 but since the U.K. has better hedge properties, its role switches with Canada.

5.3. More countries

In the analysis so far, we have focused upon three countries, demonstrating how the framework can extend beyond two-country models (e.g., Colacito and Croce, 2010; Stathopoulos, 2012). In principle, however, our framework holds with an arbitrary number of countries. To show the analysis with more countries, we now apply our framework to seven countries by including Australia, France, Germany, and Japan.

As above, we consider the effects of persistent consumption risk under the two alternative equity identifications (1) as the consumption asset; and (2) as the dividend asset. For the new countries, we again use SMM to target moments and fit consumption parameters. We then use these parameters together with the prior estimates for the U.S., U.K., and Canada to re-evaluate the risk sharing gains. In the interest of parsimony, we only report the results for the dividend asset model under the $\phi = 3$ case.

For each of the four new countries, Table 8 Panel A reports the set of consumption and dividend parameters $\left[\mu^j, \sigma^j, \varphi_e^j, \phi^j, \mu_d^j, \varphi_d^j\right]$ along with the associated persistent and total volatilities, σ_e^j and σ_{gc}^j. The variability in persistent consumption risk, σ_e^j, is similar across countries. Although Japan has the lowest variability of persistent consumption, it also has the highest variability in transitory consumption risk. Panel B gives the set of target data moments and implied model moments. To fit asset returns, implied consumption variability is higher than the data as found for the prior three countries. Moreover, while the autocorrelation in consumption is close to the data for most countries, it is clearly too high to match the tiny data autocorrelation for Australia.

Panel C of Table 8 shows the implications for risk sharing using the fitted parameters for the four new countries together with the corresponding parameters for the U.S., U.K., and Canada previously reported in Table 5. The first column summarizes the data correlations between each individual country's dividend growth and the world. These correlations demonstrate low correlations in dividends compared to those in equity returns. All dividend correlations are less than 0.55 and are lower than the corresponding equity return correlations (not shown). The next two columns report the implied correlations between the world and country persistent shock, e^i, as well as the transitory shock, η^i. Once again, the implied correlations in persistent risk are very high and close to one.

The final columns show the welfare gains. As in the population-weighted case, the decentralized economy does not have a steady state equilibrium. We therefore report the range of Pareto efficient allocations as before. Under the column labeled "Gains", we report the maximum gain for the row country while setting the gains for all other countries equal to zero given by Eq. (18). The following three columns report the maximum share for that country when setting all other country gains to zero, the gain due to increases in wealth-to-consumption "W/C", and the change in initial consumption "C^*/C^B". For

[14] For an equilibrium to exist, lifetime utility must be bounded and rational along the equilibrium path for each country. This condition may be violated in the risk sharing economy if the price of the consumption stream from country j in world markets, P^{j*}, goes to infinity.

Table 8
Many countries and welfare gains.

Panel A: Parameters	Consumption Parameters					Dividend Parameters	
	Mean (μ^j)	Trans (σ^j)	$\frac{Persist}{Trans}$ (φ_e^j)	Persist ($\sigma_e^j \equiv \sigma^j \varphi_e^j$)	Total (σ_{gc}^j)	Mean (μ_d^j)	SD (σ_d^j)
Australia	0.170	0.620	0.082	0.051	0.668	0.280	4.32
France	0.212	0.672	0.073	0.049	0.714	0.267	5.25
Germany	0.157	0.562	0.078	0.044	0.602	0.398	4.50
Japan	0.322	1.092	0.033	0.036	1.111	0.233	5.15
Implied World	0.195	0.403	NA	0.042	0.454	NA	NA

Panel B: Target moments	Equity Prem	Equity S.D.	Rfree Mean	Rfree S.D.	Con S.D.	Con A.C.	Div S.D.	Div A.C.
Australia – Data	*7.1*	*22.1*	*1.6*	*6.3*	*2.2*	*0.03*	*11.8*	*0.48*
Model	7.6	20.4	1.6	0.8	3.0	0.62	13.7	0.4
France – Data	*7.6*	*25.6*	*1.8*	*5.9*	*1.8*	*0.52*	*14.0*	*0.19*
Model	7.9	23.4	1.9	0.9	3.1	0.60	16.4	0.4
Germany – Data	*6.4*	*23.1*	*4.2*	*4.5*	*1.6*	*0.61*	*12.6*	*0.43*
Model	6.6	21.2	1.8	0.8	2.7	0.62	14.3	0.4
Japan – Data	*2.2*	*25.0*	*2.6*	*5.2*	*3.2*	*0.68*	*10.2*	*0.61*
Model	3.6	20.9	2.4	0.6	3.6	0.39	15.0	0.3

Panel C: Correlations and welfare gains	Div Corr with world	Implied Corr		Efficient set range				
		(e^i, e^w)	(η^i, η^w)	Max[a]				Min[b]
				Gains	Share	W/C	C^*/C^B	Share
United States	0.44	0.96	0.42	127	28	16	96	12
United Kingdom	0.33	1.0	0.28	100	31	−9	119	16
Canada	0.54	0.91	0.37	122	29	11	100	13
Australia	0.50	0.88	0.06	192	24	75	67	08
France	0.47	1.0	0.35	180	24	64	70	09
Germany	0.51	0.92	0.32	125	28	14	97	13
Japan	0.48	0.83	0.38	111	30	1	108	14

This table shows identified model parameters, target data moments, simulated model moments, implied correlation, and percentage welfare gains for many countries, in the case when equity is assumed to be the dividend asset. Panel A reports consumption (Con) growth, persistent risk, and dividend (Div) growth parameters using the identification listed in Table 4. Panel B provides data moments and simulated model moments for mean, standard deviation (S.D.), and first-order autocorrelation (A.C.). Panel C shows implied correlations on persistent risk identified from the data and bounds for welfare gains. Parameters in Panel A are in monthly percent, and all variables in Panel B are in annual percent. All reported simulated model moments assume common preference parameters of $\rho = 0.979$, $\gamma = 10$, $\psi = 1.5$, and annual $\beta = 0.985$.

[a] Results give bounds for efficient allocations where $\Delta = 0$ for all countries but row country.

[b] Shares that imply $\Delta = 0$ for row country.

example, when the gains are zero for all other countries, the gain for the U.S. is 127% and its residents receive 28% of world per capita income. The gains from wealth-to-consumption are only 16% while the gains from receiving initial consumption are 96%. On the other hand, the last column reports the lowest world consumption share required such that the U.S. is not made worse off. At 12%, this share is significantly lower than the maximum.

The welfare gains may appear high relative to earlier tables, but the reasons are clear. First, these numbers represent the maximum possible per country if all the surplus were given to that one country. For the U.S. gains, for example, dividing by seven would imply a significantly lower average gain per country of 17%. Second, the gains are larger because more countries participate, increasing the potential gains from trade.

6. Conclusion

International asset returns incorporate market valuations of risk and these valuations are central to understanding potential gains from global consumption risk sharing. Nevertheless, many studies of the gains from international risk sharing ignore the implications of these markets. In this paper, we have begun to bridge this gap by noting how features that bring the model closer to data impact perceived benefits of risk sharing.

Low frequency variations in consumption risk are key to generating the size of the equity premium and the volatility of asset returns. In this paper, we consider these variations as a small but persistent component of consumption shocks. For this purpose, we use data on consumption, asset returns, and dividends to determine the best fit for seven industrialized economies.

We find that international equity return correlations and those of their payouts imply high correlations in persistent consumption risk across countries. Since persistent risk is already highly diversified, only transitory risk can be shared. Moreover, we show that diversification in persistent consumption risk generates much greater gains than transitory risk. Thus, higher persistent risk correlation means that significant international consumption risk is already shared. Surprisingly, consumption risk sharing gains look more similar to those generated by macroeconomic models that do not target asset returns.

Overall, our results shed new light on conventional views about the gains from international consumption risk sharing when disciplined by asset returns. Nevertheless, these results should be interpreted with caution. Our results are based upon a long literature that treats consumption data as the endogenous outcome of a larger model that includes production and investment. Without specifying the full model, however, it is not known how general our conclusions are. Moreover, in this study we have focused upon advanced economies. The lower correlation in emerging market equity returns could possibly overturn the implication that persistent risk correlations are high. We leave these and other interesting questions as avenues for future research.

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Appendix. Supplementary analysis

Supplementary analysis associated with this paper can be found in the online version at http://dx.doi.org/10.1016/j.jmoneco.2014.11.010.

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