Global Risk Sharing Through Trade in Goods and Assets: Theory and Evidence*

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Abstract

Exporting provides firms not only with profit opportunities, but can also provide for risk diversification if demand is imperfectly correlated across countries. This paper shows that the correlation pattern of demand shocks across countries constitutes a hitherto unexplored source of comparative advantage that shapes trade flows and persists even if financial markets are perfect. With exporters making market-specific choices under uncertainty, countries whose shocks are riskier in the sense that they contribute more to aggregate volatility are less attractive destinations for both investment and exports. A gravity-type regression lends support to the hypothesis that, conditional on trade cost and market size, exporters sell smaller quantities in riskier destinations. I develop a general equilibrium trade model with risk-averse investors and complete asset markets which rationalizes this novel fact. A counterfactual experiment shows that risk-based comparative advantage accounts for 5% of global trade. Country-level exports would grow by -19% to +13% if all diversification opportunities were eliminated, entailing welfare losses in the range of 4% to 26%.

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1 Introduction

Trade's potential for consumption risk sharing between countries is well understood; its effectiveness in doing so, however, is rarely confirmed by the data (Backus and Smith, 1993). Goods market frictions limit the attractiveness of trade as a means of equalizing differences in marginal utility of consumption across countries.[1] Likewise, asset market frictions inhibit consumption risk sharing by means of international portfolio investment.[2] Nevertheless, competitive firms strive to maximize the net present value of their operations conditional on the prevalence of goods and asset market frictions. For firms owned by risk-averse shareholders who dislike consumption volatility this means taking into account that the shareholders care not only about the level of expected profits, but also about the extent to which they contribute to aggregate risk, that is, consumption volatility. This paper shows that the distribution of demand shocks across countries constitutes a hitherto unexplored source of comparative advantage shaping global trade in goods, as it endows countries with varying degrees of aggregate risk. I document, rationalize, and quantify the degree to which risk sharing through exporting shapes the pattern of trade and contributes to welfare.

The contributions of this paper are fourfold. First, I document a novel salient feature of the global pattern of trade consistent with a diversification motive. Then, I build a model of trade in goods and capital which rationalizes this pattern and allows me to quantify the extent to which risk-based comparative advantage shapes global goods trade. On the theory side, the model challenges Helpman and Razin (1978)'s result that trade patterns based on traditional sources of comparative advantage persist under uncertainty if financial markets are complete. Rather, I find that a country's riskiness is itself a source of comparative advantage that persists if asset markets are complete. Lastly, by modeling trade under varying degrees of global financial market integration the paper complements the extant literature on internationalization choices of firms under uncertainty, which, for tractability, assumes either risk-neutral decision making on the part of all agents or complete absence of financial markets.

Using data for 21 exporting countries and 175 destination markets, I provide reduced-

[1] See Obstfeld and Rogoff (2001) for a comprehensive discussion of the role of goods market frictions in explaining the failure of consumption risk sharing.

[2] Ample evidence shows that international equity markets continue to be fairly disintegrated to date. See Fama and French (2012) for recent evidence and a comprehensive overview of previous evidence based on equity return data. Fitzgerald (2012) finds that conditional on the presence of trade cost, risk sharing is close to complete among developed countries, but significantly impeded by asset market frictions between developed and developing countries.

form empirical evidence for the hypothesis that diversification concerns shape the global pattern of trade. Looking at variation across time within country-pair-product cells, I find that, conditional on market size and trade cost, the pattern of exports across destination markets can in part be explained by the correlation pattern of destination-market-specific demand shocks with stock market returns or consumption growth in the exporting country.

To rationalize this finding, I first build a simple model of exporting firms and portfolio returns to show that the covariances used in the reduced-form regressions reflect countries' contributions to the risk of a representative investor's portfolio. The model links portfolio returns to fundamentals, that is, country-specific demand shocks, through firms' export pattern and investors' portfolio composition. Calibrated with trade and production data only, the model does a strikingly good job at reproducing the observed cross-sectional pattern of aggregate stock market volatility across countries, as well as the cross-section of capital asset pricing model (CAPM)-based risk premia for country-specific demand shocks. Then, I embed these simple relationships in a multi-country monopolistic competition model where firms owned by risk-averse investors who trade assets in a financial market make exporting decisions under uncertainty. The model encompasses different degrees of global financial market integration; nationally segregated, regionally segregated, and globally integrated financial markets. In either setting, shareholder-value maximization incentivizes firms to ceteris paribus ship smaller quantities to markets whose shocks carry more aggregate risk, reflected in a smaller covariance between demand shocks and marginal utility growth of their investors. Equilibrium trade flows follow a gravity equation featuring a bilateral risk premium on top of trade costs. The risk premia capture the destination markets' aggregate risk contribution and are endogenously determined in the financial market equilibrium, which is described by the CAPM. Equilibrium risk premia are large for countries that are popular export destinations according to non-risk related determinants of trade (for example, trade cost and market size), and feature shocks that are positively correlated with other popular export markets. Low covariances with demand shocks in popular destinations for exports thus endows countries with a comparative advantage.

To quantify the importance of risk-based comparative advantage, I calibrate the model to the world economy and conduct a counterfactual analysis. The counterfactual experiment is designed to reveal how global trade flows would change if all countries' shocks became perfectly correlated such that all diversification possibilities were eliminated. In the counterfactual equilibrium global trade is 5% lower. Country-level exports are affected vastly differently, depending on the initial degree of a country's comparative advantage and the degree of risk aversion: Exports in the counterfactual equilibrium deviate from the baseline by -19% to +13%. Welfare losses range between 4% and 26%.

How should one think about the notion of comparative advantage in the context of the second moments of demand shocks? Consider the simplified case of two countries and two states of nature. Then we may treat demand for a country's good in the two states just like demand for two different kinds of goods. Suppose the distribution of demand across the two states for country A is $[Y_A(1) = 1, Y_A(2) = 2]$ and for country B it is $[Y_B(1) = 3, Y_B(2) = 3]$. Then, country B has an absolute advantage with regard to both states and a comparative advantage with regard to state one. State one is the *risky* state from a global investor's point of view, since global expenditure is low. Risk aversion and aggregate risk (differences in global expenditure across states) are essential for this source of comparative advantage to exist. If investors were risk neutral or world demand was constant across states, the two-goods analogy would break down since expected expenditure in states one and two would be perfectly substitutable. This notion of comparative advantage across states of nature goes back to Svensson (1988), who shows how it shapes global capital flows. The contribution of my paper is to show that comparative advantage across states of nature also shapes global goods trade flows and, importantly, that this can be true even if global financial markets are perfectly integrated. In this simple example, the model's key result boils down to the prediction that firms from both countries, who may be owned by the same global investor, produce more for market B than what is justified by the difference in expected demand.

Four assumptions are essential for this result: Risk aversion and the presence of aggregate risk, a well-defined firm boundary together with a motive for trade that is independent of diversification considerations, and firms having to make export decisions under uncertainty, that is, *before* demand is known. Under these assumptions, firms' incentive to exploit the correlation pattern of shocks to the benefit of their investors prevails *even if* financial markets are complete and fully integrated internationally.

While financial market completeness provides for costless diversification of *idiosyncratic* risk, insurance against aggregate risk is costly nevertheless. And as long as insurance against aggregate risk is costly, it is optimal for firms to sacrifice some expected return in order to reduce investors' exposure to the aggregate risk implied by their exporting decisions. Hence, firms deviate from the first-best quantity under risk neutrality.[3] Survey evidence confirms this. Based on the responses of 392 chief financial officers (CFO) to a survey conducted among U.S. firms in 1999, Graham and Harvey (2001) report that more

[3]Brainard and Cooper (1968) describe this mechanism for a small open economy in a two-country world where the social cost of volatility derive from a concave social welfare function.

than 70% use discount factors that account for the covariance of returns with movements in investors' total wealth to evaluate the profitability of an investment.[4] The concept of optimal decision-making based on expected payoffs *and* riskiness as perceived by investors, that goes back to the seminal contribution of Modigliani and Miller (1958), is prevalent in the literature on firms' optimal choices of production technologies[5] and in the literature on international trade and investment under uncertainty.[6] Yet, to date, it has not made its way into the literature devoted to firms' exporting decisions under demand uncertainty, which predominantly considers risk-neutral agents.[7] A smaller strand of literature analyzes risk-averse firms acting in the absence of financial markets (see, for example, Maloney and Azevedo, 1995; Riaño, 2011; Allen and Atkin, 2016; Esposito, 2019). In these settings, exporters engage in diversification of firm-specific risk by exploiting imperfectly correlated demand shock in foreign markets. In contrast, in my setting with risk-averse shareholders, idiosyncratic risk is diversified through asset trade and only aggregate risk embodied in a countries' demand fluctuation influences exporting decisions.

Besides aggregate risk, exporters' diversification incentives hinge on the assumption that firms make production decisions for every market under uncertainty about the price at which they will sell. This implies that the exporting decision for every market is defacto an investment problem. In contrast, the sizeable extant literature on capital flows and trade under uncertainty following Helpman and Razin (1978), Grossman and Razin (1984), and Helpman (1988) has focused on settings where capital allocation takes place under uncertainty, while trade patterns are determined after the uncertainty is resolved.[8] Another key element for the novel predictions of my paper which is distinct from this literature and the earlier model of Brainard and Cooper (1968), where export choices are made under price uncertainty, is the existence of a well-defined boundary of the firm. Without a firm boundary and a motive for goods trade beyond diversification, a global investor could replicate the optimal allocation by choosing the corresponding units of domestically-selling firms. In the model, the firm boundary and the export motive are

[4]Asked specifically about projects in foreign markets, more than 50% of the CFOs responded that they adjust discount rates for country-specific factors when evaluating the profitability of their operations.

[5]See, for example, Cochrane (1991, 1996), Jermann (1998), Li et al. (2006), and Belo (2010).

[6]Compare Helpman and Razin (1978) Grossman and Razin (1984), and Helpman (1988).

[7]See, for example, Das et al. (2007), Ramondo et al. (2013), and Dickstein and Morales (2018).

[8]A related strand of literature following Turnovsky (1974) analyzes whether financial market incompleteness prevents countries from specializing according to their sectoral comparative advantage of the traditional kind but does not explore the implications of comparative advantage across states of nature (see, for example, Koren, 2004; di Giovanni and Levchenko, 2011; Islamaj, 2014; Kucheryavyy, 2017).

rooted in the New Trade Theory assumptions of increasing returns to scale at the firm level, product differentiation, and love-for-variety preferences. Under these assumptions, investors' portfolio choices determine the number of firms in each country whereas firms' decide upon the sales per market. Optimality and absence of frictions requires that the risk-return trade-off for both investment problems is identical at the margin.

There is ample evidence that exporters face significant time lags between production and sales of their goods.[9] In the survey by Graham and Harvey (2001), CFOs were asked to state whether and, if so, what kind of risk factors in addition to market risk (the overall correlation with the stock market) they use to adjust discount rates. Many of the important risk factors mentioned (cp. Fig. 4 in Graham and Harvey, 2001) are linked to the time lag between investment and cash flows; interest rate risk, exchange rate risk, inflation, and commodity price risk all indicate that firms have limited ability to timely adjust their operations to current conditions. The reduced-form evidence presented in this paper also lends support to the time lag assumption. Exploiting variation across products and country pairs, I find that the covariances are more important if products are shipped over long distances and by slow means of transportation.

As regards the role of aggregate risk for investment decisions, a sizeable literature documents that investors care about firms' operations in foreign markets and the potential of these operations to diversify the risk associated with volatility of aggregate consumption or the aggregate domestic stock market (see, e.g., Rowland and Tesar, 2004; Ramondo and Rappoport, 2010; Fillat et al., 2015; Fillat and Garetto, 2015). Fillat and Garetto (2015) find that investors demand compensation in the form of higher returns for holding shares of internationally active firms. Fillat et al. (2015) provide evidence that those excess returns are systematically related to the correlation of demand shocks in destination markets with the consumption growth of investors in the firms' home country. However, little is known about whether firms respond to investors' desire for consumption smoothing and how this affects the pattern of aggregate bilateral trade and the degree of global risk sharing. Here lies the contribution of my paper. It focuses on the optimal export choices of firms and exploits a simpler dynamic structure to endogenize the distribution of investors' marginal utility growth in general equilibrium.

Thereby, this paper relates to the literature on international asset pricing building on Stulz (1981) and the literature on general equilibrium models of asset pricing following Jermann (1998), that models the supply and demand for equity by linking both firms'

[9]Djankov et al. (2010) report that export goods spend between 10 to 116 days in transit after leaving the factory gate before reaching the vessel, depending on the country of origin. Hummels and Schaur (2010) document that shipping to the United States by vessel takes another 24 days on average.

investment returns and investors' consumption to the same volatile economic fundamentals such as productivity shocks. My paper provides a microfoundation for a linear factor model featuring country-specific demand shocks as factors, which can be translated into real exchange rate shocks. The model delivers microfounded exposures ("betas") of firms to these country-specific shocks that derive from a gravity model of trade, as well as endogenous factor prices for the country-specific risk. It predicts that the correlation between destination-market-specific shocks and domestic stock returns can to a great degree be explained by the level of trade with the destination country and the level of trade with other countries exhibiting correlated shocks. In fact, I find that the model-predicted country risk premia constructed with trade data only align strikingly well with stock market data based risk premia for country shocks. Risk premia are higher for countries which are central in the trade network, either for being large or for being geographically close to many other countries, making it harder to diversify their shocks. This aligns well with the results of Richmond (2019) and Lustig and Richmond (2017) who show that centrality in the trade network and bilateral trade cost proxies such as geographical and cultural distance help explain the cross-section of currency risk premia.

My paper also builds on a large literature that provides structural microfoundations for the gravity equation of international trade (for a comprehensive survey of this literature, see Costinot and Rodriguez-Clare, 2014). I introduce risk-averse investors and shareholder-value-maximizing firms into this framework to show that demand uncertainty and, in particular, cross-country correlations of demand volatility alter the cross-sectional predictions of standard gravity models. Moreover, by modeling international investment explicitly, the model rationalizes and endogenizes current account deficits and thereby addresses an issue that severely constrains counterfactual analysis based on static quantitative trade models (see, e.g., Ossa, 2014, 2016).

The paper proceeds as follows. Section 2 presents stylized facts and a simple model about the relationship between trade and the covariances of demand shocks. Section 3 develops the general model and Section 4 presents the counterfactual analysis. Section 5 concludes.

2 Export and Covariances: Stylized Facts

This section presents new stylized facts on the relationship between exports and the covariance of demand shocks in export destination countries with stock returns and consumption growth in the exporting country.

First, I explore how differences in these covariances across destinations and time affect bilateral exports at the micro level—in search for a diversification motive. Based on the predominant empirical trade model, the "gravity equation," I show that bilateral exports disaggregated at the product level are larger for destination markets with *negatively* correlated shocks. Consistent with the presumption that exposure to these shocks derives from uncertainty about demand conditions at the time of production, this relationship is found to be particularly strong for shipments characterized by longer shipping times.

Second, I analyze fundamental and endogenous determinants of the covariances with the help of a simple model that links portfolio returns to country-specific demand shocks. The partial equilibrium model goes a long way in fitting the relevant moments of actual stock return data used in the reduced-form estimation and provides a simple rationale for why the distribution of demand shocks constitutes a source of comparative advantage. The simple model will also constitute a building block for the general equilibrium model of international trade and investment developed below.

From a shareholder's point of view, firms contribute to risk diversification if their profits covary negatively with shareholders' income, consumption, or more generally, if their profits covary positively with shareholders' marginal utility growth. This statement holds conditional on the availability of other means of diversification available to an investors and his choice of an optimal consumption plan. To simplify, I will henceforth use consumption growth as an inverse proxy for marginal utility growth. For an investor who can buy and sell other assets but has no other stochastic sources of income, risk in terms of consumption volatility will be closely linked to the return on his optimally chosen wealth portfolio. To simplify further, I use the country-level or supranational regional-level stock market returns to describe return to the wealth portfolio for a *representative investor* in these markets. This implies that I abstract fully from the actual ownership structure in an economy. As will be discussed in the theoretical section, this simplification can be justified by the assumption (among others) that *within* a national or supra-national regional financial market agents fully exploit diversification opportunities through trading shares and financial assets, such that every investor's marginal utility growth across time and states is perfectly aligned with the marginal utility growth of a "synthetic" representative investor who possesses the equilibrium wealth portfolio of a country or region.

Throughout the empirical and theoretical part of the paper, I do not take a stand on the actual degree of global financial market integration. In the empirical part where I construct measures of the degree to which shocks in a given destination market constitute risk for the representative investors of exporters from other countries, I compute three different measures consistent with alternative assumptions regarding the degree of global financial market integration. First, I compute the covariance between aggregate national stock market returns and demand shocks in destination countries. This reflects most closely a scenario where financial markets are integrated within countries but not across borders. Secondly, I substitute national stock market returns with the total return on an aggregate regional stock market (an optimal portfolio of a subset of national stock markets) grouping countries into regions along the lines of Fama and French (2012). This is consistent with regionally but not globally integrated financial markets. Lastly, I compute the covariance of demand shocks with consumption growth in the exporting country. This measure is agnostic about the degree of international financial market integration. In the theoretical part, I show that the qualitative implications of diversification incentives of exporters are similar under different assumptions about the degree of global financial market integration. Only in the quantitative part, where I calibrate the model to the current state of the world economy, will I specify the degree of financial integration, namely, that financial markets are regionally integrated, but not globally.

2.1 Diversification Through Exporting

2.1.1 Empirical Model and Data

To assess if and how the covariance of demand shocks with aggregate stock market returns or consumption growth affects trade, I estimate a product-level gravity equation,

$$\begin{aligned}\ln q_{pij,t} = {} & \beta_1 \mathrm{Cov}_t\left(M_i, \widehat{Y}_j\right) + \beta_{21} EU_{ij,t} + \beta_{22} \mathrm{L5}.EU_{ij,t} + \beta_{23} \mathrm{L10}.EU_{ij,t} + \beta_{31} FTA_{ij,t} \\ & + \beta_{32} \mathrm{L5}.FTA_{ij,t} + \beta_{33} \mathrm{L10}.FTA_{ij,t} + d_{pi,t} + d_{pj,t} + d_{pij} + u_{pij,t}, \end{aligned} \tag{1}$$

where the dependent variable is the quantity (in kilograms) of product p shipped from country i to j in year t.[10] The data, sourced from UN Comtrade, is disaggregated into 766 products (defined by the 4-digit level of SITC classification, Rev. 2).[11] I use four equally-spaced time periods between 1985 and 2015. More years of data are considered in a robustness analysis.

On the right-hand side of (1), importer-product-time and exporter-product-time fixed

[10] See Head and Mayer (2014) for a summary of the history and applications of the empirical gravity model.

[11] In my baseline estimations I use a sample covering 175 out of 245 destination countries and a median 95% (96%,92%,78%) of the total exports of 21 (21,16,15) countries in 2015 (2005,1995,1985). The set of exporters per year is limited by the availability of stock return data for the computation of the covariances. The small loss of observations per exporter is primarily due to missing data on monthly imports which are also needed to compute the bilateral risk premia.

effects capture expected demand in the destination market and the importer's price index (also known as "multilateral resistance"), the exporter's production cost, as well as time-varying trade cost specific to the exporter or the importer. Country-pair-product fixed effects as well as dummy variables for joint membership in the EU or a free trade agreement (FTA) control for bilateral trade cost.[12] Tab. A.10 summarizes the estimation sample and provides details regarding data sources and variable definitions. Appendix A.2 provides further details about the data.

To compute the covariance term on the right-hand side, I use data on monthly stock market returns by country ($R^M_{i,t}$) or region ($R^M_{\iota,t}$) from *Kenneth R. French's Data Library.* This data is available for 21 mostly industrialized countries forming the following five regions: North America; East Asia and Pacific; Europe (excl. United Kingdom, Ireland, Scandinavia); United Kingdom and Ireland; and Scandinavia. To proxy demand growth $\widetilde{Y}_{j,t}$, I use growth in total monthly imports by country with respect to the previous month. For consumption growth $\widetilde{C}_{i,t}$, I use quarterly growth rates with respect to the previous period and quarterly demand growth. Growth rates are adjusted for seasonality. To capture variation across time I compute covariances for rolling time windows of a ten-year length. That is, for $M_{i,t} = \{R^M_{i,t}, R^M_{\iota,t}, \widetilde{C}_{i,t}\}$ I compute $\mathrm{Cov}_t\left[M_{i,t+1}, \widetilde{Y}_{j,t+1}\right] = T^{-1}\sum_{s=0}^{T}\left[M_{i,t-s}\cdot\widetilde{Y}_{j,t-s}\right] - T^{-2}\sum_{s=0}^{T} M_{i,t-s}\cdot\sum_{s=0}^{T}\widetilde{Y}_{j,t-s}$. This results in a set of covariances for 21 exporters and 175 destination markets and every year between 1984 to 2017, each based on monthly or quarterly data from the 10 most recent years.

The coefficient on the covariance in this equation is identified using variation within country pairs over time only. A potential concern about omitted variables bias is due to bilateral time-varying factors, such as unobserved trade barriers or demand and supply shocks, affecting both product-level trade and the bilateral covariance. In fact, the simple portfolio model outlined below will demonstrated that the covariances depend positively on degree of trade integration between the two countries. Naturally, demand shocks in the destination country will be more correlated with the domestic stock market the higher the level of bilateral exports. This implies that any omitted variable affecting the left-hand side will be correlated with the risk premium as well. Yet, omitted variables that correlate positively with trade on the left-hand side will also be positively correlated with $\mathrm{Cov}\left(M_i, \widehat{Y}_j\right)$ and, hence, work against me finding a negative coefficient. Likewise, for omitted variables which are negatively correlated with product-level trade on the left-hand

[12] In line with recent empirical gravity literature I include five-year and ten-year lags of the these dummies to capture phase-in effects of entry into trade agreements; cp. Baier et al. (2014).

side and with aggregate trade. In other words, the positive correlation between aggregate trade and the bilateral covariance implies that omitted variables like unobserved time-varying bilateral demand or supply shocks will lead to an upward bias in this equation, such that the estimate must be interpreted as an upper bound. I explore this reasoning below, where I run multiple specifications with stricter trade cost and demand controls added subsequently. Even without omitted variables, there remains a concern about reverse causality due to product-level exports being positively correlated with aggregate exports. However, for the same reason as outlined before, this leads to an upward bias of the estimate. Moreover, the concern is ameliorated by the fact that product-level exports on the left-hand side make up only a small part of aggregate exports.

In additional regressions I allow for heterogeneity of the effect of $\mathrm{Cov}\left(M_i, \widehat{Y}_j\right)$ across products and markets to test the hypothesis that the correlation pattern of demand shocks matters because exporters are faced with a time lag between production and sales, which creates uncertainty about demand conditions at the time when production decisions are made. If firms could immediately adjust quantities to the current demand level, they would still exhibit volatile profits and thus expose their investors to risk, yet current sales would be perfectly explained by the current level of demand and the covariances should not matter. Trade relationships that are exposed to longer time lags are therefore expected to be more affected by the dampening effect of positively correlated shocks. To assess this prediction, I interact the covariances with the distance between the exporter and the importer, presuming that distance correlates with shipping time. To further tease out the role of the time lag, I split the sample into goods shipped primarily by vessel (or ground transportation) rather than air, presuming that shipping over long distances implies a significant time lag only if the goods are not transported by air. Product-specific indicators for the primary transport mode (vessel/air) are computed using product-level shipments to and and from the U.S. which are recorded by mode of transport; see Appendix A.2 for details. I then re-run the specification including the covariances interacted with distance in both subsamples. Alternatively, I include a triple interaction $\mathrm{Cov}\left(M_i, \widehat{Y}_j\right) \times \ln \mathit{Dist} \times \mathit{Vessel}$ in an estimation based on the full sample, for the same effect. Since the triple interaction term varies by country pair, time, and product, it can also be identified when country-pair-time fixed effects are included.

To account for potential correlation in the error term due to the finer level of disaggregation on the left-hand side and also due to the fact that the covariances do not vary across products, I compute two-way clustered standard errors which are robust to arbitrary correlation of errors within product categories and within country pairs, as advocated by Cameron et al. (2011).

Table 1: Gravity estimations with covariance

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	Vessel	Air	All	All
$\text{Cov}\left(\widehat{M}, \widehat{Y}\right)$	-0.012*	0.140*	0.241***	-0.032	-0.050	
	(0.007)	(0.074)	(0.077)	(0.086)	(0.089)	
$\times$ ln *Dist*		-0.018**	-0.030***	0.002	0.004	
		(0.009)	(0.009)	(0.010)	(0.010)	
$\times$ Vessel					-0.035***	-0.031***
					(0.009)	(0.008)
$\times$ Vessel					0.299***	0.269***
					(0.074)	(0.071)
Observations	2080695	2080695	1316842	763853	2080695	2080346
Adjusted R^2	0.783	0.783	0.755	0.773	0.783	0.787

All columns include importer-product-time, exporter-product-time, country-pair-product fixed effects, binary indicators for joint membership in the EU or an FTA, as well as two five-year-spaced lags thereof. Col. 6 also includes country-pair-time fixed effects. S.e. (in parentheses) robust to two-way clusters on product and country-pair level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity (in kg) by product, country-pair, and time. Col. 3 (4) based on subsample of products shipped primarily by vessel/ground transportation (air) only. Estimates based on years 1985, 1995, 2005, 2015. $\text{Cov}(\widehat{M}, \widehat{Y})$ is the standardized covariance between the monthly aggregate stock market return in the exporting country and aggregate import growth in the destination.

2.1.2 Results

Col. 1 of Tab. 1 shows parameter estimates from the baseline specification (1). I find that a higher covariance has a significantly negative effect on export quantities. The estimates in Col. 1 imply that a 1 unit increase in the covariance goes along with an increase in exports by about 34%.[13] In terms of economic magnitude, this means, for example, that the .0004-unit-increase in the covariance of demand shocks in China with the U.S. stock market between 1992 and 2004 was associated with -1.4% lower exports compared to a counterfactual world where covariances do not influence firms' exporting decisions. In other words, the coefficient estimate suggest that the aggregate increase in U.S. exports to China in that period was slowed down by -1.4% due to a corresponding increase in the bilateral covariance. Arguably, the economic magnitude of the effect of covariances on trade seems modest. However, as I show next, there is substantial heterogeneity of the effect across country pairs and products that needs to be taken into account when assessing the economic importance of the diversification motive.

As Col. 2 of Tab. 1 shows, the effect of the covariance on trade depends crucially on the distance between exporter and importer. Higher covariances impede trade more if countries are more distant. As argued above, this supports the hypothesis that the correlation of shocks matters due to the presence of a time lag between production and

[13]For comparability, the covariances are standardized. The non-standardized coeffcient is $.012/.00035 = 34.29$.

Table 2: Gravity estimations with covariance: Regional CAPM and consumption growth

	(1)	(2)	(3)	(4)	(5)	(6)
	Regional CAPM			Consumption growth		
$\text{Cov}\left(\widehat{M}, \widehat{Y}\right)$	-0.027***	-0.245**		-0.015**	-0.262***	
	(0.010)	(0.109)		(0.007)	(0.080)	
$\times$ ln *Dist*		0.025**			0.029***	
		(0.013)			(0.009)	
$\times$ Vessel		-0.065***	-0.061***		-0.038***	-0.037***
		(0.011)	(0.011)		(0.008)	(0.007)
$\times$ Vessel		0.553***	0.530***		0.324***	0.321***
		(0.096)	(0.094)		(0.065)	(0.063)
Observations	2175616	2175616	2175214	1699404	1699404	1699160
Adjusted R^2	0.781	0.781	0.785	0.790	0.790	0.794

All columns include importer-product-time, exporter-product-time and country-pair-product fixed effects. Cols. 3,6 also include country-pair-time fixed effects. Cols. 1,2,4,5 include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter. S.e. (in parentheses) robust to two-way clusters on product and country-pair level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity (in kg) by product, country-pair, and time. Estimates based on years 1985, 1995, 2005, 2015. In Cols. 1-3 (4-6) $\text{Cov}(\widehat{M}, \widehat{Y})$ is the standardized covariance between the monthly (quarterly) aggregate stock market return (consumption growth) in the exporting country and monthy (quarterly) aggregate import growth in the destination.

sales. Cols. 3 and 4 lend further support to this hypothesis, showing the interaction with distance separately for the subsample of products that are shipped primarily by vessel or by air, respectively. Distance matters only if goods are shipped by vessel, that is, when a larger distance actually implies significantly longer shipping times. This is confirmed by the results presented in Col. 5, which is based on the full sample and features a triple interaction of the risk premium, distance, and the binary indicator for goods shipped by vessel. Col. 6 shows that the inclusion of country-pair-time fixed effects, which absorb all observed and unobserved bilateral time-varying trade cost, does not impair this result.

The interaction term with distance implies that for country pairs at the 75th percentile of the distance distribution, which are 8900 kilometers apart, the effect of a change in the risk premium is twice as large as the average effect in Col. 1. Accounting for the distance between China and the U.S., the effect of the increase in the risk premium on exports between 1992 and 2004 is quantified at -3.2%. If the we consider exports by vessel, the effect is -4.4%.

2.1.3 Robustness

I conduct various tests to analyze the robustness of my results with regard to changes in the exact specification of Eq. (1). Moreover, I analyze the potential for omitted variables bias using observable trade cost variables and fixed effects. Results are collected in Tab. 2 and Tabs. A.8 and A.9 in the Appendix, which also discusses additional robustness checks regarding the sample period and the aggregation level of the dependent variable.

Regional stock market returns and consumption growth correlations. Tab. 2 presents results using the two alternative covariance measures described above, showing that alternative assumptions on the degree of financial market integration do not impair the results. Cols. 1-3 (4-6) show that similar results obtain when the return to the domestic stock market is replaced by the aggregate return on a supranational regional stock market (country-level consumption growth).

Omitted variables bias. In Tab. A.8 I analyze the validity of the model-based presumption, discussed in more detail above, that omitted factors determining trade on the left-hand side lead to an upward bias of the coefficient of $\text{Cov}\left(M_i, \widehat{Y}_j\right)$. Col. 1 presents the correlation between $\text{Cov}\left(M_i, \widehat{Y}_j\right)$ and product-level exports, conditioning only on importer/exporter-product-time fixed effects. As expected, it is strongly positive, as more bilateral trade implies a higher covariance. In Cols. 2 and 3 I subsequently add time-constant and time-varying bilateral trade cost proxies. This lowers the coefficient estimate, which is consistent with the presumption that the upward bias is reduced. Col. 4 repeats the baseline specification of Tab. 1, featuring in addition country-pair-product fixed effect to control for unobserved bilateral trade cost, as well other supply and demand shifters, which produces a negative and statistically significant effect of the risk premia. Cols. 5 and 6 explore the effect of adding tariffs. The tariff data are available at the product-level, but time and country coverage is very patchy. Hence, I lose a significant number of observations. Col. 5 shows that in this smaller sample the effect of the covariance is still significant. Col. 6 shows that adding tariffs does not affect the estimate.

Alternative proxies for demand shocks. Cols. 5-8 of Tab. A.9, upper panel, present results for covariances based on different proxies for demand shocks in the destination markets; monthly indices of industrial production and retail sales, respectively. Country coverage for these indicators is limited (36 in the case of industrial production and 37 for retail sales) and heavily focused on industrialized countries. The estimated effects point in the same direction, but significance is weaker.

Dependent variable. The main empirical specification uses export quantities rather than values. Quantities are fixed by the time production starts, whereas the value of sales depends on the realization of the demand shock. When I observe trade values at the exporter's (or possibly also at the importer's) border, it is unclear whether the demand shock has been realized and whether the reported value of a good is the final or the expected sales value. On average, export values registered at customs should still be negatively related to risk premia, but the coefficient likely reflects a mix of expected and realized values. On the positive side, data on export values is supposedly of higher quality, since some of the export weight entries in the Comtrade database are estimated. Cols. 9 and 10 of Tab. A.9, upper panel, show that the positive effect of lower covariances prevails indeed when considering export values, and so does the interaction with distance and the vessel indicator.

Sectoral comparative advantage. A competing explanation for the negative effect of the covariance on trade is the possibility that sectoral specialization explains both greater bilateral trade volumes as well as a low correlation of shocks. While the baseline estimation cannot rule out the possibility the that negative coefficient is driven by this alternative mechanism, the heterogeneous effects with regard to distance and transport mode provide evidence in favour of the risk-diversification mechanism.

To summarize, I find a robustly *negative* and significant effect of the covariances on exports at the product level, suggesting that firms do adjust relative sales across markets in accordance with investors' desire for smooth consumption. The differential effects by distance and modes of transportation lends support to hypothesis that demand volatility constitutes a risk because of a time lag between production and sales. In the following I outline a simple model of portfolio returns and country-specific demand shocks to demonstrate that the covariances used in the regression measure a destination market's comparative advantage in terms of risk-diversification potential. The simple model is a building block for the subsequent theoretical analysis that describes firms' and investors' choices in general equilibrium.

2.2 Demand Shocks and Comparative Advantage

Let $N_i \phi_{ij} \mathrm{E}[Y_j]$ denote expected exports from country i to j, where $\mathrm{E}[Y_j]$ denotes country j's expected expenditure, ϕ_{ij} is the share country j spends on a typical variety from i, and N_i is the number of firms in i. Now consider a representative investor for a world region ι consisting of a subset $\mathcal{J}_\iota \subseteq \mathcal{J}$ of countries whose financial markets are perfectly integrated. Investor ι holds a portfolio containing a constant share ν of all firms from countries $i \in \mathcal{J}_\iota$, endowing her with a claim to a share ν of every firms' realized sales value $\phi_{ij} Y_j$ in every markets. The return to her portfolio is thus

$$R_\iota^M = \boldsymbol{\beta}_\iota' \widetilde{\boldsymbol{Y}}, \quad \text{where} \quad \beta_{\iota j} = \sum_{i \in \mathcal{J}_\iota} \frac{N_i \phi_{ij} \mathrm{E}[Y_j]}{A_\iota^M} \quad \text{and} \quad \widetilde{Y}_j = \frac{Y_j}{\mathrm{E}[Y_j]} \tag{2}$$

are typical elements of the vectors $\boldsymbol{\beta}_\iota$ and $\widetilde{\boldsymbol{Y}}$, respectively. The global investor's portfolio return is stochastic since it depends on realized sales of the firms in her portfolio which, in turn, depend on the realization of demand in the destination market, Y_j. $\beta_{\iota j}$ is a measure of the portfolio's exposure to demand shocks in country j, given by the expected sales to market j by all firms in the portfolio relative to the portfolio value.

The variance of the portfolio return decomposes into contributions by all countries as

$$\sigma^2_{R_\iota^M} = \sum_{j \in \mathcal{J}} \beta_{\iota j} \text{Cov}\left[R_\iota^M, \widetilde{Y}_j\right], \quad \text{where} \quad \text{Cov}\left[R_\iota^M, \widetilde{Y}_j\right] = \sum_h \beta_{\iota h} \sigma_{\widetilde{Y}_j \widetilde{Y}_h}, \tag{3}$$

yielding a straightforward interpretation of the covariances in the regression. $\text{Cov}\left[R_\iota^M, \widetilde{Y}_j\right]$ reflects country j's contribution to the volatility of the exporter's investor's portfolio.

The model encompasses the two polar cases of globally integrated and autarkic financial markets. With globally integrated financial markets, the globally representative investor holds a share of the global fund containing all firms, $\mathcal{J}_\iota = \mathcal{J}$, hence the variance decomposition yields country-specific contributions to aggregate risk equal to

$$\text{Cov}\left[R^M, \widetilde{Y}_j\right] = \sum_{h \in \mathcal{J}} \beta_h \sigma_{\widetilde{Y}_j \widetilde{Y}_h}. \tag{4}$$

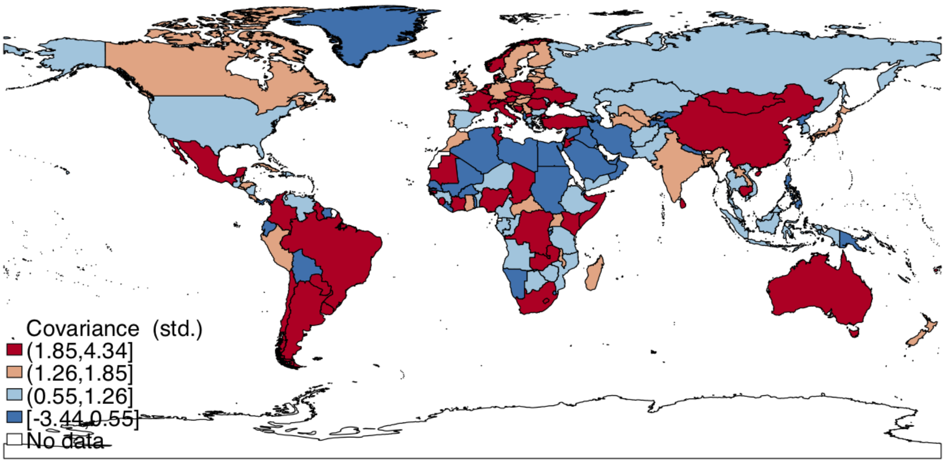
With autarkic financial markets, $\mathcal{J}_\iota = \{i\}$, the investor owns only domestic firms and the country-specific contributions are

$$\text{Cov}\left[R_i^M, \widetilde{Y}_j\right] = \sum_{h \in \mathcal{J}} \beta_{ih} \sigma_{\widetilde{Y}_j \widetilde{Y}_h}. \tag{5}$$

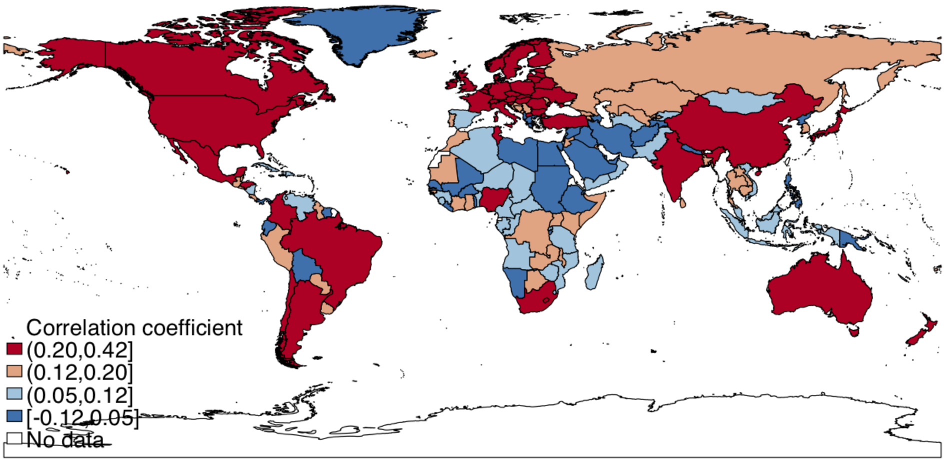
Aggregate risk contributions are partly endogenous, since the β's reflect optimal choices of firms (ϕ_{ij}) and investors (N_i). The exogenous part $\sigma_{\widetilde{Y}_j \widetilde{Y}_h}$, however, constitutes a source of comparative advantage that is particular to the setting with risk-averse agents: Conditional on $\boldsymbol{\beta}$, countries featuring shocks that are negatively correlated with most other countries contribute less to aggregate volatility. Moreover, suppose that large β's with some markets reflect these markets' comparative advantage of the traditional kind. Then, any country j featuring negatively correlated shocks with "large-β" countries is a particularly attractive destination. Finally, note that the direct exposure to market j through $\beta_{\iota j} \sigma_{\widetilde{Y}_j \widetilde{Y}_j} \geq 0$ always contributes positively to aggregate risk since $\sigma_{\widetilde{Y}_j \widetilde{Y}_j} \geq 0$. Given a negative impact of $\text{Cov}\left[R_\iota^M, \widetilde{Y}_j\right]$ on bilateral trade as established above, uncertainty in Y_j thus weakens the impact of other sources of comparative advantage on trade.

Fig. 1, Panel (a) visualizes country risk as measured by a country's contributions to the global investor's portfolio (4). The four different colors reflect quartiles of the

Figure 1: Global risk contributions by country



(a) Covariance

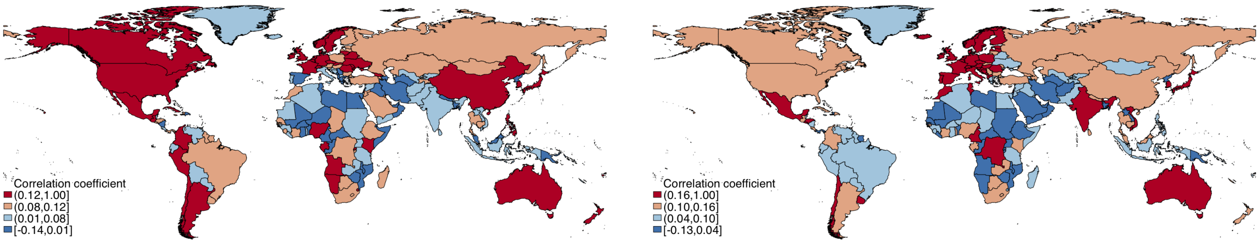


(b) Correlation

Panel (a) shows the covariance of all countries' demand shocks with global demand growth, Panel (b) shows the corresponding correlation coefficient.

distribution of the risk measure. South and Central America, Subsaharan Africa, and Eastern Europe host many of the riskiest countries. Yet, shocks in China, Australia, France, Norway and Italy also contribute significantly to global volatility. A country's riskiness according to this measure derives from two sources: The degree of correlation with global demand and, conditional on the sign of the correlation, the volatility of its demand. Panel (a) reflects the combination of the two. Panel (b) shows correlation coefficients, which mute the impact of country-specific volatility. It reveals that nearly all developed and emerging countries are found in the highest quartile, while developing countries score lower. This is in line with the above reasoning that more popular import destinations are also more risky ceteris paribus, as shocks to their demand have a bigger

Figure 2: Correlations with national stock markets



(a) USA (b) Germany

impact on the global portfolio. Yet, Panel (a) makes clear that the volatility dimension does matter for separating countries according to their riskiness. The combination of the two sources of riskiness yields a pattern of comparative advantage that does not exhibit an obvious correlation with other well-established determinants of trade.

To the extent that financial markets are disintegrated internationally, the pattern of comparative advantage becomes even richer. For example, comparing the correlation of country-shocks with the return to the market portfolio of U.S. firms versus German firms shows that destination markets contribute quite differently to the volatility of these portfolios. Fig. 2 Panel (a) shows that the correlations of demand shocks with the U.S. portfolio resemble the pattern for the global portfolio. Yet, the portfolio of German firms is much more correlated with its European neighbors than with countries from the Americas. Hence, if most stock ownership is local, exports to Brazil provide sizeable diversification benefits to a representative German investor, but not to a U.S. investor. Conversely, a negative contribution by Spain to the variance of the U.S. market portfolio makes Spain an attractive export destination for U.S. firms, while the opposite is true for exporters from Germany.

How well does this simple portfolio model describe actual correlations of country shocks with stock market returns? A simple transformation of $\mathrm{Cov}\left[R_i^M, \widetilde{Y}_j\right] = \sum_{h\in\mathcal{J}} \beta_{ih}\sigma_{\widetilde{Y}_j\widetilde{Y}_h}$ yields

$$\frac{\mathrm{Cov}\left[R_i^M, \widetilde{Y}_j\right]}{R_i^M \sigma_{\widetilde{Y}_j}} = \sum_{h\in\mathcal{J}} \frac{N_i \phi_{ih} \mathrm{E}\left[Y_h\right]}{\sum_{h\in\mathcal{J}} N_i \phi_{ih} \mathrm{E}\left[Y_h\right]} \frac{\sigma_{\widetilde{Y}_j\widetilde{Y}_h}}{\sigma_{\widetilde{Y}_j}}. \tag{6}$$

Fig. 3 plots the right-hand side of (6), computed with trade data only on the vertical axis against the scaled stock-return-data-based covariances (left-hand side of (6)) that are used in the regressions above on the horizontal axis.[14] The model-based covariances

[14] $\sigma_{\widetilde{Y}_j,\widetilde{Y}_h}$ is computed alike $\mathrm{Cov}\left[M_{i,t+1}, \hat{Y}_{h,t+1}\right]$ based on ten years of monthly data as described in

Figure 3: Covariance of country shocks and stock returns: Model vs. data

The figures plot scaled covariances between domestic aggregate stock returns and demand shocks in other countries constructed from trade data consistent with the model on the vertical axis against same scaled covariance computed using actual stock returns on the horizontal axis. The left panel shows the correlations for the U.S. as exporter, the right panel shows the correlation for 21 exporters for which national stock return data are available.

reproduce the actual cross-section of country shocks strikingly well.[15]

How important is risk-based comparative advantage for global trade? To address this question I integrate the above relationship between trade and portfolio returns into a general equilibrium model. This model rationalizes the influence of countries' aggregate risk contributions on firms' exporting decisions, endogenizes portfolio choices and firm entry, and delivers the country-specific risk aggregate risk contributions as endogenous equilibrium outcomes. It paves the way for the subsequent counterfactual analysis which quantifies the impact of risk-based comparative advantage on trade.

Section 2.1.1. I use average stock market returns and average trade flows over the same period for the computation of the two measures.

[15] This is in spite of the fact that for lack of domestic sales data, the trade-data-based covariances can only approximate the right-hand side of (6).

3 Theory

Consider a world consisting of countries indexed by $i, j \in \mathcal{J}$. Each country is part of a region $\iota \in \mathcal{R}$. The set of countries forming region ι is $\mathcal{J}_\iota$. Individuals in all countries derive utility from consumption of a final good and earn income from the ownership and trade of assets whose returns are stochastic. Preferences are of the von Neumann-Morgenstern type with concave per-period utility functions, and individuals hold identical beliefs about the probabilities with which uncertain events occur. Within regions, financial markets are complete. That is, there are no frictions to trading assets within regional financial markets and idiosyncratic risks can be eliminated through diversification. Under these assumptions, aggregate investment and consumption patterns of a region resulting in the decentralized equilibrium can be described by the optimal choices of a representative investor for every region who possesses the sum of all individuals' wealth (see Constantinides, 1982).[16]

The set of assets available to investor ι consists of a globally traded risk-free bond and shares of the firms in her region that produce differentiated intermediate goods.[17] Firms are homogenous within countries and indexed to their home country i. There is free entry and N_i denotes the number of intermediate goods producers from country i. Intermediate goods are sold to domestic and foreign final goods sectors whose output is subject demand shocks, rendering intermediate goods producers' profits stochastic. The model encompasses two polar cases: Financial autarky, where each country is a separate region, $\mathcal{R} = \mathcal{J}$, and global financial market integration, where there is a single region spanning all countries, $\mathcal{J}_\iota = \mathcal{J}$.

[16]Constantinides (1982) also shows that the representative investor's preferences inherit the von Neumann-Morgenstern property and the concavity of individuals' utility functions.

[17]Note that, in Dybvig and Ingersoll (1982)'s terminology, the representative investor cares only about "primary" assets and not about "financial" assets. Primary assets, that is, firm shares or bonds from outside the region, affect the aggregate wealth of a region. In contrast, financial assets, such as insurance policies, options, or futures, affect only the distribution of wealth within a region since, by definition, they are in zero net supply. They are essential for eliminating idiosyncratic risks and thus for facilitating the description of the financial market equilibrium by means of a representative investor in the first place. But since they have no bearing on the aggregate wealth of the economy they do not influence the representative investor's problem.

3.1 Utility, Consumption, and Investment

Investor ι's utility from consumption over her lifetime is given by

$$U_t = u_\iota(C_{\iota,0}) + \delta \mathrm{E}\left[u_\iota(C_\iota)\right] \qquad \text{with} \qquad u'_\iota(\cdot) > 0,\ u''_\iota(\cdot) < 0 \tag{7}$$

where δ is the time preference rate. Let $W_{\iota,0}$ denote the investor's initial wealth. In period zero, wealth is split between consumption $C_{\iota,0}$, investment $a^f_{\iota,0}$ in the globally-traded risk-free bond that yields a certain gross return R^f in the next period, and risky investments $a_{\iota i,0}$ in shares of firms of type $i \in \mathcal{J}_\iota$, that yield a stochastic gross return R_i in period one. In the polar case of autarkic financial markets $\mathcal{J}_\iota$ contains only the homogenous domestic firms. In the case of a globally integrated financial market, $\mathcal{J}_\iota$ contains firms from all countries. The budget constraint is given by

$$W_{\iota,0} = A_{\iota,0} + C_{\iota,0} \qquad \text{with} \qquad A_{\iota,0} = \sum_{i \in \mathcal{J}_\iota} a_{\iota i,0} + a^f_{\iota,0}. \tag{8}$$

Consumption expenditure in period one is given by the return on period-zero investments:

$$C_\iota = R^W_\iota A_{\iota,0} \qquad \text{with} \qquad R^W_\iota = \sum_{i \in \mathcal{J}_\iota} \frac{a_{\iota i,0}}{A_{\iota,0}} R_i + \frac{a^f_{i,0}}{A_{i,0}} R^f, \tag{9}$$

where R^W_ι denotes the gross return to the wealth portfolio $A_{\iota,0}$.

The investor chooses investments $a^f_{\iota,0}$ and $\boldsymbol{a}_{\iota,0} = [a_{\iota 1,0}, ..., a_{\iota i,0}, ..., a_{\iota J_\iota,0}]$, where J_ι is the number of assets in $\mathcal{J}_\iota$, to maximize (7) subject to (8) and (9). Optimal investments observe the Euler equations

$$\mathrm{E}\left[m_\iota\right] R^f = 1 \qquad \text{and} \qquad \mathrm{E}\left[m_\iota R_i\right] = 1 \quad \forall\ i \in \mathcal{J}_\iota \tag{10}$$

for the risk-free asset and for the risky assets, respectively, where

$$m_\iota := \delta \frac{u'_\iota(C_\iota)}{u'_\iota(C_{\iota,0})} \tag{11}$$

denotes the investor's expected marginal utility growth, commonly referred to as stochastic discount factor (SDF). In the present setting where asset returns are given by the firms stochastic sales over the price of their equity, $R_i = \frac{s_i}{v_{i,0}}$, the Euler equations (10) determine the equilibrium market value of firm i's equity in period zero as the investor's willingness to pay for the ownership of firm i's sales value in the next period:

$$v_{i,0} = \mathrm{E}\left[m_\iota s_i\right] = \frac{\mathrm{E}\left[s_i\right]}{R^f} + \mathrm{Cov}\left[m_\iota, s_i\right]. \tag{12}$$

Accordingly, the investor's willingness to pay for an asset with stochastic payoff s_i is determined not only by the asset's expected payoff discounted with the risk-free rate, but also by the payoff's covariance with the investor's SDF. The SDF is an inverse measure of change in the investor's well-being: In good times, when expected consumption growth is high, the SDF is small since an additional unit of consumption tomorrow is less valuable. In contrast, the SDF is large in bad times, when consumption is low relative to today and marginal utility growth is high. Eq. (12) states that assets whose payoffs tend to be high in times when expected marginal utility is high are more valuable to the investor and trade at higher prices in equilibrium. Note that the variance of asset i has no bearing on its price. This owes to the assumption of financial market completeness that facilitates perfect and costless diversification of *idiosyncratic* risk. The only risk that remains is *aggregate* risk, reflected in the volatility of the representative investor's marginal utility growth. Assets are priced according to their aggregate risk content, reflected in the covariance with the SDF. The distribution of the SDF is endogenous to the investor's investment choices and so are the covariances of assets with the SDF. Any investment lowers consumption today and thus lowers expected marginal utility growth. Moreover, as a given asset's share in the investor's total portfolio increases, the asset's return becomes more correlated with the investor's total wealth. Hence, it becomes less attractive as a means of consumption smoothing and the investor's willingness to pay declines.

The Euler equations determine the demand side of the asset market. Asset market clearing implies that the representative investor will hold all available shares in equilibrium. The supply of shares and the stochastic properties of their returns are endogenously determined by firms' entry and production decisions, which are described in the following section.

3.2 Final Demand with Taste Shocks

The consumption and investment good (numéraire) is composed of all countries' final goods Q_j according to

$$C = \left(\sum_j \left(\psi_j Q_j\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}, \tag{13}$$

where ψ_j is a taste or quality shift parameter for goods produced in country j and $\sigma > 1$. The aggregator (13) is common across consumers from all countries, and so is the taste parameter ψ_j. Global demand for final goods from country j thus obtains as

$$Y_j = P_j Q_j = (\psi_j Q_j)^{\frac{\sigma-1}{\sigma}} C^{\frac{1}{\sigma}} \tag{14}$$

where $C = \sum_j P_j Q_j$ observes the global income-equals-expenditure condition. The taste shocks ψ_j are stochastic, rendering global demand for any given country's final good stochastic as well.

3.3 Production

Production involves two stages. Each country produces varieties of a differentiated good and a final good. The final good in country $j \in \mathcal{J}$ is produced with a nested-CES production function that combines imported and domestically produced intermediate goods:

$$Q_j = \left(\sum_{i \in \mathcal{J}} Q_{ij}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \qquad \text{with} \qquad Q_{ij} = \left(\sum_{\omega \in \otimes_i} q_{ij}(\omega)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \tag{15}$$

where $\varepsilon > 1$ is the elasticity of substitution between composites of varieties from different countries and $\theta > 1$ is the elasticity of substitution between varieties from the same country. I assume that varieties from the same country are closer substitutes than varieties from different countries, that is, $\varepsilon < \theta$. Final goods producers choose optimal inputs such as to maximize profits, observing final goods demand (14). Anticipating symmetry among firms from the same country, inverse demand for a typical variety from country i is

$$p_{ij} = \left(\frac{Q_{ij}}{Q_j} \right)^{\frac{\varepsilon-1}{\varepsilon}} \left(\frac{q_{ij}}{Q_{jh}} \right)^{\frac{\theta-1}{\theta}} \frac{Y_j}{q_{ij}}. \tag{16}$$

In the differentiated goods sector, firms from country $i \in \mathcal{J}$ produce varieties using c_i units of the composite good per unit of output. When shipping goods to country j, they face iceberg-type trade costs $\tau_{ij} \geq 1$. To set up production, firms pay a fixed cost α_i.

Demand for a firm's variety in any destination market j is uncertain because it depends on the global demand for country j's final goods, Y_j. I assume that variety producers have to decide on the optimal output quantity for every market j *before* Y_j is known because production and shipping take time. Hence, at time zero they choose the quantity $q_{ij,0} = q_{ij}$ to be sold in period one and they base this decision on expectations.[18] Consequently, the

[18]I have thus implicitly assumed that firms cannot reallocate quantities across markets once the demand

amount of the composite good Q_j available in period one when demand uncertainty is resolved is predetermined as well. Hence, uncertainty about Y_j is due to uncertainty about the price of country j's final good P_j.[19]

With quantities predetermined, the real sales value $s_{ij} = p_{ij}q_{ij}$ obtained by variety producers in period one in accordance with (16) depends on the realization of P_j. Firm i's total sales are $s_i(\boldsymbol{q}_{i,0}) = \sum_{j\in\mathcal{J}} s_{ij}(q_{ij,0})$, where $\boldsymbol{q}_{i,0} = [q_{i1,0}..q_{ij,0}..q_{iJ,0}]$. In period zero, firm i chooses $\boldsymbol{q}_{i,0}$ to maximize its net present value in accordance with (12):

$$\max_{\boldsymbol{q}_{i,0}\geq 0} V_{i,0} = \mathrm{E}\left[m_\iota s_i(\boldsymbol{q}_{i,0})\right] - \sum_{j\in\mathcal{J}} c_i\tau_{ij}q_{ij,0} - \alpha_i \tag{17}$$

As prescribed by Modigliani and Miller (1958), the shareholder-value-maximizing firm uses the SDF of the representative investor to discount expected sales, taking the distribution of m_ι as a given.[20] This is central to the results of this paper because it incentivizes the firm to take into account how risky any given destination market is from the point of view of its investors when deciding upon optimal export quantities. This can be seen immediately by noting that the value of firm i is equal to the value of a portfolio of J assets paying risky returns s_{ij}, respectively. In accordance with (12), we can split the value of such a portfolio into a discounted expected payoff and a risk adjustment equal to the covariance of m_ι and s_{ij}:

$$v_{i,0} = \mathrm{E}\left[m_\iota s_i\right] = \sum_{j\in\mathcal{J}}\left[\frac{\mathrm{E}\left[s_{ij}\right]}{R^f} + \mathrm{Cov}\left[m_\iota, s_{ij}\right]\right] = \sum_{j\in\mathcal{J}}\left[\frac{1-\lambda_{\iota j}}{R^f}\mathrm{E}\left[s_{ij}\right]\right], \tag{18}$$

uncertainty has been resolved or, more generally, that the costs of adjusting market-specific quantities are prohibitive. I thus ignore the possibility that firms engage in (costly) inventory holdings or rely on fast transportation to hedge demand volatility. The implications of non-prohibitive adjustment cost for the theoretical results are addressed below.

[19]The assumption that firms fix quantities but not prices is less restrictive than it appears at first sight. Firms do implicitly fix prices in units of country j's final goods when quantity decisions are made. Uncertainty, however, prevails regarding the exchange rate of country j's final goods against the global investment and consumption good. This is akin to the problem of a firm that engages in local currency pricing in the presence of nominal exchange rate uncertainty.

[20]As described by Fisher (1930) and Hirshleifer (1965), complete financial markets facilitate separation of investors' consumption and portfolio choices from firms' optimal decisions on productive investments. Maximization of the utility of lifetime consumption given asset prices on the part of investors and maximization of net present value based on a common, market-determined discount factor on the part of firms leads to a constraint Pareto-efficient allocation of resources.

where the last equality uses the fact that $\frac{s_{ij}}{\mathrm{E}[s_{ij}]} = \frac{Y_j}{\mathrm{E}[Y_j]}$ following (16) and

$$\lambda_{\iota j} := -R^f \mathrm{Cov}\left[m_\iota, \widetilde{Y}_j\right] \qquad \text{with} \qquad \widetilde{Y}_j := \frac{Y_j}{\mathrm{E}\left[Y_j\right]}. \tag{19}$$

$\lambda_{\iota j}$ is the "risk premium" of market j determined in region ι's financial market. It is positive for markets that are risky in the sense that demand shocks on these markets are positively correlated with investor ι's consumption, and negative otherwise. According to the pricing equation (12), $\lambda_{\iota j}/R^f$ is also equal to the equilibrium price of an asset with a stochastic return of $\frac{\mathrm{E}[Y_j]-Y_j}{\mathrm{E}[Y_j]}$, that is, an asset which perfectly insures the owner against shocks in market j.[21] Hence, the value of firm i in (18) is equal to firm i's discounted expected sales in every market minus the value of a portfolio of insurance assets that neutralizes the demand risk in each market.[22] The value of the firm is larger if sells relatively more to markets where insurance is cheap, that is, $\lambda_{\iota j}$ is small or even negative.[23]

The first-order condition of the firm's problem in (17) yields an optimal quantity for every market j that is produced in period zero and is to be sold in period one equal to

$$q^*_{ij,0} = \frac{\Theta N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{\iota j})^{\varepsilon} \left(c_i \tau_{ij} R^f\right)^{-\varepsilon}}{\sum_{i\in\mathcal{J}} N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{\iota j})^{\varepsilon-1} \left(c_i \tau_{ij} R^f\right)^{1-\varepsilon}} \frac{\mathrm{E}\left[Y_j\right]}{N_i}, \tag{20}$$

[21]More precisely, $\lambda_{\iota j}/R^f$ is the price of an asset that entitles (and compels) the owner to receive or pay the difference between the expected and realized price per unit of expected sales. This asset takes away both the downside and upside risk of shocks in market j and trades in period zero at a positive (negative) price if the payoff covaries positively (negatively) with the SDF.

[22]The fact that the firm can take the distribution of the SDF and hence the $\lambda_{\iota j}$s as given greatly simplifies its problem compared to models where the firm is risk averse as, e.g., in Esposito (2019), since it breaks the interdependence of market-specific choices. In Esposito (2019), market-specific choices constitute a difficult combinatorial problem since changes to the sales in one market affect the marginal diversification benefit of selling to other markets with correlated shocks. In my paper, the price in terms of higher or lower capital cost for selling to a risky market is determined in the financial market and, from the point of view of the firm, independent of its choices.

[23]The problem of the firm in (17) can equivalently be stated as

$$\max_{\boldsymbol{q}_{i,0}\geq 0} V_i = \frac{\mathrm{E}\left[s_i\right]}{R^f} - \frac{\mathrm{E}\left[R_i\right]}{R^f}\left(\sum_{j\in\mathcal{J}} c_i \tau_{ij} q_{ij,0} + \alpha_i\right),$$

where $\frac{\mathrm{E}[R_i]}{R^f}$ is firm i's weighted average cost of capital given by $\frac{\mathrm{E}[R_i]}{R^f} = \left(1 - \sum_{j\in\mathcal{J}} \frac{\mathrm{E}[s_{ij}]}{\mathrm{E}[s_i]}\lambda_{\iota j}\right)^{-1}$. Importantly, the firm acknowledges the dependency of its weighted average cost of capital on its market-specific choices. In particular, it takes into account that placing greater quantities in markets where the value of sales covaries positively with m_ι lowers the riskiness of the firm from the point of view of its representative investor and thus brings down the its capital cost.

where $\Theta = \frac{\theta-1}{\theta}$. Eq. (20) states that firms ship larger quantities to markets with lower trade cost and higher expected demand. They ship less in times of high interest rates, that is, when current consumption is highly valued over consumption tomorrow, because production cost and trade cost accrue today, while revenue is obtained tomorrow. Moreover, firms ship more to those markets where demand growth is positively correlated with their investors' SDF, reflected in a smaller risk premium $\lambda_{\iota j}$. This is the central prediction of the model. It rationalizes the empirical finding that, conditional on expected sales captured by the gravity variables, firms trade more with markets offering diversification benefits of the kind that sales tend to be large in times when the investors' total consumption is low.

Note that the elasticity of trade with respect to $\frac{1}{1-\lambda_{\iota j}}$ is equal to the trade cost elasticity. Why? Recall from the above discussion that $\lambda_{\iota j}/R^f$ is the price per unit of sales of an insurance against a demand shock in country j. Hence, in the eyes of the investor $\lambda_{\iota j}$ works like an ad-valorem tax or subsidy on tomorrow's sales.

Optimal quantities as in (20) imply that expected prices feature a constant markup $1/\Theta$ over marginal cost including the bilateral risk premium:

$$\mathrm{E}\left[p_{ij}\right] = \frac{c_i \tau_{ij}}{\Theta} \frac{R^f}{1-\lambda_{\iota j}}. \tag{21}$$

Once the demand uncertainty is resolved, the firm's revenue in market j is

$$s_{ij}(q^*_{ij,0}) = \phi_{ij} Y_j \qquad \text{with} \qquad \phi_{ij} = \frac{N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{\iota j})^{\varepsilon-1} \left(c_i \tau_{ij} R^f\right)^{1-\varepsilon}}{\Pi^{1-\varepsilon}} \frac{1}{N_i} \tag{22}$$

and $\Pi_j = \left(\sum_{i\in\mathcal{J}} N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{\iota j})^{\varepsilon-1} \left(c_i \tau_{ij} R^f\right)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}$. ϕ_{ji} denotes firm i's trade share in market j, that is, the share of country j's real expenditure devoted to a variety from country i. Eq. (22) is a gravity equation with bilateral trade cost augmented by a bilateral risk premium. There are a number of special cases under which sales predicted by the model follow the standard law of gravity. Suppose, first, that the time lag between production and sales is eliminated. Then, demand volatility becomes irrelevant as firms can always optimally adjust quantities to the current demand level ($\mathrm{E}\left[Y_j\right] = Y_j$). Next, suppose that investors are risk neutral, so that marginal utility is constant. Then, the SDF does not vary over time and hence has a zero covariance with demand shocks. In this case, (22) will differ from the standard gravity equation only due to the presence of the time lag, which introduces the risk-free rate as an additional cost parameter. The same relationship obtains if demand growth is deterministic. Moreover, full integration of international financial markets implies a common SDF and common λs across source countries. Hence, the covariance terms cancel each other out in the trade share equation. Note, however, that in this case, risk premia still influence optimal quantities, as given by (20). Firms still ship larger quantities to countries with smaller λs and investors value these firms more, but since all their competitors from other countries behave accordingly, trade *shares* are independent of λ. Finally, the covariances could be set to zero *endogenously* provided an investment strategy that equalizes consumption across all possible states is feasible and deemed optimal by the investor. Generally, however, the investor is willing to trade some volatility for a higher expected return, implying non-zero covariances in (19).

3.3.1 Firm Entry and Market Clearing

Perfect competition in the capital market and free entry of variety producers implies that in equilibrium the net present value of entry is zero:

$$V_{i,0}^{*} = 0 \qquad \Leftrightarrow \qquad v_{i,0} = \mathrm{E}\left[m_{\iota} s_{ij}\right] \equiv \sum_{j \in \mathcal{J}} c_i \tau_{ij} q_{ij,0}^{*} + \alpha_i. \tag{23}$$

This implies that variety producers enter until the investor's willingness to pay for shares of their type is equal to the firm's demand for capital. Without loss of generality, the number of shares per firm is set to one. Combining (12) and (23) shows that capital demand per firm and thus equilibrium share prices are constant

$$v_{i,0} = \frac{\alpha_i}{1-\theta}.$$

Market clearing condition for each type of equity implies

$$N_i v_{i,0} = a_{\iota i,0}. \tag{24}$$

Finally, global market clearing for the risk-free bond pins down the equilibrium risk-free rate:

$$\sum_{\iota \in \mathcal{R}} a_{\iota,0}^{f} = 0. \tag{25}$$

Intermediate goods supply (20) and final goods supply (15) imply

$$\mathrm{E}\left[P_j\right] = \frac{\Pi_j}{\Theta}, \tag{26}$$

final goods demand (14) requires

$$\mathrm{E}\left[P_j\right] = \mathrm{E}\left[\psi_j^{\frac{\sigma-1}{\sigma}} Q_j^{-\frac{1}{\sigma}} \left(\sum_j \left(\psi_j Q_j\right)^{\frac{\sigma-1}{\sigma}}\right)^{\frac{1}{\sigma-1}}\right]. \tag{27}$$

Eqs. (26) and (27) pin down the market clearing final goods output $Q_j \; \forall \; j \in \mathcal{J}$.

3.4 Equilibrium

An equilibrium is described by investment and consumption choices maximizing (7) subject to (8) and (9), optimal firm-level output as in (20), final goods prices observing (27), a risk-free rate determined by (25), country-risk premia as described in (19), and a number of firms in each country consistent with (23).

3.5 The Stochastic Discount Factor and Country Risk Premia

In this section I describe how the equilibrium distribution of the SDF is derived from the distribution of country-specific demand shocks and how, accordingly, the country risk premia $\lambda_{\iota j}$ are determined. Thereby, this section delivers a structural foundation for the risk contributions described in Section 2.2. To that end, note first that with sales determined by (22), the return to holding a share of firm i is equal to

$$R_i = \frac{s_i}{v_{i,0}} = \sum_{j \in \mathcal{J}} \beta_{ij} \widetilde{Y}_j \qquad \text{with} \quad \beta_{ij} := \frac{\phi_{ij} \mathrm{E}\left[Y_j\right]}{v_{i,0}}. \tag{28}$$

Returns depend linearly on demand shocks in the destination markets. Every market is weighted by a firm-market-specific factor β_{ij} that equals the share of expected sales in market j in the total value of the firm. Denoting with $A^M_{\iota,0} = \sum_{i \in \mathcal{J}_\iota} a_{\iota i,0}$ investor ι's total investment in risky assets and observing (24), it follows that total return on the risky portfolio can be written as a linear combination of country shocks $R^M_\iota = \boldsymbol{\beta}_{\boldsymbol{\iota}}' \widetilde{\boldsymbol{Y}}$, just as displayed in (2).

Combining (11) and (9), the SDF can be written as a function of the stochastic return to the wealth portfolio and variables determined at time zero only and approximated by a first-order Taylor expansion around $\mathrm{E}\left[R^W_\iota\right]$ as

$$m_\iota = \delta \frac{u'_\iota(R^W_i A_{\iota,0})}{u'_\iota(C_{\iota,0})} \approx \bar{\zeta}_{\iota,0} - \zeta_{\iota,0} R^M_\iota, \tag{29}$$

where $\bar{\zeta}_{\iota,0} = \delta \frac{u'_\iota\left(\mathrm{E}\left[R^W_\iota\right] A_{\iota,0}\right)}{u'_\iota(C_{\iota,0})} + \zeta_{\iota,0}\mathrm{E}[R^M_\iota]$ and $\zeta_{\iota,0} = -\delta \frac{u''\left(\mathrm{E}\left[R^W_\iota\right] A_{\iota,0}\right)}{u'(C_{\iota,0})} A^M_{\iota,0}$. Accordingly, the country risk premia follow as

$$\frac{\lambda_{\iota j}}{R^f} = -\mathrm{Cov}\left[m_\iota, \widetilde{Y}_j\right] = \zeta_{\iota,0}\mathrm{Cov}\left[R^M_\iota, \widetilde{Y}_j\right]. \tag{30}$$

The country risk premia reflect the contribution of shocks in market j to aggregate risk in terms of SDF volatility faced by investor ι. Thanks to the linear approximation of the SDF, the country risk premia turn out to be proportional to the aggregate portfolio risk contributions described in (3). Rewriting (30) as

$$\frac{\lambda_{\iota j}}{R^f} = b_{\iota j}\sigma^2_{\widetilde{Y}_j} + \sum_{k \neq j} b_{\iota k}\sigma_{\widetilde{Y}_j,\widetilde{Y}_k}, \qquad \text{where} \qquad b_{\iota j} = \zeta_{\iota,0}\sum_{i \in \mathcal{J}_\iota} \frac{a_{\iota i,0}}{A^M_{\iota,0}} \frac{\phi_{ij}\mathrm{E}\left[Y_j\right]}{v_{i,0}}$$

reveals the dependency of the equilibrium risk premia on the global trade and investment pattern. $b_{\iota j}$ measures investor ι's direct exposure to shocks in market j through her ownership of firms from countries $i \in \mathcal{J}_\iota$, measured by portfolio shares $\frac{a_{\iota j,0}}{A^M_{\iota,0}}$, and these firms' exposure to shocks in j through trade, measured by $\frac{\phi_{ij}\mathrm{E}[Y_j]}{v_{i,0}}$. In addition to the direct exposure to $\sigma^2_{\widetilde{Y}_j}$ through $b_{\iota j}$, investor ι is indirectly affected by shocks in market j due to exposure to other markets $b_{\iota k}$, $k \neq j$, featuring shocks that are correlated with market j as measured by $\sigma_{\widetilde{Y}_j,\widetilde{Y}_k}$.[24]

4 Counterfactual Analysis

How important is risk-based comparative advantage for trade? To answer this question, I compare actual trade flows to trade flows in a counterfactual equilibrium where all countries' shocks are perfectly correlated. To isolate the effect on trade and, at the same time, to keep the problem tractable, I consider a counterfactual equilibrium where expected global expenditure on each countries' final good is held constant. The counterfactual equilibrium can be found with the help of "hat algebra", outlined in the following. But first the general equilibrium comparative statics require two additional assumption:

[24] In the model's two polar cases, autarkic financial markets and globally integrated financial markets, the bilateral exposures can be simplified. Under financial autarky featuring one representative investor for each country investing only in domestic firms ($\mathcal{J}_\iota = i, A^M_{\iota,0} = a_{ii,0}$), the direct bilateral exposures obtain as $b_{ij} = \zeta_{i,0}\frac{N_i\phi_{ij}\mathrm{E}[Y_j]}{a_{ii,0}}$, that is, total expected exports from i to j over country i's total investment. With globally integrated financial markets, where there is one globally representative investor ($\mathcal{J}_\iota = \mathcal{J}$, $A^M_{\iota,0} = A^M_0 = \sum_{j \in \mathcal{J}} a_{\iota j,0}$), the bilateral exposures are $b_j = \zeta_0 \frac{\mathrm{E}[Y_j]}{A^M_0}$, since $\sum_{i \in \mathcal{J}} N_i\phi_{ij} = 1$. Through integrated financial markets, all countries' bilateral exposures to country j are identical and given by expected global expenditure on final goods from j divided by global investment.

Specifying the representative investors' utility function and specifying the distribution of shocks. Regarding the latter, I assume multivariate normality of the demand shocks:

$$\widetilde{\boldsymbol{Y}} \sim MVN\left(\mathbf{1}, \boldsymbol{\Sigma}_{\widetilde{Y}}\right) \tag{31}$$

Preferences are assumed to be of the constant absolute risk aversion type. Specifically:

$$u_\iota(C_\iota) = -e^{-\gamma_\iota C_\iota} \qquad \text{with} \qquad \gamma_\iota > 0.$$

With these preferences, investor ι's optimal investment choices in line with (10) observe

$$\boldsymbol{a}_{\iota,0} = \boldsymbol{\Sigma}_{R_\iota}^{-1} \frac{\mathrm{E}\left[\boldsymbol{R}_\iota\right] - \boldsymbol{R^f}}{\gamma_\iota} \qquad \Rightarrow \qquad A_{\iota,0}^M = \frac{\mathrm{E}\left[R_\iota^M\right] - R^f}{\gamma_\iota \sigma_{R_\iota}^2} \tag{32}$$

$$a_{\iota,0}^f = \frac{W_{\iota,0}}{R^f+1} - A_{\iota,0}^M \frac{\mathrm{E}[R_\iota^M]+1}{R^f+1} + \frac{\gamma_\iota}{2} \frac{\left(A_{\iota,0}^M\right)^2 \sigma_{R_\iota}^2}{R^f+1} + \frac{\ln\left(\delta R^f\right)}{\gamma_\iota (R^f+1)} \tag{33}$$

where Σ_{R_ι} and $\mathrm{E}\left[\boldsymbol{R}_\iota\right]$ denote, respectively, the covariance matrix and the vector of expected values of $R_i \ \forall \ i \in \mathcal{J}_\iota$ and $\sigma_{R_\iota}^2 = \frac{1}{\left(A_{\iota,0}^M\right)^2} \boldsymbol{a}_{\iota,0} \Sigma_{R_\iota} \boldsymbol{a}_{\iota,0}'$ is the variance of investor ι's portfolio. Thanks to the linear relationship between demand shocks and returns, (31) implies normality of $\boldsymbol{R}_\iota$ and R_ι^M. Hence, the linear SDF satisfying (10) is given by

$$m_\iota = \bar{\zeta}_{\iota,0} - \zeta_{\iota,0} R_\iota^M \qquad \text{with} \qquad \zeta_{\iota,0} = \frac{\gamma_\iota A_{\iota,0}^M}{R^f} \tag{34}$$

and $\bar{\zeta}_{\iota,0} = \frac{1}{R^f} + \zeta_{\iota,0}\mathrm{E}[R_\iota^M]$.[25] Moreover, with normality of R_ι^M and exponential utility, expected lifetime utility obtains as

$$U_\iota = -e^{-\gamma_\iota\left(a_{\iota,0}^f R^f + A_{\iota,0}^M \mathrm{E}\left[R_\iota^M\right]\right) + \frac{\gamma_\iota^2}{2}\sigma_{R_\iota}\left(A_{\iota,0}^M\right)^2}. \tag{35}$$

4.1 Comparative Statics of a Change in $\boldsymbol{\lambda}$

Let x' denote the counterfactual value of any variable x, and let $\hat{x} = x'/x$. Consider a change in the distribution of taste shocks $\boldsymbol{\psi}$ such that $\sigma_{\widehat{Y}_j\widehat{Y}_k}' = \sigma_{\widehat{Y}_j}\sigma_{\widehat{Y}_k} \geq \sigma_{\widehat{Y}_j\widehat{Y}_k}$ subject to $\mathrm{E}[Y_j]' = \mathrm{E}[Y_j]$. Then, the counterfactual risk premia observe (recall (30) and (3))

$$\lambda_{\iota j}' = \zeta_{\iota,0}' R^{f\prime} \sum_{k \in \mathcal{J}} \beta_{\iota k}' \sigma_{\widetilde{Y}_j\widetilde{Y}_k}'.$$

[25] Details of the derivation can be found in Cochrane (2005), p.155. Note that with normally distributed returns, the linear relationship between m and R^M is exact rather than approximate (as in the general case displayed in (29)).

The changes in risk premia induce changes in bilateral trade shares

$$\widehat{\phi}_{ij} = \left(\frac{\widehat{1-\lambda_{\iota j}}}{\widehat{R}_f}\right)^{\varepsilon-1} \frac{\widehat{N}_i^{\frac{\theta-\varepsilon}{1-\theta}}}{\widehat{\Pi}_j^{1-\varepsilon}} \quad \text{where} \quad \widehat{\Pi}_j^{1-\varepsilon} = \sum_{i\in\mathcal{J}} N_i \phi_{ij} \widehat{N}_i^{\frac{1-\varepsilon}{1-\theta}} \left(\frac{\widehat{1-\lambda_{\iota j}}}{\widehat{R}_f}\right)^{\varepsilon-1}. \tag{36}$$

The change in the number of firms follows from the free entry condition (23) as

$$\widehat{N}_i = \left[\frac{1}{N_i v_i} \sum_{j\in\mathcal{J}} \frac{1-\lambda_{\iota j}}{R^f} \left(\frac{\widehat{1-\lambda_{\iota j}}}{\widehat{R}_f}\right)^{\varepsilon} N_i \phi_{ij} \mathrm{E}\left[Y_j\right] \frac{1}{\widehat{\Pi}^{1-\varepsilon}}\right]^{\frac{1-\theta}{\varepsilon-\theta}}, \tag{37}$$

which yields new trade exposures equal to

$$\beta'_{\iota j} = \frac{\sum_{i\in\mathcal{J}_\iota} \widehat{N}_i \widehat{\phi}_{ij} N_i \phi_{ij}}{\widehat{A}^M_{\iota,0} A^M_{\iota,0}} \qquad \text{with} \qquad \widehat{A}^M_{\iota,0} = \frac{\sum_{i\in\mathcal{J}_\iota} a_{\iota i} \widehat{N}_i}{A^M_{\iota,0}}, \tag{38}$$

where the last equality follows from (24). To complete the description of the changes in trade patterns, first note that in line with (34) it holds that $\widehat{\zeta}_{\iota,0} = \widehat{A}_{\iota,0}/\widehat{R}^f$. It remains to be shown how the global risk-free rate R^f changes as the result of the new portfolio choices of the representative investors from all regions. From (25) and (33) it follows that $R^{f\prime}$ solves

$$\sum_{\iota\in\mathcal{R}} a^{f\prime}_{\iota,0} = 0 \quad \text{where} \quad a^{f\prime}_{\iota,0} = \frac{W_{\iota,0}}{R^{f\prime}+1} - A^{M\prime}_{\iota,0} \frac{\mathrm{E}[R^M_\iota]'+1}{R^{f\prime}+1} + \frac{\gamma_\iota}{2} \frac{\left(A^{M\prime}_{\iota,0}\right)^2 \sigma^{2\prime}_{R_\iota}}{R^{f\prime}+1} + \frac{\ln\left(\delta R^{f\prime}\right)}{\gamma_\iota(R^{f\prime}+1)}$$

and

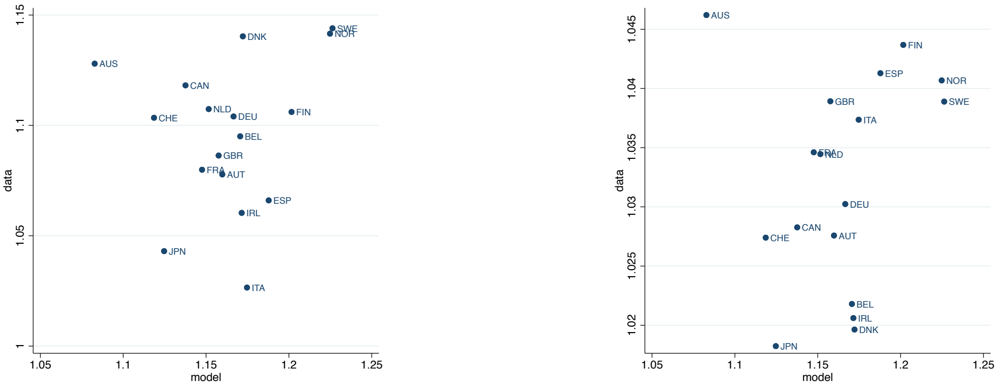
$$\mathrm{E}[R^M_\iota]' = \sum_{j\in\mathcal{J}} \beta'_{\iota j} \qquad \text{and} \qquad \sigma^{2\prime}_{R_\iota} = \sum_{j\in\mathcal{J}} \sum_{k\in\mathcal{J}} \beta'_{\iota j} \sigma'_{\widetilde{Y}_j,\widetilde{Y}_k} \beta'_{\iota k}.$$

With $a^{f\prime}_{\iota,0}, A^{M\prime}_{\iota,0}, \mathrm{E}[R^M_\iota]'$, and $\sigma^{2\prime}_{R_\iota}$ determined, utility in the counterfactual equilibrium is readily obtained from (35).

4.2 Calibration

I calibrate the model to the world economy using data for the period 2005-2014. I split the world into 12 regions. The industrialized economies of Europe and North America (consisting of 29 individual countries) form one region (henceforth referred to as EUNA), and the 10 remaining individual countries from the World Input Output Database (WIOD) as

Figure 4: Model fit: Average stock returns



(a) Total return (b) Dividends only

The figure shows the correlation between average stock returns implied by the model calibration and the average total gross stock market return in Panel (a) (gross return from dividends only in Panel b) for the period 2005-2014. Stock market data source: Kenneth R. French's data library.

well as the rest-of-the-world aggregate (ROW) all form individual regions.[26] By assumption, equity markets are fully integrated *within* regions, but strictly segmented *across*. Only the risk-free asset is globally traded. The calibration requires specifying four structural parameters, $\varepsilon, \theta, \delta, \gamma_\iota$ and a set of observable moments, namely, bilateral trade flows $N_i \phi_{ij}$ (including domestic sales), investment levels at the regional level $A^M_{\iota,0}, a^f_{\iota,0}$, the covariance matrix of demand shocks $\Sigma_{\widetilde{Y}}$ and the global risk-free rate R^f. Of the four structural parameters, γ_ι is internally calibrated, and so are the non-targeted additional moments of the baseline equilibrium, $W_{\iota,0}$ for all regions, $\frac{a_{\iota i,0}}{A^M_{\iota,0}}$ for the countries within EUNA, and $\mathrm{E}[R_i]$ and $\sigma^2_{R_i}$ for all countries. Tab. 3 summarizes the calibration, Appendix A.2 details the variable construction. As regards the non-targeted moments, the model does a good job at replicating $a_{\iota i}$, the within-region distribution of risky investments for the 29 countries forming the region EUNA: The correlation with the corresponding data from the WIOD is almost one. As regards the first and second moments of the aggregate risky return at the country level, the model underpredicts the variance of stock returns and overpredicts the mean when compared to observed total stock market returns for the same period. Yet, it does a fairly good job at replicating the cross-country variation, as shown by the correlation coefficients in the last column of Tab. 3. Fig. 4 shows that the model performs better in explaining the cross-section of average stock returns if only the

[26]Appendix A.2 lists all the countries. The choice of regional groupings is informed by the result of Fitzgerald (2012) who provides evidence in favor of strong financial market integration within the industrialized world, but not beyond.

Table 3: Calibration overview

Targeted moments		mean	min	max	source	note
$\phi_{ij}\mathrm{E}[Y_j]$	bilateral trade	6.3e+4	.2	2.3e+7	WIOD[a]	avg. 2005-2014
$A^M_{\iota,0}$	interm. inputs + wage bill + gross fixed cap. formation	8.7e+6	9.3e+5	5.2e+7	WIOD[a]	avg. 2005-2014
$a^f_{\iota,0}$	net foreign asset position	0	-4.6e+6	3.3e+6	IMF BOP[b]	avg. 2005-2014
$\Sigma_{\widetilde{Y}}$	cov. of trend-adjusted growth in total expenditure	.008	-.002	.03	WIOD[a]	2005-2014

Internally calibrated moments/parameters		mean	min	max	external data mean	external data correlation
γ_ι	Eq. (32)	5.1e-6	1.4e-7	1.5e-5		
$a_{\iota i,0}$	Eq. (32)	2.4e+6	1.8e+4	2.2e+7	2.1e+6[a]	1[a]
$W_{\iota,0}$	Eq. (33)	1.8e+7	1.4e+6	9.8e+7		
$\mathrm{E}[R_i]$	Eq. (28)	1.2	1.01	1.4	1.1[c]	.14[c]
$\sigma^2_{R_i}$	$\sum_j \sum_k \beta_{ij}\sigma_{\widetilde{Y}_j,\widetilde{Y}_k}\beta_{ik}$	.01	0.002	0.05	.08[c]	.58[c]

Structural parameters	value	source
ε	5	Costinot and Rodriguez-Clare (2014)
θ	6	
δ	.95	

Note: [a] *World Input Output Database.* [b] *IMF Balance of Payments Statistics* [c] Total stock market return from *Kenneth R. French's data library*; numbers based only on 17 of the 43 countries due to data availability. $\phi_{ij}\mathrm{E}[Y_j]$, $A^M_{\iota,0}, a^f_{\iota,0}, a_{\iota i,0}, W_{\iota,0}$ are in mio. 2005 USD.

dividend part of the observed returns is considered. Tab. 4 lists a set of baseline moments at the regional level that will be useful for the interpretation of the results.

4.3 Results: Counterfactual Equilibrium with Perfectly Correlated Shocks

The counterfactual experiment is implemented through a change in the distribution of country-specific demand shocks. The counterfactual covariance matrix of shocks features perfect correlations. That is, the counterfactual value of $\sigma_{\widetilde{Y}_j,\widetilde{Y}_k} = \rho_{jk}\sigma_{\widetilde{Y}_j}\sigma_{\widetilde{Y}_j}$, a typical element of $\Sigma_{\widetilde{Y}}$, features $\rho'_{jk} = 1$ and is thus given by $\sigma'_{\widetilde{Y}_j,\widetilde{Y}_k} = \sigma_{\widetilde{Y}_j}\sigma_{\widetilde{Y}_j}$. Moreover, I assume that $\mathrm{E}[Y_j]' = \mathrm{E}[Y_j]\ \forall\ j$. Note that $\Sigma_{\widetilde{Y}}$ and $\mathrm{E}[Y_j]$ are endogenous variables, depending crucially but not exclusively on the joint distribution of the taste shocks $\boldsymbol{\psi}$ (see Eq. 14). The counterfactual change is thus to be understood as an implicitly determined change in the distribution of $\boldsymbol{\psi}$ that produces the desired counterfactual values of $\Sigma_{\widetilde{Y}}$ and $\mathrm{E}[Y_j]$, conditional on constant values of all other exogenous model parameters.

This counterfactual experiment permits to analyze how global trade patterns would look like if all countries' shocks were perfectly correlated. The comparison of counterfactual trade flows to observed trade flows that constitute the baseline equilibrium reveals how comparative advantage with regard to the distribution of demand shocks across dif-

Table 4: Baseline values at the regional level

	$A^M_{\iota,0}$	$\frac{A^M_{\iota,0}}{A^M_{\iota,0}+a^f_{\iota,0}}$	$\sigma^2_{R^M_\iota}$	γ_ι	$\zeta_{\iota,0}$
Region	(1)	(2)	(3)	(4)	(5)
Europe & N. America	5.2e+07	1.1	0.004	5.6e-07	28.6
Australia	1.9e+06	1.4	0.011	3.8e-06	7.3
Brazil	2.5e+06	1.3	0.024	3.3e-06	8.1
China	1.7e+07	0.9	0.003	1.4e-07	2.4
India	2.4e+06	1.1	0.010	5.1e-06	11.9
Indonesia	1.0e+06	1.3	0.011	1.1e-05	11.7
Japan	7.8e+06	0.8	0.010	1.5e-06	11.9
Korea	2.3e+06	1.0	0.009	2.6e-06	6.1
Mexico	1.2e+06	1.5	0.018	1.6e-05	19.0
Russia	2.1e+06	1.0	0.035	2.1e-06	4.5
Turkey	9.3e+05	1.4	0.020	1.5e-05	13.6
Rest of the World	1.4e+07	0.8	0.008	1.4e-06	19.4

$A^M_{\iota,0}$ is in mio. 2005 USD.

ferent states of the world shapes the pattern of trade and how big the welfare gains from diversification are.

Tab. 5 present the results. Risk-based comparative advantage accounts for 5% of global trade (see Col. 3). By construction of the counterfactual, total expected world sales is constant. At the country level, trade and output effects are very heterogeneous, ranging between -19% to +13% for the former and -8% to +5% for the latter. What explains the stark heterogeneity? Intuitively, it is the exporters with the largest comparative advantage that suffer most. A key determinant of comparative advantage is the correlation pattern of shocks across trade partners, with low correlations implying stronger comparative advantage and, ceteris paribus, smaller risk premia. Fig. 5 Panel (a) plots the predicted change in openness (exports over sales) against the weighted average correlation of shocks across import partners and shows a significantly positive relationship. Countries with low average correlations reduce trade the most as comparative advantages erode. Panel (b) inspects the role of the parameter $\zeta_{\iota,0}$. Technically, $\zeta_{\iota,0} = -\frac{\partial m_\iota}{\partial R^M_\iota}$ measures to what extent investor ι's marginal utility growth fluctuates with the return to the risky portfolio. The smaller $\zeta_{\iota,0}$, the less is the investor bothered by the volatility of her portfolio, implying smaller risk premia ceteris paribus. Eq. (34) shows that, intuitively, $\zeta_{\iota,0}$ depends on the degree of risk aversion and the absolute size of the risky investment. In view of the counterfactual change in the distribution of shocks, which increases the portfolio variance everywhere, a low $\zeta_{\iota,0}$ is beneficial. China and Russia, the countries that gain most in terms of exports, are the countries with the smallest $\zeta_{\iota,0}$. Countries from EUNA, in contrast, start out with the largest $\zeta_{\iota,0}$ and end up with the largest losses. Tab. 6 shows the results from regressions of export growth and the change in openness

Table 5: Counterfactual changes at the regional level

	$\sigma^2_{R^M_\iota}$	$A^M_{\iota,0}$	exports	sales	utility
	partial change in %	general equilibrium change in %			
Region	(1)	(2)	(3)	(4)	(5)
Europe & N. America	35.1	-2.5	-9.0	-1.6	-13.1
[min;max] w/i region		[-11.9;-0.6]	[-19.0;-4.6]	[-7.9;-0.9]	
Australia	4.3	4.7	0.4	2.0	-6.5
Brazil	1.8	4.1	0.8	1.7	-7.5
China	6.3	5.1	11.9	2.0	-3.9
India	5.7	4.0	-3.7	1.6	-13.2
Indonesia	8.4	2.8	-8.9	0.9	-9.8
Japan	7.9	2.8	-12.8	0.7	-18.8
Korea	12.2	5.7	1.6	3.4	-7.2
Mexico	2.3	4.9	5.0	3.3	-6.3
Russia	2.3	6.8	13.3	4.5	-5.2
Turkey	4.0	3.4	-0.6	1.9	-7.2
Rest of the World	9.1	2.5	-6.6	0.8	-25.7
World		0.8	-5.0	0.0	
[min;max]		[-11.9;6.8]	[-19.0;13.3]	[-7.9;4.5]	

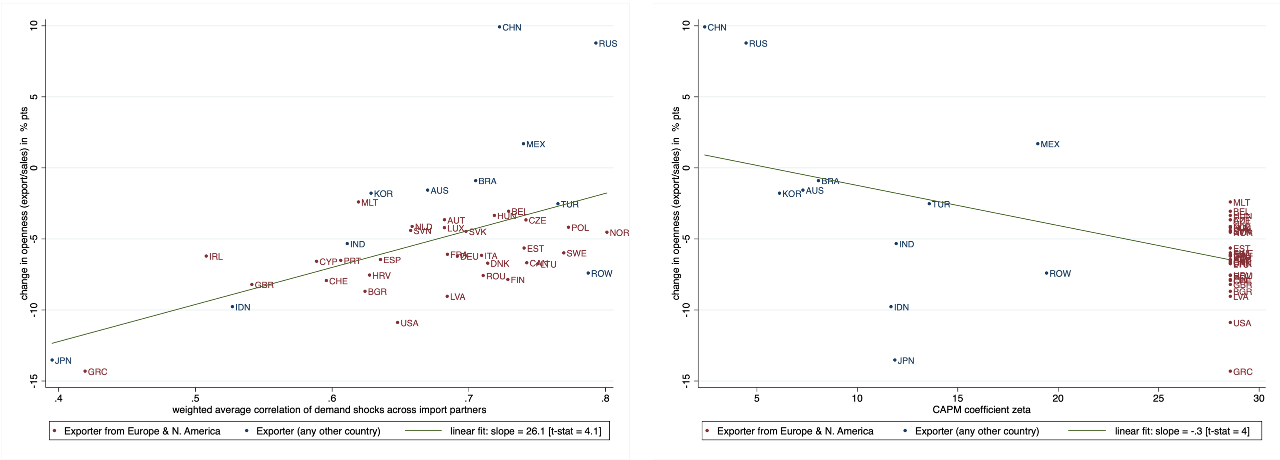
Col. 1 shows the partial effect of the counterfactual change on portfolio variances before any endogenous variables adjust. Cols. 2-5 show general equilibrium changes after all endogenous variables have adjusted.

on the initial average correlation and $\zeta_{\iota,0}$. Both variables are individually significant predictors and together explain between 73% and 56% of the variation of the counterfactual changes, respectively.

In addition to having a large initial $\zeta_{\iota,0}$, the countries from EUNA also lose their advantage of being part of an integrated financial markets. In the baseline equilibrium, risk diversification in this region takes place not only through trade but also through cross-border investment (within the region), which is reflected in a portfolio variance that is significantly smaller than the variance of most of the other individual countries; see Col. 1 of Tab. 4. In the counterfactual equilibrium the advantage of financial market integration gets fully eliminated, as all countries within a region feature exactly the same correlation pattern of shocks. Col. 1 of Tab. 5 shows that the initial effect (before any of the endogenous variables adjusts) is a huge increase in the portfolio variance of the representative investor from EUNA compared to the other countries. As a consequence, investment into the risky asset decreases in EUNA; see Col. 2. This leads to firm exit in all countries in this region in the range of -12% and -1%, and a decline in total sales (Col. 4). Firm exit in EUNA ameliorates competition in all markets, allowing other countries to increase production and expected sales despite the initial increase in volatility.

Tab. 7 looks at bilateral trade changes and confirms that the initial degree of correlation is a strong predictor of trade changes also at the bilateral level. Col. 1 shows

Figure 5: Counterfactual changes in openness



(a) Changes in openness vs. initial correlations (b) Changes in openness vs. ζ_0

Note: Average demand shock correlation on the horizontal axis in panel (a) is weighted by importer's market size.

that the correlation alone explains 14% of the variation in the log-changes in trade shares. Cols. 2 and 3 analyse to what extent geography matters for which country pairs' trade is affected more by regressing the trade share change on bilateral distance and a predicted bilateral trade share based on geographic variables only.[27] Cols. 2 and 3 show that trade growth is bigger for country pairs enjoying favorable geographic characteristics, such as short distances or a common border, highlighting that the erosion of one source of comparative advantage strengthens the relative importance of other determinants of trade. Cols. 4 and 5 show that both the initial correlation and the geographic characteristics have independent explanatory power for the trade share changes, even though they are not uncorrelated. Cols. 6 and 7 show that the previous result is robust to the inclusion of importer and exporter fixed effects.

Finally, I turn to the welfare effects presented in Tab. 5, Col. 5. In the counterfactual equilibrium with no diversification opportunities, utility is lower everywhere. All countries are negatively affected by the initial increase in the portfolio variance. The disproportional decline in competitiveness of EUNA adds to the losses of this region but ameliorates the impact on the other countries. Countries and regions are also disproportionately affected by the change in the risk-free rate, which drops by 3% as a consequence of the global increase in volatility, and the corresponding increase in global demand for the

[27] More specifcally, $\ln \phi_{geo}$ is the prediction obtained from a regression of the form $\phi_{ij} = \beta_1 \ln Dist_{ij} + \beta_2 Contig_{ij} + \beta_3 Smcty_{ij} + \delta_i + \delta_j + \epsilon_{ij}$, where $Contig_{ij}$ and $Smcty_{ij}$ are binary indicators for where countries i and j are contiguous or the same country, respectively.

Table 6: Counterfactual changes in exports and openness

	(1)	(2)	(3)	(4)	(5)	(6)
Dep.Var.:	$\widehat{exports}$			$\widehat{openness}$		
ρ_{wgt}	30.115***		31.337***	26.073***		26.693***
	(9.850)		(5.618)	(6.406)		(4.959)
ζ_0		-0.561***	-0.569***		-0.282***	-0.289***
		(0.081)	(0.061)		(0.070)	(0.054)
Constant	-27.341***	6.291***	-14.523***	-22.648***	1.586	-16.143***
	(6.663)	(2.048)	(4.043)	(4.333)	(1.780)	(3.568)
Observations	43	43	43	43	43	43
Adjusted R^2	0.166	0.530	0.729	0.270	0.265	0.563

Dep. Var. $\widehat{exports}$ ($\widehat{openness}$) is the counterfactual change in exports in % (openness = $\widehat{exports}$-$\widehat{sales}$ in % pts.). ρ_{wgt} is the initial weighted average correlation coefficient of the exporter's demand shocks with all trade partners' demand shocks using the importer's market size as weight.

Table 7: Counterfactual changes in bilateral trade

Dep.Var.: $\ln\widehat{\phi}_{ij}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ρ	0.372***			0.295***	0.247***	0.245***	0.263***
	(0.022)			(0.029)	(0.021)	(0.011)	(0.011)
$\ln Dist$		-0.059***		-0.023***		-0.017***	
		(0.004)		(0.005)		(0.002)	
$\ln \phi\_geo$			0.048***		0.039***		0.006***
			(0.002)		(0.002)		(0.001)
Constant	-0.357***	0.380***	0.237***	-0.121**	-0.000	-0.129***	-0.237***
	(0.016)	(0.034)	(0.015)	(0.059)	(0.025)	(0.023)	(0.014)
Fixed effects							
Imp/Exp	NO	NO	NO	NO	NO	YES	YES
Observations	1849	1764	1764	1764	1764	1764	1764
Adjusted R^2	0.139	0.098	0.218	0.149	0.273	0.936	0.935

risk-free asset. The lower risk-free rate affects negatively the initial lenders (identified by shares below one in Col. 2, Tab. 4): China, Japan, and ROW. For China and Russia, however, the relative gain in competitiveness moderates the losses. To summarize, the counterfactual analysis shows that risk-based comparative advantage accounts for a sizeable share of global trade and significantly impacts the cross-country pattern of production and trade.

5 Conclusions

Trade's potential for global risk sharing has long been understood, but supportive empirical evidence is rare. Following Backus and Smith (1993), a large literature has shown that the aggregate implications of effective global risk sharing are not borne out by the data. Financial market data show that asset markets continue to be fairly disintegrated (Fama and French, 2012). Nevertheless, competitive firms strive to maximize shareholder value conditional on the level of frictions inhibiting trade of goods and assets on global markets. With risk-averse investors who desire high returns but also smooth consumption over time, shareholder-value maximization implies optimization of a risk-return tradeoff for every project involving aggregate risk.

In this paper I propose a general equilibrium model of trade in goods and investment in assets that incorporates this logic. I show that irrespective of the degree of financial market integration, shareholder-value maximization incentivizes firms to take into account whether volatility inherent to profits from exporting helps investors diversify the risk of volatile consumption when choosing optimal quantities. The model predicts that firms ship more to markets where profits tend to be high in times when investors' other sources of income do not pay off very well. Aggregation of individual firms' and investors' optimal choices in turn determines the amount of aggregate risk that is taken on in equilibrium, as well as the extent to which country-specific demand shocks that determine exporting firms' profits contribute in a positive or negative way to the consumption smoothing of investors from other countries.

Using panel data on bilateral trade and stock market returns, I provide evidence in support of the model's key hypothesis: Trade is larger with markets where demand shocks covary less with the exporter's investors' income or consumption, conditional on market size and trade cost. A counterfactual analysis reveals the quantitative importance of this mechanism: Without diversification possibilities, global trade would be 5% smaller. I conclude from this analysis that the distribution of demand shocks constitutes a hitherto unexplored source of comparative advantage that exerts a sizeable impact on the global pattern of trade.

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Appendix

A.1 Robustness: Reduced-form Results

Table A.8: Gravity estimations with covariances: The role of omitted bilateral factors

	(1) All	(2) All	(3) All	(4) All	(5) Tariffs	(6) Tariffs
$\text{Cov}\left(\widehat{M}, \widehat{Y}\right)$	0.126***	0.006	0.003	-0.012*	-0.015*	-0.015*
	(0.025)	(0.013)	(0.013)	(0.007)	(0.008)	(0.008)
ln *Dist*		-1.745***	-1.684***			
		(0.039)	(0.046)			
Contiguity		0.478***	0.501***			
		(0.114)	(0.111)			
Comm. Language		0.853***	0.850***			
		(0.065)	(0.064)			
EU			0.146*	0.099*	0.068	0.065
			(0.081)	(0.054)	(0.080)	(0.080)
L5.*EU*			0.566***	0.308***	0.289***	0.288***
			(0.103)	(0.056)	(0.068)	(0.068)
L10.*EU*			-0.777***	-0.032	-0.005	0.001
			(0.108)	(0.056)	(0.061)	(0.061)
FTA			0.205***	0.043	-0.004	-0.008
			(0.059)	(0.032)	(0.032)	(0.032)
L5.*FTA*			-0.073	0.070*	0.073**	0.070*
			(0.082)	(0.039)	(0.036)	(0.036)
L10.*FTA*			0.126*	0.065**	0.042	0.039
			(0.068)	(0.031)	(0.032)	(0.032)
ln *Tariff*						-0.252***
						(0.080)
Fixed Effects						
Imp/Exp×prd×yr	YES	YES	YES	YES	YES	YES
Cty-pair×prd	NO	NO	NO	YES	YES	YES
Observations	2080695	2080695	2080695	2080695	1716482	1716482
Adjusted R^2	0.601	0.698	0.698	0.783	0.789	0.789

Dependent variable is log export quantity in kg. by product, country-pair, and time. S.e. (in parentheses) robust to two-way clusters on product and country-pair level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Cols. 5,6 based on subsample of products for which tariffs are available. *EU* (*FTA*) denotes joint membership in the EU (a free trade agreement). L5. (L10.) denotes 5 (10) -year lag. Estimates based on years 1985, 1995, 2005, 2015.

Besides the specfication discussed in the main text, Table A.9 presents a few additional robustness checks.

Sample years. My sample spans 1984-2017 and the baseline estimation uses data for the years 1985, 1995, 2005, 2015. Since the covariances are based on data reaching ten years into the past, ten-year-spaced trade data is the preferred choice. It avoids overlap and thus systematic correlations in the error term. The choice of the starting year 1985 is somewhat arbitrary. Cols. 1-6 of Tab. A.9, lower panel, show that using alternative starting years, 1984, 1986, or 1987, produces similar effects, except for the direct effect in the first and second specification being insignificant. Moreover, I re-estimate Eq. (1) using five-year-spaced data and covariances computed using the five most recent years (Cols. 7,8) or all available years of data (Cols. 9,10), with the latter in particular producing remarkably similar effects. Cols. 1-4 in the upper panel show that using the full sample years produces similar estimates also for the covariances based on regional stock market returns or consumption growth.

Aggregation level. Cols. 11 and 12 of Table A.9, upper panel, explore the importance of the aggregation level of the product classification. The coefficient estimate for $\mathrm{Cov}\left(M_i, \widehat{Y}_j\right)$ at the 2-digit level (1-digit level) becomes slightly smaller in absolute terms (insignificant), which is in line with the argument made above that a lower level of aggregation mitigates upward bias due to a reverse influence of exports on the covariance.

Table A.9: Gravity estimations with risk premia: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Robustness check:	*Regional CAPM*		*Consumption growth*		*Industrial production*		*Retails Sales*		*Dependent Variable:* ln *Exp. Value*, 1985-2015, $\Delta = 10$			
	1984-2017, $\Delta = 1$								SITC 4-digit		SITC 2-digit	SITC 1-digit
$\text{Cov}\left(\widehat{M}, \widehat{Y}\right)$	-0.019***	-0.087	-0.008*	-0.153***	-0.014*	-0.044	-0.003	0.045	-0.017**	-0.090	-0.016*	0.001
	(0.006)	(0.072)	(0.004)	(0.055)	(0.007)	(0.048)	(0.005)	(0.031)	(0.007)	(0.069)	(0.008)	(0.013)
× ln *Dist*		0.008		0.017***		0.004		-0.006		0.008		
		(0.008)		(0.006)		(0.006)		(0.004)		(0.008)		
× Vessel		-0.053***		-0.023***		-0.001		-0.015***		-0.022***		
		(0.007)		(0.005)		(0.005)		(0.004)		(0.007)		
× Vessel		0.451***		0.193***		0.010		0.117***		0.187***		
		(0.061)		(0.044)		(0.041)		(0.032)		(0.057)		
Observations	21862368	21862368	17072960	17072960	7303953	7303953	6321376	6321376	2281127	2281127	401632	85010
Adjusted R^2	0.816	0.816	0.830	0.830	0.857	0.857	0.865	0.865	0.768	0.768	0.842	0.883

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Time	1984-2014		1986-2016		1987-2017		1985-2015		1984-2017	
Spacing	$\Delta = 10$		$\Delta = 10$		$\Delta = 10$		$\Delta = 5$		$\Delta = 1$	
$\text{Cov}\left(\widehat{M}, \widehat{Y}\right)$	-0.010	-0.041	-0.009	-0.020	-0.015**	-0.120	-0.009**	0.002	-0.012***	-0.044
	(0.007)	(0.087)	(0.007)	(0.078)	(0.007)	(0.075)	(0.004)	(0.043)	(0.004)	(0.056)
× ln *Dist*		0.003		0.001		0.013		-0.001		0.004
		(0.010)		(0.009)		(0.009)		(0.005)		(0.007)
× Vessel		-0.033***		-0.017**		-0.024***		-0.008*		-0.034***
		(0.008)		(0.008)		(0.008)		(0.004)		(0.005)
× Vessel		0.283***		0.142**		0.196***		0.058		0.287***
		(0.071)		(0.070)		(0.070)		(0.037)		(0.047)
Observations	2039752	2039752	2141349	2141349	1960372	1960372	4580341	4580341	21427053	21427053
Adjusted R^2	0.783	0.783	0.785	0.785	0.779	0.779	0.800	0.800	0.818	0.818

All estimations include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter. All columns except 12 in the lower panel include importer-product-time, exporter-product-time and country-pair-product fixed effects. Col. 12 in the lower panel includes importer-time, exporter-time, and pair fixed effects. S.e. (in parentheses) robust to two-way clusters on product and country-pair level (at the country-pair level in Col. 12. lower panel). Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity in kg. by product, country-pair, and time unless indicated otherwise. *Spacing* $\Delta = 10(5, 1)$ indicates that the sample consists of 10 (5,1)-year-spaced time windows spanned by the period denoted by *Time*. $\ln(1-\lambda)$ in Cols. 5,6 (7,8) λ is based on growth in a monthly, seasonally adjusted quantity index of industrial production (retails sales) rather than aggregate imports, and also standardized. Cols. 1-6 (7-10) based on years 1985, 1995, 2005, 2015 (annual data between 1984-2017)

Table A.10: Summary statistics of the estimation sample

Variables/Categories	Description	# Obs.	# Groups	Mean	Std. Dev.	Min	Max
Value	> 0, in thsd. USD	2,080,695		7,132,654	1.20e+08	1	4.97e+10
Quantity	> 0, in kg.	2,080,695		4,735,109	5.15e+08	1	6.54e+11
$\ln Dist$	(log) bilateral distance in km	2,080,695		8.2	1.0	4.1	9.9
Contiguity	binary common border indicator	2,080,695		.05	.22	0	1
Comm. Language	binary common offic. language indicator	2,080,695		.15	.36	0	1
EU	binary joint EU membership indicator	2,080,695		.19	.39	0	1
FTA	binary joint FTA membership indicator	2,080,695		.39	.49	0	1
$\ln(1-\lambda)$	bilateral risk premium	2,080,695		-.0002	.0007	-.0066	.0071
$\ln(1-\lambda)$ (IP)	bilateral risk premium, based on *industrial production* growth	782,291		-.00007	.0003	-.0019	.0019
$\ln(1-\lambda)$ (RS)	bilateral risk premium, based on *retail sales* growth	683,900		-.00007	.0003	-.0013	.0014
$\ln(1-\lambda)$ (REG)	bilateral risk premium for five regional financial markets	2,080,695		-.0249	.0733	-.9048	.4943
$\ln(1-\lambda)$ (CG)	bilateral risk premium, based on *consumption* growth	1,746,827		-.00003	.0001	-.001	.0012
$\ln(1+Tariff)$	bilateral tariff	1,768,077		.06	.10	0	3.43
Vessel	binary indicator for primary shipment mode = vessel	2,080,695		.63	.48	0	1
# *Exporters*		2,080,695	21				
# *Importers*		2,080,695	175				
# *Products*	SITC rev. 2 4-digit codes	2,080,695	766				
# *Years*		2,080,695	4			1985	2015
Exporters p. product	with positive sales		766	19	3.5	2	21
Importers p. product	with positive sales		766	110	48	2	175
Years p. product-cty-pair	with positive sales		752,901	2.8	.8	2	4

A.2 Data

A.2.1 Data used in Section 2

Import growth. I use total monthly imports by country obtained from the IMF's *Direction of Trade Statistics* to measure demand growth. Imports are converted to constant U.S. dollars using the Bureau of Labor Statistics' monthly consumer price index. Growth is measured with respect to the previous month and rates are seasonally adjusted using the U.S. Census Bureau's X-13ARIMA-SEATS Seasonal Adjustment Program. The earliest observation used to estimate the risk premia is January 1975. To obtain continuous import series for countries evolving from the break-up of larger states or country aggregates defined by the IMF, I use a proportionality assumption to split imports reported for country groups. In particular, I use each country's share in the total group's imports in the year succeeding the break-up to split imports among country group members in all years before the break-up. This concerns member countries of the former USSR, Serbia and Montenegro, the Socialist Federal Republic of Yugoslavia, Belgium and Luxembourg, former Czechoslovakia, and the South African Common Customs Area. Moreover, I aggregate China and Taiwan, the West Bank and Gaza, and Serbia and Kosovo in order to accommodate the reporting levels of other data used in the analysis.

Industrial production. I use monthly growth of the (seasonally adjusted) index of industrial production volume from the OECD *Monthly Economic Indicators* (MEI) Database as an alternative proxy for demand growth. It is available for 36 destination countries, over varying lengths of time.

Retail sales. The third proxy for demand shocks is growth of the monthly (seasonally adjusted) index of retail sales volume taken from the OECD *Monthly Economic Indicators* (MEI) Database. It is available for 37 destination countries, over varying lengths of time.

Consumption growth. Seasonally adjusted, quarterly consumption growth is used to calculate another set of λs. The data stem from the OECD *Key Economic Indicators* (KEI) Database. It is available for all exporters in the sample except Singapore and Hongkong, but for varying lengths of time.

Tariffs. Source: WITS database. I use effectively applied tariffs including preferential rates and ad valorem equivalents of specific tariffs and quotas. Tariffs are provided at the HS six-digit level. WITS does not distinguish between missings and zeros. I replace missings with zeros whenever in a given year a country reported tariffs for some products but not for others. This concerns less than 1 percent of the sample. Additional missings are replaced with up to five lags or leads.

Primary transport mode. Source: US Census Bureau FTD. I use the dataset provided by Peter Schott through his data website.[28] For each product-country-year shipment to and from the U.S. between 1989 and 2015 I compute the share of trade by air at the HS-10-digit level. Then, I match the HS-10-digit codes with SITC four-digit codes used in my export data and then take the median over all shipments by SITC four-digit code. I define an indicator $Vessel = 1$ if this median share of air shipment is $< .5$. Note that strictly speaking, the vessel indicator captures all kinds of transport but air, including ground transport. The resulting separation into goods shipped primarily by air or vessel is pretty strict. For only 98 out of 786 products is the median air share different from zero or one.

[28] *http://faculty.som.yale.edu/peterschott/sub_international.htm*

A.3 Calibration Details and Additional Results

Table A.11: Counterfactual changes at the country level

ISO	$A^M_{\iota,0}$	exports	sales	Π_i	$\mathrm{E}[R_i]$	$\sigma^2_{R_i}$	Region
	general equilibrium change in %						
AUS	4.7	0.4	2.0	13.4	-2.6	-1.0	Australia
BRA	4.1	0.8	1.7	12.6	-2.4	-3.0	Brazil
CHN	5.1	11.9	2.0	16.5	-3.0	0.7	China
AUT	-2.3	-4.8	-1.2	-5.4	1.2	9.4	Europe & N. America
BEL	-2.4	-4.6	-1.5	-3.9	0.9	10.2	Europe & N. America
BGR	-10.7	-14.4	-5.7	-25.9	5.6	20.4	Europe & N. America
CAN	-6.1	-10.0	-3.4	-14.9	2.9	11.6	Europe & N. America
CHE	-6.5	-11.4	-3.5	-16.9	3.2	24.1	Europe & N. America
CYP	-9.1	-11.3	-4.7	-22.7	4.8	22.2	Europe & N. America
CZE	-6.9	-7.1	-3.4	-18.4	3.7	12.7	Europe & N. America
DEU	-3.0	-8.1	-1.9	-5.1	1.0	10.3	Europe & N. America
DNK	-3.5	-9.4	-2.7	-3.8	0.8	12.0	Europe & N. America
ESP	-3.9	-7.7	-1.3	-13.0	2.7	10.5	Europe & N. America
EST	-6.4	-9.3	-3.7	-14.3	2.9	12.3	Europe & N. America
FIN	-4.0	-10.7	-2.8	-6.0	1.2	8.6	Europe & N. America
FRA	-1.8	-7.2	-1.1	-3.2	0.7	7.4	Europe & N. America
GBR	-5.0	-10.1	-1.9	-16.1	3.3	19.4	Europe & N. America
GRC	-11.2	-19.0	-4.6	-31.4	7.3	28.3	Europe & N. America
HRV	-7.9	-11.6	-4.0	-20.3	4.2	16.7	Europe & N. America
HUN	-5.9	-7.0	-3.6	-11.9	2.4	13.3	Europe & N. America
IRL	-10.5	-13.1	-6.9	-23.5	4.0	37.4	Europe & N. America
ITA	-1.9	-7.2	-1.0	-4.2	0.9	6.1	Europe & N. America
LTU	-11.6	-14.7	-7.9	-19.8	4.1	15.3	Europe & N. America
LUX	-9.1	-11.5	-7.3	-11.6	2.1	25.1	Europe & N. America
LVA	-11.9	-14.4	-5.4	-32.4	7.4	22.0	Europe & N. America
MLT	-6.7	-6.5	-4.1	-14.5	2.8	33.0	Europe & N. America
NLD	-4.1	-6.8	-2.7	-7.3	1.4	13.5	Europe & N. America
NOR	-3.8	-6.4	-1.9	-9.3	2.0	11.3	Europe & N. America
POL	-5.4	-6.7	-2.5	-14.6	3.1	9.8	Europe & N. America
PRT	-4.0	-8.0	-1.5	-12.8	2.6	12.3	Europe & N. America
ROU	-7.9	-10.8	-3.2	-23.1	5.1	14.9	Europe & N. America
SVK	-10.2	-10.7	-6.2	-22.6	4.4	15.7	Europe & N. America
SVN	-5.6	-7.1	-2.7	-15.7	3.0	13.2	Europe & N. America
SWE	-4.6	-8.6	-2.6	-10.7	2.1	11.8	Europe & N. America
USA	-0.6	-11.8	-0.9	1.8	-0.4	5.2	Europe & N. America
IND	4.0	-3.7	1.6	11.7	-2.2	1.1	India
IDN	2.8	-8.9	0.9	9.8	-1.9	4.7	Indonesia
JPN	2.8	-12.8	0.7	10.7	-2.0	3.7	Japan
KOR	5.7	1.6	3.4	11.1	-2.2	7.5	Korea
MEX	4.9	5.0	3.3	7.4	-1.5	-1.7	Mexico
ROW	2.5	-6.6	0.8	9.0	-1.6	5.1	Rest of the World
RUS	6.8	13.3	4.5	11.8	-2.2	-3.2	Russia
TUR	3.4	-0.6	1.9	8.7	-1.5	0.8	Turkey