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

Inga Heiland†

This version: December 17, 2019

Very preliminary: Please visit

`http://inga-heiland.de/pdfs/Heiland_JMP.pdf`

for the latest version.

Abstract

Exporting not only provides firms 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 complete. 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 costs 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 4.6% of global trade. Country-level exports would grow by -13% to +10% if all diversification opportunities were eliminated, entailing welfare losses in the range of .4% to 16%.

JEL Classification: F15, F36, F44, G11

---

*I thank Gabriel Felbermayr, Wolfgang Keller, Carsten Eckel, Wilhelm Kohler, Lorenzo Caliendo, Martin Schmalz, Thomas Mertens, Andreas Moxnes, Michele Battisti, Andrea Ciani, Sebastian Krautheim, Anna Gumpert, Eduardo Morales, Antonio Rodriguez-Lopez, Tim Schmidt-Eisenlohr, Andy Bernard, and participants at the CESifo Area Conference on Global Economy, the EGIT workshop, the Annual Meeting of the VfS, and the ETSG, and seminar participants at the FRB San Francisco, the University of Oslo, Munich, Tuebingen, and Linz, at the IFN Stockholm, and at the Norwegian Business School in Oslo for valuable comments and suggestions. This project has received funding from the European Research Council under the European Union's Horizon 2020 research and innovation program (grant agreement 715147).

†University of Oslo. Contact details: Department of Economics, Moltke Moes vei 31, 0851 Oslo, Norway. inga.heiland@econ.uio.no

Keywords: International Trade, Structural Gravity, Global Risk Sharing, International Investment

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 the marginal utility of consumption across countries.[1] Moreover, international financial market integration has provided investors with an alternative means to engage in global risk sharing. So, does global risk sharing matter for trade after all? The extant literature on trade under uncertainty is inconclusive. In a seminal contribution, Helpman and Razin (1978) show that uncertainty about productivity does not change goods trade patterns predicted by traditional sources of comparative advantage if financial markets are complete. In contrast, the literature on exports under demand uncertainty finds that trade patterns are influenced by risk diversification concerns.[2] Yet, this literature considers risk-averse firms concerned with the diversification of firm-specific risk in the absence of financial markets.

To shed light on the importance of a risk-sharing motive for goods trade in the presence of asset trade, I analyze export patterns under demand uncertainty in a setting with complete and potentially globally integrated financial markets. In this setting, idiosyncratic risk is diversified through asset trade and only aggregate risk embodied in a country's demand fluctuations influences exporting decisions. I show that the distribution of demand shocks across countries constitutes a hitherto unexplored source of comparative advantage that exerts a forceful impact on the global pattern of goods trade and that persists even if financial markets were globally integrated and complete.

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 provides a quantitative answer to the question of how important risk-based comparative advantage is in terms of shaping global goods trade. On the theory side, the model challenges Helpman and Razin's (1979) result that trade patterns based on traditional sources of comparative advantage persist under uncertainty if financial markets are complete. Rather, I find that if uncertainty prevails with respect to demand, a country's riskiness is itself a source of comparative advantage that persists if asset markets are complete. Last, by

[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]See, for example, Maloney and Azevedo (1995), Riaño (2011), Allen and Atkin (2016), and Esposito (2019).

modeling trade under varying degrees of global financial market integration, the paper complements the extant literature on internationalization choices of firms under demand uncertainty. This literature has considered either risk-neutral decision making on the part of all agents[3], risk-averse firms acting in the absence of financial markets[4], or, for tractability, partial equilibrium aspects of the internationalization choices of firms owned by diversified investors[5].

In the empirical part of the paper, I use data on bilateral trade flows covering the years 1985 to 2015 to provide reduced-form empirical evidence for the hypothesis that diversification concerns shape the global pattern of trade. I show that exports are larger in destination markets where demand shocks covary less with stock market returns or consumption growth in the exporting country, conditional on market size and trade costs.

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 patterns 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, and at reproducing the cross-section of capital asset pricing model-based (CAPM-based) risk premia for country-specific demand shocks.

Then, I embed the simple relationship between trade flows and portfolio returns 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 demand uncertainty. The model encompasses different degrees of global financial market integration: nationally segregated, regionally segregated, and globally integrated financial markets. In any of the settings, 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 the 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 premium captures a destination market's aggregate risk contribution and is endogenously determined in the financial market equilibrium,

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

[4]See, for example, Maloney and Azevedo (1995), Riaño (2011), Allen and Atkin (2016), and Esposito (2019).

[5]See, for example, Fillat et al. (2015) and Fillat and Garetto (2015).

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 costs and market size), and feature shocks that are positively correlated with those of other popular export markets. Low covariances with demand shocks in popular destinations for exports thus endow 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 4.6% lower. Country-level exports are affected vastly differently, depending on the initial degree of a country's comparative advantage and on the degree of risk aversion: Exports in the counterfactual equilibrium deviate from the baseline by -13% to +10%. Welfare losses range between .4% and 16%.

The notion of comparative advantage across states of nature entertained in this paper goes back to Svensson (1988), who shows how it shapes global capital flows. The key theoretical 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. Four characteristics of the model environment are essential for this result: Risk aversion, the presence of aggregate risk, a well-defined optimal firm size together with a motive for trade that is independent of diversification considerations, and firms having to make market-specific export decisions under uncertainty, that is, *before* demand is known. Under these conditions, 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. Survey evidence confirms this. Based on the responses of 392 chief financial officers (CFOs) to a survey conducted among U.S. firms in 1999, Graham and Harvey (2001) report that to evaluate the profitability of an investment, more than 70% use discount factors that account for the covariance of returns with movements in investors' total wealth.[6] In an

[6]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.

international trade context, the concept of real investment decisions 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 international trade and investment under productivity uncertainty[7] and in the strand of literature modeling market entry choices of firms owned by asset-trading shareholders.[8] Yet, to date, it has not made its way into the literature devoted to firms' exporting decisions on the intensive margin, which has analyzed demand uncertainty primarily from the point of view of risk-neutral agents or less frequently from the point of view of risk-averse firms acting in the absence of financial markets.[9] In the latter setting, 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 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 de facto 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.[10] There are two additional model characteristics that are essential for the novel predictions of my paper and distinct from this literature: A well-defined optimal firm size and a motive for firms to serve multiple markets that is independent of diversification considerations. Without these two firm characteristics, a global investor could replicate the optimal allocation by choosing the corresponding units of domestically-selling firms

[7]See the literature building on Helpman and Razin (1978), Grossman and Razin (1984), and Helpman (1988).

[8]Ghironi and Melitz (2005), Ramondo and Rappoport (2010), Fillat et al. (2015), and Fillat and Garetto (2015).

[9]See, for example, Maloney and Azevedo (1995), Riaño (2011), Allen and Atkin (2016), and Esposito (2019). Brainard and Cooper (1968) consider the impact of aggregate risk for a small open economy facing export price uncertainty in a two-country world where the social cost of volatility derives from a concave social welfare function.

[10]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 (see, for example, Koren 2004; di Giovanni and Levchenko 2011; Islamaj 2014; Kucheryavyy 2017). Another related strand of literature addresses the question of whether trade increases or lowers income volatility (see, for example, Caselli et al. 2019 for a recent contribution and an overview of the previous literature). Neither of the two strands explores the implications of comparative advantage across states of nature, which is central to this paper.

in all countries. In the model, the optimal firm size and the export motive are rooted in the New Trade Theory assumptions of increasing returns to scale at the firm level, product differentiation, and love-for-variety preferences. Investors' portfolio choices then determine the number of firms in each country whereas firms decide upon the sales per market. Optimality demands that the risk-return trade-off for both investment problems be identical at the margin.

There is ample evidence that exporters face significant time lags between production and sales of their goods, exposing them to uncertainty about demand conditions at the time of production.[11] In the survey by Graham and Harvey (2001), CFOs were asked to state whether and, if so, what kinds 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 (see 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 risk, 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 larger covariances of demand shocks with consumption growth or stock returns in the exporting country are more detrimental to trade 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 aggregate risk exposure through firms' operations in foreign markets (see, for example, 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 countries. However, little is known about whether firms respond to investors' desire for consumption smoothing, to what extent it is reflected in the pattern of aggregate bilateral trade, and how it affects 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

[11] Djankov et al. (2010) report that export goods spend from 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.

Stulz (1981) and to the literature on general equilibrium models of asset pricing following Jermann (1998), the latter of which models the supply and demand for equity by linking both firms' investment returns and investors' consumption to the same volatile economic fundamentals, such as productivity shocks. Based on a model with country-specific and sector-specific productivity shocks and production linkages, Richmond (2019) has shown that trade network centrality helps explain the cross-section of currency risk premia. To the best of my knowledge, my paper is the first to link stock returns and the pricing kernel to country-specific demand shocks with the help of a general equilibrium trade model. My model provides a microfoundation for a linear factor model featuring country-specific demand shocks as factors. Moreover, the model delivers microfounded exposures ("betas") of firms to these country-specific shocks that derive from a gravity model of trade, and endogenous factor prices for the country-specific risks. 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.

My paper also builds on a large literature that provides microfoundations for the theoretical gravity equation of international trade (for a comprehensive survey of this literature, see Costinot and Rodriguez-Clare 2014). I introduce risk-averse investors, asset trade, 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 of the relationship between trade flows, demand shocks, and portfolio returns. 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 of a diversification motive. Using 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.

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,

$$\ln q_{pij,t} = \beta_1 \mathrm{Cov}_t \left[M_i, \widehat{Y}_j \right] + \boldsymbol{\beta} \boldsymbol{Z}_{ij,t} + d_{pi,t} + d_{pj,t} + d_{pij} + u_{pij,t}, \tag{1}$$

where the dependent variable is the quantity (in kilograms) of product p shipped from country i to j in year t.[12] The data, sourced from UN Comtrade, is disaggregated into 766 products (defined by the 4-digit level of SITC classification, Rev. 2). I use four equally spaced time periods between 1985 and 2015.[13] More years of data are considered in a

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

[13]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

robustness analysis.

On the right-hand side of (1), importer-product-time and exporter-product-time fixed effects capture expected demand in the destination market and the importer's price index (also known as "multilateral resistance"), the exporter's production costs, and time-varying trade costs specific to the exporter or the importer. Country-pair-product fixed effects and a vector of dummy variables for joint membership in the EU or a free trade agreement (FTA), $\boldsymbol{Z}_{ij,t}$, control for bilateral trade costs.[14] Tab. A.9 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 growth in total seasonally adjusted monthly or quarterly imports by country to proxy demand growth $\widetilde{Y}_{j,t}$ and three different proxies for income and consumption growth of an investor who is representative for the exporting country. First, I compute the covariance with the aggregate national stock market return in the exporting country, $R^M_{i,t}$. This measure is most relevant in a scenario where financial markets are integrated within countries but not across borders. Second, I substitute the national total stock market return with the total return earned in aggregate regional stock market ($R^M_{\iota,t}$, an optimal portfolio of a subset of national stock markets), grouping countries into financially integrated regions along the lines of Fama and French (2012). Finally, 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. Data on $R^M_{i,t}$ and $R^M_{\iota,t}$ obtained from *Kenneth R. French's data library* is available for 21 mostly industrialized countries forming the following five regions: North America; East Asia and Pacific; United Kingdom and Ireland; Scandinavia; and other Europe. For consumption growth $\widetilde{C}_{i,t}$, I use quarterly seasonally adjusted growth rates with respect to the previous period and quarterly import growth. 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 $\text{Cov}_t[M_{i,t+1}, \widetilde{Y}_{j,t+1}] = T^{-1}\sum_{s=0}^{T}[M_{i,t-s} \cdot \widetilde{Y}_{j,t-s}] - T^{-2}\sum_{s=0}^{T} M_{i,t-s} \cdot \sum_{s=0}^{T} \widetilde{Y}_{j,t-s}$. The result is a set of covariances for 21 exporters and 175 destination markets for every year from 1984 to 2017, each based on monthly or quarterly data from the 10 most recent years.

The coefficient on the covariance in Eq. (1) is identified using variation within country pairs over time only. A potential concern about omitted variables bias is due to bilateral

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 covariances.

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

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 demonstrate that the covariances depend positively on the 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. Hence, any omitted variable affecting the left-hand side will be correlated with the bilateral covariances as well. Yet, omitted variables that correlate positively with trade on the left-hand side will also be positively correlated with $\text{Cov}[M_i, \widehat{Y}_j]$ and vice versa for variables that negatively correlated with product-level trade. Hence, the coefficient estimate for $\text{Cov}[M_i, \widehat{Y}_j]$ must be interpreted as an upper bound. I explore this reasoning below, where I run multiple specifications, with stricter trade costs 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, reverse causality 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 analyze the heterogeneity of the effect of $\text{Cov}[M_i, \widehat{Y}_j]$ across products and markets to test the presumption that the negative effect of the covariance on exports is due to a time lag between production and sales. 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 subject to longer time lags are therefore expected to be more affected by the dampening effect of positively correlated shocks. To test for the relevancy of a time lag, 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 by 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 from the U.S. which are recorded by mode of transport; see Appendix A.2 for details. I then re-run the specification that includes the covariances interacted with distance in both subsamples. Alternatively, I include a triple interaction $\text{Cov}[M_i, \widehat{Y}_j] \times \ln \mathit{Dist} \times \mathit{Vessel}$ 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-

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)
N	2,080,695	2,080,695	1,316,842	763,853	2,080,695	2,080,346

All columns include importer-product-time, exporter-product-time, and country-pair-product fixed effects. Cols. 1–5 include binary indicators for joint membership in the EU or an FTA, and two five-year-spaced lags thereof. Col. 6 includes country-pair-time fixed effects. S.e. (in parentheses) are robust to two-way clusters at the product and country-pair levels. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable: log export quantity (in kg) by product, country pair, and time. Col. 3 (4) is based on a subsample of products shipped primarily by vessel/ground transportation (air) only. Estimates are 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.

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 (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).

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 unit increase in the covariance goes along with an increase in exports of about 34%.[15] In terms of economic magnitude, the coefficient estimate implies, 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 exports in a counterfactual world where covariances do not influence firms' exporting decisions. In other words, the coefficient estimate suggests 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 discussed above, the estimate must be interpreted as an upper bound on the negative effect. Moreover, there

[15]For comparability, the covariances are standardized. The non-standardized coefficient 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)
N	2,175,616	2,175,616	2,175,214	1,699,404	1,699,404	1,699,160

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) are robust to two-way clusters at the product and country-pair levels. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable: 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.

is substantial heterogeneity of the effect across country pairs and products that is relevant for 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 impact of the correlation of shocks on trade is due to the presence of a time lag between production and 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 covariance, 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 costs, 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 covariance 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 covariance on exports between 1992 and 2004 is quantified at -3.2%. If 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.7 and A.8 in Appendix A.1, in which I also discuss 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 to show that alternative assumptions about the degree of financial market integration do not impair the results. Cols. 1–3 (4–6) show that similar results obtain when the total domestic stock market return is replaced by the total return earned in a supranational regional stock market (country-level consumption growth).

Omitted variables bias. In Tab. A.7, I analyze the validity of the presumption that omitted factors determining trade on the left-hand side lead to an upward bias of the coefficient of $\text{Cov}[M_i, \widehat{Y}_j]$. Col. 1 presents the correlation between $\text{Cov}[M_i, \widehat{Y}_j]$ and product-level exports, conditioned only on importer/exporter-product-time fixed effects. As expected, it is strongly positive, because increased bilateral trade implies a higher covariance. In Cols. 2 and 3, I subsequently add time-constant and time-varying bilateral trade cost proxies. Consistent with the presumption that the upward bias is reduced when trade costs are included, the coefficient estimate becomes smaller. Col. 4 repeats the baseline specification of Tab. 1, which features in addition country-pair-product fixed effects to control for unobserved bilateral trade costs and other supply and demand shifters and produces a negative and statistically significant effect of the covariance term.

Alternative proxies for demand shocks. Cols. 5–8 of Tab. A.8, 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 is 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 border (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 the bilateral covariances, but the coefficient likely reflects a mix of expected and realized values. On the positive side, data on export values are supposedly of higher quality, since some of the export weight entries in the Comtrade database are estimated. Cols. 9 and 10 of Tab. A.8, upper panel, show that the negative effect of higher covariances prevails 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 greater bilateral trade volumes as well as a low correlation of shocks. While the baseline estimation cannot rule out the possibility that the negative coefficient is driven by this alternative mechanism, the heterogeneous effects with regard to distance and transport mode provide evidence in favor 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 lend support to the 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 goods produced by a typical firm from i, and N_i is the number of firms in i. Now consider a representative investor from 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 firm's realized sales value $\phi_{ij}Y_j$ in every market. The return on her portfolio is thus

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

are typical elements of the vectors $\boldsymbol{\beta}_\iota$ and $\widetilde{\boldsymbol{Y}}$, respectively. The 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, A_ι.

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

$$\sigma^2_{R^M_\iota} = \sum_{j\in\mathcal{J}} \beta_{\iota j} \text{Cov}\left[R^M_\iota, \widetilde{Y}_j\right], \quad \text{where} \quad \text{Cov}\left[R^M_\iota, \widetilde{Y}_j\right] = \sum_{k\in\mathcal{J}} \beta_{\iota k}\sigma_{\widetilde{Y}_j\widetilde{Y}_k}, \tag{3}$$

yielding a straightforward interpretation of the covariances in the regression. $\text{Cov}[R^M_\iota, \widetilde{Y}_j]$ weighted by $\beta_{\iota j}$ 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 global aggregate risk equal to

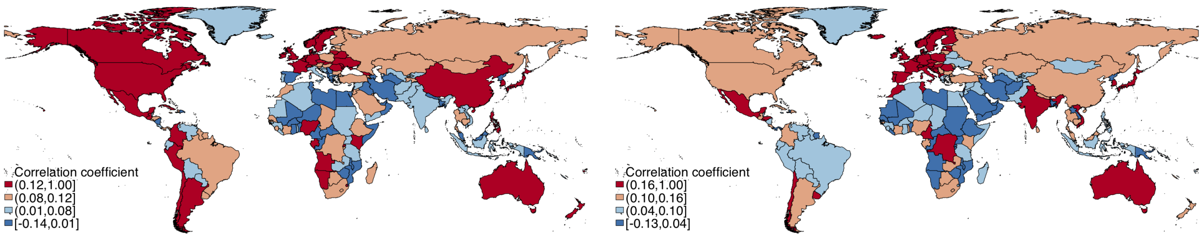
$$\text{Cov}\left[R^M, \widetilde{Y}_j\right] = \sum_{k\in\mathcal{J}} \beta_k\sigma_{\widetilde{Y}_j\widetilde{Y}_k}. \tag{4}$$

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

$$\text{Cov}\left[R^M_i, \widetilde{Y}_j\right] = \sum_{k\in\mathcal{J}} \beta_{ik}\sigma_{\widetilde{Y}_j\widetilde{Y}_k}. \tag{5}$$

Aggregate risk contributions are partly endogenous, since the βs reflect optimal choices of firms (ϕ_{ij}) and investors (N_i). The exogenous part $\sigma_{\widetilde{Y}_j\widetilde{Y}_k}$, however, constitutes an independent source of comparative advantage: Conditional on the vector $\boldsymbol{\beta}$, countries featuring shocks that are negatively correlated with shocks in most other countries contribute less to aggregate volatility. Moreover, suppose that large βs 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. Since domestic markets are by far the most important sales markets for firms from any country, $\beta_{\iota k}$ is disproportionately large for countries k that are part of region ι. Hence, countries featuring negatively correlated demand shocks with a firm's home market are attractive. Panels (a) and (b) of Fig. 1 show for all destination markets the correlation coefficient ρ_{jk} of demand shocks with the U.S. and the German domestic markets, respectively. The four different colors reflect quartiles of the distribution of the correla-

Figure 1: Demand shock correlation patterns



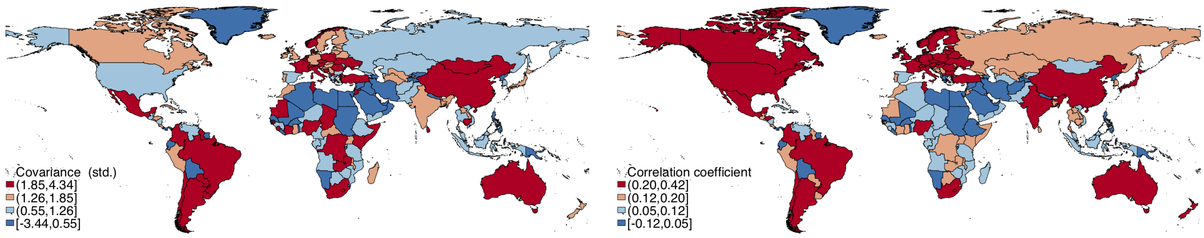
(a) USA (b) Germany

The figure shows correlation coefficients of demand shocks of all countries, with the U.S. and German markets in Panels (a) and (b), respectively. Demand shocks are proxied by growth in seasonally adjusted real imports by country. The time period is 1975–2017, or shorter for countries with limited data availability. The four colors indicate quartiles of the distribution of the correlation coefficient across destination countries.

tion coefficient. U.S. demand shocks correlate strongly with the shocks in other countries from the Americas and with China, while demand shocks in Germany are most strongly correlated with the shocks in other European countries. Hence, if most stock ownership is *local*, exports to Brazil provide sizeable diversification benefits to a German investor, but not to a U.S. investor. Conversely, the negative correlation between demand shocks in Spain and the U.S. make Spain an attractive export destination for U.S. firms, while the opposite is true for exporters from Germany. 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. Given a negative impact of $\mathrm{Cov}[R_\iota^M, \widetilde{Y}_j]$ on bilateral trade as established above, uncertainty about Y_j thus weakens the impact of other sources of comparative advantage on trade.

Fig. 2, Panel (a) visualizes country risk as measured by a country's contributions to the portfolio variance of a *global* investor (Eq. 4), who owns a constant share of all firms from all countries. The global investor's portfolio return moves in lockstep with shocks to global demand. South and Central America, sub-Saharan Africa, and Eastern Europe host many of the riskiest countries from the global investor's point of view. 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 the more popular import destinations are also more risky, ceteris paribus, because shocks to their demand have a bigger impact on the global portfolio. This fact, together with the covariance pattern of shocks and country-level volatility, yields a pattern

Figure 2: Global risk contributions by country



(a) Covariance

(b) Correlation

Panel (a) shows the standardized covariance of all countries' demand shocks with global demand growth. Panel (b) shows the corresponding correlation coefficients. Demand shocks are proxied by growth in seasonally adjusted real imports by country and at the world level, respectively. The time period is 1975–2017, or shorter for countries with limited data availability. The four colors indicate quartiles of the distribution of the covariance/correlation coefficient across countries.

of comparative advantage that does not exhibit an obvious correlation with other well-established determinants of trade.

How well does this simple portfolio model describe actual correlations of country shocks with stock market returns? A simple transformation of (5) using $R_i^M = \sum_{k \in \mathcal{J}} \beta_{ik}$ yields

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

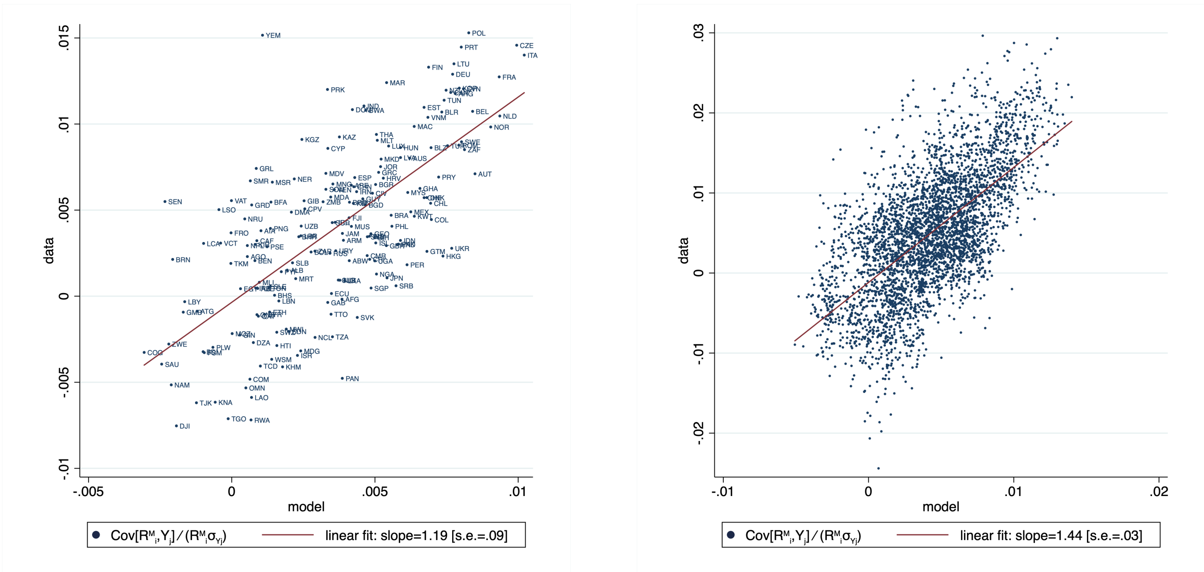
Fig. 3 plots the right-hand side of (6), computed with trade data only, on the horizontal axis, against the scaled stock-return-data-based covariances (left-hand side of (6)) that are used in the regressions above on the vertical axis.[16] The model-based covariances reproduce the actual cross-section of covariance of stock returns with demand shocks strikingly well.[17]

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 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.

[16] $\sigma_{\widetilde{Y}_j, \widetilde{Y}_h}$ is computed based on ten years of monthly data. I use average stock market returns and average trade flows over the same period for computing the two measures.

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

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



(a) U.S.

(b) All

The figure plots scaled covariances between domestic aggregate stock returns and demand shocks in other countries constructed from bilateral trade data, in line with the model, on the horizontal axis, against the same scaled covariance computed using actual stock returns on the vertical 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 is available. Time period: 2003–2012.

3 Theory

Consider a world consisting of J 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 an aggregate 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).[18]

The set of assets available to investor ι consists of a globally traded risk-free bond and

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

shares of the firms in her region that produce differentiated intermediate goods.[19] 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 to 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, $\mathcal{J}_\iota = \mathcal{J}$.

3.1 Utility, Consumption, and Investment

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

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

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 risk-free bond that yields a certain gross return R^f in period one, and risky investments $a_{\iota i,0}$ in shares of firms from country $i \in \mathcal{J}_\iota$ that yield a stochastic gross return R_i in period one. In the 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 in period zero is given by

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

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

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

where R^M_ι denotes the gross return to the risky portfolio.

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

[19] Note that in the terminology of Dybvig and Ingersoll (1982), the representative investor cares only about "primary" assets and not about "financial" assets. Primary assets, that is, firm shares or bond purchases from outside the region, affect the aggregate wealth of the region. In contrast, financial assets, such as insurance policies, options, or futures, affect only the distribution of wealth within the region since, by definition, they are in zero net supply within the region. 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.

the number of distinct assets (equalling the number of countries) 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 the 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 at 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 SDF. 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 I turn to next.

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

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

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 constant elasticity of substitution (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 are, that is, $\varepsilon < \theta$. Final goods producers choose optimal inputs so 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 fixed costs 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 must 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. Consequently, the 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. The assumption that firms fix quantities but not prices is less restrictive than it may appear 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 problem is akin to the problem of a firm that engages in local currency pricing in the presence of nominal exchange rate uncertainty.

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 representative investor's SDF to discount expected sales, taking the distribution of m_ι as a given.[20] This discounting 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. The

[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 for 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, lead to a constraint Pareto-efficient allocation of resources.

influence of the SDF on the firm's problem 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}:

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

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 it sells relatively more to markets for which insurance is cheap, that is, if $\lambda_{\iota j}$ is small or even negative.[23]

The first-order condition of the firm's problem in (17) yields an optimal quantity for

[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 prices per unit of expected sales. This asset takes away both the downside and the upside risks 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 "insurance prices" $\lambda_{\iota j}$ 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, is independent of its choices.

[23] The problem of the firm in (17) can equivalently be stated as $\max_{\boldsymbol{q}_{i,0} \geq 0} V_i = \frac{\mathrm{E}[s_i]}{R^f} - \frac{\mathrm{E}[R_i]}{R^f}(\sum_{j \in \mathcal{J}} c_i \tau_{ij} q_{ij,0} + \alpha_i)$, 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 its capital cost.

every market j that is produced in period zero and is to be sold in period one equal to

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

where $\Theta = \frac{\theta-1}{\theta}$. Eq. (20) states that firms ship larger quantities to markets with lower trade costs 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 costs and trade costs 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 costs, which include 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 costs 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 because 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 because of 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 that 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, Market Clearing and Equilibrium

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

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

Hence, 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 conditions for each type of equity imply

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

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

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

and 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 $Q_j \; \forall \; j \in \mathcal{J}$.

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).

3.4 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 on a share of firm i is equal to

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

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. Observing (24), it follows that the total return on the risky portfolio can be written as a linear combination of country shocks $R_\iota^M = \boldsymbol{\beta}_{\boldsymbol{\iota}}' \widetilde{\boldsymbol{Y}}$, just as displayed in (2).

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

$$m_\iota = \delta \frac{u_\iota'(a_{\iota,0}^f R^f + A_{\iota,0} R_\iota^M)}{u_\iota'(C_{\iota,0})} \approx \bar{\zeta}_{\iota,0} - \zeta_{\iota,0} R_\iota^M, \tag{29}$$

where $\bar{\zeta}_{\iota,0} = \delta \frac{u'_\iota(\mathrm{E}[C_\iota])}{u'_\iota(C_{\iota,0})} + \zeta_{\iota,0}\mathrm{E}[R^M_\iota]$ and $\zeta_{\iota,0} = -\delta \frac{u''(\mathrm{E}[C_\iota])}{u'(C_{\iota,0})} A_{\iota,0}$. 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

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

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 $\frac{a_{\iota j,0}}{A_{\iota,0}}$, 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 assumptions: Specifying the representative investors' utility function and specifying the distribution of

[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, the direct bilateral exposures obtain as 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, the bilateral exposures to country j are identical for all exporters i and given by expected global expenditure on final goods from j divided by global investment.

shocks. Regarding the latter, I assume multivariate normality of demand shocks:

$$\widetilde{\boldsymbol{Y}} \sim MVN\big(\mathbf{1}, \Sigma_{\widetilde{Y}}\big) \tag{31}$$

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

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

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

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 $\sigma_{R_\iota}^2 = \frac{1}{A_{\iota,0}^2}\boldsymbol{a}_{\iota,0}\Sigma_{R_\iota}\boldsymbol{a}_{\iota,0}'$ 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[25]

$$m_\iota = \bar{\zeta}_{\iota,0} - \zeta_{\iota,0} R_\iota^M \qquad \text{with} \qquad \zeta_{\iota,0} = \frac{\gamma_\iota A_{\iota,0}}{R^f} \qquad \text{and} \qquad \bar{\zeta}_{\iota,0} = \frac{1}{R^f} + \zeta_{\iota,0}\mathrm{E}[R_\iota^M]. \tag{34}$$

With normality of R_ι^M and exponential utility, the expected lifetime utility equals

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

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, recalling (30) and (3), the counterfactual risk premia observe

$$\lambda_{\iota j}' = \zeta_{\iota,0}' R^{f\prime} \sum_{k \in \mathcal{J}} \beta_{\iota k}' \sigma'_{\widetilde{Y}_j\widetilde{Y}_k}. \tag{36}$$

[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 equal to

$$\widehat{\phi}_{ij} = \left(\frac{\widehat{1-\lambda_{\iota j}}}{\widehat{R}_f}\right)^{\varepsilon-1} \frac{\widehat{N}_i^{\frac{\theta-\varepsilon}{1-\theta}}}{\widehat{\Pi}_j^{1-\varepsilon}} \quad \text{where} \quad \widehat{\Pi}_j^{1-\varepsilon} = \sum_{i\in\mathcal{J}} N_i \phi_{ij} \widehat{N}_i^{\frac{1-\varepsilon}{1-\theta}} \left(\frac{\widehat{1-\lambda_{\iota j}}}{\widehat{R}_f}\right)^{\varepsilon-1}. \tag{37}$$

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

$$\widehat{N}_i = \left[\frac{1}{N_i v_i} \sum_{j\in\mathcal{J}} \frac{1-\lambda_{\iota j}}{R^f} \left(\frac{\widehat{1-\lambda_{\iota j}}}{\widehat{R}_f}\right)^{\varepsilon} N_i \phi_{ij} \mathrm{E}\left[Y_j\right] \frac{1}{\widehat{\Pi}^{1-\varepsilon}}\right]^{\frac{1-\theta}{\varepsilon-\theta}}. \tag{38}$$

Using (24), new trade exposures obtain as

$$\beta'_{\iota j} = \frac{\sum_{i\in\mathcal{J}_\iota} \widehat{N}_i \widehat{\phi}_{ij} N_i \phi_{ij}}{\widehat{A}_{\iota,0} A_{\iota,0}} \qquad \text{with} \qquad \widehat{A}_{\iota,0} = \frac{\sum_{i\in\mathcal{J}_\iota} a_{\iota i} \widehat{N}_i}{A_{\iota,0}}. \tag{39}$$

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

$$\sum_{\iota\in\mathcal{R}} a^{f\prime}_{\iota,0} = 0 \qquad \text{where}$$

$$a^{f\prime}_{\iota,0} = \frac{W_{\iota,0}}{R^{f\prime}+1} - A'_{\iota,0} \frac{\mathrm{E}[R^M_\iota]'+1}{R^{f\prime}+1} + \frac{\gamma_\iota}{2} \frac{\left(A'_{\iota,0}\right)^2 \sigma^{2\prime}_{R_\iota}}{R^{f\prime}+1} + \frac{\ln\left(\delta R^{f\prime}\right)}{\gamma_\iota(R^{f\prime}+1)}, \tag{40}$$

$$\mathrm{E}[R^M_\iota]' = \sum_{j\in\mathcal{J}} \beta'_{\iota j}, \qquad \text{and} \qquad \sigma^{2\prime}_{R_\iota} = \sum_{j\in\mathcal{J}} \sum_{k\in\mathcal{J}} \beta'_{\iota j} \sigma'_{\widetilde{Y}_j \widetilde{Y}_k} \beta'_{\iota k}. \tag{41}$$

With $a^{f\prime}_{\iota,0}, A'_{\iota,0}, \mathrm{E}[R^M_\iota]'$, 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 32 individual countries) form one region (henceforth referred to as EUNA), and the 10 remaining individual countries and the rest-of-the-world aggregate (ROW) from the World Input Output Database (WIOD) all form individual regions.[26] By assumption,

[26] Appendix A.2 lists all the countries. The choice of regional groupings is informed by the results of Fitzgerald (2012), Bekaert et al. (2011), and Callen et al. (2015), who provide evidence in favor of financial market integration within the industrialized world, but not beyond.

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 shares $N_i\phi_{ij}$ (including domestic sales), investment levels at the regional level $A_{\iota,0}, a^f_{\iota,0}$, expected expenditure by country $\mathrm{E}[Y_j]$, 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 remaining moments of the baseline equilibrium: $W_{\iota,0}$ for all regions, $\frac{a_{\iota i,0}}{A_{\iota,0}}$ for the countries within EUNA, and $\mathrm{E}\left[R_i\right]$ and $\sigma^2_{R_i}$ for all countries. To calibrate $A_{\iota,0}$, I use the total value of inputs in production plus fixed costs, as implied by the free-entry condition (23). Accordingly, $A_{\iota,0}$ is calibrated to match total expenditure on inputs, excluding capital, plus expenditures for fixed capital formation of a region. Hence, the bridge between the data and the model featuring only capital as input is built on the assumption that capital is used to pay for other production factors and fixed costs at the time of production, and then remunerated with the stochastic sales value in the next period. Tab. 3 summarizes the calibration, Appendix A.3 contains details.

As regards the non-targeted moments, the model does a very 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. A.1 shows that the model performs better in explaining the cross-section of average stock returns if only the dividend part of the observed returns is considered. Tab. A.10 lists a set of baseline moments at the regional level that will be useful for interpreting the results.

4.3 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).

Table 3: Calibration overview

Targeted moments		mean	min	max	source	note
ϕ_{ij}	bilateral trade shares	.02	1.2e-7	.93	WIOD^a	avg. 2005-2014
$\mathrm{E}[Y_j]$	expected expenditure	2.7e+6	2.1e+4	2.4e+7	WIOD^a	avg. 2005-2014
$A_{\iota,0}$	interm. inputs + wage bill + gross fixed cap. formation	8.8e+6	9.5e+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 IIP^b	avg. 2005-2014
$\Sigma_{\widetilde{Y}}$	cov. of trend-adjusted growth in total expenditure	.008	-.002	.03	WIOD^a	2005-2014
R^f	global risk-free rate (%)	.87	.87	.87	multiple^d	w.avg. 2005-2014^e

Internally calibrated moments/parameters		mean	min	max	external data mean	external data correlation
γ_ι	Eq. (32)	4.7e-6	2.1e-8	1.5e-5		
$a_{\iota i,0}$	Eq. (32)	2.5e+6	1.8e+4	2.2e+7	2.1e+6^a	1^a
$W_{\iota,0}$	Eq. (33)	1.8e+7	1.5e+6	9.8e+7		
$\mathrm{E}[R_i]$	Eq. (28)	1.2	1.01	1.3	1.1^c	.13^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/note
ε	5	Costinot and Rodriguez-Clare (2014)
θ	6	robustness checks: $\theta = 8, 10$
δ	.96	Gourinchas and Parker (2002)

Note: [a] *World Input Output Database.* [b] *IMF Balance of Payments and International Investment Positions Statistics* [c] Total stock market return from *Kenneth R. French's data library*; numbers based on only 17 of the 43 countries due to data availability. [d] *IMF International Financial Statistics, OECD Key Economic Indicators, ECB Statistical Data Warehouse, BIS Statistics Warehouse.* [e] Weighted average of country-specific rates using country size (total expenditure) as weights. $\mathrm{E}[Y_j], A_{\iota,0}, a^f_{\iota,0}, a_{\iota i,0}, W_{\iota,0}$ are in million 2005 USD.

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 me to analyze what global trade patterns would look like if all countries' shocks were perfectly correlated. Comparing counterfactual trade flows with observed trade flows that constitute the baseline equilibrium reveals how comparative advantage regarding the distribution of demand shocks across different states of the world shapes trade patterns.

Tab. 4 presents the results for the main variables at the regional level.[27] Risk-based comparative advantage accounts for 4.6% of global trade (see Col. 3). By construction, total expected world sales in the counterfactual equilibrium is the same as in the baseline equilibrium. At the country level, trade and total sales effects are very heterogeneous, ranging from -13% to +10% for the former and -5% to +4% for the latter. What explains the stark heterogeneity? Intuitively, it is that the exporters with the largest comparative

[27] Tab. A.11 presents the changes at the country level. Tab. A.12 shows the general equilibrium changes at the regional level using alternative values of θ. The results are only marginally different.

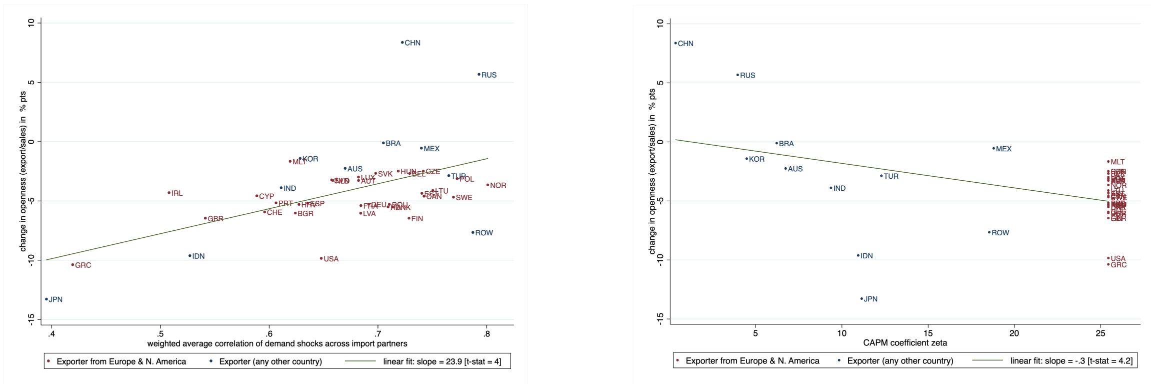
Table 4: Counterfactual changes at the regional level

	$\sigma^2_{R_\iota^M}$	$A_{\iota,0}$	E[exports]	E[sales]	utility
	partial change in %	general equilibrium change in %			
Region	(1)	(2)	(3)	(4)	(5)
Europe & N. America	35.1	-2.7	-7.3	-1.2	-2.4
[min; max] w/i region		[-9.5; -1.2]	[-13.3; -4.0]	[-5.3; -0.8]	
Australia	4.2	3.3	-0.6	1.6	-3.8
Brazil	1.8	3.2	1.4	1.5	-4.0
China	6.3	3.7	10.0	1.7	-0.4
India	5.6	3.1	-2.3	1.6	-6.9
Indonesia	8.3	1.7	-8.9	0.7	-5.4
Japan	7.8	1.7	-12.7	0.6	-11.5
Korea	12.2	4.5	1.7	3.1	-3.5
Mexico	2.3	3.0	1.8	2.4	-2.3
Russia	2.3	4.9	9.1	3.5	-3.0
Turkey	4.0	2.3	-1.4	1.5	-3.8
Rest of the World	9.0	1.0	-7.4	0.2	-16.0
World		-0.0	-4.6	0.0	
[min; max]		[-9.5; 4.9]	[-13.3; 10.0]	[-5.3; 3.5]	

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.

advantage 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. 4 Panel (a) plots the predicted change in openness (exports over sales) against the weighted average correlation of shocks across import partners, exhiting a strong 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, $\zeta_{\iota,0} = -\frac{\partial m_\iota}{\partial R_\iota^M}$ measures to what extent investor ι's marginal utility growth fluctuates with the return to the risky portfolio. The smaller $\zeta_{\iota,0}$ is, the less the investor is 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. 5 shows the results from regressions of export growth and the change in openness on the initial average correlation and $\zeta_{\iota,0}$. Both variables are individually significant predictors and together explain 68% and 47% of the variation in the counterfactual changes, respectively.

Figure 4: Counterfactual changes in openness



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

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

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 market. 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 portfolio variance of most of the other individual countries; see Col. 1 of Tab. A.10. 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. 4 shows that the initial effect (before any of the endogenous variables adjust) is a huge increase in the portfolio variance of the representative investor from EUNA compared to the portfolio variance of the representative investors from the other countries. As a consequence, investment in the risky asset decreases in EUNA; see Col. 2. This decrease leads to firm exit in all countries in this region in the range of -11% to -1%, and to 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. 6 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 that the correlation alone explains 14% of the variation in the log changes in trade shares. Next, I analyze whether geography matters for which country pairs' trade is affected more. Cols. 2 and 3 present the results of regressions of the trade share changes on bilateral distance and on a bilateral trade shares predicted with geographic variables.[28] Cols. 2 and 3 show

[28]More specifically, $\ln \phi_{geo}$ is the prediction obtained from a regression of the form $\phi_{ij} = \beta_1 \ln Dist_{ij} +$

Table 5: Counterfactual changes in exports and openness

	(1)	(2)	(3)	(4)	(5)	(6)
Dep. Var.:		$\widehat{exports}$			$\widehat{openness}$	
ρ_{wgt}	22.720***		23.608***	21.058***		21.496***
	(7.147)		(4.432)	(5.176)		(4.418)
ζ_0		-0.427***	-0.434***		-0.208***	-0.214***
		(0.069)	(0.053)		(0.066)	(0.053)
Constant	-20.628***	3.714**	-11.963***	-18.287***	0.258	-14.016***
	(4.834)	(1.553)	(3.180)	(3.501)	(1.494)	(3.169)
Observations	43	43	43	43	43	43
Adjusted R^2	0.178	0.473	0.684	0.270	0.175	0.469

Dep. Var. $\widehat{exports}$ ($\widehat{openness}$) is the counterfactual change in exports in % (openness = $\widehat{exports\text{-}sales}$ 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.

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. 4, 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 2.1 percentage points as a consequence of the increase in global demand for the risk-free asset that accompanies the increase in global volatility. The lower risk-free rate affects negatively the initial lenders (identified by shares below one in Col. 2, Tab. A.10): China, Japan, and ROW. For China, 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.

$\beta_2 Contig_{ij} + \beta_3 Smcty_{ij} + \delta_i + \delta_j + \epsilon_{ij}$, where $Contig_{ij}$ and $Smcty_{ij}$ are binary indicators for whether countries i and j are contiguous or the same country, respectively.

Table 6: Counterfactual changes in bilateral trade

Dep. Var.: $\ln \widehat{N_i \phi_{ij}}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ρ	0.331***			0.265***	0.220***	0.217***	0.233***
	(0.019)			(0.026)	(0.019)	(0.010)	(0.010)
$\ln Dist$		-0.052***		-0.020***		-0.015***	
		(0.004)		(0.005)		(0.002)	
$\ln \phi\_geo$			0.042***		0.035***		0.005***
			(0.002)		(0.002)		(0.001)
Constant	-0.317***	0.337***	0.211***	-0.113**	-0.001	-0.114***	-0.209***
	(0.015)	(0.030)	(0.013)	(0.052)	(0.022)	(0.021)	(0.013)
Fixed effects							
Imp/Exp	NO	NO	NO	NO	NO	YES	YES
N	1,849	1,764	1,764	1,764	1,764	1,764	1,764

Dep. Var. is the counterfactual log change in exports in bilateral trade shares. ρ is the inital correlation between demand shocks in the exporting and importing country, $\ln Dist$ denotes the bilateral distance between the trade partners, and ϕ_{geo} is a predicted trade share from a regression of observed trade flows on geographic characteristics.

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 the 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 trade-off 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 costs. A counterfactual analysis reveals the quantitative importance of this mechanism: Without diversification possibilities, global trade would be 4.6% 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.

References

Allen, Treb and David Atkin (2016). Volatility and the Gains from Trade. NBER Working Paper 22276, National Bureau of Economic Research.

Backus, David K. and Gregor W. Smith (1993). Consumption and Real Exchange Rates in Dynamic Economies with Non-Traded Goods. *Journal of International Economics 35*(3-4), 297–316.

Baier, Scott L., Jeffrey H. Bergstrand, and Michael Feng (2014). Economic Integration Agreements and the Margins of International Trade. *Journal of International Economics 93*(2), 339–350.

Bekaert, Geert, Campbell R. Harvey, Christian T. Lundblad, and Stephan Siegel (2011). What Segments Equity Markets? *Review of Financial Studies 24*(12), 3841–3890.

Brainard, William C. and Richard N. Cooper (1968). Uncertainty and Diversification in International Trade. *Food Research Institute Studies 8*(3), 1–29.

Callen, Michael, Jean Imbs, and Paolo Mauro (2015). Pooling Risk Among Countries. *Journal of International Economics 96*(1), 88–99.

Cameron, A. Colin, Jonah B. Gelbach, and Douglas L. Miller (2011). Robust Inference with Multiway Clustering. *Journal of Business & Economic Statistics 29*(2), 238–249.

Caselli, Francesco, Miklós Koren, Milan Lisicky, and Silvana Tenreyro (2019). Diversification Through Trade. *The Quarterly Journal of Economics 135*(1), 449–502.

Cochrane, John H. (2005). *Asset Pricing*. Princeton University Press.

Constantinides, George M. (1982). Intertemporal Asset Pricing with Heterogeneous Consumers and Without Demand Aggregation. *Journal of Business 2*, 253–267.

Costinot, Arnaud and Andres Rodriguez-Clare (2014). Trade Theory with Numbers: Quantifying the Consequences of Globalization. In G. Gopinath, E. Helpman, and K. Rogoff (Eds.), *Handbook of International Economics*, Volume 4, Chapter 4, pp. 197–261.

Das, Sanghamitra, Mark J. Roberts, and James R. Tybout (2007). Market Entry Costs, Producer Heterogeneity, and Export Dynamics. *Econometrica 75*(3), 837–873.

di Giovanni, Julian and Andrei A. Levchenko (2011). The Risk Content of Exports: A Portfolio View of International Trade. In *NBER International Seminar on Macroeconomics 2011*, NBER Chapters, pp. 97–151. National Bureau of Economic Research.

Dickstein, Michael J and Eduardo Morales (2018). What do Exporters Know? *The Quarterly Journal of Economics 133*(4), 1753–1801.

Djankov, Simeon, Caroline Freund, and Cong S. Pham (2010). Trading on Time. *Review of Economics and Statistics 92*(1), 166–173.

Dybvig, Philip H. and Jonathan E. Jr. Ingersoll (1982). Mean-Variance Theory in Complete Markets. *Journal of Business 55*(2), 233–251.

Esposito, Federico (2019). Risk Diversification and International Trade. Unpublished manuscript.

Fama, Eugene F. and Kenneth R. French (2012). Size, Value, and Momentum in International Stock Returns. *Journal of Financial Economics 105*(3), 457–472.

Fillat, José L. and Stefania Garetto (2015). Risk, Returns, and Multinational Production. *Quarterly Journal of Economics 130*(4), 2027–2073.

Fillat, José L., Stefania Garetto, and Lindsay Oldenski (2015). Diversification, Cost Structure, and the Risk Premium of Multinational Corporations. *Journal of International Economics 96*(1), 37–54.

Fisher, Irving (1930). *The Theory of Interest*. New York: Macmillian.

Fitzgerald, Doireann (2012). Trade Costs, Asset Market Frictions, and Risk Sharing. *American Economic Review 102*(6), 2700–2733.

Ghironi, Fabio and Marc Melitz (2005). International Trade and Macroeconomic Dynamics with Heterogeneous Firms. *The Quarterly Journal of Economics 120*(3), 865–915.

Gourinchas, Pierre-Olivier and Jonathan A. Parker (2002). Consumption Over the Life Cycle. *Econometrica 70*(1), 47–89.

Graham, John and Campbell Harvey (2001). The Theory and Practice of Corporate Finance: Evidence from the Field. *Journal of Financial Economics 60*, 187–243.

Grossman, Gene M. and Assaf Razin (1984). International Capital Movements Under Uncertainty. *Journal of Political Economy 92*(2), 286–306.

Head, Keith and Thierry Mayer (2014). Chapter 3 - Gravity Equations: Workhorse,Toolkit, and Cookbook. In E. H. Gita Gopinath and K. Rogoff (Eds.), *Handbook of International Economics*, Volume 4 of *Handbook of International Economics*, pp. 131–195. Elsevier.

Helpman, Elhanan (1988). Trade Patterns under Uncertainty with Country Specific Shocks. *Econometrica 56*(3), 645–659.

Helpman, Elhanan and Assaf Razin (1978). Uncertainty and International Trade in the Presence of Stock Markets. *Review of Economic Studies 45*(2), 239–250.

Hirshleifer, J. (1965). Investment Decision Under Uncertainty: Choice-Theoretic Approaches. *Quarterly Journal of Economics 79*(4), 510–536.

Hummels, David L. and Georg Schaur (2010). Hedging Price Volatility Using Fast Transport. *Journal of International Economics 82*(1), 15–25.

Islamaj, Ergys (2014). Industrial Specialization, Financial Integration and International Consumption Risk Sharing. *The B.E. Journal of Macroeconomics 14*(1), 1–33.

Jermann, Urban J. (1998). Asset Pricing in Production Economies. *Journal of Monetary Economics 41*(2), 257–275.

Koren, Miklós (2004). Financial Globalization, Portfolio Diversification, and the Pattern of International Trade. *IMF Working Papers 03*.

Kucheryavyy, Konstantin (2017). Comparative Advantage and International Risk Sharing: Together at Last. Unpublished manuscript.

Maloney, William F. and Rodrigo R. Azevedo (1995). Trade Reform, Uncertainty, and Export Promotion: Mexico 1982-88. *Journal of Development Economics 48*(1), 67–89.

Modigliani, Franco and Merton H. Miller (1958). The Cost of Capital, Corporation Finance and the Theory of Investment. *American Economic Review 48*(3), 261–297.

Obstfeld, Maurice and Kenneth Rogoff (2001). The Six Major Puzzles in International Macroeconomics: Is There a Common Cause? In *NBER Macroeconomics Annual 2000, Volume 15*, NBER Chapters, pp. 339–412. NBER.

Ossa, Ralph (2014). Trade Wars and Trade Talks with Data. *American Economic Review 104*(12), 4104–4046.

Ossa, R. (2016). Chapter 4 - Quantitative Models of Commercial Policy. Volume 1 of *Handbook of Commercial Policy*, pp. 207–259. North-Holland.

Ramondo, Natalia and Veronica Rappoport (2010). The Role of Multinational Production in a Risky Environment. *Journal of International Economics 81*(2), 240–252.

Ramondo, Natalia, Veronica Rappoport, and Kim J. Ruhl (2013). The Proximity-Concentration Tradeoff Under Uncertainty. *Review of Economic Studies 80*(4), 1582–1621.

Riaño, Alejandro (2011). Exports, Investment and Firm-Level Sales Volatility. *Review of World Economics / Weltwirtschaftliches Archiv 147*(4), 643–663.

Richmond, Robert J. (2019). Trade Network Centrality and Currency Risk Premia. *The Journal of Finance 74*(3), 1315–1361.

Rowland, Patrick F. and Linda L. Tesar (2004). Multinationals and the Gains from International Diversification. *Review of Economic Dynamics 7*(4), 789–826.

Stulz, René M. (1981). A Model of International Asset Pricing. *Journal of Financial Economics 9*(4), 383–406.

Svensson, Lars E. O. (1988). Trade in Risky Assets. *The American Economic Review 78*(3), 375–394.

Turnovsky, Stephen J. (1974). Technological and Price Uncertainty in a Ricardian Model of International Trade. *The Review of Economic Studies 41*(2), 201–217.

Appendix

A.1 Robustness: Reduced-form Results

Table A.7: 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
N	2,080,695	2,080,695	2,080,695	2,080,695	1,716,482	1,716,482

Dependent variable: log export quantity in kg. by product, country pair, and time. S.e. (in parentheses) are robust to two-way clusters at the product and country-pair levels. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Cols. 5 and 6 are based on a 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 are based on years 1985, 1995, 2005, 2015.

Besides the specifications discussed in the main text, Tabs. A.7 and A.8 present a few additional robustness checks.

Tariffs. Cols. 5 and 6 of Tab. A.7 explore the effect of adding tariffs. The tariff data is 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.

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.8, 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 specifications being insignificant. Moreover, I re-estimate Eq. (1) using five-year-spaced data and covariances computed using the five most recent years (Cols. 7 and 8) or all available years of data (Cols. 9 and 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.8, upper panel, show the importance of the aggregation level of the product classification. The coefficient estimate for $\mathrm{Cov}[M_i, \widehat{Y}_j]$ at the 2-digit level (1-digit level) becomes smaller in absolute terms (positive) and 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.8: 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	-0.011	0.002
	(0.006)	(0.072)	(0.004)	(0.055)	(0.007)	(0.048)	(0.005)	(0.031)	(0.007)	(0.069)	(0.009)	(0.015)
$\times$ ln *Dist*		0.008		0.017***		0.004		-0.006		0.008		
		(0.008)		(0.006)		(0.006)		(0.004)		(0.008)		
$\times$ Vessel		-0.053***		-0.023***		-0.001		-0.015***		-0.022***		
		(0.007)		(0.005)		(0.005)		(0.004)		(0.007)		
$\times$ Vessel		0.451***		0.193***		0.010		0.117***		0.187***		
		(0.061)		(0.044)		(0.041)		(0.032)		(0.057)		
N	21862368	21862368	17072960	17072960	7,303,953	7,303,953	6,321,376	6,321,376	2,281,127	2,281,127	401,632	85,010

	(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)
$\times$ ln *Dist*		0.003		0.001		0.013		-0.001		0.004
		(0.010)		(0.009)		(0.009)		(0.005)		(0.007)
$\times$ Vessel		-0.033***		-0.017**		-0.024***		-0.008*		-0.034***
		(0.008)		(0.008)		(0.008)		(0.004)		(0.005)
$\times$ Vessel		0.283***		0.142**		0.196***		0.058		0.287***
		(0.071)		(0.070)		(0.070)		(0.037)		(0.047)
N	2,039,752	2,039,752	2,141,349	2,141,349	1,960,372	1,960,372	4,580,341	4,580,341	21427053	21427053

All estimations include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter, importer-product-time, exporter-product-time and country-pair-product fixed effects. S.e. (in parentheses) are robust to two-way clusters at the product and country-pair levels. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The 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*. In Cols. 5 and 6 (7 and 8) $\text{Cov}(\widetilde{M}, \widehat{Y})$ is based on growth in a monthly, seasonally adjusted quantity index of industrial production (retails sales) rather than aggregate imports.

Table A.9: 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
$\text{Cov}_t\,(M,Y)$	bilateral covariance, main specification	2,080,695		.0001	.0003	-.0033	.0041
$\text{Cov}_t\,(M,Y)$ (IP)	bilateral covariance, based on *industrial production* growth	782,291		.00004	.0002	-.0009	.001
$\text{Cov}_t\,(M,Y)$ (RS)	bilateral covariance, based on *retail sales* growth	683,900		.00004	.0001	-.0007	.0007
$\text{Cov}_t\,(M,Y)$ (REG)	bilateral covariance for five regional financial markets	2,080,695		.0001	.0003	-.0025	.0036
$\text{Cov}_t\,(M,Y)$ (CG)	bilateral covariance, based on *consumption* growth	1,746,827		.00003	.0001	-.0012	.0009
$\ln(1 + Tariff)$	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 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 (series CUUR0000SA0). 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. These adjustments concern 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.

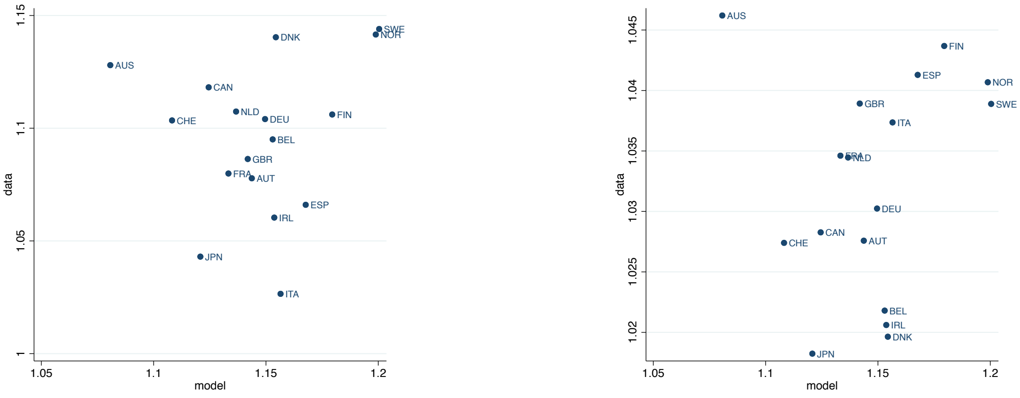
Consumption growth. Seasonally adjusted, quarterly consumption growth is used to calculate another set of covariances. The data stem from the OECD *Key Economic Indicators* (KEI) Database. It is available for all exporters in the sample except Singapore and Hong Kong, but for varying lengths of time.

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 issue concerns less than 1 percent of the sample. Additional missings are replaced with up to five lags or leads.

Primary transport mode. Source: U.S. Census Bureau FTD. I use the dataset provided by Peter Schott through his data website.[29] For each product-country-year shipment

[29] *https://sompks4.github.io/sub_data.html*

Figure A.1: 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.

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 except air, including ground transport. The resulting separation into goods shipped primarily by air or vessel is pretty strict. For only 98 of 786 products is the median air share different from zero or one.

A.3 Calibration Details, Solution Method, and Additional Results

A.3.1 Data and Variable Definitions

Unless stated otherwise, all data is obtained from the World Input Output Database (WIOD, Release 2016). Current price levels are converted to 2005 USD using the U.S. GDP deflator from the World Development Indicators database (series NY.GDP.DEFL.ZS). China and Taiwan are aggregated for lack of specific data from other sources. **Bilateral trade shares** are matched to average trade shares over the period 2005–2014. **Expected expenditure** is matched with average expenditure during 2005–2014. Intermediate input expenditure and gross fixed capital formation for the construction of **risky investments** are taken out of WIOD directly, labor costs are obtained from the supplementary Socioeconomic Accounts Data provided by WIOD. Labor costs are not available for the ROW aggregate. I construct them using the average share of intermediate goods and labor expenditure in total production for five developing and emerging economies in my sample: China, Indonesia, India, Mexico, Turkey. This share is then applied to the output of

Table A.10: Baseline values at the regional level

	$A_{\iota,0}$	$\frac{A_{\iota,0}}{A_{\iota,0}+a^f_{\iota,0}}$	$\sigma^2_{R^M_\iota}$	γ_ι	$\zeta_{\iota,0}$
Region	(1)	(2)	(3)	(4)	(5)
Europe & N. America	5.2e+07	1.1	0.004	4.9e-07	25.4
Australia	1.9e+06	1.4	0.011	3.5e-06	6.7
Brazil	2.6e+06	1.3	0.022	2.4e-06	6.2
China	1.7e+07	0.9	0.003	2.1e-08	0.4
India	2.4e+06	1.1	0.009	3.9e-06	9.4
Indonesia	1.0e+06	1.3	0.011	1.1e-05	10.9
Japan	7.8e+06	0.8	0.010	1.4e-06	11.1
Korea	2.4e+06	1.0	0.009	1.9e-06	4.5
Mexico	1.2e+06	1.5	0.018	1.6e-05	18.8
Russia	2.2e+06	1.0	0.034	1.8e-06	4.0
Turkey	9.5e+05	1.4	0.019	1.3e-05	12.3
Rest of the World	1.4e+07	0.8	0.008	1.3e-06	18.5

$A_{\iota,0}$ is in million 2005 USD.

ROW. For EUNA, the aggregate risky investment of the region is matched. Country-level risky investments within EUNA are internally calibrated using (32). **Risk-free investments** are matched with the net international investment position (series IFR_BP6_USD) from the IMF's *Balance of Payments and International Investment Positions Statistics Database*. Demand shocks used to construct Σ_Y are obtained as the residuals of the regression

$$\mathrm{d}\ln Y_{j,t} = \delta_j + \epsilon_{j,t},$$

where $Y_{j,t}$ equals the annual total expenditure of country j at time t. $Y_{j,t}$ is taken from WIOD directly and the covariance matrix of residuals is computed over the period 2005–2014. The **global risk-free rate** is computed as weighted average over all countries' annualized government bond rates net of inflation using country size (total expenditure) as weights. The primary source of government bond rates is the IMF's *International Financial Statistics Database*, missing data is supplemented with rates from the OECD's *Key Economic Indicators*, and the ECB's *Statistical Data Warehouse*. Consumer price inflation rates for all countries are obtained from the *BIS Statistics Warehouse*.

A.3.2 Solution Method

The numerical solution algorithm starts with guessing $R^{f'}$ and $\boldsymbol{\lambda'}$. First, it iterates over (37), (38), (39) for a given $R^{f'}$ until the risk premia in (36) converge, producing intermediate solutions for the changes in the number of firms $\widehat{\boldsymbol{N}}(R^{f'})$, trade shares $\widehat{\boldsymbol{\psi}}(R^{f'})$, and risk premia $\widehat{\boldsymbol{\lambda}}(R^{f'})$, and intermediate solutions for the covariance matrix $\Sigma'_{R_i}(R^{f'})$ and expected values of individual and portfolio returns $\boldsymbol{R}'(R^{f'})$ in accordance with (41). Second, the algorithm iterates over $R^{f'}$ until the global surplus in demand for the risk-free asset, in accordance with (40), is zero.

A.3.3 Additional Results

Table A.11: Counterfactual changes at the country level

ISO	$A_{\iota,0}$	exports	sales	Π_i	$E[R_i]$	$\sigma^2_{R_i}$	Region
	general equilibrium change in %						
AUS	3.3	-0.6	1.6	6.8	-1.6	1.0	Australia
BRA	3.2	1.4	1.5	6.9	-1.6	-1.4	Brazil
CHN	3.7	10.0	1.7	9.4	-2.0	2.7	China
AUT	-2.8	-4.4	-1.1	-7.1	1.7	10.6	Europe & N. America
BEL	-2.8	-4.0	-1.3	-5.8	1.5	11.5	Europe & N. America
BGR	-8.5	-9.5	-3.4	-22.8	5.5	19.7	Europe & N. America
CAN	-5.3	-6.9	-2.3	-14.3	3.2	12.2	Europe & N. America
CHE	-5.7	-8.3	-2.4	-15.9	3.5	25.0	Europe & N. America
CYP	-7.6	-7.6	-3.0	-20.5	4.9	22.3	Europe & N. America
CZE	-5.9	-4.7	-2.2	-17.1	3.9	12.9	Europe & N. America
DEU	-3.2	-6.9	-1.6	-6.6	1.7	11.7	Europe & N. America
DNK	-3.6	-7.7	-2.1	-5.4	1.5	13.3	Europe & N. America
ESP	-3.9	-6.1	-0.9	-13.2	3.1	11.2	Europe & N. America
EST	-5.6	-6.9	-2.6	-13.5	3.2	12.6	Europe & N. America
FIN	-3.9	-8.7	-2.2	-7.1	1.8	9.8	Europe & N. America
FRA	-2.3	-6.3	-0.9	-5.4	1.3	8.8	Europe & N. America
GBR	-4.8	-7.8	-1.3	-15.6	3.6	20.0	Europe & N. America
GRC	-9.4	-13.3	-3.0	-27.9	7.1	27.5	Europe & N. America
HRV	-6.6	-7.8	-2.5	-18.6	4.3	16.7	Europe & N. America
HUN	-5.0	-4.8	-2.4	-11.7	2.8	13.9	Europe & N. America
IRL	-7.4	-7.8	-3.5	-21.0	4.1	37.1	Europe & N. America
ITA	-2.4	-6.4	-0.9	-6.2	1.5	7.4	Europe & N. America
LTU	-9.0	-9.4	-5.3	-16.8	4.1	14.5	Europe & N. America
LUX	-6.2	-6.8	-3.9	-10.8	2.5	25.4	Europe & N. America
LVA	-9.5	-9.3	-3.2	-27.9	6.9	19.9	Europe & N. America
MLT	-5.4	-4.1	-2.5	-13.9	3.1	33.9	Europe & N. America
NLD	-3.8	-5.2	-1.9	-8.3	2.0	14.8	Europe & N. America
NOR	-3.9	-5.2	-1.5	-10.0	2.4	12.3	Europe & N. America
POL	-5.0	-4.9	-1.8	-14.1	3.4	10.3	Europe & N. America
PRT	-3.9	-6.2	-1.0	-13.0	3.0	13.1	Europe & N. America
ROU	-6.8	-7.4	-2.1	-20.8	5.0	14.3	Europe & N. America
SVK	-7.8	-6.4	-3.7	-20.0	4.5	15.5	Europe & N. America
SVN	-5.0	-5.0	-1.8	-15.0	3.3	13.7	Europe & N. America
SWE	-4.4	-6.6	-1.9	-10.9	2.6	12.6	Europe & N. America
USA	-1.2	-10.7	-0.8	-1.4	0.4	6.9	Europe & N. America
IND	3.1	-2.3	1.6	6.0	-1.4	2.7	India
IDN	1.7	-8.9	0.7	4.2	-0.9	6.6	Indonesia
JPN	1.7	-12.7	0.6	5.0	-1.1	5.7	Japan
KOR	4.5	1.7	3.1	5.2	-1.4	9.2	Korea
MEX	3.0	1.8	2.4	2.0	-0.6	0.5	Mexico
ROW	1.0	-7.4	0.2	4.0	-0.7	6.9	Rest of the World
RUS	4.9	9.1	3.5	5.3	-1.3	-1.1	Russia
TUR	2.3	-1.4	1.5	3.8	-0.8	2.4	Turkey

Table A.12: Counterfactual changes at the regional level: Alternative θs

	$A_{\iota,0}$	E[exports]	E[sales]	utility	$A_{\iota,0}$	E[exports]	E[sales]	utility
	$\theta = 8$				$\theta = 10$			
Region	general equilibrium change in %							
Europe & N. America	-2.8	-7.5	-1.3	-2.4	-2.7	-7.3	-1.2	-2.4
[min; max] w/i region	[-9.8; -1.2]	[-14.5; -4.0]	[-6.0; -0.8]		[-9.5; -1.2]	[-13.3; -4.0]	[-5.3; -0.8]	
Australia	3.3	-0.4	1.7	-3.8	3.3	-0.6	1.6	-3.8
Brazil	3.2	1.8	1.6	-3.9	3.2	1.4	1.5	-4.0
China	3.8	10.6	1.7	-0.4	3.7	10.0	1.7	-0.4
India	3.1	-1.9	1.7	-6.9	3.1	-2.3	1.6	-6.9
Indonesia	1.7	-8.8	0.7	-5.3	1.7	-8.9	0.7	-5.4
Japan	1.7	-12.6	0.6	-11.4	1.7	-12.7	0.6	-11.5
Korea	4.7	2.2	3.2	-3.5	4.5	1.7	3.1	-3.5
Mexico	3.1	2.3	2.5	-2.0	3.0	1.8	2.4	-2.3
Rest of the World	1.0	-7.3	0.3	-15.9	1.0	-7.4	0.2	-16.0
Russia	5.0	10.1	3.7	-2.9	4.9	9.1	3.5	-3.0
Turkey	2.3	-1.0	1.6	-3.6	2.3	-1.4	1.5	-3.8
World		-4.6	0.0			-4.6	0.0	
[min; max]	[-9.8; 5.0]	[-14.5; 10.6]	[-6.0; 3.7]		[-9.5; 4.9]	[-13.3; 10.0]	[-5.3; 3.5]	