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

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Abstract

Firms facing uncertain demand at the time of production expose their shareholders to volatile returns. Risk-averse investors trading multiple assets will favor stocks that tend to yield high returns in bad times, that is, when the marginal utility of consumption is high. In this paper, I develop a firm-level gravity model of trade with risk-averse investors to show that firms seeking to maximize their present value will take into account that shareholders discount expected profits depending on the correlation with their expected marginal utility of consumption. The model predicts that, ceteris paribus, firms sell more to markets where profits covary less with the income of their investors. This holds true even in the presence of complete and internationally integrated financial markets. To test the model's prediction, I use data on stock returns to estimate covariances between demand growth in export markets and expected marginal utility growth of investors in 21 countries. I then show that the covariance pattern is reflected in the pattern of these countries' exports across destination markets and time within narrowly defined product-level categories, as predicted by the model. I conclude that by maximizing shareholder value, exporters are actively engaged in global risk sharing.

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1 Introduction

Firms engaged in international trade expose their shareholders to income volatility if profits earned in foreign destination markets are stochastic. At the same time, however, firms' international activity has the potential to diversify the income risk associated with shocks to shareholders' other sources of income. Trade's potential for consumption risk sharing between countries is well understood; its effectiveness in doing so, however, is rarely confirmed by the data (Backus and Smith, 1993). Goods market frictions limit the attractiveness of trade as a means of equalizing differences in marginal utility of consumption across countries.[1] Likewise, asset market frictions prevent full consumption risk sharing from being achieved by means of international portfolio investment.[2]

Nevertheless, competitive firms strive to maximize the net present value of their operations conditional on the prevalence of goods and asset market frictions. For firms owned by risk-averse shareholders who dislike consumption volatility this means taking into account that the shareholders care not only about the level of expected profits, but also about their distribution across good states and bad states. Survey evidence confirms this. Based on the responses of 392 chief financial officers (CFO) to a survey conducted among U.S. firms in 1999, Graham and Harvey (2001) report that more than 70% always or almost always use discount factors that account for the covariance of returns with movements in investors' total wealth to evaluate the profitability of an investment. 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. Although the concept of optimal decision-making based on expected payoffs *and* riskiness as perceived by investors trading multiple assets is prevalent in the literature on firms' optimal choices of production technologies[3] and in the literature on international trade and investment under uncertainty,[4] the concept has not, to date, made its way into the literature devoted to firms' exporting decisions under demand un-

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

[2]Ample evidence shows that international equity markets continue to be fairly disintegrated to date. See Fama and French (2012) for recent evidence and a comprehensive overview of previous evidence based on equity return data. Fitzgerald (2012) finds that conditional on the presence of trade cost, risk sharing is close to complete among developed countries, but significantly impeded by asset market frictions between developed and developing countries. Bekaert et al. (2011) and Callen et al. (2015) reach a similar conclusion.

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

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

certainty. This literature considers either risk-neutral firms[5] or risk-averse firms acting in the absence of internationally integrated financial markets.[6] My paper addresses this oversight.

I show both theoretically and empirically that investors' desire for smooth consumption has important consequences for firms' optimal pattern of exports across destination markets. Moreover, I show that firms' incentive to exploit the correlation pattern of shocks to the benefit of their investors prevail *even if* financial markets are complete and fully integrated internationally. This incentive hinges *only* on the presence of aggregate risk, that is, fluctuations in aggregate consumption over time. Completeness of financial markets implies the existence of markets for insurance, thus allowing for costless diversification of idiosyncratic risk. Insurance against aggregate risk, however, is costly nevertheless. In this environment, shareholder-value-maximizing firms' marginal cost of capital differ across export destination markets, depending on the degrees to which demand shocks in a destination market constitute aggregate or diversifiable risk. Through the cost of capital, firms are incentivized to trade off expected profits against the cost of insuring the aggregate risk involved in exporting to a specific market. 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, they deviate from the first-best quantity under risk neutrality. The data support this theory: using bilateral product-level exports for multiple countries, I find that, conditional on market size and trade cost, more is exported to those markets where expected profits correlate negatively with the income of investors in the exporting country.

I build a general equilibrium model with multiple countries where firms owned by risk-averse investors make exporting decisions under uncertainty. The key assumption is that firms have to make production decisions for *every* destination market *before* knowing the level of demand. There is ample evidence that exporters face significant time lags between production and sales of their goods.[7] Moreover, a sizable literature documents that investors care about firms' operations in foreign markets and the potential of these operations to diversify the risk associated with volatility of aggregate consumption or the aggregate domestic stock market (see, e.g., Rowland and Tesar, 2004; Fillat et al.,

[5]See, for example, Das et al. (2007), Ramondo et al. (2013), Dickstein and Morales (2015), and Morales et al. (2015).

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

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

2015). However, little is known about how investors' desire for consumption smoothing changes firms' incentives to export to specific markets, or what this means for the pattern of aggregate bilateral trade and global risk sharing. Here lies the contribution of my paper. I show that introducing risk-averse investors and a time lag between production and sales in an otherwise standard monopolistic competition setup leads to a firm-level gravity equation that includes a novel determinant of bilateral trade flows: the model predicts that, ceteris paribus, firms ship more to countries where demand shocks are more positively correlated with the marginal utility of firms' investors.

In the model, the stochastic process of aggregate consumption and, in particular, the implied volatility of marginal utility, which reflects the amount of aggregate risk borne by a representative agent in equilibrium, are determined as aggregate outcomes of firms' and investors' optimal decisions. Under some additional assumptions regarding the stochastic nature of the underlying shocks, the model facilitates an intuitive decomposition of the equilibrium amount of aggregate volatility into contributions by individual countries, which are determined by the volatility of country-specific shocks and endogenous aggregate bilateral exposures to these shocks through trade and investment. From those country-specific contributions to aggregate risk, I derive a structural expression for the covariances of country shocks with expected marginal utility growth of investors, which are key for investors' and firms' individual optimal decisions.

Based on methodology developed in the asset pricing literature, I use the structure of the model to estimate the covariance pattern of demand shocks in 175 destination markets with with marginal utility growth of representative investors for 21 exporting countries. With those estimated covariances at hand, I then test the main prediction of the model using a panel of exports by country pair and product. Looking at variation across time within narrowly defined country-pair-product cells, I find that, conditional on market size and trade cost, changes in the pattern of exports across destination markets over 30 years can in part be explained by changes in the correlation pattern of destination-market-specific demand shocks with the exporters' investors' marginal utility growth. This implies that exporters respond to investors' desire for consumption smoothing and hence, by virtue of shareholder-value maximization, play an active role in global risk sharing.

Moreover, I find differential effects across country pairs and products, lending support to the model's key assumption–the time lag between production and sales. I find that the correlation pattern has a stronger impact on exports between more distant markets. The effect of distance is particularly strong for products shipped by vessel rather than by air, for which distance constitutes a relevant time cost. These findings suggest that time lags are indeed key to understanding the importance of demand volatility for exports and, in particular, the role of the correlation pattern of country shocks in determining the pattern of exports across destination markets.

These results are consistent with other findings from the survey by Graham and Harvey (2001). In that survey, CFOs were asked to state whether and, if so, what kind of risk factors in addition to market risk (the overall correlation with the stock market) they use to adjust discount rates. Interest rates, foreign exchange rates, and the business cycle are the most important risk factors mentioned, but inflation and commodity prices were also listed as significant sources of risk.[8] Many of these risk factors are linked to the term structure of investment and returns; interest rate risk, exchange rate risk, inflation, and commodity price risk all indicate that firms have limited ability to timely adjust their operations to current conditions.

2 Related Literature

The model developed in this paper builds on the literature that provided structural microfoundations for the gravity equation of international trade (for a comprehensive survey of this literature, see Costinot and Rodriguez-Clare, 2014). I introduce risk-averse investors and shareholder-value-maximizing firms into this framework to show that demand uncertainty and, in particular, cross-country correlations of demand volatility alter the cross-sectional predictions of standard gravity models.[9] 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).

This paper is also related to the literature on international trade and investment under uncertainty. Helpman and Razin (1978) show that the central predictions of neoclassical trade models remain valid under technological uncertainty in the presence of complete contingent claims markets. Grossman and Razin (1984) and Helpman (1988) analyze the pattern of trade and capital flows among countries in the absence of trade frictions. Egger and Falkinger (2015) recently developed a general equilibrium framework with international trade in goods and assets encompassing frictions on both markets. In these

[8] Cp. Figure 4 in Graham and Harvey (2001).

[9] The model proposed in this paper nests the standard gravity equation as a special case. Trivially, elimination of the time lag implies that export quantities are always optimally adjusted to the current level of demand and, hence, cross-sectional predictions follow the standard 'law of gravity.' Likewise, the covariance pattern of demand growth plays no role if investors are risk neutral or if demand grows deterministically.

models, countries exhibit fluctuations in productivity. Risk-averse agents may buy shares of domestic and foreign firms whose returns are subject to productivity shocks in their respective home countries. Grossman and Razin (1984) point out that in this setting, investment tends to flow toward the country where shocks are positively correlated with marginal utility. Once productivity is revealed, production takes place and final goods are exported to remunerate investors. In contrast to this literature where diversification is solely in the hand of investors, I argue that there are incentives in addition to profit maximization for internationally active firms to engage in diversification. The key assumption I make in this regard is market specificity of the ex-ante decided-upon optimal quantities, which implies that firms can alter the riskiness of expected profits in terms of their covariance with investors' marginal utility by producing more or less for markets characterized by correlated demand shocks. If, in contrast, only total output, but not the market-specific quantities, has to be determined ex-ante, as in the earlier literature, then relative sales across markets will be perfectly adjusted to current conditions and this additional decision margin of firms vanishes.

The foreign direct investment model developed by Ramondo and Rappoport (2010) shows that market specificity of investment opens up the possibility for firms to engage in consumption smoothing even in the presence of perfectly integrated international asset markets. In their model, free trade in assets leads to perfect comovement of consumption with world output. Multinational firms' location choices affect the volatility of global production and their optimal choices balance the diversification effects of locations that are negatively correlated with the rest of the world and gains from economies of scale that are larger in larger markets. My paper complements these findings by showing that a similar rationale applies to firms' market-specific export decisions under various degrees of financial market integration.[10]

Empirical evidence supports the relevancy of market specificity of investment through which firms' international activities expose shareholders to country-specific volatility. Fillat et al. (2015) and Fillat and Garetto (2015) find that investors demand compensation in the form of higher returns for holding shares of internationally active firms and 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 firm's home

[10]My paper also differs with regard to the increasing returns to scale assumption. Even though there are increasing returns at the firm level, I assume that aggregate country-level output exhibits decreasing returns to scale, which is another natural force limiting the possibility of risk diversification through trade and investment. Decreasing returns in the aggregate imply that more investment in a market offering great diversification benefits thanks to negatively correlated shocks with the rest of the world decreases the expected return to that investment. Optimal investment choices balance these two opposing forces.

country. In their model, demand volatility in foreign markets exposes shareholders to additional risk because firms may be willing to endure losses for some time if they have sunk costs to enter these markets. Once sunk costs have been paid, firms maximize per-period profits for whatever demand level obtains. Hence, the fact that firms' investors perceive some markets as riskier than others influences the market entry decision, but does not impact the level of sales. I do not consider entry cost and instead focus on the implications of longer time lags between production and foreign sales, which have an impact on the intensive margin of firms' optimal exports. My paper is similar to Fillat and Garetto (2015) and Fillat et al. (2015) in that I also develop a structural model linking firm values to the distribution of marginal utility growth, which, in turn, depends on the distribution of country shocks. However, those authors analyze asset returns conditional on firms choices, whereas my focus lies on the optimal choices themselves. Moreover, thanks to its simpler dynamic structure, I am able to close the model and determine the distribution of investors' marginal utility growth in general equilibrium.

The paper is related to the literature on firm investment under uncertainty, specifically the strand following Jermann (1998) that models the supply and demand side for equity in general equilibrium by linking both firms' investment and investors' consumption to volatile economic fundamentals such as productivity shocks. Models augmented with various types of friction, such as capital adjustment cost (Jermann, 1998), financial constraints (Gomes et al., 2003), and inflexible labor (Boldrin et al., 2001), have proven more successful in matching macroeconomic dynamics and replicating the cross-section of asset returns. In this paper, I show that market specificity of investment in conjunction with a time lag between production and sales caused by longer shipping times for international trade have the potential to play a role similar to adjustment costs.

Demand volatility in conjunction with time lags between production and sales or, more generally, in conjunction with adjustment cost, has been shown to impact various decision margins of (risk-neutral) exporters and importers (Aizenman, 2004; Alessandria et al., 2010; Hummels and Schaur, 2010; Békés et al., 2015). Demand volatility in these settings is costly because it can lead to suboptimal levels of supply or incur expenses for hedging technologies such as fast but expensive air shipments, costly inventory holdings, or high-frequency shipping. My findings contribute to this literature by showing that risk aversion on the part of firms' investors changes the perceived costliness of destination-market-specific volatility depending on the correlation with marginal utility growth.[11]

[11]Even though the model ignores the possibility of hedging risk by means of inventory holdings or fast transport, it implies that optimal market-specific hedging choices will be affected by investors' perception of costliness. Differential perception of the costliness of volatility depending on the covariance with aggregate risk is prevalent in the literature on optimal inventory choices with regard to domestic

A small but growing literature analyzes the problem of risk-averse firms in the absence of financial markets (Maloney and Azevedo, 1995; Riaño, 2011; Esposito, 2016). In this setup, firms optimize a mean-variance tradeoff by exploiting imperfectly correlated demand shocks in foreign markets. For these firms, a lower variance of total demand is always desirable. I show that this logic does not carry over to the arguably more realistic case of risk-averse investors who have access to multiple assets. Since investors aim to minimize the variance of consumption, it is the sign and the magnitude of the covariance of firms' profits with investors' consumption that guides shareholder-value-maximizing firms' diversification incentives, rather than the variance of profits per se.[12]

3 Theory

Consider a world consisting of H countries inhabited by individuals who derive utility from consumption of a final good and earn income from the ownership of assets, including shares of firms that produce differentiated intermediate goods. These goods are sold to domestic and foreign final goods producers whose productivity is subject to country-specific shocks, rendering intermediate goods producers' profits stochastic. Hence, their investors' income is (partly) stochastic as well. I consider two scenarios of financial market integration: financial autarky and globally integrated financial markets. Under financial autarky, the set of firm shares available to an investor from any country is the set of homogeneous domestic intermediate goods producers. Under globally integrated financial markets, the set of available firm shares encompasses all domestic and foreign firms.[13]

I assume that financial markets are complete, that is, asset trade is unrestricted and costless within national financial markets (on the global financial market) in the case of financial autarky (globally integrated financial markets). Completeness of financial markets means that creating and trading assets contingent on any state of the world is unrestricted and costless and, hence, idiosyncratic risk can be fully diversified. Moreover, I assume that individuals have von Neumann-Morgenstern preferences, concave per-period utility functions, and hold identical beliefs about the probabilities with which uncertain

demand volatility (see, e.g., Khan and Thomas, 2007).

[12]This does not, however, preclude a direct effect of demand volatility on expected profits running through the expected incurrence of adjustment cost, which exists independently of firms' or investors' risk preferences.

[13]The model can be extended to encompass an intermediate case of financial market integration, where unrestricted asset trade is possible within blocks of countries or regions, but not across regional borders. For the sake of notational simplicity, I describe only the two polar cases.

events occur. Under those assumptions, aggregate investment and consumption patterns resulting in the decentralized equilibrium with lifetime-utility-maximizing individuals can be described by the optimal choices of a representative investor who possesses the sum of all individuals' wealth and invests only in "primary" assets, that is, firm shares and the risk-free asset (see Constantinides, 1982).[14] In a complete financial market, the creation and trade of "financial" assets, such as insurance policies, options, or futures, has no bearing on the representative investor's optimal consumption or investment decisions.[15] This does not mean that none of those assets are traded; in fact, they are essential for eliminating idiosyncratic risk and, therefore, for facilitating the description of equilibrium by means of a representative investor in the first place. However, since by definition they must be in zero net supply, they cannot mitigate aggregate risk. Thus, their presence does not have an impact on the representative investor's tradeoff between risky assets and the risk-free investment, nor on his tradeoff between consumption and investment.

3.1 Utility, Consumption, and Investment

The expected utility that a risk-averse agent who is representative of country i derives from lifetime consumption $\{C_{i,t+s}\}_{s=0}^{\infty}$ is given by

$$U_{i,t} = \mathrm{E}_t \sum_{s=0}^{\infty} \rho_i^s u_i(C_{i,t+s}) \qquad \text{with} \qquad u_i'(\cdot) > 0,\ u_i''(\cdot) < 0, \tag{1}$$

where ρ_i is his time preference rate. In the case of autarkic financial markets, there is a distinct representative investor for every country $i \in \mathcal{H}$ who owns the total wealth of all agents in country i. In the case of globally integrated financial markets, there is only one investor who is representative of all countries and owns the total of all countries' wealth.

Let the agent's wealth in either case be denoted with $W_{i,t}$. Every period, the agent splits his wealth between consumption $C_{i,t}$, investment $a_{i,t}^f$ in a risk-free asset that yields a certain gross return $R_{i,t+1}^f$ in the next period, and risky investments $a_{ij,t}$ in shares of firms of types $j \in \mathcal{J}_i$, that yield stochastic gross return $R_{j,t+1}$. His budget constraint is

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

[15]I follow Dybvig and Ingersoll (1982)'s terminology in differentiating "financial" or "derivative" assets from "primary" assets, where the former are defined by being in zero net supply and therefore, in contrast to the latter which are in positive net supply, have no impact on *aggregate* wealth of the economy. Firm shares are the prototype of primary assets. More generally, primary assets can be characterized by the set of assets which form the aggregate asset wealth portfolio.

thus

$$W_{i,t} = A_{i,t} + C_{i,t} \quad \text{where} \quad A_{i,t} = \sum_{j \in \mathcal{J}_i} a_{ij,t} + a^f_{i,t} \tag{2}$$

and his wealth evolves over time according to

$$W_{i,t+1} = R^W_{i,t+1} \left(W_{i,t} - C_{i,t} \right) \quad \text{with} \quad R^W_{i,t+1} = \sum_{j \in \mathcal{J}_i} \frac{a_{ij,t}}{A_{i,t}} R_{j,t+1} + \frac{a^f_{i,t}}{A_{i,t}} R^f_{i,t+1}, \tag{3}$$

where $R^W_{i,t+1}$ denotes the gross return to the wealth portfolio $A_{i,t}$. Every period, the investor chooses optimal investments $a^f_{i,t}$ and $\boldsymbol{a}_{i,t} = [a_{i1,t}, ..., a_{ij,t}, ..., a_{iJ_i,t}]$, where J_i is the number of available assets in $\mathcal{J}_i$ which depends on the degree of financial market integration. His optimization problem reads

$$\max_{\boldsymbol{a}_{i,t}, a^f_{i,t}} \ \mathrm{E}_t \sum_{s=0}^{\infty} \rho_i^s u_i(C_{i,t+s}) \quad \text{s.t.} \quad \text{Equations (2), (3), and} \lim_{s \to \infty} \frac{A_{i,t+s}}{\mathrm{E}_t \left[R^W_{i,t+s} \right]} = 0. \tag{4}$$

The last constraint is the no-Ponzi-game condition. The investor's first-order conditions yield an Euler equation for the risk-free asset,

$$\mathrm{E}_t \left[\rho_i \frac{u_i'(C_{i,t+1})}{u_i'(C_{i,t})} \right] R^f_{i,t+1} = 1, \tag{5}$$

and Euler equations for the risky assets,

$$\mathrm{E}_t \left[\rho_i \frac{u_i'(C_{i,t+1})}{u_i'(C_{i,t})} R_{j,t+1} \right] = 1 \quad \forall \ j \in \mathcal{J}_i. \tag{6}$$

The Euler equations describe the solution to the consumption-investment tradeoff: investment (disinvestment) occurs until the price paid today, that is, one unit of the consumption good, is smaller (larger) than the expected return tomorrow. The return tomorrow is scaled by the time preference rate and expected marginal utility growth to account for the investor's impatience and a possible change in his valuation of an additional unit of the consumption good. This scaling factor

$$m_{i,t+1} := \rho_i \frac{u_i'(C_{i,t+1})}{u_i'(C_{i,t})} \tag{7}$$

is commonly referred to as the stochastic discount factor (SDF). More investment in any asset increases expected consumption tomorrow at the expense of consumption today so that expected growth in marginal utility decreases.

The Euler equations also describe the representative investor's willingness to pay for assets with different risk characteristics. Consider an asset with a stochastic payoff $s_{j,t+1}$ that trades at some price $v_{i,t}$ so that its return per unit of investment is $R_{j,t+1} = \frac{s_{j,t+1}}{v_{j,t}}$. Then, the investor's first-order condition (6) demands that in equilibrium

$$v_{j,t} = \mathrm{E}_t\left[m_{i,t+1}s_{j,t+1}\right] = \frac{\mathrm{E}_t\left[s_{j,t+1}\right]}{R^f_{i,t+1}} + \mathrm{Cov}_t\left[m_{i,t+1}, s_{j,t+s}\right], \tag{8}$$

the equilibrium price of asset j must be equal to the representative investor's willingness to pay, which is equal to the payoff $s_{j,t+1}$ discounted with the SDF. The second equality uses Equation (5) to substitute $1/R^f_{i,t+1}$ for $\mathrm{E}_t[m_{i,t+1}]$ and shows that the investor's willingness to pay for any asset is determined not only by its expected value discounted with the risk-free interest rate, but also by the *covariance* of its payoff with $m_{i,t+1}$, 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 expected consumption tomorrow is less valuable. In contrast, the SDF is large in bad times, when consumption is small relative to today and marginal utility growth is high. Equation (8) states that assets whose payoffs tend to be high in times when expected marginal utility is high are more valuable to the investor.[16] Note that the distribution of consumption growth is endogenous to the investor's investment choices, and so are the covariances of assets with the SDF. As the share of asset j in the investor's total portfolio, $\frac{a_{ij,t}}{A_{i,t}}$, increases, its return becomes more correlated with the investor's total wealth $R^W_{i,t+1}A_{i,t}$. Asset j becomes less attractive as a means of consumption smoothing and, hence, the investor becomes less willing to pay for additional units of this asset.

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. For a given number of available firm shares with specific stochastic payoffs, Equation (8) thus determines share prices. The supply of shares and the stochastic properties of their returns will be endogenously determined by firms' entry and production decisions, which are described in the following section. The risk-free asset is assumed to be in unlimited supply.

[16]Note that this is an immediate implication of investors' risk aversion. With risk neutrality ($u'' = 0$), the discount factor would be constant and thus perfectly uncorrelated with any dividend stream.

3.2 Firm Behavior

The production process involves two stages. Each country produces differentiated tradable varieties and a final investment and consumption good that uses domestic and imported differentiated varieties as inputs. The final good is freely tradable and serves as numéraire. It is either consumed, invested in the risk-free asset, or used as an input in the production of differentiated varieties. Final good producers in country h bundle $\bar{q}_{jh,t}$ units of domestic and imported varieties $j \in \mathcal{N}_t$ into the composite good $Y_{h,t}$ based on the production function

$$Y_{h,t} = \psi_{h,t} \bar{Q}_{h,t}^{\eta} \quad \text{with} \quad \bar{Q}_{h,t} = \left(\sum_{j \in \mathcal{N}_t} (\bar{q}_{jh,t})^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \tag{9}$$

with $\varepsilon > 1$ and $0 < \eta < 1$. Moreover, I assume that $\eta\varepsilon/(\varepsilon - 1) < 1$, which implies that the elasticity of output with respect to the number of varieties is smaller than one and that the marginal productivity of the first variety is infinite. $\psi_{h,t}$ describes country h's state of technology at time t. I assume that at each point in time, country-specific productivities $\psi_{h,t}$ are drawn from a multivariate distribution with non-negative support and finite expected values.[17] The distribution is known to all agents of the model.

Inverse demand for any individual variety of the differentiated good is

$$p_{jh,t}(\bar{q}_{jh,t}) = \eta \left(\frac{\bar{q}_{jh,t}}{\bar{Q}_{h,t}} \right)^{-\frac{1}{\varepsilon}} \frac{Y_{h,t}}{\bar{Q}_{h,t}}, \tag{10}$$

where $p_{jh,t}$ is the price of variety j in country h.

In the differentiated goods sector, firms from country $i \in \mathcal{H}$ produce varieties using c_i units of the composite good per unit of output and, when shipping goods to country h, they face iceberg-type trade costs $\tau_{ih} \geq 1$. Moreover, each period, firms pay a fixed cost α_i.[18] I assume that firms within each country are homogeneous with respect to cost, but every firm produces a distinct variety. Since I will be considering a representative firm for a given country, I henceforth index firms by their home country i. The number of firms and varieties from country i, that is endogeneously determined by a free entry condition, is $N_{i,t}$.

[17] As discussed in more detail below, some further assumptions about the distribution will be needed for parts of the general equilibrium analysis.

[18] Production and trade cost may well vary over time. However, this has no bearing on the qualitative predictions of the model and therefore, for the sake of simplicity, I omit time indices on these variables.

Demand for a firm's variety in any destination market h is volatile because it depends on the destination country's stochastic state of productivity $\psi_{h,t}$. I assume that variety producers have to decide on the optimal output quantity for a given market *before* the productivity of the destination country is known because production and shipping take time. Hence, at time t they choose the quantity $q_{ih,t} = \bar{q}_{ih,t+1}$ to be sold in $t+1$ and they base this decision on expectations.[19] Consequently, the amount of the composite good at time t is also determined a period in advance and follows as $\bar{Q}_{h,t+1} = Q_{h,t} = \left(\sum_{i \in \mathcal{H}} N_{i,t} \left(q_{ih,t}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}$.

With quantities determined, the price that variety producers expect depends on the realization of the stochastic productivity level in the destination country:

$$\mathrm{E}_t\left[p_{ih,t+1}\right] = \eta \left(\frac{q_{ih,t}}{Q_{h,t}}\right)^{-\frac{1}{\varepsilon}} Q_{h,t}^{\eta-1} \mathrm{E}_t\left[\psi_{h,t+1}\right] = \eta \left(\frac{q_{ih,t}}{Q_{h,t}}\right)^{-\frac{1}{\varepsilon}} \frac{\mathrm{E}_t\left[Y_{h,t+1}\right]}{Q_{h,t}} \tag{11}$$

At time t, firm i thus expects to make the following operating profit in market h at time $t+1$:

$$\mathrm{E}_t\left[\pi_{ih,t+1}\right] = \mathrm{E}_t\left[p_{ih,t+1}(q_{ih,t}) \cdot q_{ih,t} - c_i \tau_{ih} q_{ih,t+1}\right] \tag{12}$$

Note that current revenue depends on the quantity produced at time t, while current costs depend on the quantity produced in $t+1$. Total profits are $\pi_{i,t+1} = \sum_{h \in \mathcal{H}} \pi_{ih,t+1} - \alpha_i$.

Firm i maximizes its net present value, acknowledging that its investors' discount factor is stochastic and potentially correlated with the profit it expects to make in different markets. For firm i, the relevant discount factor is $m_{i,t+1}$, the SDF of the representative investor for country i.[20] Remember that if financial markets are globally integrated, the representative investor for country i is also the representative investor for all other countries. Hence, in that case $m_{i,t+1} = m_{t+1} \; \forall \; i \in \mathcal{H}$. The firm takes the distribution of

[19] I have thus implicitly assumed that firms cannot reallocate quantities across markets once the demand uncertainty has been resolved or, more generally, that the costs of adjusting market-specific quantities are prohibitive. I thus ignore the possibility that firms engage in (costly) inventory holdings or rely on fast transportation to hedge demand volatility. The implications of non-prohibitive adjustment cost for the theoretical results are addressed below.

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

the SDF as given; hence, its optimization problem reads

$$\max_{[q_{ih,t+s}\geq 0]_{s=0}^{\infty}\ \forall h} \quad V_{i,t} = \mathrm{E}_t\left[\sum_{s=0}^{\infty} m_{i,t+s}\cdot \pi_{i,t+s}\right]. \tag{13}$$

Since quantities can always be adjusted one period ahead of sales, the optimal choice of $q_{ih,t}$ at any time t can be simplified to a two-period problem, that is,

$$\max_{q_{ih,t}\geq 0\ \forall h} \quad \mathrm{E}_t\left[m_{i,t+1}\cdot \sum_{h\in\mathcal{H}} p_{ih,t+1}(q_{ih,t})\cdot q_{ih,t}\right] - \sum_{h\in\mathcal{H}} c_i\tau_{ih}q_{ih,t} - \alpha_i. \tag{14}$$

Equivalently, the shareholder-value-maximizing firm's problem can be stated in terms of cost of capital. First note that Equations (6), (5), and (7) can be combined to show that the return on any risky assets j that investors demand in equilibrium is given by

$$\mathrm{E}_t\left[R_{j,t+1}\right] = R_{i,t+1}^f - \mathrm{Cov}_t\left[\frac{m_{i,t+1}}{\mathrm{E}_t\left[m_{i,t+1}\right]}, R_{j,t+1}\right],$$

the risk free rate plus an excess return compensating for the risk. Rearranging and multiplying (14) by $R_{i,t+1}^f$ yields an equivalent maximization problem:

$$\max_{q_{ih,t}\geq 0\ \forall h} \quad \sum_{h\in\mathcal{H}} \mathrm{E}_t\left[p_{ih,t+1}(q_{ih,t})\cdot q_{ih,t}\right] - \sum_{h\in\mathcal{H}} \mathrm{E}_t\left[R_{ih,t+1}\right] c_i\tau_{ih}q_{ih,t} - \alpha_i R_{i,t+1}^f,$$

where $E_t\left[R_{ih,t+1}\right] = R_{i,t+1}^f - \mathrm{Cov}_t\left[\frac{m_{i,t+1}}{\mathrm{E}_t[m_{i,t+1}]}, R_{ih,t+1}\right]$ is the firm's marginal capital cost of output for market h, which promises a risky marginal return of $R_{ih,t+1} = \frac{p_{ih,t+1}}{c_i\tau_{ih}}$.

The first-order condition yields an optimal quantity for any market h that is produced at time t and is to be sold in $t+1$ equal to

$$q_{ih,t}^* = \frac{\theta(1-\lambda_{ih,t})^{\varepsilon}\left(R_{i,t+1}^f c_i\tau_{ih}\right)^{-\varepsilon}}{\sum_{i\in\mathcal{H}} N_{i,t}(1-\lambda_{ih,t})^{\varepsilon-1}\left(R_{i,t+1}^f c_i\tau_{ih}\right)^{1-\varepsilon}}\cdot \mathrm{E}_t\left[Y_{h,t+1}\right], \tag{15}$$

where I have defined $\theta := \frac{\eta(\varepsilon-1)}{\varepsilon} < 1$ and

$$\lambda_{ih,t} := -R_{i,t+1}^f \mathrm{Cov}_t\left[m_{i,t+1}, \frac{Y_{h,t+1}}{\mathrm{E}_t\left[Y_{h,t+1}\right]}\right]. \tag{16}$$

To arrive at Equation (15), I used $Q_{h,t}^{\frac{\varepsilon-1}{\varepsilon}} = \sum_{i\in\mathcal{H}} N_{i,t}(q_{ih,t}^*)^{\frac{\varepsilon-1}{\varepsilon}}$ and Equation (5) to substitute for the expected value of the SDF.[21] Demand growth comoves one to one with the

[21]See Appendix A.1 for details.

country-specific productivity shock $\psi_{h,t+1}/\mathrm{E}_t[\psi_{h,t+1}]$; see Equation (9).

I call $\lambda_{ih,t}$ the "risk premium" of market h. It is positive for markets that are *risky* in the sense that demand shocks on these markets are positively correlated with the investor's consumption, and negative otherwise. Equation (15) states that firms ship larger quantities to markets with lower trade cost and higher expected demand. They ship less in times of high real interest rates, that is, when current consumption is highly valued over consumption tomorrow, because production cost and trade cost accrue in t, while revenue is obtained in $t+1$. Moreover, firms ship more to those markets where demand growth is positively correlated with their investors' SDF, since investors value revenues more if, ceteris paribus, they tend to be high in bad times and low in good times. This is the central prediction of the model, which I believe is new to the trade literature, and is subjected to empirical testing in Section 4. First, however, I relate the model's predictions to the standard gravity framework and close the model to show how the risk premia are determined in general equilibrium and how they can be estimated. I also show that they will be zero only under special circumstances, namely, if the exogenous distribution of productivity shocks and financial market integration permit complete elimination of *aggregate* risk, and if investors endogenously choose to, trading off risk against returns.

Once the destination country's productivity is revealed in $t+1$, the firm's revenue in market h is

$$p_{ih,t+1}(q^*_{ih,t})q^*_{ih,t} = \phi_{ih,t}Y_{h,t+1}, \tag{17}$$

where

$$\phi_{ih,t} = \left(\frac{q^*_{ih,t}}{Q_{h,t}}\right)^{\frac{\varepsilon-1}{\varepsilon}} = \frac{(1-\lambda_{ih,t})^{\varepsilon-1}\left(R^f_{i,t+1}c_i\tau_{ih}\right)^{1-\varepsilon}}{\sum_{i\in\mathcal{H}} N_{i,t}(1-\lambda_{ih,t})^{\varepsilon-1}\left(R^f_{i,t+1}c_i\tau_{ih}\right)^{1-\varepsilon}}$$

denotes firm i's trade share in market h, that is, the share of country h's real expenditure devoted to a variety from country i. Equation (17) is a firm-level gravity equation with bilateral trade cost augmented by a risk-adjusted interest rate. Note that Equation (17) nests the gravity equation derived from the Krugman (1980) model with homogenous firms and monopolistic competition as a special case.[22] In fact, there are a number of special cases under which sales predicted by the model follow the standard law of gravity. Suppose, first, that the time lag between production and sales is eliminated. Then, demand volatility becomes irrelevant as firms can always optimally adjust quantities to

[22]See, for example, Head and Mayer (2014) for a description of this model.

the current demand level ($\mathrm{E}_t[Y_{h,t}] = Y_{h,t}$). 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, Equation (17) will differ from the standard gravity equation only due to the presence of the time lag, which introduces the risk-free rate as an additional cost parameter. The same relationship obtains if demand growth is deterministic. Moreover, full integration of international financial markets will equalize SDFs across countries, so that the covariance terms (and the risk-free rates) are identical across source countries and hence cancel each other out in the trade share equation. Note, however, that in this last case, the covariance will still influence optimal quantities, as described in Equation (15). 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, covariances could be set to zero *endogenously*, a possible but unlikely case, as I will discuss in more detail below.

3.3 Firm Entry and Asset Market Clearing

The number of firms in each country is determined by a free entry condition. Let V^* denote the maximum net present value of firm i, which is given by

$$\begin{aligned} V_{i,t}^* &= \sum_{h\in\mathcal{H}} \left(\mathrm{E}_t\left[m_{i,t+1}\cdot p_{ih,t+1}(q_{ih,t}^*)q_{ih,t}^*\right] - c_i\tau_{ih}q_{ih,t}^*\right) - \alpha_i \\ &= (1-\theta)\sum_{h\in\mathcal{H}} \frac{1-\lambda_{ih,t}}{R_{i,t+1}^f}\phi_{ih,t}\mathrm{E}_t\left[Y_{h,t+1}\right] - \alpha_i, \end{aligned} \tag{18}$$

the sum of expected sales, adjusted by an inverse markup factor $0 < (1-\theta) < 1$ and discounted with a market-specific risk-adjusted interest rate, minus fixed cost. Free entry implies that new variety producers enter as long $V_{i,t}^* > 0$. Hence, the equilibrium number of firms, $N_{i,t}$, is determined by

$$V_{i,t}^* = 0 \qquad \Leftrightarrow \qquad \mathrm{E}_t\left[m_{i,t+1}\cdot\sum_{h\in\mathcal{H}} p_{ih,t+1}(q_{ih,t}^*)q_{ih,t}^*\right] = \sum_{h\in\mathcal{H}} c_i\tau_{ih}q_{ih,t}^* + \alpha_i. \tag{19}$$

Entry lowers the price of incumbents' varieties and thus their profits due to the concavity of the final goods production function in the composite good.[23] Moreover, entry of additional

[23] There is a countervailing positive effect of firm entry on incumbents' profits arising from the love of variety inherent in the CES production function of the composite good, which is inversely related to ε, the elasticity of substitution. The assumption that $\eta\varepsilon/(\varepsilon-1) < 1$ assures that concavity dominates

firms in country i implies that the share of assets of this particular type in the investor's portfolio increases and the asset becomes more risky in the sense that its payoff correlates more with the investor's total wealth. Hence, $V_{i,t}^*$ is driven down to zero as new firms enter.

Let $s_{i,t+1} := \sum_{h \in \mathcal{H}} p_{ih,t+1}(q_{ih,t}^*)q_{ih,t}^*$ denote the total sales of firm i at time $t+1$. Then, combining Equation (19), which determines the supply side of assets, with the demand side of the asset market as described by the Euler equation (8) shows that the equilibrium share price of firm i is equal to the cost of production:

$$v_{i,t} = \sum_{h \in \mathcal{H}} c_i \tau_{ih} q_{ih,t}^* + \alpha_i. \tag{20}$$

With share prices and sales determined, the return to holding a share of firm i in $t+1$ is

$$R_{i,t+1} = \frac{s_{i,t+1}}{v_{i,t}} = \sum_{h \in \mathcal{H}} \beta_{ih,t} \left(\frac{Y_{h,t+1}}{\mathrm{E}_t \left[Y_{h,t+1} \right]} \right) \qquad \text{with} \tag{21}$$

$$\beta_{ih,t} := \frac{\phi_{ih,t} \mathrm{E}_t \left[Y_{h,t+1} \right]}{v_{i,t}}. \tag{22}$$

Returns depend linearly on demand growth in the destination markets. Every market is weighted by a firm-specific factor $\beta_{ih,t}$ that equals the share of expected sales in market h in the total discounted value of the firm.

3.4 Equilibrium

Equilibrium is determined as follows. Investors' optimal choices of investment and consumption, conditional on a given supply of assets with specific stochastic properties, imply a risk premium for every market. The supply of assets and their stochastic properties are, in turn, determined by firms' optimal quantity and entry decisions, conditional on investors' risk premia.

More specifically, let $\boldsymbol{N}_t$, $\boldsymbol{\psi}_t$ denote $(H \times 1)$ vectors collecting, respectively, the number of firms and the productivity level in each country. Let $\boldsymbol{q}_t$ denote the $(H \times H)$ matrix of all firms' market-specific quantities with typical element $q_{ih,t}$ and $\boldsymbol{q}_{h,t}$ ($\boldsymbol{q}_{i,t}$) denoting the hth column (ith row) vector. Let $\boldsymbol{\beta}_t$ be defined accordingly. Moreover, let $\boldsymbol{\Psi}_t = \left[\boldsymbol{\psi}_t, \boldsymbol{\psi}_{t-1}, ... \right]$ denote the history of realizations of productivity levels.

love of variety.

Equilibrium with autarkic financial markets. To describe the equilibrium under autarkic financial markets, I also define $\boldsymbol{\lambda}_t$ as the $(H \times H)$ matrix of all investors' risk premia with typical element $\lambda_{ih,t}$ and $\boldsymbol{\lambda}_{i,t}$ ($\boldsymbol{\lambda}_{h,t}$) denoting the ith row (hth column) vector. Since in autarkic financial markets the set of assets available to investor i is the set of homogeneous domestic firms, investor i's choice of risky investments is $\boldsymbol{a}_{i,t} = a_{ii,t}$.

The equilibrium at time t characterized by initial conditions $\boldsymbol{X}_{i,t} = \left\{W_{i,t}, \{R^f_{i,t+s}\}_{s=1}^{\infty}, \boldsymbol{\Psi}_t\right\}$ is defined by optimal choices of $a_{ii,t}, a^f_{i,t}, C_{i,t}, \boldsymbol{q}_{i,t}$ according to investors' optimization problem (4) and firms' optimization problem (13) $\forall\ i \in \mathcal{H}$, and equilibrium values of the endogenous variables $\boldsymbol{N}_t$, $\boldsymbol{\lambda}_t$, $\boldsymbol{\beta}_t$ determined by Equations (19), (16), and (22). More specifically, $\forall\ i \in \mathcal{H}$ the equilibrium is described by

Investors' first-order conditions (5) and (6):	$a^f_{i,t}\left[\boldsymbol{\beta}_{i,t}, \boldsymbol{X}_t\right]$ and $a_{ii,t}\left[\boldsymbol{\beta}_{i,t}, \boldsymbol{X}_t\right]$	
Budget constraint (2):	$C_{i,t}\left[a^f_{i,t}, a_{ii,t}, \boldsymbol{\beta}_{i,t}, \boldsymbol{X}_t\right]$	
Risk premia (16):	$\lambda_{ih,t}\left[C_{i,t}, a^f_{i,t}, a_{ii,t}, \boldsymbol{\beta}_{i,t}, \boldsymbol{X}_t\right]$	$\forall\ h \in \mathcal{H}$
Firms' first-order conditions (15):	$q_{ih,t}\left[\boldsymbol{q}_{h,t}, \boldsymbol{N}_t, \boldsymbol{\lambda}_{h,t}, \mathrm{E}_t[\psi_{h,t+1}]\right]$	$\forall\ h \in \mathcal{H}$
Free entry condition (19):	$N_{i,t}\left[\boldsymbol{q}_t, \boldsymbol{N}_t, \boldsymbol{\lambda}_t, \mathrm{E}_t[\boldsymbol{\psi}_{t+1}]\right]$	
Firm-market βs (22):	$\beta_{ih,t}\left[\boldsymbol{q}_t, \boldsymbol{N}_t, \boldsymbol{\lambda}_t, \mathrm{E}_t[\boldsymbol{\psi}_{t+1}]\right]$	$\forall\ h \in \mathcal{H}$

Equilibrium with internationally integrated financial markets. In the globally integrated financial market, the representative investor is the same for every country, hence I drop the investor index i. The set of available assets comprises the shares of the representative firms from all countries, that is, $\boldsymbol{a}_{i,t} = \boldsymbol{a}_t = [a_{1,t}, ..., a_{i,t}, ..., a_{H,t}]$. Risk premia differ across destination markets, but not by source country. Hence, $\boldsymbol{\lambda}_t$ is of dimension $(1 \times H)$.

The equilibrium at time t characterized by initial conditions $\boldsymbol{X}_t = \left\{W_t, \{R^f_{i,t+s}\}_{s=1}^{\infty}, \boldsymbol{\Psi}_t\right\}$ is given by

The Investor's first-order conditions (5) and (6):	$a^f_t\left[\boldsymbol{\beta}_t, \boldsymbol{X}_t\right]$ and $\boldsymbol{a}_t\left[\boldsymbol{\beta}_t, \boldsymbol{X}_t\right]$	
Budget constraint (2):	$C_t\left[a^f_t, \boldsymbol{a}_t, \boldsymbol{\beta}_t, \boldsymbol{X}_t\right]$	
Risk premia (16):	$\lambda_{h,t}\left[C_t, a^f_t, \boldsymbol{a}_t, \boldsymbol{\beta}_t, \boldsymbol{X}_t\right]$	$\forall\ h \in \mathcal{H}$

and firms' first-order conditions, the free-entry condition, and the firm-market betas as above.

This describes the equilibrium from the point of view of the representative investor holding the sum of wealth of all individuals from all countries. The equilibrium values for investment and consumption thus describe aggregates of all countries in $\mathcal{H}$. Consumption or investment at the national level, as well as bilateral financial flows, are not determined at this point. To pin down those values in the case of integrated international financial markets, further assumptions about the distribution of wealth and the utility functions are needed. Note that to this point and also in what follows, no restrictions are placed on the distribution of wealth across countries or even across individuals. The only assumptions about preferences made so far state that all individuals' utility functions are of the von Neumann-Morgenstern-type and exhibit risk aversion. In Appendix A.1, I show how countries' current accounts can be derived once country-level consumption and bilateral investment flows are determined.[24]

3.5 The Stochastic Discount Factor and Country Risk Premia

In this section I describe how the distribution of the SDF is derived from the distribution of country-specific productivity shocks and how, accordingly, the country risk premia $\lambda_{ih,t} = R^f_{i,t+1}\mathrm{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right]$ are determined and evolve over time.[25] I again display the results in general notation, encompassing both the case of autarkic and integrated financial markets.[26] Optimal consumption and investment plans in conjunction with the stochastic properties of firms' profits pin down the distribution of future consumption and link the SDF to the country-specific shocks. To make this link explicit, I impose the following additional assumptions:

[24] Country-level (or even individual-level) consumption and bilateral investment flows can, for example, easily be determined under the assumption that individuals' preferences exhibit identical degrees of *constant relative risk aversion*, that is, all individuals' per-period utility functions observe $u(c_{k,t}) = c_{k,t}^{(1-\gamma)}/(1-\gamma)$ for $\gamma > 1$ or $u(c_{k,t}) = \ln c_{k,t}$. Then, every individual in an integrated financial market will own a fraction of the same wealth portfolio, which is the portfolio chosen by the representative agent. The fraction owned by an individual corresponds to his share of wealth in total wealth. Analogously, individual consumption is proportional to the representative investor's consumption, depending, again, only on the individual's share in total wealth (see Rubinstein, 1974; Grossman and Razin, 1984). It follows that for all countries k in $\mathcal{H}$, country-level consumption $C_{k,t}$ and bilateral investment $a_{ki,t}$ are proportional to the representative investor's consumption C_t and investment in the firms from all countries, $a_{i,t}$, with the factor of proportionality equal to $W_{k,t}/W_t$ where $W_t = \sum_{k\in\mathcal{H}} W_{k,t}$.

[25] I use the hat notation for "shocks," that is, deviations from expected values. Hence, $\hat{Y}_{h,t+1} := \frac{Y_{h,t+1}}{\mathrm{E}_t[Y_{h,t+1}]}$.

[26] That is, I let country i's representative investor be either the representative agent from country i or the global representative investor.

(i) productivity levels are independently and identically distributed over time:

$$f(\boldsymbol{\psi_{t+1}}|\boldsymbol{\Psi_t}) = f(\boldsymbol{\psi})$$

(ii) the risk-free rate is constant over time: $R^f_{i,t+s} = R^f_{i,t}$ for $s = 1, ..., \infty$

(iii) investors expect constant βs for a given level of $W_{i,t}$

$$\boldsymbol{\beta}_{i,t+s} = \boldsymbol{\beta}_{i,t} \text{ if } W_{i,t+s} = W_{i,t} \text{ for } s = 0, ..., \infty$$

Assumption (iii) is trivially true if investors take firms' action as given and constant over time. Moreover, investor's expectations as assumed in (iii) are consistent with the ex-post relationship between $\boldsymbol{\beta}_{i,t+s}$ and $W_{i,t+s}$ provided that assumptions (i) and (ii) are fulfilled and financial markets are globally integrated; see Appendix A.1 for details. I also show in the Appendix how the derivation of the risk premia can be generalized if assumption (iii) is dispensed with in the case of autarkic financial markets.

Under assumptions (i)-(iii), the stochastic properties of the set of investment opportunities as *perceived* by the investor are constant. As Fama (1970) shows, this implies that the multiperiod consumption choice problem can be reduced to a two-period problem of a choice between consumption today and wealth tomorrow. The utility of an additional unit of consumption tomorrow may then be replaced with the value of a marginal unit of income tomorrow, so that the SDF can be written as

$$m_{i,t+1} = \rho \frac{u_i'(C_{i,t+1})}{u_i'(C_{i,t})} = \rho \frac{V_i'(W_{i,t+1})}{u_i'(C_{i,t})}, \tag{23}$$

where $V_i(W_t)$ denotes the maximum value function that solves the investor's lifetime utility maximization problem (4).[27] Replacing $W_{i,t+1} = R^W_{i,t+1} A_{i,t}$, I can write the SDF given in Equation (23) as $g_{i,t}(R^W_{i,t+1})$, a function of the return to wealth in $t+1$ and variables determined in the previous period, with the latter being subsumed in the i, t index of the function. Generally, the precise relationship $g_{i,t}(\cdot)$ depends crucially on the functional form of $u_i(\cdot)$. However, as the pioneers of the Capital Asset Pricing Model (CAPM) (Sharpe, 1964; Lintner, 1965; and Black, 1972) show, $g_{i,t}(\cdot)$ is *linear* in $R^W_{i,t+1}$ if returns are normally distributed, *independently* of the functional form of $u_i(\cdot)$.

As shown above (Equation 21), returns to firm shares are linear in demand shocks $\widehat{Y}_{h,t+1}$, which, by Equation (9), comove one to one with the productivity shocks: $\widehat{Y}_{h,t+1} =$

[27] A detailed derivation of Equation (23), whose essential parts follow Cochrane (2005) and Fama (1970), can be found in Appendix A.1

$\widehat{\psi}_{h,t+1}\ \forall\ h \in \mathcal{H}$. Hence, returns can be written as

$$R_{i,t+1} = \sum_{h \in \mathcal{H}} \beta_{ih,t} \widehat{\psi}_{h,t+1}.$$

Assuming that

(iv) productivity levels follow a multivariate log-normal distribution:

$$\boldsymbol{\psi} \sim Lognormal\left(\boldsymbol{\mu}, \boldsymbol{\Sigma}\right),$$

productivity shocks $\widehat{\boldsymbol{\psi}}_{\boldsymbol{t}} = [\widehat{\psi}_{1t}, ..., \widehat{\psi}_{h,t}, ..., \widehat{\psi}_{H,t}]$ and returns $\boldsymbol{R}_{t+1} = [R_{1,t+1}, ..., R_{i,t+1} ..., R_{I,t+1}]$ follow an approximate multivariate normal distribution.[28] Moreover, the total return to wealth $R^W_{i,t+1}$, as given in Equation (3), also follows a normal distribution. Applying Stein's Lemma to the investor's first-order condition (6), I obtain[29]

$$m_{i,t+1} = \zeta_{i,t} - \gamma_{i,t} R^W_{i,t+1} \quad \text{where} \quad \gamma_{i,t} > 0. \tag{24}$$

The linear model for the SDF facilitates deriving an explicit expression for $\boldsymbol{\lambda}_{i,t}$, the covariances of the SDF with the country-specific productivity shocks. Using Equation (21) together with the expression for $R^W_{i,t+1}$ in Equation (3), I can write the SDF as a linear function of demand shocks:

$$m_{i,t+1} = \zeta_{i,t} - \gamma_{i,t} \sum_{j \in \mathcal{J}_i} \frac{a_{ij,t}}{A_{i,t} v_{j,t}} \sum_h \phi_{jh,t} \mathrm{E}_t \left[Y_{h,t+1}\right] \left(\frac{Y_{h,t+1}}{\mathrm{E}_t \left[Y_{h,t+1}\right]} \right). \tag{25}$$

Equation (25) implies that *partial* covariances of $m_{i,t+1}$ with demand growth in any country h are given by the coefficients from a linear regression of the form $m_{i,t+1} = b_{i0,t} - \boldsymbol{b}'_{i,t} \hat{\boldsymbol{Y}}_{\boldsymbol{t+1}}$ with $\boldsymbol{b}'_{i,t} = [b_{i1,t}, ..., b_{ih,t}, ..., b_{iI,t}]$ and $\hat{\boldsymbol{Y}}'_t = \left[\hat{Y}_{1,t}, ..., \hat{Y}_{h,t}, ..., \hat{Y}_{H,t}\right]$, where

$$b_{ih,t} = \gamma_{i,t} \sum_{j \in \mathcal{J}_i} \frac{a_{ij,t}}{A_{i,t} v_{j,t}} \phi_{jh,t} \mathrm{E}_t \left[Y_{h,t+1}\right]. \tag{26}$$

Equation (26) shows that these partial covariances are given by the weighted sum of exports to market h by all firms in the investor's portfolio, where each firm is weighted by its portfolio share. Note that the theory implies $\gamma_{i,t} > 0$; hence, a larger exposure to demand shocks in h through higher exports implies a stronger *negative* partial correlation with the SDF.

[28]The approximation works best in the neighborhood of one.

[29]For details of the derivation, which follows Cochrane (2005, Ch. 9), see Appendix A.1.

Under autarkic financial markets, where $\mathcal{J}_i = i$ and asset market clearing requires $N_{i,t} = \frac{a_{ii,t}}{v_{i,t}}$, I obtain the bilateral exposures as

$$b_{ih,t} = \gamma_{i,t} \frac{\phi_{ih,t} \mathrm{E}_t \left[Y_{h,t+1} \right]}{A_{i,t}}, \tag{27}$$

that is, expected sales of all domestic firms to country h over country i's total investment. With globally integrated financial markets, where $\mathcal{J}_i = \mathcal{H}$ and the asset market clearing condition is $N_{i,t} = \frac{a_{i,t}}{v_{i,t}}$, the bilateral exposures are

$$b_{h,t} = \gamma_t \frac{\mathrm{E}_t \left[Y_{h,t+1} \right]}{A_t}$$

since $\sum_{j \in \mathcal{H}} N_{j,t} \phi_{jh,t} = 1$. Through integrated financial markets, all countries' bilateral exposures with country h become identical, and are given by total expected sales in h divided by global investment.

What matters for investors' perception of riskiness, however, is not the partial correlation of demand shocks with the SDF, but the overall correlation, which takes into account that firms also sell to other countries exhibiting demand shocks that may be correlated with the shocks in country h. The covariances of country-specific shocks with country i's SDF (scaled with the risk-free rate) are thus given by

$$\boldsymbol{\lambda}_{i,t} = -R^f_{i,t+1} \mathrm{Cov}_t \left[m_{i,t+1}, \hat{\boldsymbol{Y}}_{t+1} \right] = R^f_{i,t+1} \mathrm{Cov}_t \left[\hat{\boldsymbol{Y}}_{t+1}, \hat{\boldsymbol{Y}}'_{t+1} \right] \boldsymbol{b}_{i,t}, \tag{28}$$

with the hth element equal to

$$\lambda_{ih,t} = -R^f_{i,t+1} \mathrm{Cov}_t \left[m_{i,t+1}, \hat{Y}_{h,t+1} \right] = R^f_{i,t+1} \left(\sigma_t^{\hat{Y}_h} \right)^2 b_{ih,t} + R^f_{i,t+1} \sum_{k \neq h} \sigma_t^{\hat{Y}_h, \hat{Y}_k} b_{ik,t}. \tag{29}$$

Note that the bs are themselves functions of the λs so that Equation (29) is an implicit expression for $\lambda_{ih,t}$.

Using the linear SDF from Equation (25) to rewrite the Euler equation (6) as

$$\mathrm{E}_t \left[R_{i,t+1} \right] - R^f_{i,t+1} = \boldsymbol{\lambda}'_{i,t} \boldsymbol{\beta}_{i,t} \tag{30}$$

shows that the λs can be interpreted as monetary risk premia.[30] Equation (30) decomposes the return that j's share earns in excess of the risk-free rate on average, which is the compensation investors demand for its riskiness, into a risk price and a risk quantity associated with the firm's activity in every market. The quantity component $\beta_{ih,t}$, as

[30]See Appendix A.1 for details of the derivation.

given in Equation (22), measures firm i's exposure to demand volatility in market h. More precisely, $\beta_{ih,t}$ is the elasticity of the firm's value with respect to demand growth in market h. The price component, $\lambda_{ih,t}$, measures how much compensation in terms of average return in excess of the risk-free rate investor i demands per unit of exposure $\beta_{ih,t}$ to volatility in market h.

3.6 Equilibrium Risk Premia and the Risk-Return Tradeoff

The equilibrium risk premia are aggregate outcomes of investors' risk-return tradeoff. This section explains the intuition behind this tradeoff and, more specifically, it shows that the risk premia will generally be nonzero, even with perfectly integrated international asset markets. In complete financial markets, investors can freely trade and create assets. However, the creation of primary assets is subject to the stochastic properties of the investment opportunities, and the creation of other financial assets is subject to the restriction that they be in zero net supply in equilibrium. The latter implies that financial assets can be used to eliminate investors' idiosyncratic risk, but cannot mitigate aggregate risk, since zero net supply means that somebody's gain from holding such an asset must be somebody else's loss.

The amount of aggregate risk present in equilibrium, defined as volatility of the SDF, is thus purely an outcome of investment choice. Aggregate risk is absent if and only if consumption does not vary across states of nature. Equation (25) shows that the volatility of the SDF derives from the volatility of the country-specific shocks, where the individual countries' contributions depend on firms' export choices $\phi_{jh,t}\mathrm{E}_t[Y_{h,t+1}]$ and investors' portfolio choices $a_{ij,t}$. It is apparent that the potential for eliminating consumption risk through portfolio management is constrained by the correlation pattern of country shocks. Unless some shocks are perfectly negatively correlated, the only way to set the variance of the SDF to zero is zero investment in risky assets. This means that no firm is active and investors put all their savings into the risk-free asset. All λs will then be zero. For this to be an equilibrium outcome, however, the value of creating a new firm must be zero. Rewriting Equation (18) in terms of exogenous variables and λ only yields

$$V_{i,t}^{*} = \frac{1-\theta}{\theta^{\frac{\eta}{\eta-1}}} \sum_{h\in\mathcal{H}} \frac{(1-\lambda_{ih,t})^{\varepsilon}(c_i\tau_{ih}R_{i,t+1}^{f})^{-\varepsilon}\mathrm{E}_t\left[\psi_{h,t+1}\right]^{\frac{\eta}{1-\eta}}}{\left(\sum_{i\in\mathcal{H}} N_{i,t}(c_i\tau_{ih}R_{i,t+1}^{f})^{1-\varepsilon}(1-\lambda_{ih,t})^{\varepsilon-1}\right)^{\frac{\varepsilon-\eta\varepsilon-1}{(\varepsilon-1)(\eta-1)}}} - \alpha_i. \tag{31}$$

Since $\varepsilon - \eta\varepsilon - 1 > 0$, the value of creating a new firm goes to infinity as the number of firms approaches zero. This is because marginal productivity of the first variety is infinite, by the assumption that $\frac{\eta\varepsilon}{\varepsilon-1} < 1$, and it holds for $\lambda \lesseqgtr 0$. Hence, avoiding any exposure to aggregate risk by not investing in firms at all cannot be an equilibrium outcome.

Now suppose that the covariance structure of country shocks permits hedging aggregate risk because at least one country's shocks are perfectly negatively correlated with the rest. Investors can exploit the hedging opportunity by investing in firms from the country with negatively correlated shocks. Or, more generally, by investing in firms that sell a lot to this market. This is precisely what the Euler equation commands: willingness to pay is larger for assets that correlate positively with the SDF. However, only under special conditions will it be optimal to exploit the hedging opportunity to its full extent, that is, to completely eliminate aggregate risk. The reason for this again involves the decreasing returns to scale inherent in the production function. Financing more firms that ship a lot to a certain destination market that correlates negatively with the SDF means that the amount of the composite good produced in this country increases. This implies a decrease in the marginal productivity of the composite good and a decrease in firms' expected market-specific profits. Equation (31) shows that, ceteris paribus, the value of an individual firm falls in the number of firms selling to a given market. Hence, investors are faced with a classical risk-return tradeoff where the optimal choice is generally not to fully eliminate aggregate risk.

A two-country example makes this point very clear. Suppose there are two countries, i and h, which are identical with regard to production cost for varieties, trade cost, and the risk-free rate. That is, suppose $\mathcal{H} = (i, h)$, $c_i = c_h = c, \alpha_i = \alpha_j = \alpha, \tau_{ih} = \tau_{hi} = \tau, \tau_{ii} = \tau_{hh} = 1$. Moreover, suppose that the variance of productivity shocks is identical in both countries, $\sigma^{\hat{\psi}_h} = \sigma^{\hat{\psi}_i} = \sigma^{\hat{\psi}} = \sigma^{\hat{Y}}$, and that shocks are perfectly negatively correlated, $\rho_i^{\hat{Y}_i,\hat{Y}_h} = \frac{\sigma^{\hat{Y}_i,\hat{Y}_h}}{\sigma^{\hat{Y}_i}\sigma^{\hat{Y}_h}} = -1$. The two countries may differ in their initial level of asset wealth $A_{i,t} \lesseqgtr A_{h,t}$ and in the mean of the productivity level. Further suppose, without loss of generality, that $\mathrm{E}_t\left[\psi_{h,t+1}\right] \geq \mathrm{E}_t\left[\psi_{i,t+1}\right]$. Finally, assume, for simplicity, that asset markets are fully integrated and preferences exhibit constant relative risk aversion. Complete elimination of aggregate risk would then imply that the country risk premia as described in Equation (29) jointly obey

$$
\begin{aligned}
& \lambda_{k,\ell} = -R^f_{k,t+1}\mathrm{Cov}_t\left[m_{k,t+1}, \hat{Y}_{\ell,t+1}\right] = 0 \quad \forall\ k, \ell = i, h \\
\Leftrightarrow \quad & \mathrm{E}_t\left[Y_{\ell,t+1}\right]\left(a_{k\ell}\phi_{\ell\ell,t} + a_{kk}\phi_{k\ell,t}\right) = -\rho_i^{\hat{Y}_k,\hat{Y}_\ell} \cdot \mathrm{E}_t\left[Y_{k,t+1}\right]\left(a_{kk}\phi_{kk,t} + a_{k\ell}\phi_{\ell k,t}\right) \quad \forall\ k, \ell = i, h \\
\Leftrightarrow \quad & \mathrm{E}_t\left[Y_{h,t+1}\right] = \mathrm{E}_t\left[Y_{i,t+1}\right]. \qquad (32)
\end{aligned}
$$

The third step follows from the fact that with fully integrated international asset markets and constant and equal degrees of relative risk aversion, investors in both countries will own a share of the same international market portfolio. That is, $a_{ii,t} = \varphi N_{i,t}$, $a_{hi,t} =$

$(1-\varphi)N_{i,t}$, $a_{ih,t} = \varphi N_{h,t}$, $a_{hh,t} = (1-\varphi)N_{h,t}$, where $\varphi/(1-\varphi) = A_{h,t}/A_{i,t}$. Equation (32) states that zero risk premia obtain if expected final goods production between the two countries is equalized. Note that Equation (32) together with $\mathrm{E}_t[\psi_{i,t+1}] \leq \mathrm{E}_t[\psi_{h,t+1}]$ implies $Q_{i,t} \geq Q_{h,t}$, that is, the output of the composite good is larger in the less productive market, suggesting that an allocation yielding $\lambda_{ih} = 0$ is not efficient. To make this argument formally, I show in Appendix A.1 that to obtain equal expected output in both countries, the number of firms in the less productive country i must be larger and, hence, firms from country i face a more competitive environment. This is reflected in smaller equilibrium net present values of firms from country i compared to firms from country h, which is inconsistent with the free entry condition mandating that net present values be equal and zero in both countries. It follows that $\lambda_{k\ell} = 0 \; \forall \; k, \ell = i, h$ can be an equilibrium consistent with optimal choices of firms and investors only in the knife-edge case where expected productivity levels in country i and country h are identical.

Generally, firms make larger profits by selling more to more productive and less crowded markets. The amount of aggregate risk taken on by investors in equilibrium balances the incentive to finance firms that make higher profits with the desire for smooth consumption. Perfect consumption insurance and zero risk premia are feasible but sub-optimal if investors put all their wealth into the risk-free asset. Alternatively, perfect consumption insurance and positive investment in firms is possible when, for every country, there is at least one other country exhibiting perfectly negatively correlated shocks. But even then, zero aggregate risk will be an equilibrium outcome only in special cases, such as the one just outlined.

3.7 Discussion

I conclude the theory section with a note on the validity of the model's central prediction under more general assumptions. As shown in the previous section, firms' incentive to take the covariance pattern of shocks into account in their export decisions depends crucially on the presence of aggregate risk, that is, non-zero risk premia, and exposure to risk, that is, imperfect ability to adjust quantities to the current level of demand. Neither the assumption of homogeneous firms nor the assumption of love for variety as a driving force for trade is essential. Moreover, without further assumptions, the model can be extended to encompass an intermediate case of financial market integration, where free asset trade is possible within regions or blocks of countries but not across regional borders.

In Equation (15), the *variance* of demand shocks per se does not influence the quantity shipped to a certain destination. This is because in a world where firms' investors trade multiple assets, firms' objective (besides maximizing profits) is not to minimize the variance of profits, but the *covariance* with investors' portfolio. This objective is different from the predictions found in the literature analyzing risk-averse firms (Maloney and Azevedo, 1995; Riaño, 2011; Esposito, 2016). The absence of a direct effect of the variance of demand shocks on the optimal quantity also owes to the assumption of prohibitive adjustment cost, which is implicit in the time-lag assumption. If firms can adjust quantities to current levels by drawing on (costly) inventory holdings (cp. Békés et al., 2015) or fast but expensive air shipment (Hummels and Schaur, 2010, 2013), expected profits fall in the variance of demand shocks, as more costly adjustments are expected ex-ante. The model's prediction with regard to the risk premia, however, is not impaired by allowing profits to be directly affected by volatility through non-prohibitive adjustment cost. In the empirics, country-time fixed effects will control for a possible direct effect of demand volatility.

The model's assumptions are restrictive insofar as they imply that the risk inherent to volatile demand is borne exclusively by the exporter who faces a volatile price for his predetermined quantity of goods. In many cases, however, export contracts specify both a price and a quantity before production or shipping has even started. In such a situation, the risk of a deviation of demand from its expected value is assumed by the importer, who then faces a mirrowed version of the exporter's problem described by the model.[31] Shareholder-value maximization will command that he imports smaller quantities if his investors demand a non-zero risk premium for demand volatility in the home market. In terms of the model, the quantity shipped from country i to country h would then depend on λ_{hh} rather than λ_{ih}. Moreover, as Carballo (2015) documents, a large share of trade reflects transactions between related parties (for the U.S., 28% of imports and 50% of exports). In these cases, the risk associated with a demand shock lies always with the same firm, and depending on the source of finance, the risk premium of investors from the exporting, the importing, or both countries can be relevant. The model implies that λ_{hh} and λ_{ih} are identical if these countries' financial markets are perfectly integrated and, in general, they can be expected to be positively correlated.

The model also precludes multinational production. For a flexible interpretation of the firm boundary, however, the free entry condition (19) for any country i may equally be viewed as an indifference condition for a foreign firm with regard to opening up a production facility in country i. Under the assumptions of the model (fixed costs α_i

[31] The (risk-neutral) importer's problem in the presence of demand uncertainty is, for example, studied by Aizenman (2004), Alessandria et al. (2010), and Clark et al. (2016).

are specific to the production of a certain variety in a specific location), a new variety producer is indistinguishable from a firm producing another variety. This type of fixed costs together with consumers' love for variety imply that it is never optimal to produce the same variety in different locations. At the same time, it is always optimal to export to all destinations once a production facility has been set up in some country. Hence, in this model, multinational production cannot substitute for trade. However, even under more general assumptions facilitating a nuanced description of multinational production, it holds true that as long as there are incentives to trade, its pattern will be influenced by the riskiness of destinations in the presence of time lags, demand volatility, and aggregate risk.[32]

4 Empirics

4.1 Estimating λ

There are three challenges to estimating $\lambda_{ih,t}$. First, the stochastic discount factor is not observed; hence, direct linear estimation as suggested by Equation (24) is not feasible. Second, the theory (see Subsection 3.5 and Appendix A.1) implies that, generally, the coefficients $\zeta_{i,t}, \gamma_{i,t}$ vary over time as investors make changes to their consumption plans depending on current wealth. Third, as implied by Equation (26), bilateral exposures $b_{ih,t}$ change when investors change their portfolio and firms adjust their sales structure. I use methodology from the empirical asset pricing literature to address the first and second issues by means of GMM estimation of an unconditional version of investors' first-order conditions in conjunction with the linear model for the SDF. I address the third issue by estimating the λs for rolling time windows.

The Euler equations (5) and (6) imply that $m_{i,t+1}$ prices every asset $j \in \mathcal{J}_i$. Hence, I obtain a moment condition of the form

$$1 = \mathrm{E}_t\left[m_{i,t+1} R_{j,t+1}\right] \qquad \text{where} \qquad m_{i,t+1} = \zeta_{i,t} - \gamma_{i,t} R^W_{i,t+1} \tag{33}$$

that holds for every asset at each point in time, and one additional condition that identifies

[32]The choice of a production location, of course, may to some extent be driven by the desire to decrease the time lag between production and sales (Evans and Harrigan, 2005). However, as with other costly measures that firms employ to improve their timeliness of delivery, such as inventory holdings or fast transportation, it is unlikely that time lags are fully eliminated.

the mean of the SDF as the inverse of the risk-free rate:

$$\frac{1}{R^f_{i,t+1}} = \mathrm{E}_t\left[m_{i,t+1}\right]. \tag{34}$$

The moment conditions are functions of the parameters $\zeta_{i,t}, \gamma_{i,t}$ and the data, namely, the return to the wealth portfolio. By the law of iterated expectations and under the assumption that $\zeta_{i,t}$ and $\gamma_{i,t}$ are uncorrelated with $R^W_{i,t}$, taking expectations of the conditional moment conditions (33) and (34) over time yields unconditional moments

$$1 = \mathrm{E}\left[\left(\zeta_i - \gamma_i R^W_{i,t+1}\right) R_{j,t+1}\right]\ \forall\ j \in \mathcal{J}_i \qquad \text{and} \qquad 1 = \mathrm{E}\left[\left(\zeta_i - \gamma_i R^W_{i,t+1}\right) R^f_{i,t+1}\right], \tag{35}$$

where $\zeta_i = E[\zeta_{i,t}]$ and $\gamma_i = E[\gamma_{i,t}]$. The assumption of zero covariances between $\zeta_{i,t}, \gamma_{i,t}$ and $R^W_{i,t+1}$ is not innocuous. It trivially holds if the parameters are themselves constants, an assumption that underlies a great deal of the empirical literature on the CAPM or linear factor models in general.[33] However, linear factor models derived from multiperiod models generally imply time-varying parameters (see, e.g., Merton, 1973).[34] In Appendix A.1, I show that in the model developed in this paper, where the distributions of returns derive endogenously from the distribution of productivity shocks, constant ζ_i, γ_i are implied by assumptions (i),(ii), CRRA preferences, and globally integrated financial markets.

I estimate Equation (35) with GMM using data on $R^W_{i,t}$ and data on asset returns $R_{j,t}$, which are described below. With the estimated parameters, I predict a time series of the SDF based on Equation (24) and then compute $\lambda_{ih,t} = -R^f_{i,t+1}\mathrm{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right]$ for rolling time windows of length T, that is, I compute $R^f_{i,t} = T^{-1}\sum_{s=0}^T R^f_{i,t-s}$ and $\mathrm{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right] = T^{-1}\sum_{s=0}^T\left[m_{i,t-s}\cdot\hat{Y}_{h,t-s}\right] - T^{-2}\sum_{s=0}^T m_{i,t-s}\cdot\sum_{s=0}^T\hat{Y}_{h,t-s}$. In this way, I obtain risk premia for 21 exporters and 175 destination markets.[35] The export data used in the subsequent analysis span the years 1984 to 2017. I estimate a $\lambda_{ih,t}$ for every country pair in every year based on monthly data reaching 10 years into the past. More precisely, for every year, I estimate the covariance of demand shocks with the predicted series of the SDF using the 120 most recent monthly observations.

This empirical strategy is based on the assumption that the SDF of investors trading only in the home market is the relevant SDF for exporters. There is ample evidence that financial markets are not globally integrated. Yet, tests of regional financial market

[33]See Fama and French (2015) for an overview of recent developments in this field.

[34]Well known exceptions are the cases of CRRA or quadratic preferences with i.i.d. returns (see Cochrane, 2005, Ch. 9).

[35]The set of exporters is defined by the set of countries for which detailed and comparable asset price data is available.

integration fare better (see, e.g., Fama and French, 2012). I provide an additional set of results which is valid under the assumption that financial markets are integrated within the following five regions: North America; East Asia and Pacific; Europe (excl. United Kingdom, Ireland, Scandinavia); United Kingdom and Ireland; and Scandinavia.[36]

I produce an alternative set of risk premia based on an approximation of marginal utility growth with consumption growth rather than asset income. Subject to the assumption that within an integrated financial market there are no transaction cost, this approach is agnostic about the degree of financial market integration across countries. Within a transaction-cost-free financial market, be it at the country, regional, or global level, all agents' marginal utility growth moves in lockstep. To the extent that consumption growth is a reasonable proxy for marginal utility growth (which, for the cross-section requires that utility functions be not too different across agents), it provides an alternative strategy for tying the representative investor's SDF to data. While placing stricter assumptions on the utility function, this approach does not require any of the assumptions regarding the set of available assets, or the stochastic properties of the returns, which underly the description of the SDF in terms of asset income (cp. Section 3.5). The correlations between demand shocks in the destination markets and consumption growth are based on quarterly data and, as before, I compute them based on data reaching ten years into the past.

4.1.1 Data

Theoretically, every asset and every portfolio of assets available to investors in a given market could be used to estimate Equation (35). I use 8 portfolios provided by Kenneth R. French through his Data Library for monthly asset returns traded in the financial markets of the 21 exporters in my sample. The portfolios are value-weighted growth and value portfolios formed along the ratios of book-to-market (B/M); earnings to price (E/P); cash earnings to price (CE/P); and dividend yield (D/P). I follow the asset pricing literature by approximating R_t^W, the return on the wealth portfolio, with the return to the value-weighted market portfolio including all stocks traded on domestic exchanges.[37] I use total monthly imports by country obtained from the IMF's Direction of Trade Database to measure demand growth with respect to the previous month. Growth rates are adjusted

[36]As noted above, such an intermediate case of financial market integration, where investors trade freely within a supranational asset market but not across is encompassed by the model, but not discussed for the sake of brevity.

[37]Data on the market portfolio and the risk-free rate are also from Kenneth R. French's Data Library.

Table 1: Country-specific and region-specific CAPM estimations

	(1) ζ	(2) γ	(3) J-stat	(4) $P(\chi^2_7 > J)$	(5) first year
AUT	1.00***	1.55*	18.43	0.01	1989
AUS	1.00***	2.06***	20.43	0.00	1975
BEL	1.00***	2.90***	4.81	0.68	1975
CAN	1.00***	2.07**	19.79	0.01	1977
DNK	1.00***	2.73***	2.99	0.89	1989
FIN	1.00***	1.62***	5.08	0.65	1988
FRA	1.00***	1.99***	17.10	0.02	1975
DEU	1.00***	2.01***	11.98	0.10	1975
HKG	1.00***	2.06***	17.95	0.01	1975
IRL	1.00***	1.62*	7.22	0.41	1991
ITA	1.00***	1.10*	13.69	0.06	1975
JPN	1.00***	1.30*	23.03	0.00	1975
NLD	1.00***	3.08***	12.14	0.10	1975
NZL	1.00***	1.51*	6.56	0.48	1988
NOR	1.00***	1.68**	7.84	0.35	1986
SGP	1.00***	1.58***	14.64	0.04	1975
ESP	1.00***	1.38**	7.25	0.40	1975
SWE	1.00***	2.28***	10.43	0.17	1975
CHE	1.00***	2.75***	2.32	0.94	1975
GBR	1.00***	2.33***	6.57	0.47	1975
USA	1.00***	3.75***	29.34	0.00	1951
	ζ	γ	J-stat	$P(\chi^2_7 > J)$	first year; countries
East Asia & Pacific	1.00***	1.62**	31.00	0.00	1975; AUS,HKG,MYS, NZL,SGP
Europe (excl. UK, IRL, Scand.)	1.00***	2.54***	15.20	0.03	1975; AUT,BEL,CHE, DEU,ESP,FRA,GRC, ISR,ITA,NLD,PRT
North America	1.00***	3.75***	29.34	0.00	1951; USA,CAN
Scandinavia	1.00***	2.37***	11.75	0.11	1975; DNK,FIN,NOR, SWE
UK & Ireland	1.00***	2.33***	6.46	0.49	1975; GBR,IRL

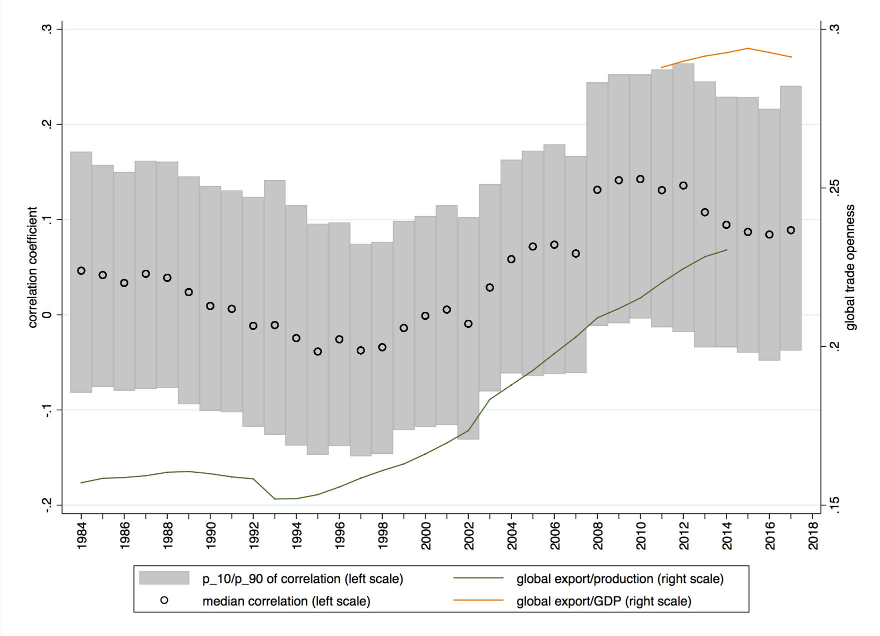
Results from country and region-specific iterated GMM estimations using the demeaned market portfolio as factor and 8 portfolios as assets. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

for seasonality.

4.1.2 Results

Table 1 summarizes the results from GMM estimation of Equation (35) for the 21 individual financial markets, as well as for five aggregated regions. All estimates are significant

Figure 1: Distribution of correlation coefficients over countries and time, and openness

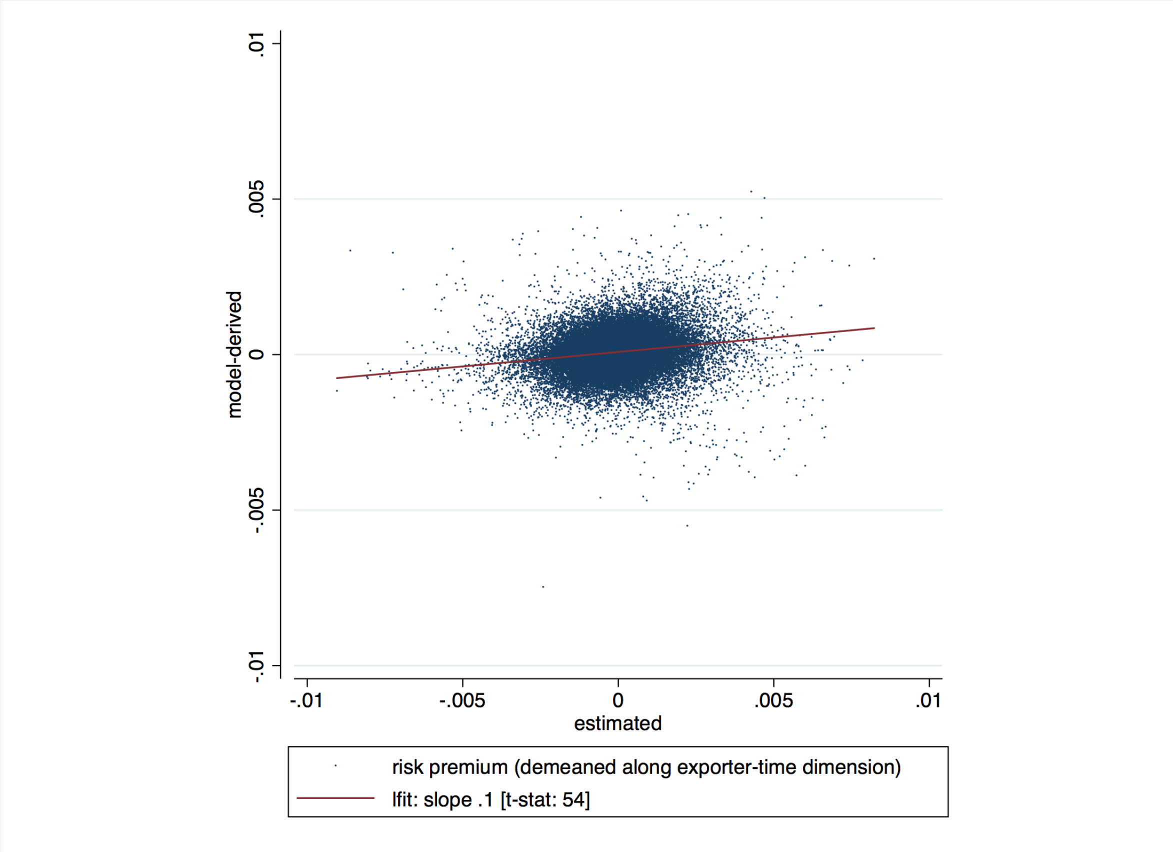


The figure shows the distribution of correlation coefficients of demand shocks in 175 countries with the market portfolio of investors in 21 exporting countries together with the ratio of global exports over production (GDP), computed for each point in time as average over the past 10 years. Gray bars indicate the 10th to 90th percentile range of the distribution of correlation coefficients across country pairs.

at least at the 10% level. As suggested by the theory, γ is positive; hence, a higher return to the market portfolio signals a good state where the investors' SDF is low. I use the estimates in Column (1) of Table 1 to compute the risk premia as described in the previous section. Figure A.2 presents an overview of the results. To filter out the effect of changes in the sample composition, the figure plots the changes in the distribution over time for three subsamples; country pairs present in the sample in 1984 (upper panel), countries present in 1991 but not 1984 (middle panel), and countries present in 2000 but not in 1991 (lower panel). Three trends emerge from these pictures: Risk premia were declining until the mid nineties, increasing or stable until 2012 and declining since then. In view of Equation (29), this may be interpreted as reflecting changes in the degree of global integration.

Focusing on trade integration, I find indeed a positive correlation between trade openness and the median risk premium. This correlation becomes more pronounced when purging the risk premia from changes in the standard deviation of shocks and the risk free rate, that is, by focusing on the correlation coefficient $\rho_{ih,t}$ in $\lambda_{ih,t} = R^f_{i,t+1}\gamma_{i,t}\sigma^{\widehat{Y}}\sigma^m\rho_{ih,t}$, where $\rho_{ih,t} = \text{Corr}\left[R^W_{i,t}, \widehat{Y}_{h,t}\right]$. Figure 1 plots the distribution and median of correlation coefficients across country pairs together with the share of world exports in world production

Figure 2: Estimated vs. model-consistent constructed bilateral risk premia



The figure plots estimated bilateral risk premia against their model-consistent counterparts. Each dot is a country-pair-year observation.

(or world GDP). Since the covariance measures are backward-looking (based on the most recent ten years), for each point in time I compute the openness measure as average over the past ten years. For data availability reasons I supplement the export over production ratio with exports over GDP in recent years. The figure shows that the decline of the correlation of shocks until the mid 90ies, the subsequent increase until around 2010, and the decline thereafter commensurate approximately with the changes in trade openness. Figure A.3 displays the development of trade openness and the median correlation of destination-specific demand shocks with the market portfolio for the major countries in my sample of exporters, showing strikingly strong correlations for France, Great Britain, Italy, and Norway. Figure A.4 plots openness against the median correlation coefficient for all exporters and years in the sample, confirming the positive association.

The structural equation for the equilibrium λs, (29), permits to relate the estimated risk premia to data in a more sophisticated way. As described in Section 3.5, under fully disintegrated financial markets the bilateral exposures $b_{ih,t}$ in Equation (26) reduce to the share of expected bilateral trade in the exporting country's total asset wealth (scaled with $\gamma_{i,t}$). Inserting Equation (27) in (29), I obtain

$$\tilde{\lambda}_{ih,t} = o_{i,t} \sum_k \frac{\mathrm{E}\left[X_{ik,t}\right]}{\mathrm{E}\left[X_{i,t}\right]} \sigma_t^{\widehat{Y}_k, \widehat{Y}_h} \tag{36}$$

where $o_{i,t} = R^f_{i,t+1} \gamma_{i,t} \frac{\mathrm{E}[X_{i,t}]}{A_{i,t}}$ is an exporter-time-specific scaling factor, $\mathrm{E}\left[X_{ik,t}\right] = N_{i,t} \phi_{ik,t} \mathrm{E}\left[Y_{k,t}\right]$ equals total expected bilateral trade (domestic sales for $i = k$) and $\mathrm{E}\left[X_{i,t}\right] = \sum_k \mathrm{E}\left[X_{ik,t}\right]$ is total expected production. Using contemporaneous or past bilateral trade flows to proxy expected trade, I construct this model-based bilateral risk premium $\tilde{\lambda}_{ih,t}$ up to the scaling factor $o_{i,t}$ and contrast it with the estimated covariances. Figure 2 plots for all country pairs and years the estimated risk premia against $\tilde{\lambda}_{ih,t}$ as defined in Equation (36), after substracting means along the exporter-time dimension. The slope coefficient of .1 is fairly far off the theoretical benchmark of one. But, nevertheless, the figure reveals a strong positive correlation between the premia estimated based on returns and demand growth and their model-consistent constructed counterparts.

4.2 Testing the Relevance of Risk Premia in the Gravity Model

4.2.1 Empirical Model and Data

With the estimated risk premia in hand, I can now test the main prediction of the model, which is that exports are, ceteris paribus, higher to markets exhibiting shocks that are less positively correlated with the domestic stock market. My main estimation equation is a log-linear version of Equation (15),

$$\ln q_{jih,t} = \varepsilon \ln(1 - \lambda_{ih,t}) - \varepsilon \ln \tau_{jih,t} - \varepsilon \ln \left(R^f_{i,t+1} c_{ji,t}\right) + \ln \theta + \ln \mathrm{E}_t \left[Y_{jh}\right] + \ln \Pi_{jh,t}, \tag{37}$$

where $\Pi_{jh,t} = \sum_{i \in \mathcal{H}} \sum_{j \in \mathcal{N}_{i,t}} (1 - \lambda_{ih,t})^{\varepsilon - 1} \left(R^f_{i,t+1} c_{ji,t} \tau_{jih,t}\right)^{1-\varepsilon}$. In the empirical model, j now indicates a product from country i. h denotes the destination market. The dependent variable is the quantity (in kilograms) of product j shipped from country i to h in year t. Note that I added an index t to the cost parameters to acknowledge that they are potentially time varying as well. The data, sourced from UN Comtrade, is disaggregated into 766 products (defined by the 4-digit level of SITC classification, Rev. 2).[38] I use four

[38] 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 that goes into the estimation of λ. The small loss of observations per exporter is primarily due to missing data on monthly imports

equally spaced time periods between 1985 and 2015. More years of data are considered in a robustness analysis.

On the right-hand side of Equation (37) I use importer-product-time and exporter-product-time fixed effects to capture expected demand in the destination market, the importer's price index $\Pi_{jh,t}$ (also known as multilateral resistance), the exporter's production cost and the risk-free rate, and time-varying trade cost specific to the exporter and importer. To further control for bilateral trade cost, I include country-pair-product fixed effects as well as dummy variables for joint membership in the EU or a free trade agreement (FTA).[39] Since the availability of tariff data is limited, I include them only in a robustness analysis. Table A.5 summarizes the sample used for the baseline estimations and contains details regarding data sources and variable definitions. Appendix A.2 provides further details. The regression equation used to test the model's central prediction is thus

$$\begin{aligned}\ln q_{jih,t} = \beta_1 \ln(1-\lambda_{ih,t}) + \beta_{21} EU + \beta_{22}\mathrm{L5}.EU + \beta_{23}\mathrm{L10}.EU \\ + \beta_{31} FTA + \beta_{32}\mathrm{L5}.FTA + \beta_{33}\mathrm{L10}.FTA + d_{ji,t} + d_{jh,t} + d_{jih} + u_{jih,t}. \quad (38)\end{aligned}$$

Identification comes from variation within country pairs over time only. A potential concern about omitted variables bias is due to bilateral time-varying factors, such as unobserved trade barriers, or demand and supply shocks, affecting both product-level trade and the bilateral risk premium. In fact, Equation (29) makes clear that the bilateral risk premia depend on the existing degree of trade integration between the two countries. Naturally, demand shocks in the destination country will be more correlated with the domestic stock market the higher the level of bilateral exports. This implies that any omitted variable affecting the left-hand side will be correlated with the risk premium as well. However, the theory makes a clear prediction on the sign of this correlation, translating into a clear prediction about the direction of the bias. Omitted variables that correlate positively with trade on the left-hand side will also be positively correlated with λ and, hence, work against me finding a positive effect of $1-\lambda$. Likewise, for omitted variables which are negatively correlated with trade on the left-hand side and with aggregate trade. In other words, the model implies that omitted variables like unobserved time-varying bilateral demand or supply shocks will lead to a downward bias. I explore this reasoning below, where I run multiple specifications with stricter trade cost and demand

which are also needed to compute the bilateral risk premia.

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

controls added subsequently. Even without omitted variables, there remains a concern about reverse causality due to product-level exports being correlated with aggregate exports. However, for the same reasons outlined before, this leads to a downward bias of the estimate since, according to the model, aggregate exports are positively correlated with λ. 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.

I also run augmented regressions allowing for heterogeneity of the effect of λ across products and markets to assess the validity of the model's key assumption, which is that the correlation pattern of demand shocks matters because of 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 λs should not matter. Trade relationships that are exposed to longer time lags are therefore expected to be more affected by the dampening effect of positively correlated shocks. To assess this prediction, I interact the bilateral risk premia with the distance between exporter and the importer, $\ln(1-\lambda) \times \ln Dist$, presuming that distance correlates with shipping time. To further tease out the role of the time lag, I split the sample into goods shipped primarily by vessel (or ground transportation) rather than air, presuming that shipping over long distances implies a significant time lag only if the goods are not transported by air. Product-specific indicators for the primary transport mode (vessel/air) are computed using product-level shipments to and and from the U.S. which are recorded by mode of transport; see Appendix A.2 for details. I then re-run the specification including the risk premia interacted with distance in both subsamples. Alternatively, I include a triple interaction $\ln(1-\lambda) \times \ln Dist \times Vessel$ in an estimation based on the full sample, for the same effect. Since the triple interaction term varies by country pair, time, and product, it can also be identified when country-pair-time fixed effects are included.

To account for potential correlation in the error term due to the finer level of disaggregation on the left-hand side and also due to the fact that the λs do not vary across products, I compute two-way clustered standard errors which are robust to arbitrary correlation of errors within the 766 product groups and within country pairs, as advocated by Cameron et al. (2011).

4.2.2 Results

Column (1) of Table 2 shows parameter estimates from the baseline specification (38). I find that the risk premia have a significantly negative effect on export quantities. The

Table 2: Gravity estimations with risk premia

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	Vessel	Air	All	All
$\ln(1-\lambda)$	19.549**	-274.460***	-446.177***	35.068	55.714	
	(9.540)	(100.712)	(107.696)	(120.135)	(123.495)	
$\times$ ln *Dist*		34.905***	54.843***	-0.905	-3.387	
		(11.689)	(12.504)	(13.957)	(14.352)	
$\times$ Vessel					59.500***	53.760***
					(12.910)	(12.366)
$\times$ Vessel					-512.314***	-466.836***
					(110.937)	(105.997)
EU	0.098*	0.092*	0.169***	-0.025	0.093*	
	(0.054)	(0.054)	(0.057)	(0.069)	(0.053)	
L5.*EU*	0.308***	0.300***	0.299***	0.303***	0.300***	
	(0.056)	(0.057)	(0.064)	(0.073)	(0.057)	
L10.*EU*	-0.032	-0.028	-0.021	-0.040	-0.027	
	(0.056)	(0.056)	(0.063)	(0.072)	(0.056)	
FTA	0.042	0.047	0.056	0.025	0.047	
	(0.032)	(0.032)	(0.036)	(0.036)	(0.032)	
L5.*FTA*	0.071*	0.066*	0.066	0.068	0.066*	
	(0.039)	(0.038)	(0.043)	(0.044)	(0.038)	
L10.*FTA*	0.064**	0.057*	0.065*	0.041	0.057*	
	(0.031)	(0.031)	(0.036)	(0.033)	(0.031)	
Observations	2080695	2080695	1316842	763853	2080695	2080346
Adjusted R^2	0.783	0.783	0.755	0.773	0.783	0.787

All columns include importer-product-time, exporter-product-time and country-pair-product fixed effects. Column 6 also includes country-pair-time fixed effects. S.e. (in parentheses) robust to two-way clusters on product and country-pair level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity (in kg) by product, country-pair, and time. Column 3 (4) based on subsample of products shipped primarily by vessel/ground transportation (air) only. *EU* (*FTA*) denotes joint membership in the EU (a free trade agreement). L5. (L10.) denotes 5 (10)-year lag. Estimates based on years 1985, 1995, 2005, 2015.

estimates in Column (1) imply that a 1% increase in $1-\lambda$ increases trade by about 20%. Note that since λ is close to zero, percentage changes in $1-\lambda$ are well approximated by $-d\lambda$. In view of Figure A.2, upper panel, the magnitude of the coefficient means that, for example, the increase in the median country's risk premium from 0 in 1995 to .0005 in 2010 corresponds to a decline in trade with the median country by 1% compared to a counterfactual world where risk premia do not influence firms' exporting decisions. Taking a broader view on the model, this implies that the increase in trade integration observed over this time period was slowed down by a corresponding increase in risk premia, as more integration lead to more correlated shocks. Arguably, the economic magnitude of the effect of risk premia seems modest. For a commonly assumed value of the trade cost elasticity of 5, the above effect of the increase in the medium risk premium is equal to the effect of a .2 percentage point increase in tariffs. However, for individual country pairs the effects are more sizeable. For example, U.S. investors' risk premium with China increased by .00185 between 1992 and 2001, slowing down export growth by 3.6% according to the average estimate. Moreover, as I show next, there is substantial heterogeneity of the effect across country pairs and products that needs to be taken into account when assessing the economic importance of the risk premia.

As Column (2) of Table 2 shows, the effect of changes in risk premia on trade depends crucially on the distance between exporter and importer. Higher risk premia impede trade more if countries are more distant. As argued above, this supports the key assumption of the model according to which the correlation of shocks matters only in the presence of a time lag between production and sales. Columns (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 for the effect of risk premia on exports 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 Column (5), which is based on the full sample and features a triple interaction of the risk premium, distance, and the binary indicator for goods shipped by vessel. Column (6) shows that the inclusion of country-pair-time fixed effects, which absorb all observed and unobserved bilateral time-varying trade cost, does not impair the the results.

The interaction term with distance implies that for country pairs at the 75th percentile of the distance distribution, which are 8900 kilometers apart, the effect of a change in the risk premium is twice as large as the average effect in Column (1). Accounting for the distance between China and the U.S., the effect of the increase in the risk premium on exports between 1992 and 2001 is quantified at -9.5%. If the we consider exports by vessel, the effect is -12%.

To summarize, I find a negative and significant effect of risk premia on export quantities, 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 imply that demand volatility constitutes a risk because of a time lag between production and sales, thus lending support to the model's key assumption.

4.2.3 Robustness

I conduct various tests to analyze the robustness of my results with regard to changes in the exact specification of Equation (38). Moreover, I analyze the potential for omitted variables bias using observable trade cost variables and fixed effects. Results are collected in Tables A.6 and A.7 in the Appendix.

Omitted variables bias. In Table A.6 I analyze the validity of the model-based presumption, discussed in more detail above, that omitted factors determining trade on the left-hand side lead to a downward bias of the coefficient of $\ln(1-\lambda)$. Column (1) presents the correlation between $\ln(1-\lambda)$ and product-level exports, conditioning only on importer/exporter-product-time fixed effects. As expected, it is strongly negative, as more bilateral trade implies a higher λ. In Columns (2,3) I subsequently add time-constant and time-varying bilateral trade cost proxies. This increases the coefficient estimate, which is consistent with the model based presumption that the downward bias is reduced. Column (4) repeats the baseline specification of Table 2, featuring in addition country-pair-product fixed effect to control for unobserved bilateral trade cost, as well other supply and demand shifters, which produces a larger and statistically significant effect of the risk premia. Columns (5,6) explore the effect of adding tariffs. The tariff data are available at the product-level, but time and country coverage is very patchy. Hence, I lose a significant number of observations. Column (5) shows that in this smaller sample the effect of λ is still significant. Column (6) shows that adding tariffs if anything increases the coefficient.

Sample years. My sample spans 1984-2017 and the baseline estimation uses data for the years 1985, 1995, 2005, 2015. Since the λs 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. Columns (1-6) of Table A.7, upper panel, show that using alternative starting years, 1984, 1986, or 1987, produces similar effects, except for the direct effect in the first specification being insignificant. Moreover, I re-estimate Equation (38) using five-year-spaced data and covariances computed using the five most recent years (Columns 7,8) or all available years of data together with the baseline λs (Columns 9,10), with the latter in particular producing remarkably similar effects.

Production time lags. Time lags between production and sales are not only caused by shipping times, but likely also by the production process itself. Possibly, firms choose optimal quantities well before the goods arrive at the exporters' customs. To analyze whether production time lags are important, I use lagged risk premia instead of the contemporaneous ones. Column (11) of Table A.7, upper panel, shows no strong support for this hypothesis. The direct effect of the lagged risk premia is positive but insignificant.

Dependent variable and aggregation level. The main testable hypothesis of the model refers to export quantities rather than values. Quantities are fixed by the time production starts, whereas the value of sales depends on the realization of the demand shock. When I observe trade values at the exporter's (or possibly also at the importer's) border, it is unclear whether the demand shock has been realized and whether the reported value of a good is the final or the expected sales value. On average, export values registered

Table 3: Gravity estimations with risk premia: Regional CAPM

	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(1-\lambda)$	0.035***	0.218*		0.024***	0.083	
	(0.011)	(0.112)		(0.006)	(0.071)	
$\times$ ln *Dist*		-0.021			-0.007	
		(0.013)			(0.008)	
$\times$ Vessel		0.053***	0.050***		0.051***	0.048***
		(0.012)	(0.011)		(0.007)	(0.007)
$\times$ Vessel		-0.464***	-0.436***		-0.435***	-0.417***
		(0.101)	(0.097)		(0.061)	(0.059)
Observations	2080695	2080695	2080346	21427053	21427053	21425130
Adjusted R^2	0.783	0.783	0.787	0.818	0.818	0.821

All columns include importer-product-time, exporter-product-time and country-pair-product fixed effects. Columns 3,6 also include country-pair-time fixed effects. Columns 1,2,4,5 include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter. S.e. (in parentheses) robust to two-way clusters on product and country-pair level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity (in kg) by product, country-pair, and time. Estimates in Columns 1-3 (4-6) based on years 1985, 1995, 2005, 2015 (annual observations between 1984-2017). $\ln(1-\lambda)$ standardized.

at customs should still be negatively related to risk premia, but the coefficient likely reflects a mix of expected and realized values. On the positive side, data on export values is supposedly of higher quality, since some of the export weight entries in the Comtrade database are estimated. Columns (1,2) of Table A.7, lower panel, show that the positive effect of lower λs prevails indeed when considering export values, and so does the interaction with distance and the vessel indicator. Columns (3,4) explore the importance of the aggregation level of the product classification. The coefficient estimate for $\ln(1-\lambda)$ at the 2-digit level (aggregated bilateral level) becomes smaller (insignificant) which is in line with the model-based argument that a lower level of aggregation mitigates downward bias.

Alternative risk premia estimates. Table A.7, Columns (7-10) in the lower panel, present results for alternative sets of risk premia, based on different proxies for demand shocks in the destination markets; monthly indices of industrial production and retail sales, respectively. Country coverage for these indicators is limited (36 in the case of industrial production and 37 for retail sales) and heavily focused on industrialized countries. To make up for the loss in cross-sectional variation, I use all years of available data in those estimations. The risk premia in these regressions are standardized to obtain comparability (Columns 5,6 show the effects from the baseline specification (Columns 1,5 of Table 2) for standardized $\ln(1-\lambda)$). The estimated effects point in the same direction, but significance is weaker. For the risk premia based on industrial production I find a direct effect that is significant and very similar in terms of magnitudes to the main effect in the baseline estimation. For the risk premia based on retail sales, I find a smaller and

Table 4: Gravity estimations with risk premia: Consumption growth correlations

	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(1-\lambda)$	0.015**	0.263***		0.008*	0.153***	
	(0.007)	(0.080)		(0.004)	(0.055)	
× ln *Dist*		-0.029***			-0.017***	
		(0.009)			(0.006)	
× Vessel		0.038***	0.037***		0.023***	0.023***
		(0.008)	(0.007)		(0.005)	(0.005)
× Vessel		-0.324***	-0.321***		-0.193***	-0.196***
		(0.065)	(0.063)		(0.044)	(0.043)
Observations	1699404	1699404	1699160	17072960	17072960	17071499
Adjusted R^2	0.790	0.790	0.794	0.830	0.830	0.833

All columns include importer-product-time, exporter-product-time and country-pair-product fixed effects. Columns 3,6 also include country-pair-time fixed effects. Columns 1,2,4,5 include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter. S.e. (in parentheses) robust to two-way clusters on product and country-pair level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity (in kg) by product, country-pair, and time. Estimates in Columns 1-3 (4-6) based on years 1985, 1995, 2005, 2015 (annual observations between 1984-2017). $\ln(1-\lambda)$ standardized.

insignificant direct effect but a positive and significant interaction with distance and the vessel indicator.

4.2.4 Financial Market Integration

The results discussed so far are all based on correlations of demand shocks with national stock markets, assuming that investors are based in the exporting country and are primarily invested in domestic assets. In this section, I show that this assumption can be relaxed. First, I test the gravity equation using stock market indices of five aggregated regions rather than 21 national markets to model the representative investor's SDF. Secondly, I provide results based on an approximation of the SDF with consumption growth rather than asset income.

Table 3 presents the results based on risk premia obtained by using the market portfolio of the five supranational regional stock markets (listed in Table 1) for the stochastic discount factor. I find significant effects which are are about one and a half to two times as large after adjusting for the differences in standard deviations (cp. Column 5,6 of the lower panel of Table A.7 for the effect of $\ln(1-\lambda)$ in the baseline model in terms of standard deviations). These results do not constitute a test of the degree of financial market integration, but show that the results do not hinge on a respective assumption. Given that national stock markets within regions are highly positively correlated, it is not surprising to see both models producing qualitatively similar effects.

Table 4 presents the results obtained from using consumption-growth-based risk premia. The main effect and the interactions are highly significant, and similar in terms of magnitudes in the 10-year-spaced sample (Columns 1-3).

5 Conclusion

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

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

Using data on returns to firm shares from 21 countries, I estimate correlations of country-specific shocks with marginal utility growth of investors for the years 1984 to 2017. The correlations indicate that despite phases of declining openness, the world has become increasingly integrated over the course of four decades, with a consequent decrease in diversification benefits from trade. Based on product-level export data for these 21 countries and their trading partners, I show that the differential change in the correlation pattern across countries is consistent with long-term changes in the pattern of trade across destination markets within narrowly defined product categories.

I conclude from this analysis that risk diversification through trade matters at the level of the individual firm and has shaped trade patterns during the past four decades.

This finding implies that risk aversion and trade in assets not only matter for the pattern of bilateral trade, but also for the welfare effects of trade liberalization. Likewise, trade patterns influence the welfare effects of financial market integration. An analysis of the relative importance of the two for global welfare is left for future research.

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Appendix

A.1 Model Details

The firm's optimization problem. Starting from Equation (12), inserting Equation (10), and rearranging terms shows that the maximization problem can be written as

$$\max_{q_{ih,t}\geq 0\ \forall h} \sum_{h\in\mathcal{H}} \eta \left(\frac{q_{ih,t}}{Q_{h,t}}\right)^{\frac{\varepsilon-1}{\varepsilon}} \left(\mathrm{E}_t\left[Y_{h,t+1}\right]\mathrm{E}_t\left[m_{i,t+1}\right] + \mathrm{Cov}_t\left[m_{i,t+1}, Y_{h,t+1}\right]\right) - \sum_{h\in\mathcal{H}} c_i \tau_{ih} q_{ih,t} - \alpha_i.$$

The first-order condition yields the optimal quantity as

$$\begin{aligned} q^*_{ih,t} &= \left(\frac{\eta(\varepsilon-1)}{\varepsilon}\right)^{\varepsilon} (c_i\tau_{ih})^{-\varepsilon} Q^{1-\varepsilon}_{h,t+1} \mathrm{E}_t\left[Y_{h,t+1}\right]^{\varepsilon} \left(\mathrm{E}_t\left[m_{i,t+1}\right] + \mathrm{Cov}_t\left[m_{i,t+1}, \frac{Y_{h,t+1}}{\mathrm{E}_t\left[Y_{h,t+1}\right]}\right]\right)^{\varepsilon} \\ &= \frac{(\theta\lambda_{ih,t})^{\varepsilon}\left(c_i\tau_{ih}R^f_{i,t+1}\right)^{-\varepsilon}}{\left(\sum_i (\theta\lambda_{ih,t})^{\varepsilon-1}\left(c_i\tau_{ih}R^f_{i,t+1}\right)^{1-\varepsilon}\right)^{\frac{\varepsilon}{\varepsilon-1}}} \cdot Q_{h,t+1}. \end{aligned}$$

Using $\lambda_{ih,t}$ defined as in Equation (16) and Equation (5) to substitute for the expected value of the SDF, and substituting $q^*_{ih,t}$ into $Q^{\frac{\varepsilon-1}{\varepsilon}}_{h,t} = \sum_{i\in\mathcal{H}} N_{i,t}(q^*_{ih,t})^{\frac{\varepsilon-1}{\varepsilon}}$ yields Equation (15).

The investor's optimization problem. The investor's optimization problem is

$$\begin{aligned} &\max_{\boldsymbol{a}_{i,t},a^f_{i,t}} \mathrm{E}_t \sum_{s=0}^{\infty} \rho_i^s u_i(C_{i,t+s}) \\ \text{s.t.}\quad & W_{i,t} = A_{i,t} + C_{i,t} \quad \text{with} \quad A_{i,t} = \sum_{j\in\mathcal{J}_i} a_{ij,t} + a^f_{i,t} \\ & W_{i,t+1} = R^W_{i,t+1}\left(W_{i,t} - C_{i,t}\right) \quad \text{with} \quad R^W_{i,t+1} = \sum_{j\in\mathcal{J}_i} \frac{a_{ij,t}}{A_{i,t}} R_{j,t+1} + \frac{a^f_{i,t}}{A_{i,t}} R^f_{i,t+1} \\ & 0 = \lim_{s\to\infty} \frac{A_{i,t+s}}{\mathrm{E}_t\left[R^W_{i,t+s}\right]}. \end{aligned}$$

Inserting the first two constraints and writing out the expectation yields

$$\max_{\boldsymbol{a}_{i,t},a^f_{i,t}} \sum_{s=0}^{\infty} \rho_i^s \int_{W_{i,t+s}} u_i\left(\boldsymbol{R}^{i\,\prime}_{t+s}\boldsymbol{a}_{i,t+s-1} + R^f_{i,t+s}a^f_{i,t+s-1} - \boldsymbol{1}'_{J_{i,t}}\boldsymbol{a}_{i,t+s} - a^f_{i,t+s}\right) \mathrm{d}F_t\left[W_{i,t+s}\right]$$

$$\text{s.t.}\quad 0 = \lim_{s\to\infty}\frac{A_{i,t+s}}{\mathrm{E}_t\left[R^W_{i,t+s}\right]},$$

where $\mathbf{1}_{J_i}$ denotes a column vector of ones of dimension J_i. Using Equation (3), which describes the evolution of wealth and returns, together with Equation (21) and observing that, except for the productivity level in $t+1$, all determinants of wealth and the distribution of $\boldsymbol{\psi}_{t+1}|\boldsymbol{\Psi}_t$ are determined at time t,[40] the distribution of wealth at time t can be written as $\mathrm{d}F_t[W_{i,t+1}] = \mathrm{d}G[W_{i,t+1}|\boldsymbol{a}_{i,t}, a^f_{i,t}, \boldsymbol{\beta}_{i,t}, R^f_{i,t+1}, \boldsymbol{\Psi}_t]$. The Bellman equation is then

$$V_i(\mathcal{X}_i) = \max_{\boldsymbol{a}_{i,t}, a^f_{i,t}} \; u_i(W_{i,t} - \mathbf{1}'_{J_i}\boldsymbol{a}_{i,t} - a^f_{i,t}) + \rho_i \mathrm{E}_t V_i(\mathcal{X}_{i,t+1}) \tag{A.1}$$

where $\mathcal{X}_{i,t} = \{W_{i,t}, \boldsymbol{\beta}_{i,t}, \{R^f_{i,t+s}\}_{s=1}^{\infty}, \boldsymbol{\Psi}_t\}$ is the vector of state variables and the conditional expectation is based on $\mathrm{d}H(\mathcal{X}_{i,t+1}|\mathcal{X}_{i,t}, \boldsymbol{a}_{i,t}, a^f_{i,t})$.

Derivation of risk premia under assumptions (i)-(iv). Under assumptions (i) $f(\boldsymbol{\psi_{t+1}}|\boldsymbol{\Psi_t}) = f(\boldsymbol{\psi})$, (ii) $R^f_{i,t+s} = R^f_{i,t}$ for $s = 1, ..., \infty$, and (iii) $\boldsymbol{\beta}_{i,t+s} = \boldsymbol{\beta}_{i,t}$ if $W_{i,t+s} = W_{i,t}$ for $s = 0, ..., \infty$ (cp. Section 3.5), the set of state variables reduces to $\mathcal{X}_{i,t} = W_{i,t}$, since then the conditional distribution of wealth $\mathrm{d}F_t[W_{i,t+1}]$ depends on time only through the investor's choice variables $\boldsymbol{a}_{i,t}, a^f_{i,t}$. Generally, the βs depend on firms' choices conditional on other firms' choices, which, in turn, depend on the choices of investors in other countries. Hence, in the case of autarkic financial markets, equilibrium firm βs depend on the distribution of wealth across countries, which varies over time. With globally integrated financial markets and a single representative investor, the distribution of wealth becomes irrelevant and all firms' equilibrium βs depend only on the global investor's choices. Therefore, under assumptions (i) and (ii) and globally integrated financial markets, the investor's expectation about the βs as assumed in (iii) are consistent with the equilibrium relationship between $W_{i,t}$ and $\boldsymbol{\beta_t}$.

The first-order conditions of the optimization problem in Equation (A.1) for optimal investments $\boldsymbol{a}_{i,t}, a^f_{i,t}$ then obtain as

$$1 = \mathrm{E}_t\left[\rho_i \frac{V_i'(W_{i,t+1})}{u_i'(C_{i,t})}\right] R^f_{i,t+1} \quad \text{and} \quad 1 = \mathrm{E}_t\left[\rho_i \frac{V_i'(W_{i,t+1})}{u_i'(C_{i,t})} R_{j,t+1}\right] \quad \forall\, j \in \mathcal{J}_i,$$

which implies Equation (23).

Under assumption (iv) (cp. Section 3.5), $R_{j,t+1}$ and $R^W_{i,t+1}$ are approximately bivariate normal distributed variables $\forall\, j \in \mathcal{J}_i$. Using Stein's Lemma, I obtain an approximate linear relationship between the SDF and the return to the wealth portfolio. The following derivation closely follows Cochrane (2005, Ch. 9).

[40]Remember that $R^f_{i,t+1}$ is defined as the risk-free return for investments made at time t.

Stein's Lemma: If f, R are bivariate normal (BVN), $g(f)$ is differentiable, and $\mathrm{E}[|g'(f)|] < \infty$, then $\mathrm{Cov}[g(f), R] = \mathrm{E}[g'(f)]\mathrm{Cov}[f, R]$.

Now, assume $\mathrm{E}_t\left[\left|g'_{i,t}(R^W_{i,t+1})\right|\right] < \infty$ and $g_{i,t}(\cdot)$ is differentiable. Then, $R^W_{i,t+1}$ and $R_{j,t+1} \underset{approx.}{\sim} BVN \; \forall\, j \in \mathcal{J}_i$, $m_{i,t+1} = g_{i,t}(R^W_{i,t+1})$, the investor's first-order conditions

$$1 = \mathrm{E}_t[m_{i,t+1}R_{j,t+1}] \quad \Leftrightarrow \quad 1 = \mathrm{E}_t[m_{i,t+1}]\mathrm{E}_t[R_{j,t+1}] + \mathrm{Cov}_t[m_{i,t+1}, R_{j,t+1}], \tag{A.2}$$

and Stein's lemma imply that

$$1 = \mathrm{E}_t[g_{i,t}(R^W_{i,t+1})]\mathrm{E}_t[R_{j,t+1}] + \mathrm{E}_t[g'_{i,t}(R^W_{i,t+1})]\mathrm{Cov}_t[R^W_{i,t+1}, R_{j,t+1}].$$

Hence, a SDF of the form $m_{i,t+1} = \mathrm{E}_t[g_{i,t}(R^W_{i,t+1})] + \mathrm{E}_t[g'_{i,t}(R^W_{i,t+1})](R^W_{i,t+1} - \mathrm{E}_t[R^W_{i,t+1}])$ exists that is linear in $R^W_{i,t+1}$ and satisfies Equation (A.2) for all $j \in \mathcal{J}_i$.

Derivation of λ under autarkic financials markets without assumption (iii). Under autarkic financial markets and assumptions (i) and (ii), investor i's value function at time t depends not only on his own wealth, but on the whole distribution of wealth across countries. Even though financial markets are completely disintegrated, investors' choices are linked to each other through the interaction of firms on global goods markets. Every investor's current wealth determines the number of firms in his home country, and since those firms compete with each other in global markets, a larger number of firms from any country i increases the degree of competition and thus decreases all other firms' expected profits in all markets $h \in \mathcal{H}$.

Therefore, firm-market βs depend on all investors' choices and hence, under assumptions (i) and (ii), investor i's set of state variables is $\mathcal{X}_{i,t} = \{\boldsymbol{W}_t\}$, where
$\boldsymbol{W}_t = [W_{1,t}, ..., W_{i,t}..., W_{I,t}]$.

Investor i's first-order condition is then

$$1 = \mathrm{E}_t\left[\rho_i \frac{V_{iW_i}(\boldsymbol{W}_{t+1})}{u'_i(C_{i,t})}\right] R^f_{i,t+1} \quad \text{and} \quad 1 = \mathrm{E}_t\left[\rho_i \frac{V_{iW_i}(\boldsymbol{W}_{t+1})}{u'_i(C_{i,t})} R_{i,t+1}\right]$$

where I use V_{iW_i} as shorthand for $\frac{\partial V_i(\boldsymbol{W}_{t+1})}{\partial W_{i,t+1}}$. The stochastic discount factor is

$$m_{i,t+1} = h_{i,t}(\boldsymbol{R^W}_{t+1}) := \frac{V_{iW_i}(\boldsymbol{W}_{t+1})}{u'_i(C_{i,t})} \tag{A.3}$$

where $\boldsymbol{R^W}_{t+1} = [R^W_{1,t+1}, ..., R^W_{i,t+1}..., R^W_{I,t+1}]$. Under assumption (iv) an Intertemporal

Capital Asset Pricing Model

$$m_{i,t+1} = \tilde{\zeta}_{i,t} - \tilde{\gamma}_{i,t} R^W_{i,t+1} - \sum_{j \in \mathcal{H}} \gamma_{ij,t} R^W_{j,t+1}$$

in the spirit of Merton (1973) can be derived applying Stein's Lemma as above. The $\gamma_{ij,t}$s are given by

$$\gamma_{ij,t} = -\frac{\partial h_{i,t}}{\partial R^W_{j,t+1}} = -\frac{\partial h_{i,t}}{\partial \boldsymbol{\beta}_{i,t+1}} \frac{\partial \boldsymbol{\beta}_{i,t+1}}{\partial R^W_{j,t+1}},$$

where the second inequality highlights that investor i's SDF depends on wealth in other countries through the firm-market βs. Using, as above, the linear relationship between returns and productivity shocks $R^W_{i,t+1} = \frac{a_{ii,t}}{A_{i,t}} \sum_{h \in \mathcal{H}} \beta_{ih,t} \widehat{Y}_{h,t+1} + \frac{a^f_{ii,t}}{A_{i,t}} R^f_{i,t+1}$, I can also express the SDF given in Equation (A.3) as a linear combination of demand shocks. That is,

$$m_{i,t+1} = \tilde{\zeta}_{i,t} - \tilde{\gamma}_{i,t} \frac{a_{ii,t}}{A_{i,t}} \sum_{h \in \mathcal{H}} \beta_{ih,t} \hat{\psi}_{h,t+1} - \sum_{j \in \mathcal{H}} \gamma_{ij,t} \frac{a_{jj,t}}{A_{j,t}} \sum_{h \in \mathcal{H}} \beta_{jh,t} \hat{\psi}_{h,t+1} = \tilde{\zeta}_{i,t} - \tilde{\boldsymbol{b}}'_{i,t} \widehat{\boldsymbol{Y}}_{\boldsymbol{t+1}}. \quad \text{(A.4)}$$

The bilateral exposures are given by

$$\tilde{b}_{ih,t} = \tilde{\gamma}_{i,t} \frac{a_{ii,t}}{A_{i,t}} \beta_{ih,t} \mathrm{E}_t[Y_{h,t+1}] + \sum_{j \in H} \gamma_{ij,t} \frac{a_{jj,t}}{A_{j,t}} \beta_{jh,t} \mathrm{E}_t[Y_{h,t+1}].$$

The direct bilateral exposure through exports of domestic firms, $\frac{a_{ii,t}}{A_{i,t}} \beta_{ih,t} \mathrm{E}_t[Y_{h,t+1}]$ is the same as above. In addition, the $\tilde{b}$'s also take into account that investors from other countries $j \in \mathcal{H}$ are exposed to the same productivity shock and that their associated changes in investment will affect the profit opportunities of the firms in investor i's portfolio.

The case of perfect financial market integration and CRRA preferences. Under the assumption of CRRA preferences and globally integrated financial markets (in addition to assumptions (i),(ii),(iv)), λs, βs, and bilateral exposures $\boldsymbol{b}$ are all constants. This can be shown as follows.

Note first that assumptions (i) and (ii) imply that for $t, s = 1, ..., \infty$, $R^f_{t+s} = R^f$, $\mathrm{E}_t[\boldsymbol{\psi}_{t+s}]$ $=\mathrm{E}[\boldsymbol{\psi}]$, and $\mathrm{Cov}_t\left[\hat{\boldsymbol{\psi}}_{t+1}, \hat{\boldsymbol{\psi}}'_{t+1}\right] = \mathrm{Cov}\left[\hat{\boldsymbol{\psi}}, \hat{\boldsymbol{\psi}}'\right]$. CRRA preferences imply that for i.i.d. returns the composition of the wealth portfolio is independent of wealth (see Hakansson, 1970). With i.i.d. returns, constant portfolio shares, and constant risk-free rates, the return to total wealth is also i.i.d. It follows from the Euler equations that ζ, γ are constants (see Cochrane, 2005, Ch. 8). It remains to show that under the above assumptions, the distribution of returns is in fact independent and identical over time.

In addition to the (i.i.d.) productivity shocks, returns also depend on the firm-market βs summarizing firms' optimal choices conditional on other firms' choices, which, generally, vary over time as the number of firms in each country changes due a change in the amount of investment. However, in the special case of CRRA preferences and a global representative investor, the βs are constant. A key observation is that the βs are homogeneous of degree zero in the number of firms in *all* countries, and that in the special case of CRRA preferences and a single globally representative investor, investment in every asset and, hence, the number of firms in all countries changes proportionately to total investment.

Suppose first that portfolio shares $a_{i,t}/A_t$ and λs are constant. Then, sales to any market h

$$\begin{aligned} s_{ih,t+1} = \phi_{ih,t} Y_{h,t+1} &= \frac{\left(c_i \tau_{ih}\right)^{1-\varepsilon}}{\sum_{i\in\mathcal{H}} N_{i,t}\left(c_i \tau_{ih}\right)^{1-\varepsilon}} Y_{h,t+1} \\ &= \frac{\left(c_i \tau_{ih}\right)^{1-\varepsilon}}{\sum_{i\in\mathcal{H}} N_{i,t}\left(c_i \tau_{ih}\right)^{1-\varepsilon}} \left(\sum_{i\in\mathcal{H}} N_{i,t}(1-\lambda_h)^{\varepsilon-1}(R^f c_i \tau_{ih})^{1-\varepsilon}\right)^{\frac{\varepsilon-\varepsilon\eta+1}{(\varepsilon-1)(1-\eta)}} \frac{\psi_{h,t+1}}{(\theta \mathrm{E}\left[\psi_h\right])^{\frac{1}{\eta-1}}} \end{aligned}$$

are homogeneous of degree $\nu = \frac{\eta}{1-\eta}\frac{\varepsilon-\eta\varepsilon-1}{\varepsilon-1} - 1 < 0$ in the number of firms $\boldsymbol{N}_t$. Likewise, expected sales $\phi_{ih,t}\mathrm{E}_t[Y_{h,t+1}]$ are homogeneous of degree ν in the number of firms and so are share prices

$$v_{i,t} = \sum_{h\in\mathcal{H}} \mathrm{E}_t\left[m_{t+1}\cdot s_{ih,t+1}\right] = \sum_{h\in\mathcal{H}} \frac{1-\lambda_h}{R^f}\phi_{ih,t}\mathrm{E}_t\left[Y_{h,t+1}\right].$$

It follows that $\beta_{ih,t} = \frac{\phi_{ih,t}\mathrm{E}_t\left[Y_{h,t+1}\right]}{v_{i,t}}$ is homogeneous of degree zero in $\boldsymbol{N}_t$. Hence, for constant λ, firm-market βs are constant and returns are i.i.d.. Now consider the λs. Rewriting the bilateral exposures in (26) in terms of βs gives

$$b_{h,t} = \gamma_{i,t}\sum_{i\in\mathcal{H}}\frac{a_{i,t}}{A_t}\beta_{ih,t}.$$

For constant portfolio shares, constant βs, and constant γ_i, the bs are also constant, and so are the λs, which, using Equation (28), follow as

$$\boldsymbol{\lambda} = R^f \mathrm{Cov}\left[\hat{\boldsymbol{\psi}}, \hat{\boldsymbol{\psi}}'\right]\boldsymbol{b}.$$

With i.i.d. returns and constant portfolio shares, the return to total wealth is also i.i.d.. It is given by

$$R^W_{t+1} = \sum_{i\in\mathcal{H}}\sum_{h\in\mathcal{H}}\frac{a_{i,t}}{A_{i,t}}\frac{\phi_{ih,t}\mathrm{E}_t[Y_{h,t+1}]}{v_{i,t}}Y_{h,t+1} = \frac{\sum_{i\in\mathcal{H}}\sum_{h\in\mathcal{H}} N_{i,t}\phi_{ih,t}Y_{h,t+1}}{A_t} = \frac{Y_{W,t+1}}{A_t},$$

where $Y_{W,t+1} = \sum_{h\in\mathcal{H}} Y_{h,t+1}$. The return to the global wealth portfolio is given by global final goods production over total investment.[41]

Current account and balance of payments. Let $\tilde{a}_{ki,t}$ ($\tilde{a}^f_{ki,t}$) denote the risky (risk-free) assets from country $i \in \mathcal{H}$ held by country $k \in \mathcal{H}$. Then, the current account of country $k \in \mathcal{H}$ defined as net exports plus net earnings from foreign investment obtains as the sum of final goods net exports $Y_{k,t} + \sum_i \tilde{a}^f_{ik,t-1} R^f_{k,t} - \Big(C_{k,t} + \sum_i (\tilde{a}_{ik,t} + \tilde{a}^f_{ik,t})\Big)$ (final goods output including returns from investment minus domestic absorption for consumption and investment minus final goods imports), net domestic intermediate exports $N_{k,t-1} \sum_h \phi_{kh,t-1} Y_{h,t} - \sum_i \phi_{ik,t-1} Y_{k,t}$ (exports by variety producers minus intermediate imports by final goods producers), and asset income from investment in foreign assets $\sum_i (\tilde{a}_{ki,t-1} r_{i,t} + \tilde{a}^f_{ki,t-1} r^f_{i,t})$ minus asset income owned by foreign investors in the home country $\sum_i \tilde{a}_{ik,t-1} r_{k,t} + \tilde{a}^f_{ik,t-1} r^f_{k,t}$.[42] Using $r_{i,t} = R_{i,t} - 1 = \frac{s_{i,t}}{v_{i,t-1}} - 1$, $\mathrm{d}a_{ik,t} = a_{ik,t} - a_{ik,t-1}$, $\sum_i a_{ik,t} = N_{k,t} v_{k,t}$ (asset market clearing), and inserting the budget constraint (2) shows that the current account

$$\begin{aligned} CA_{k,t} = {} & Y_{k,t} + \sum_i \tilde{a}^f_{ik,t-1} R^f_{k,t} - \left(C_{k,t} + \sum_i (\tilde{a}_{ik,t} + \tilde{a}^f_{ik,t}) \right) \\ & + N_{k,t-1} \sum_h \phi_{kh,t-1} Y_{h,t} - \sum_i N_{i,t-1} \phi_{ik,t-1} Y_{k,t} \\ & + \sum_i (\tilde{a}_{ki,t-1} r_{i,t} + \tilde{a}^f_{ki,t-1} r^f_{i,t}) - \sum_i (\tilde{a}_{ik,t-1} r_{k,t} + \tilde{a}^f_{ik,t-1} r^f_{k,t}) \\ = {} & -\sum_i (\mathrm{d}\tilde{a}_{ki,t} + \mathrm{d}\tilde{a}^f_{ki,t}) + \sum_i (\mathrm{d}\tilde{a}_{ik,t} + \mathrm{d}\tilde{a}^f_{ik,t}) \end{aligned}$$

is equal to net foreign investment, that is, it is equal to the capital account. Hence, the international payment system is balanced.

Expected return-beta representation. The structural equation of the SDF (25) falls into the class of *linear factor models*, which are commonly used in the asset pricing literature to analyze asset returns by means of their correlations with *factors*, typically portfolio returns or macro variables. In my case the factors are country-specific productivity shocks.

[41] The second equality uses the asset market clearing condition $N_{i,t} v_{i,t} = a_{i,t}$. The third equality uses $\sum_{i\in\mathcal{H}} N_{i,t} \phi_{ih,t} = 1$.

[42] I include domestic sales and domestic earnings in inflows and outflows to save on notation. They net each other out in all positions.

As shown in Cochrane (1996), every linear factor model has an equivalent *expected return-beta* representation which implies that the λs can be interpreted as monetary *factor risk premia* or *factor prices*.

The Euler equation for risky assets (6) implies that, in equilibrium, the return to every asset $j \in \mathcal{J}_i$ observes

$$1 = \mathrm{E}_t\left[m_{i,t+1} R_{j,t+1}\right] \qquad \text{where} \qquad m_{i,t+1} = b_{i0,t} - \boldsymbol{b}'_{i,t} \hat{\boldsymbol{Y}}_{t+1}.$$

Following Cochrane (2005, Ch. 6), I can rewrite this as

$$\begin{aligned} \mathrm{E}_t\left[R_{j,t+1}\right] - R^f_{i,t+1} &= R^f_{i,t+1} \boldsymbol{b}'_{i,t} \mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, R_{j,t+1}\right] \\ &= R^f_{i,t+1} \boldsymbol{b}'_{i,t} \mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, \hat{\boldsymbol{Y}}'_{t+1}\right] \mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, \hat{\boldsymbol{Y}}'_{t+1}\right]^{-1} \mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, R_{j,t+1}\right]. \end{aligned} \tag{A.5}$$

Define $\boldsymbol{\beta}_{j,t} := \mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, \hat{\boldsymbol{Y}}'_{t+1}\right]^{-1} \mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, R_{j,t+1}\right]$ as the vector of coefficients resulting from a multivariate time-series regression of firm j's return on the factors. Then, Equation (28) implies that (A.5) can be written as

$$\mathrm{E}_t\left[R_{j,t+1}\right] - R^f_{i,t+1} = \boldsymbol{\lambda}'_{i,t} \boldsymbol{\beta}_{j,t}.$$

A special case of $\boldsymbol{\lambda} = \mathbf{0}$. To show that $\boldsymbol{\lambda}_t = 0$ and $\mathrm{E}_t\left[\psi_{h,t+1}\right] \geq \mathrm{E}_t\left[\psi_{i,t+1}\right]$ imply that the number of firms in country i is weakly larger, I consider the amount of composite good production consistent with firms' optimal quantity decisions as given in Equation (15) evaluated at $\boldsymbol{\lambda}_t = 0$:

$$Q_{i,t} = \left(\sum_{j=i,h} N_{j,t} (q^*_{ji,t})^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}} = \theta \mathrm{E}_t\left[Y_{i,t+1}\right] \left(N_{i,t} c^{1-\varepsilon} + N_{h,t} (c\tau)^{1-\varepsilon}\right)^{\frac{\varepsilon}{\varepsilon-1}}$$

Since $\mathrm{E}_t\left[Y_{h,t+1}\right] = \mathrm{E}_t\left[Y_{i,t+1}\right]$, $Q_{i,t} \geq Q_{h,t}$ implies $N_{i,t} c^{1-\varepsilon} + N_{h,t}(c\tau)^{1-\varepsilon} \geq N_{i,t}(c\tau)^{1-\varepsilon} + N_{j,t} c^{1-\varepsilon}$. This holds true if $N_{i,t} \geq N_{h,t}$ and it means that market i is more competitive since it features a larger number of domestic firms that do not incur trade costs to access the market compared to country h where the number of foreign firms is larger than the number of domestic firms. Comparing optimum firm values as given in Equation (18) evaluated at $\boldsymbol{\lambda}_t = 0$, shows that

$$\begin{aligned} V^*_{h,t} - V^*_{i,t} &= \frac{\mathrm{E}_t\left[Y_{h,t+1}\right]}{R^f_{t+1}} \left(\psi_{hh,t} + \psi_{hi,t} - \psi_{ii,t} - \psi_{ih,t}\right) \\ &= \frac{\mathrm{E}_t\left[Y_{h,t+1}\right]}{R^f_{t+1}} (1 - \tau^{1-\varepsilon}) \left(\frac{1}{N_i \tau^{1-\varepsilon} + N_j} - \frac{1}{N_i + N_j \tau^{1-\varepsilon}}\right) \geq 0. \end{aligned}$$

Hence, the only case where the free entry condition is not violated is the knife-edge case $\mathrm{E}_t[\psi_{h,t+1}] = \mathrm{E}_t[\psi_{i,t+1}]$.

A.2 Data Appendix

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

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

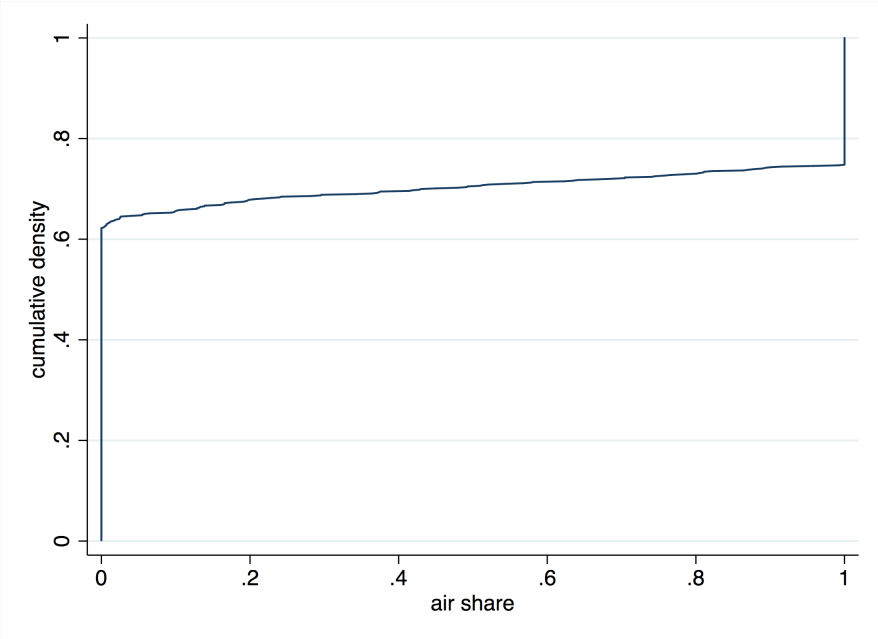
Retail sales. The third proxy for demand shocks is growth of the monthly (seasonally adjusted) index of retail sales volume taken from the OECD *Monthly Economic Indicators* (MEI) Database. It is available for 37 destination countries, over varying lengths of time.

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

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

Primary transport mode. Source: US Census Bureau FTD. I use the dataset provided by Peter Schott through his data website.[43] For each product-country-year shipment to and from the U.S. between 1989 and 2015 I compute the share of trade by air at the HS-10-digit level. Then, I match the HS-10-digit codes with SITC four-digit codes used in my export data and then take the median over all shipments by SITC four-digit code. I define an indicator $Vessel = 1$ if this median share of air shipment is $< .5$. Note that strictly speaking, the vessel indicator captures all kinds of transport but air, including ground transport. Figure A.2 plots the cumulative distribution of median air shares across products. The resulting separation into goods shipped primarily by air or vessel is pretty strict. For only 98 out of 786 products is the median air share different from zero or one.

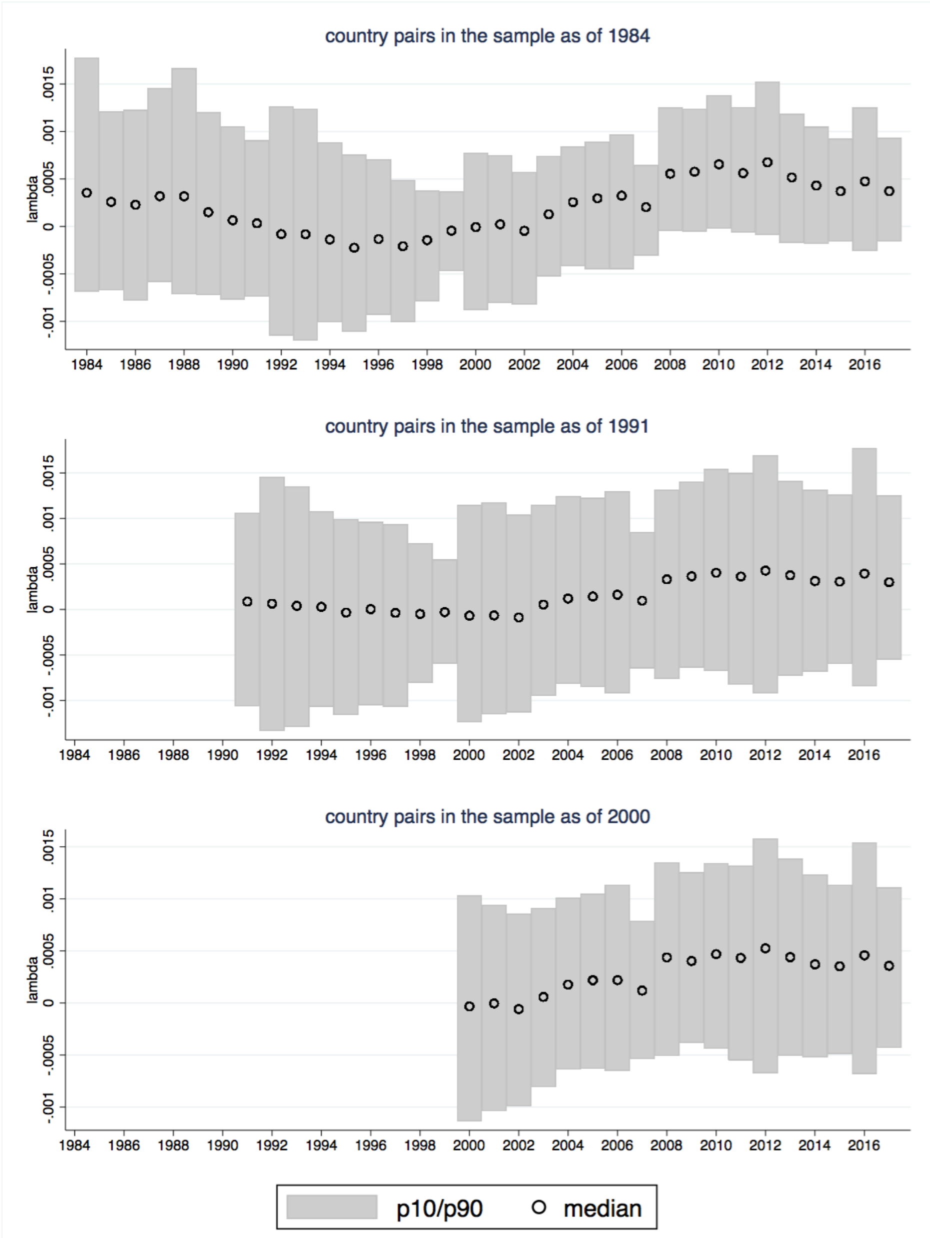
Figure A.1: Distribution of median share of air transport across products in total U.S. trade 1989-2015



Source: U.S. Census Bureau FTD. Products defined as 4-digit codes of SITC Rev.2.

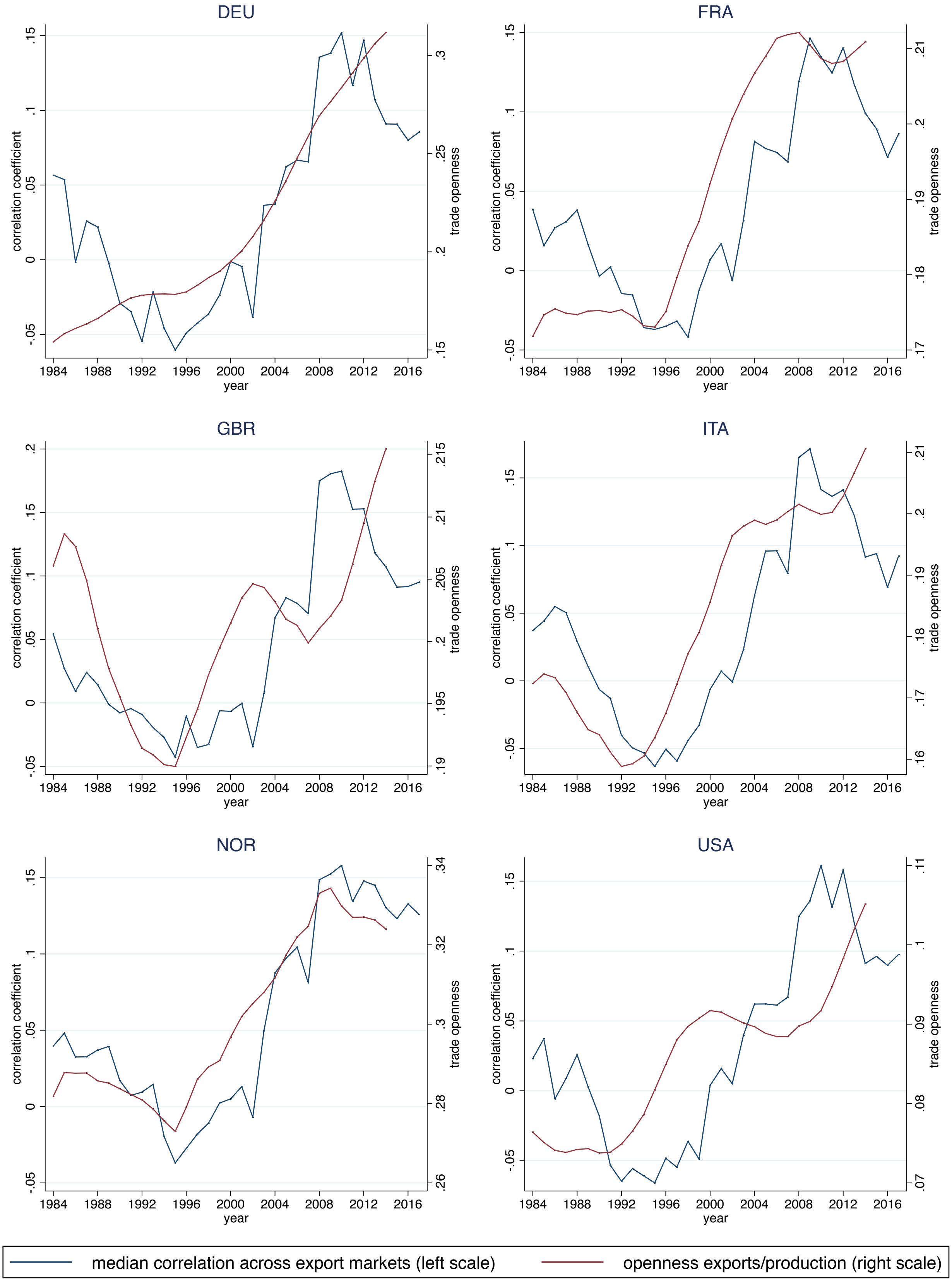
[43] *http://faculty.som.yale.edu/peterschott/sub_international.htm*

Figure A.2: Distribution of risk premia over countries and time



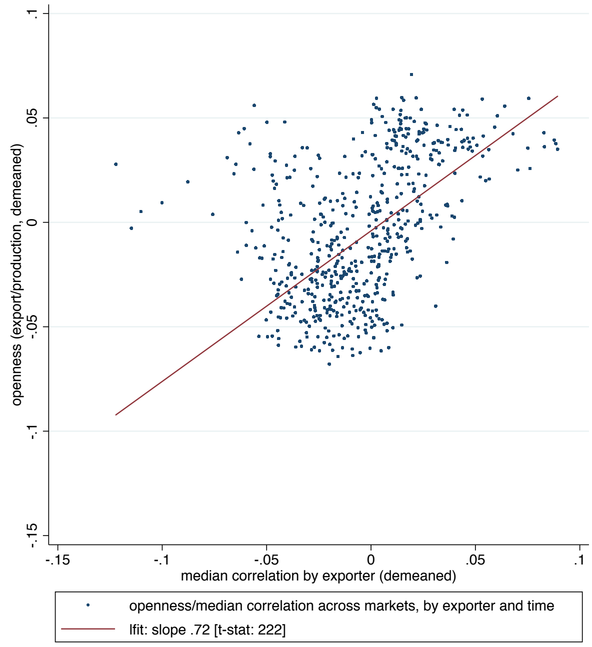
The figure shows the distribution of risk premia across country pairs. Gray bars denote the range of the distribution between the 10th and 90th percentile. Each panel shows a subsample of country pairs.

Figure A.3: Openness and median correlation of shocks for individual exporters



The figure shows correlation coefficients of country-specific demand shocks with investors' SDF (median across destination markets, left scale) and trade openness (right scale) for selected exporting countries. Trade openness at a given point in time reflects the average over the current and past 9 years, the same time horizon over which the correlation coefficients have been computed.

Figure A.4: Openness and median correlation of shocks for all exporters and years



The figure plots correlation coefficients of country-specific demand shocks with investors' SDF (median across destination markets) against trade openness. Each dot reflects one exporting country in a specific year (1984-2013). Trade openness at a given point in time reflects the average over the current and past 9 years, the same time horizon over which the correlation coefficients have been computed.

Table A.5: Summary statistics of variables used in the gravity estimations

Variables/Categories	Description	# Obs.	# Groups	Mean	Std. Dev.	Min	Max	Source, notes
Value	> 0, in thsd. USD	2,080,695		7,132,654	1.20e+08	1	4.97e+10	UN Comtrade
Quantity	> 0, in kg.	2,080,695		4,735,109	5.15e+08	1	6.54e+11	UN Comtrade
$\ln Dist$	(log) bilateral distance in km	2,080,695		8.2	1.0	4.1	9.9	CEPII gravity dataset
Contiguity	binary common border indicator	2,080,695		.05	.22	0	1	CEPII gravity dataset
Comm. Language	binary common offic. language indicator	2,080,695		.15	.36	0	1	CEPII gravity dataset
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	Baier & Bergstrand FTA database, WTO RTA database
$\ln(1-\lambda)$	bilateral risk premium	2,080,695		-.0002	.0007	-.0066	.0071	IMF Dots, Fama & French Data Library
$\ln(1-\lambda)$ (IP)	bilateral risk premium, based on *industrial production* growth	782,291		-.00007	.0003	-.0019	.0019	IMF Dots, OECD MEI
$\ln(1-\lambda)$ (RS)	bilateral risk premium, based on *retail sales* growth	683,900		-.00007	.0003	-.0013	.0014	IMF Dots, OECD MEI
$\ln(1-\lambda)$ (REG)	bilateral risk premium for five regional financial markets	2,080,695		-.0249	.0733	-.9048	.4943	IMF Dots, Fama & French Data Library
$\ln(1-\lambda)$ (CG)	bilateral risk premium, based on *consumption* growth	1,746,827		-.00003	.0001	-.001	.0012	IMF Dots, OECD KEI
$\ln(1+Tariff)$	bilateral tariff	1,768,077		.06	.10	0	3.43	WITS
Vessel	binary indicator for primary shipment mode = vessel	2,080,695		.63	.48	0	1	US Census FTD, cp. Peter Schott's data website
# 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	

Table A.6: Gravity estimations with risk premia: The role of omitted bilateral factors

	(1) All	(2) All	(3) All	(4) All	(5) Tariffs	(6) Tariffs
$\ln(1-\lambda)$	-165.847***	1.095	1.924	19.549**	21.036*	21.081*
	(31.691)	(17.439)	(17.430)	(9.540)	(11.126)	(11.128)
ln *Dist*		-1.746***	-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*	0.098*	0.067	0.064
			(0.081)	(0.054)	(0.079)	(0.079)
L5.*EU*			0.567***	0.308***	0.289***	0.288***
			(0.103)	(0.056)	(0.068)	(0.068)
L10.*EU*			-0.777***	-0.032	-0.005	0.000
			(0.108)	(0.056)	(0.061)	(0.061)
FTA			0.204***	0.042	-0.004	-0.008
			(0.059)	(0.032)	(0.032)	(0.032)
L5.*FTA*			-0.073	0.071*	0.073**	0.070**
			(0.082)	(0.039)	(0.035)	(0.035)
L10.*FTA*			0.126*	0.064**	0.041	0.038
			(0.068)	(0.031)	(0.032)	(0.032)
ln *Tariff*						-0.252***
						(0.080)
Fixed Effects						
Imp/Exp×prd×yr	YES	YES	YES	YES	YES	YES
Cty-pair×prd	NO	NO	NO	YES	YES	YES
Observations	2080695	2080695	2080695	2080695	1716482	1716482
Adjusted R^2	0.601	0.698	0.698	0.783	0.789	0.789

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

Table A.7: Gravity estimations with risk premia: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)		
Time Spacing	1984-2014 $\Delta = 10$		1986-2016 $\Delta = 10$		1987-2017 $\Delta = 10$		1985-2015 $\Delta = 5$		1984-2017 $\Delta = 1$		1985-2015 $\lambda = L1.\lambda_t$	
$\ln(1-\lambda)$	12.333 (9.549)	54.836 (112.048)	15.187* (8.705)	-5.409 (104.041)	18.464* (9.889)	156.352 (111.263)	8.975** (3.586)	55.184 (38.941)	18.483*** (5.753)	63.369 (72.007)	8.422 (9.728)	32.371 (110.546)
$\times$ ln *Dist*		-4.138 (13.085)		3.013 (12.133)		-16.639 (12.973)		-6.033 (4.563)		-5.608 (8.341)		-1.877 (12.774)
$\times$ Vessel		47.861*** (11.421)		34.289*** (11.057)		39.743*** (12.210)		8.374** (4.220)		48.938*** (7.479)		50.445*** (10.973)
$\times$ Vessel		-412.812*** (97.142)		-295.107*** (94.797)		-329.982*** (104.049)		-62.778* (36.196)		-409.445*** (64.265)		-435.365*** (93.814)
Observations	2039752	2039752	2141349	2141349	1960372	1960372	4580341	4580341	21427053	21427053	2072580	2072580
Adjusted R^2	0.783	0.783	0.785	0.785	0.779	0.779	0.800	0.800	0.818	0.818	0.783	0.783

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Robustness check:	*Dependent Variable:* ln *Exp. Value*				*Dependent Variable:* ln *Quantity*					
	SITC 4-digit		SITC 2-digit	Total bil. trade	$\ln(1-\lambda) = \frac{\ln(1-\lambda^{org})}{\sigma^{\ln(1-\lambda^{org})}}$		*Industr. Production*		*Retails Sales*	
$\ln(1-\lambda)$	25.105*** (8.862)	101.095 (93.000)	18.766* (9.836)	26.809 (19.110)	0.015** (0.007)	0.043 (0.095)	0.016** (0.007)	0.019 (0.050)	0.005 (0.005)	-0.042 (0.031)
$\times$ ln *Dist*		-8.172 (10.715)				-0.003 (0.011)		-0.001 (0.006)		0.006 (0.004)
$\times$ Vessel		40.061*** (9.568)				0.046*** (0.010)		0.000 (0.005)		0.013*** (0.004)
$\times$ Vessel		-350.424*** (82.992)				-0.395*** (0.086)		-0.001 (0.040)		-0.097*** (0.031)
Observations	2281127	2281127	401632	10474	2080695	2080695	7303953	7303953	6321376	6321376
Adjusted R^2	0.768	0.768	0.842	0.950	0.783	0.783	0.857	0.857	0.865	0.865

All estimations include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter. All columns except Column 4 in the lower panel include importer-product-time, exporter-product-time and country-pair-product fixed effects. Column 4 in the lower panel includes importer-time, exporter-time, and pair fixed effects. S.e. (in parentheses) robust to two-way clusters on product and country-pair level (at the country-pair level in Column 4 lower panel). Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable is log export quantity in kg. by product, country-pair, and time unless indicated otherwise. *Spacing* $\Delta = 10(5,1)$ indicates that the sample consists of 10 (5,1)-year-spaced time windows spanned by the period denoted by *Time*. In Columns 11,12, upper panel, the first lag of λ is used in place of the contemporaneous value. In the lower panel, Columns (5,6) repeat the baseline estimation as in Table 2 with standardized $\ln(1-\lambda)$. $\ln(1-\lambda)$ in Columns 7,8 (9,10) λ is based on growth in a monthly, seasonally adjusted quantity index of industrial production (retails sales) rather than aggregate imports, and also standardized. Columns 1-6 (7-10) based on years 1985, 1995, 2005, 2015 (annual data between 1984-2017)