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 correlations between demand growth in export markets and expected marginal utility growth of U.S. investors. I then show that the covariance pattern is reflected in the pattern of U.S. 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 and futures. However, insurance against aggregate risk is costly. Firms' diversification incentives result from a tradeoff between the cost of insuring against the aggregate risk involved in exporting and the cost of deviating from the first-best quantity under risk neutrality. In other words, as long as insurance against aggregate risk is costly, it is optimal for shareholder-value maximizing firms to sacrifice some expected return in order to reduce investors' exposure to the aggregate risk implied by their exporting decisions. Using product-level export data from the United States, 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 U.S. investors.

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., 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 the degree of global risk sharing. Here lies the contribution of

[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.

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. I provide empirical support for this hypothesis based on a panel of product-level exports from the United States to 169 destination markets.

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 with U.S. investors' marginal utility growth for 169 destination markets. With those estimated covariances at hand, I then test the main prediction of the model using a panel of U.S. exports by product and destination. I find strong support for the hypothesis. Looking at variation across time within narrowly defined product-country cells, I find that, conditional on "gravity," changes in the pattern of U.S. exports across destination markets over 20 years can in part be explained by changes in the correlation pattern of destination-market-specific demand shocks with U.S. investors' marginal utility growth. This implies that exporters respond to investors' desire for consumption smoothing and hence play an active role in global risk sharing.

Moreover, I find differential effects across exporting sectors and across modes of transportation, 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 from sectors characterized by greater reliance on upfront investment according to the measure developed by Rajan and Zingales (1998). I also find stronger effects for shipments by vessel compared to shipments by air. Both 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. As described above, my export data set, which comprises shipments by mode of transportation, allows me to test the relevance of this particular type of friction.

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

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

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 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.

assume that individuals have von Neumann-Morgenstern preferences, concave per-period utility functions, and hold identical beliefs about the probabilities with which uncertain 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

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[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.

firms of types $j \in \mathcal{J}_i$, that yield stochastic gross return $R_{j,t+1}$. His budget constraint is 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 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 $N_{i,t}$.

Demand for a firm's variety in any destination market h is volatile because it depends

[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.

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 and the empirics 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,

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

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

$$q^*_{ih,t} = \frac{\theta(1+\lambda_{ih,t})^{\varepsilon}\left(R^f_{i,t+1}c_i\tau_{ih}\right)^{-\varepsilon}}{\sum_{i\in\mathcal{H}} N_{i,t}(1+\lambda_{ih,t})^{\varepsilon-1}\left(R^f_{i,t+1}c_i\tau_{ih}\right)^{1-\varepsilon}}\cdot \mathrm{E}_t\left[Y_{h,t+1}\right], \tag{14}$$

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

$$\lambda_{ih,t} := R^f_{i,t+1}\mathrm{Cov}_t\left[m_{i,t+1}, \frac{Y_{h,t+1}}{\mathrm{E}_t\left[Y_{h,t+1}\right]}\right]. \tag{15}$$

To arrive at Equation (14), 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]

I call $\lambda_{ih,t}$ the "risk premium" of market h. It is negative for markets that are *risky* in the sense that demand shocks on these markets are negatively correlated with the SDF, and positive otherwise. Demand growth comoves one to one with the country-specific productivity shock $\psi_{h,t+1}/\mathrm{E}_t\left[\psi_{h,t+1}\right]$; see Equation (9).

Equation (14) 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

[21]See Appendix A.1 for details.

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

$$p_{ih,t+1}(q^*_{ih,t})q^*_{ih,t} = \phi_{ih,t} Y_{h,t+1}, \tag{16}$$

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 (16) is a firm-level gravity equation with bilateral trade cost augmented by a risk-adjusted interest rate. Note that Equation (16) nests the gravity equation of derived from model of Krugman (1980) with homogenous firms and monopolistic competion 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 the current demand level ($\mathrm{E}_t\left[Y_{h,t}\right] = Y_{h,t}$). 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 (16) 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 (14). Firms still ship larger quantities to countries with positive λs and investors value these firms more, but since all their competitors from

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

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.

Note that the *variance* of demand shocks per se does not influence the quantity shipped to a certain destination.[23] This is because in a setup where firms' investors trade multiple assets, firms' objective (besides maximizing profits) is not to minimize the variance of profits, but the *covariance* with investors' (imperfectly) diversified 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, I show that the results are robust to allowing for a direct effect of the variance on optimal quantities.

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

$$
\begin{aligned}
V^*_{i,t} &= \sum_{h\in\mathcal{H}} \left(\mathrm{E}_t\left[m_{i,t+1}\cdot p_{ih,t+1}(q^*_{ih,t})q^*_{ih,t}\right] - c_i\tau_{ih}q^*_{ih,t}\right) - \alpha_i \qquad (17)\\
&= (1-\theta)\sum_{h\in\mathcal{H}} \frac{1+\lambda_{ih,t}}{R^f_{i,t+1}}\phi_{ih,t}\mathrm{E}_t\left[Y_{h,t+1}\right] - \alpha_i,
\end{aligned}
$$

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

[23]The standard deviation enters only as a scaling factor of the covariance. Hence, its influence on q depends on the sign of the correlation.

of firms, $N_{i,t}$, is determined by

$$V_{i,t}^* = 0 \qquad \Leftrightarrow \qquad \mathrm{E}_t\left[m_{i,t+1} \cdot \sum_{h\in\mathcal{H}} p_{ih,t+1}(q_{ih,t}^*)q_{ih,t}^*\right] = \sum_{h\in\mathcal{H}} c_i\tau_{ih}q_{ih,t}^* + \alpha_i. \tag{18}$$

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.[24] Moreover, entry of additional 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 (18), 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:

$$v_{i,t} = \sum_{h\in\mathcal{H}} c_i\tau_{ih}q_{ih,t}^* + \alpha_i. \tag{19}$$

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

$$R_{i,t+1} = \frac{s_{i,t+1}}{v_{i,t}} = \sum_{h\in\mathcal{H}} \beta_{ih,t}\left(\frac{Y_{h,t+1}}{\mathrm{E}_t\left[Y_{h,t+1}\right]}\right) \qquad \text{with} \tag{20}$$

$$\beta_{ih,t} := \frac{\phi_{ih,t}\mathrm{E}_t\left[Y_{h,t+1}\right]}{v_{i,t}}. \tag{21}$$

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,

[24]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 love of variety.

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.

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 (18), (15), and (21). 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 (15):	$\lambda_{ih,t}\left[C_{i,t}, a^f_{i,t}, a_{ii,t}, \boldsymbol{\beta}_{i,t}, \boldsymbol{X}_t\right]$	$\forall\ h \in \mathcal{H}$
Firms' first-order conditions (14):	$q_{ih,t}\left[\boldsymbol{q}_{h,t}, \boldsymbol{N}_t, \boldsymbol{\lambda}_{h,t}, \mathrm{E}_t[\psi_{h,t+1}]\right]$	$\forall\ h \in \mathcal{H}$
Free entry condition (18):	$N_{i,t}\left[\boldsymbol{q}_t, \boldsymbol{N}_t, \boldsymbol{\lambda}_t, \mathrm{E}_t[\boldsymbol{\psi}_{t+1}]\right]$	
Firm-market βs (21):	$\beta_{ih,t}\left[\boldsymbol{q}_t, \boldsymbol{N}_t, \boldsymbol{\lambda}_t, \mathrm{E}_t[\boldsymbol{\psi}_{t+1}]\right]$	$\forall\ h \in \mathcal{H}$

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):	$a^f_t\,[\boldsymbol{\beta}_t, \boldsymbol{X}_t]$ and $\boldsymbol{a}_t\,[\boldsymbol{\beta}_t, \boldsymbol{X}_t]$	
Budget constraint (2):	$C_t\left[a^f_t, \boldsymbol{a}_t, \boldsymbol{\beta}_t, \boldsymbol{X}_t\right]$	
Risk premia (15):	$\lambda_{h,t}\left[C_t, a^f_t, \boldsymbol{a}_t, \boldsymbol{\beta}_t, \boldsymbol{X}_t\right]$	$\forall\ h \in \mathcal{H}$

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.[25]

3.5 The Stochastic Discount Factor and Country Risk Premia

This section contains a more detailed description of how the distribution of the SDF is derived from the distribution of country-specific productivity shocks in order to understand how the country risk premia $\lambda_{ih,t} = R^f_{i,t+1}\text{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right]$ are determined and evolve

[25]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 $W_t = \sum_{k\in\mathcal{H}} W_{k,t}$.

over time.[26] I again display the results in general notation, encompassing both the case of autarkic and integrated financial markets.[27] 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:

(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

$$m_{i,t+1} = \rho \frac{u_i'(C_{i,t+1})}{u_i'(C_{i,t})} = \rho \frac{V_i'(W_{i,t+1})}{u_i'(C_{i,t})}, \tag{22}$$

where $V_i(W_t)$ denotes the maximum value function that solves the investor's lifetime utility maximization problem (4).[28] Replacing $W_{i,t+1} = R^W_{i,t+1} A_{i,t}$, I can write the SDF

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

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

[28] A detailed derivation of Equation (22), whose essential parts follow Cochrane (2005) and Fama (1970), can be found in Appendix A.1

given in Equation (22) 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 20), 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: $\widehat{Y}_{h,t+1} = \widehat{\psi}_{h,t+1}\ \forall\ h \in \mathcal{H}$. 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:

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

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.[29] 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[30]

$$m_{i,t+1} = \zeta_{i,t} + \gamma_{i,t}R^W_{i,t+1} \quad \text{where} \quad \gamma_{i,t} < 0. \tag{23}$$

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 (20) 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:

$$m_{i,t+1} = \zeta_{i,t} + \gamma_{i,t} \sum_{j\in\mathcal{J}_i} \frac{a_{ij,t}}{A_{i,t}v_{j,t}} \sum_h \phi_{jh,t}\mathrm{E}_t\left[Y_{h,t+1}\right]\left(\frac{Y_{h,t+1}}{\mathrm{E}_t\left[Y_{h,t+1}\right]}\right). \tag{24}$$

Equation (24) 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 $m_{i,t+1} =$

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

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

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

Equation (25) 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 growth in h through higher exports implies a stronger *negative* partial correlation with the SDF.

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

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

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

$$\boldsymbol{\lambda}_{i,t} = R^f_{i,t+1} \mathrm{Cov}_t \left[m_{i,t+1}, \hat{\boldsymbol{Y}}_{t+1}\right] = R^f_{i,t+1} \mathrm{Cov}_t \left[\hat{\boldsymbol{Y}}_{t+1}, \hat{\boldsymbol{Y}}'_{t+1}\right] \boldsymbol{b}_{i,t}, \tag{26}$$

with the hth element equal to

$$\lambda_{ih,t} = R^f_{i,t+1} \mathrm{Cov}_t \left[m_{i,t+1}, \hat{Y}_{h,t+1}\right] = R^f_{i,t+1} \left(\sigma_t^{\hat{Y}_h}\right)^2 b_{ih,t} + R^f_{i,t+1} \sum_{k \neq h} \sigma_t^{\hat{Y}_h, \hat{Y}_k} b_{ik,t}. \tag{27}$$

Note that the bs are themselves functions of the λs so that Equation (27) is an implicit expression for $\lambda_{ih,t}$.

Using the linear SDF from Equation (24) to rewrite the Euler equation (6) as

$$\mathrm{E}_t\left[R_{i,t+1}\right] - R^f_{i,t+1} = -\boldsymbol{\lambda}'_{i,t}\boldsymbol{\beta}_{i,t} \tag{28}$$

shows that the λs can be interpreted as monetary risk premia.[31] Equation (28) 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 given in Equation (21), 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 (24) 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

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

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 (17) in terms of exogenous variables and λ only yields

$$V^*_{i,t} = \frac{1-\theta}{\theta^{\frac{\eta}{\eta-1}}} \sum_{h\in\mathcal{H}} \frac{(1+\lambda_{ih,t})^{\varepsilon}(c_i\tau_{ih}R^f_{i,t+1})^{-\varepsilon}\mathrm{E}_t\left[\psi_{h,t+1}\right]^{\frac{\eta}{1-\eta}}}{\left(\sum_{i\in\mathcal{H}} N_{i,t}(c_i\tau_{ih}R^f_{i,t+1})^{1-\varepsilon}(1+\lambda_{ih,t})^{\varepsilon-1}\right)^{\frac{\varepsilon-\eta\varepsilon-1}{(\varepsilon-1)(\eta-1)}}} - \alpha_i. \tag{29}$$

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 (29) 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 (27) jointly obey

$$\lambda_{k,\ell} = R^f_{k,t+1}\mathrm{Cov}_t\left[m_{k,t+1}, \hat{Y}_{\ell,t+1}\right] = 0 \quad \forall\, k,\ell = i,h$$

$$\Leftrightarrow \quad \mathrm{E}_t\left[Y_{\ell,t+1}\right]\left(a_{k\ell}\phi_{\ell\ell,t} + a_{kk}\phi_{k\ell,t}\right) = -\rho_i^{\hat{Y}_k,\hat{Y}_\ell} \cdot \mathrm{E}_t\left[Y_{k,t+1}\right]\left(a_{kk}\phi_{kk,t} + a_{k\ell}\phi_{\ell k,t}\right) \quad \forall\, k,\ell = i,h$$

$$\Leftrightarrow \qquad \mathrm{E}_t\left[Y_{h,t+1}\right] = \mathrm{E}_t\left[Y_{i,t+1}\right]. \tag{30}$$

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 (30) states that zero risk premia obtain if expected final goods production between the two countries is equalized. Note that Equation (30) together with $\mathrm{E}_t\left[\psi_{i,t+1}\right] \leq \mathrm{E}_t\left[\psi_{h,t+1}\right]$ 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 suboptimal 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.

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.[32] 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}, which are identical if these countries' financial markets are perfectly integrated and, in general, can be expected to be positively correlated.

The model also precludes multinational production. However, note that for a flexible interpretation of the firm boundary, the free entry condition (18) 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 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 also incentives to trade, its pattern will be influenced by

[32]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).

the riskiness of destinations in the presence of time lags, demand volatility, and aggregate risk.[33]

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 (23) 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 (24), 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

$$1 = \mathrm{E}_t \left[m_{i,t+1} R_{j,t+1} \right] \qquad \text{where} \qquad m_{i,t+1} = \zeta_{i,t} + \gamma_{i,t} R^W_{i,t+1} \tag{31}$$

that holds for every asset at each point in time, and one additional condition that identifies the mean of the SDF as the inverse of the risk-free rate:

$$\frac{1}{R^f_{i,t+1}} = \mathrm{E}_t \left[m_{i,t+1} \right]. \tag{32}$$

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 (31) and (32) over time yields unconditional moments

$$1 = \mathrm{E}\left[\left(\zeta_i + \gamma_i R^W_{i,t+1} \right) R_{j,t+1} \right] \ \forall \ j \in \mathcal{J}_i \qquad \text{and} \qquad 1 = \mathrm{E}\left[\left(\zeta_i + \gamma_i R^W_{i,t+1} \right) R^f_{i,t+1} \right], \tag{33}$$

[33] 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.

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.[34] However, linear factor models derived from multiperiod models generally imply time-varying parameters (see, e.g., Merton, 1973).[35] 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 coefficients ζ_i, γ_i are implied by assumptions (i),(ii), CRRA preferences, and globally integrated financial markets.

I estimate Equation (33) with GMM using data on $R^W_{i,t}$ and data on individual asset returns $R_{j,t}$, which are described below. With the estimated parameters, I predict a time series of the SDF 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 $\mathrm{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right] = T^{-1}\sum_{s=0}^{T}\left[m_{i,t-s}\cdot\hat{Y}_{h,t-s}\right] - T^{-2}\sum_{s=0}^{T} m_{i,t-s}\cdot\sum_{s=0}^{T}\hat{Y}_{h,t-s}$.

4.2 Estimating λs for the U.S. Financial Market

I estimate risk premia with respect to 180 countries for the U.S. financial market since my empirical analysis of the impact of risk premia on exports will be based on U.S. exports. Hence, I assume that the SDF of investors trading on the U.S. financial market is the relevant SDF for U.S. firms. From the point of view of the model, this is consistent with financial autarky as well as with global financial market integration.[36]

The export data span the years 1992 to 2012 and I estimate a $\lambda^{US}_{h,t}$ for every market 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.

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

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

[36] It is also consistent with an intermediate case of financial market integration, where investors from a subset of all countries including the United States trade freely on a supranational asset market. As noted above, this case is also encompassed by the model, but not discussed for the sake of brevity.

4.2.1 Data

For monthly asset returns I use 49 value-weighted industry portfolios provided by Kenneth R. French through his Data Library. The portfolios are constructed based on all stocks traded on NYSE, AMEX, and NASDAQ. Theoretically, every asset and every portfolio of assets available to U.S. investors could be used to estimate Equation (33). Figure A.1 in the Appendix plots the distribution of excess returns to the industry portfolios. 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 NYSE, AMEX, and NASDAQ.[37]

I use total monthly imports by country obtained from the IMF's Direction of Trade Database to measure demand growth. Growth is measured with respect to the previous month and rates are adjusted for constant monthly factors. Table 1 summarizes the data used to estimate the risk premia. Appendix A.2 provides more details.

4.2.2 Results

Table 2 summarizes the results from GMM estimation of Equation (33). Column (1) shows parameter estimates based on the full sample period; these are strongly significant. As suggested by the theory, γ is negative; hence, the return to the market portfolio is negatively related to the SDF. Columns (2) through (4) repeat the estimation for consecutive subperiods of the sample, each covering 12.5 years. In view of the assumption that the coefficients $\zeta_{i,t}, \gamma_{i,t}$ are uncorrelated with returns, which underlies the unconditional moments (33), it is reassuring that the estimates do not change much over time.

I use the estimates in Column (1) of Table 2 to predict a time series of the SDF in accordance with Equation (23) and then compute covariances with import growth scaled with the average risk-free rate as in Equation (27) for each point in time, always going back 120 months into the past. Figure 1 presents an overview of the results. The left panel plots correlation coefficients based on 10-year windows of monthly import growth data and the predicted time series of the SDF; the right panel shows the distribution of estimated λs. Both panels show that the median values, as well as the whole distribution, have been shifting downward over time. In view of Equation (27), this may be interpreted as the United States becoming more integrated with the rest of the world and taking more advantage of the diversification benefits available in integrated international goods

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

Table 1: Summary statistic of return and demand growth data

Returns	#Obs.	Mean	Std. Dev.	Min	Max
Time	450			1977M1	2014M6
r^f	1	0.41	0.29	0	1.35
r^W	1	1.02	4.49	-22.64	12.89
$\overline{R}^e$	49	.73	.17	.37	1.24
Import growth					
Time	360			1983M1	2012M12
$\mu^{\hat{Y}}$	360	0.04	0.05	0.01	0.45
$\sigma^{\hat{Y}}$	360	0.27	0.35	0.06	2.61
# Countries p. year		180	0	180	180
Industrial production growth					
Time	360			1983M1	2012M12
$\mu^{\hat{Y}}$	360	0.003	0.003	0.000	0.015
$\sigma^{\hat{Y}}$	360	0.027	0.014	0.006	0.073
# Countries p. year		33.31	4.75	21	37
Retail sales growth					
Time	360			1983M1	2012M12
$\mu^{\hat{Y}}$	360	0.004	0.004	-0.000	0.015
$\sigma^{\hat{Y}}$	360	0.028	0.018	0.009	0.124
# Countries p. year		39.49	11.79	16	51

Returns in %. $\overline{R}^e$ is the average excess return (gross return minus risk-free rate) of industry portfolios over time. r^f denotes the net risk-free rate (U.S. one-month Treasure bill rate), r^W denotes the (net) return to a value-weighted portfolio of all stocks traded on NYSE, AMEX, and NASDAQ. $\mu^{\hat{Y}}$ ($\sigma^{\hat{Y}}$) denotes the mean (standard deviation) of the proxies for country-specific demand shocks over time.

and asset markets. The difference between the two panels is due to heterogeneity in the volatility of country shocks, which affects the absolute size of the λs but not the correlation coefficient. From the right panel it is apparent that volatility in general has been decreasing. The figure also shows correlation patterns for two example countries, Canada and China. Both panels reveal a strong downward trend for Canada, indicating that Canada and the United States have steadily become more integrated. In contrast, China's risk premium has been increasing and was among the highest in 2012, suggesting that trade with China still offers substantial diversification benefits.

Figure A.2 in the Appendix shows how other countries' risk premia evolved over time. Generally, I find patterns similar to Canada's for Mexico, Brazil, the EU countries, Australia, and New Zealand. I find trends resembling China's also, for example, for Indonesia.

Table 2: Parameter estimates of the linear SDF model

Time period:	1977M1–2014M6	1977M1– 1989M6	1989M7–2001M12	2002M1–2014M6
ζ_{US}	1	.99	1	1
[t-stat.]	[133]	[90.4]	[80.2]	[80.2]
γ_{US}	-3.37	-2.92	-3.81	-3.61
[t-stat.]	[-2.54]	[-1.50]	[-1.86]	[-1.24]
# Moment Conditions	50	50	50	50
# Observations	450	150	150	150
# Parameters	2	2	2	2
Test of joint signific.: χ^2_e	49280	35166	12818	17206
$P(\chi^2_2 > \chi^2_e)$	0	0	0	0
J-Test: J-Stat	97	397.8	161.5	196.8
$P(\chi^2_{48} > J)$	0	0	0	0

Results from first-stage GMM. ζ^{US}, γ^{US} are the parameters of the linear SDF model. Estimates based on 49 value-weighted industry portfolios and the risk-free rate (U.S. one-month T-bill rate) over different time periods.

Russia's risk premium exhibits barely any change. Table A.3 in the Appendix lists the risk premia for all countries in selected years.

4.2.3 Alternative risk premia estimates

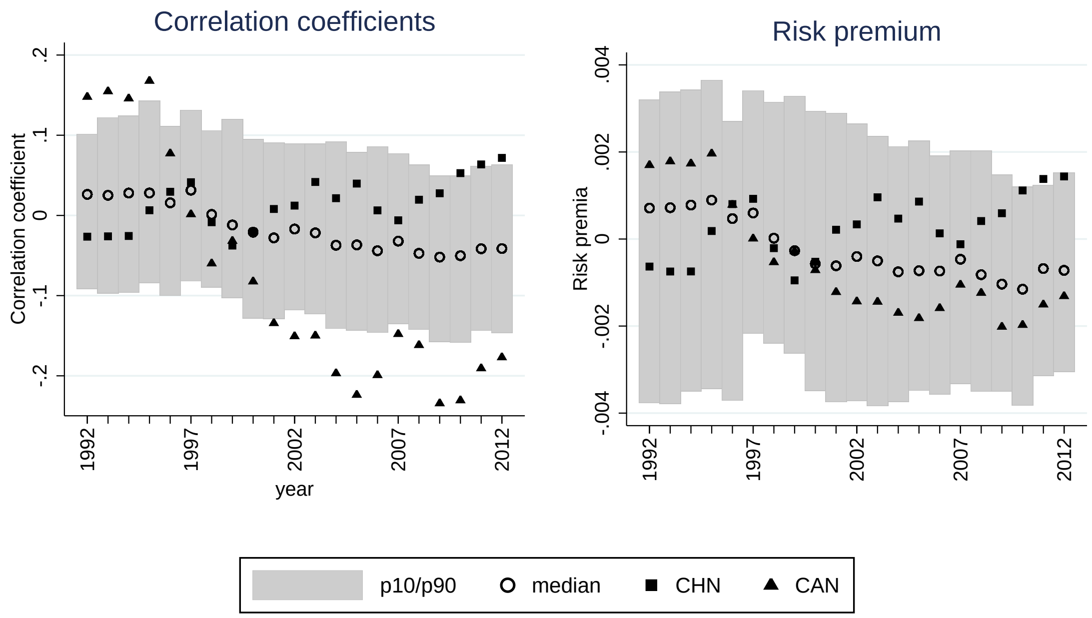
I obtain alternative sets of risk premia to analyze the robustness with regard to the choice of portfolios and the empirical model used for the estimation of the SDF, as well as with regard to the proxy for demand shocks used to calculate the covariances. Specifically, I use Fama and French's 25 benchmark assets as an alternative set of test assets to obtain estimates of γ^{US}, ζ^{US}.[38] Moreover, I use the four-factor model proposed by Fama and French (2015) as an alternative to the CAPM to obtain a predicted time series of the SDF. The four-factor model uses three mean return spreads of diversified portfolios sorted by size (R^{SMB}), profitability (R^{RMW}), and investment levels (R^{CMA}) in addition to the return on the market portfolio to describe the SDF as

$$m_{i,t+1} = \zeta_i + \gamma_i R^W_{i,t+1} + \gamma_i^{SMB} R^{SMB}_{i,t+1} + \gamma_i^{RMW} R^{RMW}_{i,t+1} + \gamma_i^{CMA} R^{CMA}_{i,t+1}. \tag{34}$$

This model is very successful in explaining the cross-section of mean asset returns, but it does not have a theoretical foundation. Table A.4 presents the parameter estimates obtained from GMM estimation as described in Subsection 4.1 using the alternative test

[38] These portfolios are constructed based on all stocks traded on NYSE, AMEX, and NASDAQ, which are sorted two ways: by size in terms of equity and by value (ratio of book equity to market equity). In the empirical asset pricing literature, this method of portfolio construction, described in detail in Fama and French (1993), has become the benchmark for measuring model performance.

Figure 1: Estimated correlation coefficients and risk premia with U.S. investors' SDF



The figure shows correlation coefficients (left panel) and risk premia (covariances scaled by the average risk-free rate, right panel) of country-specific demand shocks with the SDF of U.S. investors. Gray bars denote the range of the distribution between the 10th and 90th percentile.

assets or the alternative SDF model. Changing the test assets has only a small impact on the CAPM estimates. Similarly, adding the additional explanatory factors as prescribed by Equation (34) to the linear model of the SDF slightly increases the estimate of γ_i but does not affect its significance. I use those alternative parameter estimates to predict time series of the SDF and obtain corresponding sets of country risk premia.

Next, I use two alternative proxies for demand shocks. The great advantage of aggregate imports, the proxy variable used above, is its wide country and time coverage – it is available for more than 180 countries continuously since 1983, at least. Although being certainly correlated with demand, (seasonally adjusted) import growth might not reflect very precisely the shock that determines the marginal productivity, or more generally the price, of a fixed quantity of goods at a given point in time in the way suggested by the theory. For example, if shipping time lags matter more than production time lags, then the value of imports registered at customs may not yet include the price effect of a deviation of demand from its expected level. Therefore, I use as an alternative proxy an index of monthly industrial production, which is more closely linked to productivity growth. Moreover, I use monthly growth in the volume of retail sales as a proxy, which is more directly linked to actual expenditure than the import values. Data availability for these series, however, is limited. For the time period 1983–2012, data is available for about 30 to 40 countries per year and the sample consist primarily of OECD countries.[39] Table 1 provides summary statistics for these series.

Figure A.3 plots for the four sets of covariances over the sample period alike Figure 1. It shows that all measures reveal relatively similar patterns for the median country, and also for Canada. Regarding China, all measures imply positive and higher than average risk premia except for the early years. In contrast to the import-based measures, the risk premia based on industrial production and retail sales growth suggest a deeper integration of China with the United States in recent years (declining λs).

4.3 Testing the Relevance of Risk Premia in the Gravity Model

4.3.1 Empirical Model and Data

With the estimated risk premia in hand, I can now test the main prediction of the model, which is that firms' optimal export quantity depends on market-specific risk premia reflecting the covariance of demand shocks with investors' stochastic discount factor, as implied by Equation (14):

$$q^*_{ih,t} = \frac{\theta(1+\lambda_{ih,t})^{\varepsilon}\left(R^f_{i,t+1}c_{i,t}\tau_{ih,t}\right)^{-\varepsilon}}{\sum_{i\in\mathcal{H}} N_{i,t}(1+\lambda_{ih,t})^{\varepsilon-1}\left(R^f_{i,t+1}c_{i,t}\tau_{ih,t}\right)^{1-\varepsilon}} \cdot \mathrm{E}_t\left[Y_{h,t+1}\right]$$

Note that I added an index t to the cost parameters to acknowledge that they are potentially time varying as well. I use finely disaggregated product-level exports from the United States to 169 destination countries to test whether exports are, ceteris paribus, higher to countries exhibiting larger covariances with the SDF of U.S. investors. The data are from the U.S. Census Bureau's Foreign Trade Division and in my baseline estimations I use a sample covering 169 out of 234 destination countries and 93% of the total value of U.S. exports.[40] I use three equally spaced time periods between 1992 and 2012 to allow structural changes in risk-premia and exports some time to come into effect. More years of data are considered in a robustness analysis. My main estimation equation is a

[39] I use data from the OECD's Monthly Economic Indicators, supplemented with information from the IMF's International Financial Statistics Database and from the Global Economic Monitor Database provided by the Worldbank. Both series are adjusted for seasonality. See also Appendix A.2.

[40] The small loss of observations is due to missing data on some of the covariates and missing data on shipment quantities in kilograms for transport modes other than air or vessel.

log-linear version of Equation (14),

$$\ln q_{jih,t} = \varepsilon \ln(1+\lambda_{ih,t}) - \varepsilon \ln \tau_{jih,t} - \varepsilon \ln \left(R^f_{i,t+1} c_{ji,t}\right) + \ln\theta + \ln \mathrm{E}_t\left[Y_h\right] + \ln \Pi_{jh,t}, \quad (35)$$

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. My dependent variable is the quantity (in kilograms) of product j shipped to country h in year t. I use an algorithm developed by Pierce and Schott (2012) to concord a total of 12,364 HS 10-digit product categories from the original dataset over time. This yields 7,056 product groups that are robust with respect to changes in the classification and the creation or elimination of product categories. Export quantities and values are aggregated to the level of these synthetic product codes.[41] I use shipments by air or vessel only, which make up more than 90% of value shipped for about 98% of all observations. For alternative transport modes (e.g., ground transportation or mail) data on quantities is provided only in *units* but not in *kilograms*, hence they cannot be aggregated. Robustness checks with regard to this sample restriction will be provided. 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.

On the right-hand side of Equation (35) I use the log of real GDP and real per capita GDP to proxy for expected demand in the destination country.[42] I use product-time fixed effects $d_{j,t}$ throughout the estimations, which absorb everything that is inherent to the product at a given point in time, but does not vary across destination markets, such as production cost, quality, or the world level of demand. These product-time fixed effects also absorb the risk-free rate. Moreover, I include product-country fixed effects d_{jh} to capture market-product-specific characteristics that do not vary over time, such as part of the trade costs and the time-constant component of country h's degree of market competition, $\Pi_{jh,t}$, also known as multilateral resistance. For the time-varying part of the trade cost, I use a binary trade agreement indicator and estimates of freight cost for

[41] I add one to all observations where the quantity is zero.

[42] Given that in the presence of time lags firms base export quantities on the *expected* level of demand, this choice is not innocuous, but it is difficult to devise a better proxy. In addition to the fact that exporters' expectations are not observed, the exact point in time at which expectations are formed is also unknown. Note that t here denotes the point in time when the goods pass U.S. customs. If production of the good took a significant amount of time, the firm might have developed the relevant expectation much earlier. This difficulty is somewhat ameliorated by the fact that I look at total shipments within a year. If expectations are rational, then the sum of expected demand over subperiods of time should converge to the total realized level of demand. I also conduct a robustness test using GDP and GDP per capita from the previous year.

shipments by vessel and air. Since I do not directly observe freight costs for U.S. exports, I use data on U.S. imports by product and country of origin from the same data source to calculate median ad valorem shipping cost by partner country and time, assuming that bilateral freight costs of imports are a reasonable proxy for bilateral freight costs of exports. Since the availability of tariff data is limited, I include them only in a robustness analysis. The empirical model used to test the model's central prediction is thus

$$\ln q_{j^{US}h,t} = \beta_1 \ln(1 + \lambda_{h,t}^{US}) + \beta_2 FreightCost_{h,t} + \beta_3 RTA_{h,t} + \beta_4 \ln GDP_{h,t} \\ + \beta_5 \ln CGDP_{h,t} + d_{jh} + d_{j,t} + u_{jh,t}. \tag{36}$$

A potential concern about omitted variables bias is that the multilateral resistance terms $\Pi_{jh,t}$ may vary across time and products and are thus not fully captured by product-destination and product-time fixed effects. Hence, consistent estimation of the coefficients in Equation (36) with OLS relies on the assumption that the time-varying component of $\Pi_{jih,t}$, which ends up in the error term $u_{jh,t}$, is uncorrelated with the regressors. The disaggregation of the data by transportation mode, which I describe below, allows addressing this issue.

First, however, I consider heterogeneity of the effect of λ across sectors 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. I use Rajan and Zingales's (1998) measure of external finance dependence to differentiate sectors based on their need for upfront investment, which is measured by the average share of capital expenditure that firms cannot finance with the cash flow from the same project. Presuming that a need for upfront investment implies that there is a relevant time lag between production and sales, I test, whether exports of products from sectors that are more dependent on upfront investment are more strongly affected by the correlation pattern of country shocks by means of an interaction term $\ln(1+\lambda_{h,t}^{US})\times$ $UpfrontInv_{s^j,t}$. s^j denotes the sector defined by the NAICS six-digit code to which product j belongs.[43]

Next, I consider heterogeneity across transportation modes. Products shipped by vessel and by air to the same market at the same point in time provide me with a nice

[43] There are a few products for which assignment to NAICS six-digit sectors is no longer unique after aggregating HS 10-digits to time-consistent product groups as described above. I use sales-weighted averages of the *UpfrontInv* measure in those cases.

opportunity to test for the relevance of a time lag caused by shipping. Arguably, air shipments are less or not at all exposed to demand volatility once the good has reached the U.S. border. To test this presumption, I estimate Equation (36) separately for shipments by air and shipments by vessel. As an alternative estimation strategy, I pool shipments by both transportation modes and assess a differential impact of λ by means of an interaction term with a zero-one indicator for air shipment. Hence, I estimate

$$\ln q^{m}_{jUS_{h,t}} = \beta_1 \ln(1+\lambda^{US}_{h,t}) + \beta_{11} \ln(1+\lambda^{US}_{h,t}) \times Air^{m}_{jh,t} + \beta_2 FreightCost^{m}_{h,t} + \beta_3 RTA_{h,t} + \beta_4 \ln GDP_{h,t} + \beta_5 \ln CGDP_{h,t} + d_{jmh} + d_{jm,t} + u_{jmh,t} \quad (37)$$

where $m \in (Air, Ves)$, to test whether risk premia have a differential effect on shipments by air relative to shipments by vessel. The disaggregation by transportation mode also allows me to estimate this interaction term with a specification where product-destination-time fixed effects take care of time-varying multilateral resistance terms:

$$\ln q^{m}_{jUS_{h,t}} = \beta_{11} \ln(1+\lambda^{US}_{h,t}) \times Air^{m}_{jh,t} + d_{jmh} + d_{jm,t} + d_{jh,t} + u_{jmh,t} \quad (38)$$

The sign of the direct effect λ on shipments by air is a priori ambiguous. Consider the extreme case where the only cause of a time lag is transit time by vessel so that production and delivery by air is possible instantly.[44] Shipments by vessel, however, have the advantage of being cheaper. In line with the logic laid out by Aizenman (2004) and Hummels and Schaur (2010), firms will ship some positive quantity by vessel and whenever demand shocks are positive and large, they will exercise the option of shipping some more by expensive air transport. Under these conditions, air shipments are fully explained by the current level of demand and the quantity previously shipped by vessel. If vessel shipments are larger to markets offering diversification benefits in terms of positive λs, then the option value of serving those markets by air is smaller. Hence, we would expect to see a negative impact of λ on shipments by air. Arguably, the case of instant delivery is extreme. Time lags caused by production and shipping to the airport, as well as customs procedures, are likely also relevant for shipments by air and hence imply some degree of exposure to market-specific demand volatility. Which effect dominates is an empirical question.

[44] Alternatively, one might consider a case where production does take time but goods do not need to be customized to a specific market.

4.3.2 Results

Column (1) of Table A.6 shows parameter estimates from the baseline specification (36). Estimations are based on three years of data, equally spaced between 1992 and 2012, and rely on variation over time within product-country cells only. Unobserved product-time-specific heterogeneity is controlled for by additional fixed effects. Throughout all estimations I calculate standard errors that are robust to two-way clusters within products and countries, as advocated by Cameron et al. (2011).

I find that the risk premia have a significantly positive effect on export quantities. To make coefficients comparable across specifications, I standardized $\ln(1+\lambda)$. The standard deviation of $\ln(1+\lambda)$ is .005; hence, the non-standardized coefficient corresponding to .033 in Column (1) is 6.6. This implies that a 1% increase in $1+\lambda$ increases trade by 6.6%. In view of Figure 1, this means, for example, that the change of .3% in Canada's risk premium from the level in 1992 to the level of 2012 has led to a decrease in trade of about 2%. Changing China's risk premium in 2012 to the level of Canada's in 2012 would result in a trade effect of similar magnitude. Note, however, that this is a partial equilibrium argument, since the λs are themselves decreasing functions of the amount of trade between the United States and a given destination market. Hence, the general equilibrium effect is likely to be smaller in absolute terms. The structural interpretation of the estimate is helpful in gauging the plausibility of its magnitude. The theoretical gravity equation implies that the elasticity of export quantities with respect to the risk premia is equal to ε, where $\varepsilon - 1$ is the elasticity of trade values with respect to trade cost. An implied trade cost elasticity of 5.6 places this estimate well inside the range typically found in the literature.[45]

In Column (2) of Table A.6 I interact the risk premia with Rajan and Zingales's sectoral measure of reliance on upfront investment. I find a positive and significant effect of the interaction, implying that exposure to demand volatility is more important for sectors that have to make considerable investment upfront. This lends support to the model's assumption of a time lag.

A similar conclusion can be derived from the analysis of differential effects across modes of transportation. In Columns (3) and (4) I present the results from estimating Equation (36) separately for shipments by vessel and by air, respectively. As discussed above, shipments by vessel are expected to be more affected by the correlation pattern

[45] See, for example, Caliendo and Parro (2015). Note, however, that the estimated magnitude is sensitive to the choice of data frequency used to calculate the covariances (see Subsection 4.1) and thus should be interpreted with caution.

of demand shocks than shipments by air, with the effect on the latter being ambiguous a priori. I find that shipments by vessel are indeed more positively and significantly affected. The estimated effect on shipments by air is also positive, but smaller and not significant. Columns (5)-(7) show the results from estimating Equations (37) and (38) based on the same data set, pooling shipments by air and vessel.[46] Column (5) shows that the direct effect of λ is slightly smaller in the estimation based on disaggregated data, which allows controlling for product-destination and product-time fixed effects interacted with the mode of transportation. The negative and significant interaction terms in Columns (6) and (7) show that the differential effect of λ on shipments by air relative to shipments by vessel, as indicated by Columns (3) and (4), is robust to controlling for unobserved heterogeneity on a more disaggregated level. It is reassuring that the inclusion of product-destination-time fixed effects to capture, among other things, time variation in multilateral resistance terms does not affect the estimate of the interaction term. To summarize, I find a positive 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 across sectors 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.

4.3.3 Robustness

I conduct various tests to analyze the robustness of my results with regard to changes in the exact specification of Equations (36) and (37). Results are collected in Tables A.7–A.11 in the Appendix.

Sample years and covariates. First, I re-estimate Equation (36) using more of the available years of data: five equally spaced time windows between 1992 and 2012 in Column (1) and all 21 years in Column (2) of Table A.7. The effect of λ remains positive and significant. Interestingly, it decreases in magnitude as time windows become narrower. This is consistent with the presumption that the effect of changes in the covariance pattern on exports takes some time to phase in. In Column (3) of Table A.7 I use freight cost per kilogram instead of ad valorem freight cost and in Column (4) I use lagged values of GDP and per capita GDP as proxies for the expected level of demand. None of these changes to the baseline specification much affects the coefficient estimate for λ (cp. Column 1 of Table A.6).

[46]Hence, the number of observations is twice as large as in Columns (1), (3), and (4) where I use either total shipments by product and destination or shipments by vessel only or by air only.

All transport modes and measurement of quantities. Columns (5) and (6) of Table A.7 analyze robustness with regard to the unit of measurement of quantities and the sample restriction regarding transport modes. As discussed above, I exclude shipments by transport modes other than air or vessel in the baseline estimations since for those shipments quantities are provided only in units, not in kilogram. Using the data at the original level of the diasaggregation by products (before aggregating to time-consistent products groups) and using quantity units rather than kilograms has no impact on the estimated effect of λ (see Column 5). Column (6) shows that using only air and vessel shipments on this higher level of product disaggregation also makes no difference.

Zeros and export values. Due to the high level of disaggregation, the dataset contains lots of zeros which I replaced with ones in order for them to be included in the log-linear estimations. As Table A.5 shows, only about 25% of all observations feature positive quantities. About two thirds of the zero observations get absorbed by the product×country fixed effects, as they are constantly zero over the whole sample period. They nevertheless enter the estimation since they provide variation used for the estimation of the product×year fixed effects. Table A.8 shows that dropping these observations in advance produces significantly larger estimates but does not qualitatively change any of the baseline results presented in Table A.6. Only the interaction term with *Upfront-Investment* becomes marginally insignificant. A concern about bias introduced by the remaining zeros remains nevertheless. Unfortunately, due to the large number of fixed effects, Poisson estimation as advocated by Silva and Tenreyro (2006) has proven infeasible. To address the issue with the zeros, I re-estimate the log-linear baseline model on higher levels of aggregation where the number of zero observations is very small. I use export sales as dependent variable for the aggregation to be sensible. Columns (7)-(10) of Table A.7 present the results. Column (7) of Table A.7 repeats the baseline estimation with export values instead of quantities, Column (8) does the same using all available years of data. I find a positive and significant effect of the risk premia on export values as well.[47] In Column (9) I aggregate exports to the highest level of the HS1992 classification (20 sections[48].) where the share of zero observations that do not get absorbed by the industry×country fixed effects is less than 10%. The effect of the risk premia remains positive and significant, but increases in magnitude. In Column (10) I aggregate exports to the country level where all observations are positive and I find results that are very similar to the baseline results for export values in Columns (7) and (8).

[47]Note that in view of Equation (16), this suggests that financial markets are not fully integrated across countries; otherwise, trade shares would be independent of λ.

[48]see http://unstats.un.org/unsd/tradekb/Knowledgebase/HS-Classification-by-Section

Tariffs. In Table A.9 I include tariffs as additional trade cost variable. The tariff data are available at the HS six-digit level, but time and country coverage is very patchy. Hence, I lose a significant number of observations. In this smaller sample, the effect of λ becomes marginally insignificant, however, it is not affected by including tariffs (cp. Columns 5 and 6).[49] When I use more than three years of data, as in the baseline estimation, I find positive and significant effects again, which are not affected by tariffs (see Columns 1-4).

Alternative risk premia estimates. Table A.10 presents results for alternative sets of risk premia, described in more detail in Section 4.1. Column (1) uses premia obtained from estimating the SDF model based on the 25 Fama French benchmark portfolios, instead of the 49 industry portfolios used in the other specifications. The risk premia in Column (2) are based on Fama and French (2015)'s four-factor model for the SDF. The results from the gravity estimations are barely affected. Moreover, I use two additional 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 (35 in the case of industrial production and 42 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. I find similar coefficient estimates in terms of magnitudes for the main effect and also with regard to the differential effect on shipments by vessel for both alternative sets of risk premia (see Columns 3-8 of Table A.10). Significance is slightly weaker.

Demand volatility. The results presented in Columns (1) and (2) of Table A.11 show that the effect of the risk premium is robust to including the standard deviation of demand growth in destination markets.[50] As discussed above, a direct negative effect of demand volatility on export shipments is expected if the cost of adjusting quantities to the current level of demand is not prohibitively large. In contrast to Békés et al. (2015), who analyze French firm-level export data, I find no significant effect of volatility on exports. Moreover, in contrast to Hummels and Schaur (2010), who look at U.S. product-level imports, I find no significantly different effect for shipments by air. Including the standard deviation reduces the magnitude of the estimated effects of the risk premia, but does not affect its significance, except for the interaction with the air shipment indicator.

Further robustness checks. In the remaining columns of Table A.11 I trim the sample to analyze whether alternative modes of transportation are confounding the results

[49] t in Table A.9 is defined as $1 + \frac{tariff}{100}$, where *tariff* is the ad-valorem rate in percent.

[50] Similar to the covariance measures, I compute destination-year-specific measures of demand volatility using the standard deviation of total import growth adjusted for constant monthly factors over 120 months prior to (and including) year t.

(see Hummels and Schaur, 2010). In Columns (3) and (4) I drop Mexico and Canada from the sample, since for contiguous countries ground transportation is a relevant alternative shipping mode and shipments by vessel and air might reflect extraordinary circumstances. Columns (5) and (6) show estimates based on a sample from which I dropped observations for which the share of shipments (in terms of value) by a transportation mode other than air or vessel exceeds 10%. This is the case for about 2% of all observations. None of these restrictions qualitatively changes the results from the baseline estimations.

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 traded on the U.S. financial market, I estimate correlations of country-specific shocks with marginal utility growth of U.S. investors for the years 1992 to 2012. The correlations indicate that over the course of three decades, the United States has become increasingly integrated with the rest of the world, with a consequent decrease in diversification benefits from trade. In a separate analysis based on product-level export data for the United States, 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 three 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 (15) and Equation (5) to substitute for the expected value of the SDF, and substituting $q^*_{ih,t}$ into $Q_{h,t}^{\frac{\varepsilon-1}{\varepsilon}} = \sum_{i\in\mathcal{H}} N_{i,t}(q^*_{ih,t})^{\frac{\varepsilon-1}{\varepsilon}}$ yields Equation (14).

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 (20) 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,[51] 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) $f(\boldsymbol{\psi}_{\boldsymbol{t+1}}|\boldsymbol{\Psi}_{\boldsymbol{t}}) = f(\boldsymbol{\psi})$, (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 (22).

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).

[51] 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 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,

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

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 $t, s = 1, ..., \infty$, $R^f_{t+s} = R^f$, $\mathrm{E}_t[\boldsymbol{\psi}_{t+s}]$ =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

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

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

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

It follows that $\beta_{ih,t} = \frac{\phi_{ih,t} \mathrm{E}_t [Y_{h,t+1}]}{v_{i,t}}$ 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 (25) 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 (26), 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.[52]

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 $Y_{k,t} + \sum_i \tilde{a}^f_{ik,t-1} R^f_{k,t} - \left(C_{k,t} + \sum_i (\tilde{a}_{ik,t} + \tilde{a}^f_{ik,t})\right)$ (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 $\sum_i \tilde{a}_{ik,t-1} r_{k,t} + \tilde{a}^f_{ik,t-1} r^f_{k,t}$.[53] Using $r_{i,t} = R_{i,t} - 1 = \frac{s_{i,t}}{v_{i,t-1}}$, $\mathrm{d}a_{ik,t} = a_{ik,t} - a_{ik,t-1}$, $\sum_i a_{ik,t} = N_{k,t} v_{k,t}$ (asset market clearing), and inserting the budget constraint (2) shows that the current account

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

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

Expected return-beta representation. The structural equation of the SDF (24) 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.

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

[53] 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

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

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 (26) 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 (14) 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 (17) 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 $\mathrm{E}_t\left[\psi_{h,t+1}\right] = \mathrm{E}_t\left[\psi_{i,t+1}\right]$.

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 adjusted for constant monthly factors. The earliest observation used to estimate the risk premia January 1983. 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.

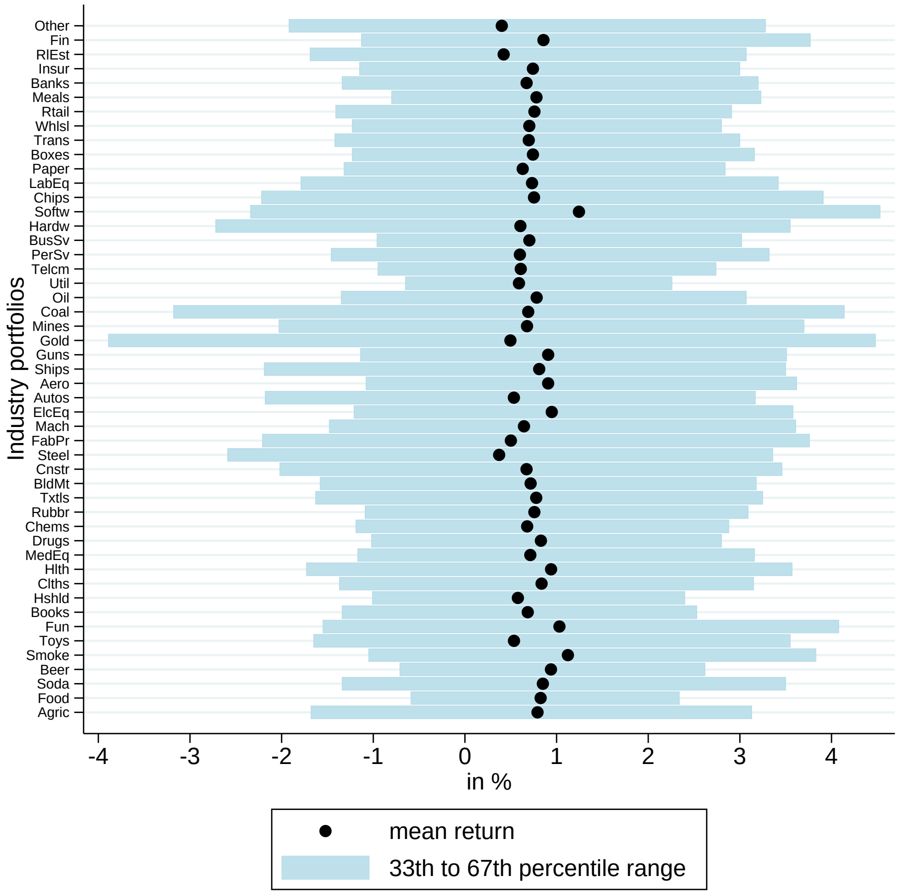
Industrial production. I use monthly growth of the (seasonally adjusted) index of industrial production volume from the OECD *Monthly Economic Indicators* (MEI) Database as an alternative proxy for demand growth. I supplement data for Australia and Switzerland from the IMF's *International Financial Statistics Database* (IFS).

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 and from the Wordbank's *Global Economic Monitor* (GEM) Database.

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 replaced 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.

Freight costs. Source: U.S. Census FTD import data provided by Peter Schott through his website at *http://faculty.som.yale.edu/peterschott/sub_international.htm.* I compute median freight cost per unit value or per kg for total shipments and by mode of transportation on the country-year level.

Figure A.1: Mean excess return of 49 value-weighted portfolios



Note: Mean excess return over risk-free rate (U.S.t-bill rate) calculated over monthly observations between January 1977 and July 2014.

Figure A.2: Risk premia estimates for selected countries

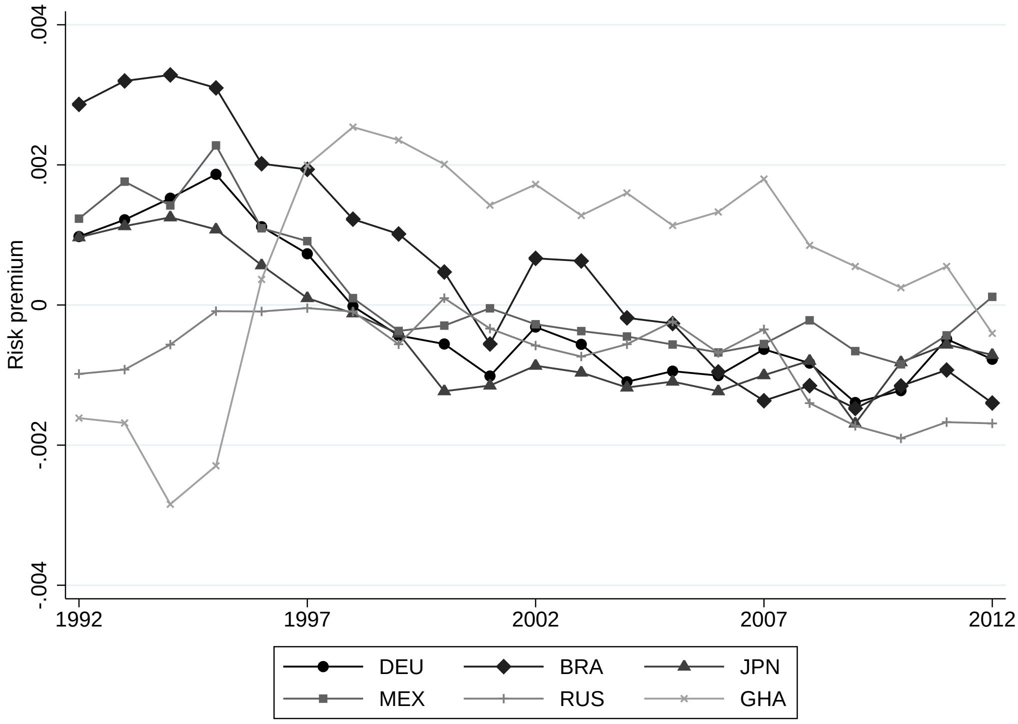


Figure A.3: Alternative risk premia estimates

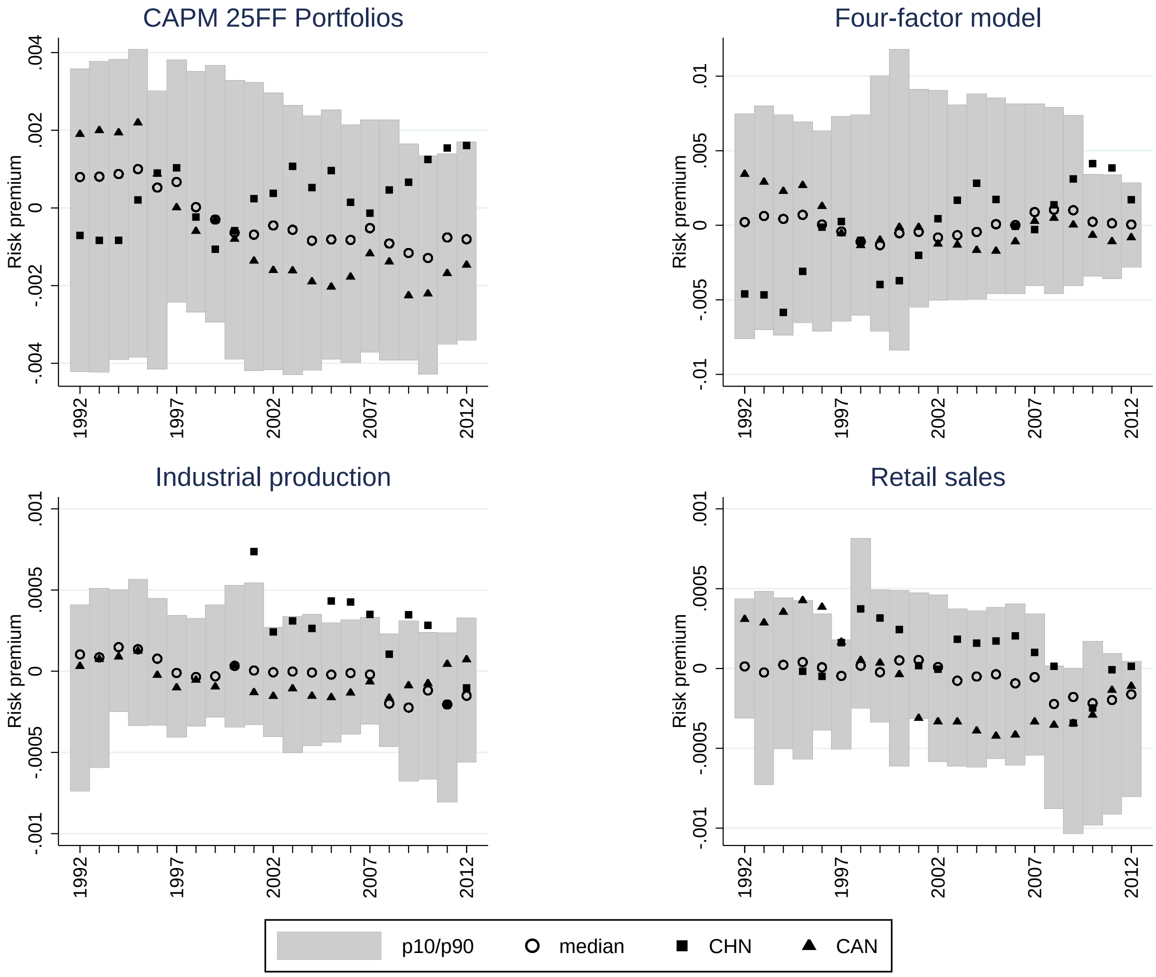


Table A.3: Estimated country risk premia for selected years

Country	ISO	$\lambda^{US}_{h,1992}$	$\lambda^{US}_{h,2002}$	$\lambda^{US}_{h,2012}$
Afghanistan	AFG	-0.0063	-0.0020	-0.0007
Angola	AGO	-0.0019	-0.0051	0.0014
Albania	ALB	0.0048	-0.0018	-0.0001
Netherlands Antilles	ANT	0.0031	-0.0020	-0.0044
United Arab Emirates	ARE	-0.0006	-0.0000	-0.0007
Argentina	ARG	0.0012	-0.0011	-0.0010
Armenia	ARM	-0.0043	-0.0064	-0.0033
Australia	AUS	0.0016	-0.0010	-0.0028
Austria	AUT	0.0007	0.0001	-0.0010
Azerbaijan	AZE	0.0007	0.0015	-0.0031
Burundi	BDI	0.0020	-0.0004	0.0007
Belgium	BEL	0.0017	-0.0005	-0.0016
Benin	BEN	0.0023	0.0007	-0.0022
Burkina Faso	BFA	0.0050	-0.0013	-0.0002
Bangladesh	BGD	0.0046	-0.0010	-0.0002
Bulgaria	BGR	-0.0026	-0.0003	-0.0003
Bahrain	BHR	-0.0019	0.0024	-0.0018
Bahamas, The	BHS	0.0007	-0.0104	0.0022
Bosnia and Herzegovina	BIH	0.0015	0.0010	-0.0004
Belarus	BLR	-0.0006	-0.0010	-0.0024
Belize	BLZ	0.0018	-0.0001	-0.0022
Bermuda	BMU	-0.0051	0.0107	0.0006
Bolivia	BOL	-0.0024	-0.0008	0.0006
Brazil	BRA	0.0029	0.0007	-0.0014
Barbados	BRB	-0.0006	0.0010	-0.0003
Brunei Darussalam	BRN	-0.0047	-0.0004	-0.0020
Central African Republic	CAF	0.0028	0.0022	-0.0157
Canada	CAN	0.0017	-0.0014	-0.0013
Switzerland	CHE	0.0015	-0.0007	0.0001
Chile	CHL	-0.0012	0.0004	-0.0014
China	CHN	-0.0006	0.0003	0.0014
Cote d'Ivoire	CIV	0.0009	0.0005	0.0041
Cameroon	CMR	-0.0014	0.0009	-0.0011
Congo, Rep.	COG	0.0031	-0.0050	0.0047
Colombia	COL	-0.0003	-0.0021	-0.0007
Comoros	COM	-0.0041	0.0022	0.0055
Cabo Verde	CPV	0.0025	-0.0153	-0.0040
Costa Rica	CRI	0.0022	-0.0004	-0.0016
Cuba	CUB	-0.0012	0.0001	-0.0006
Cyprus	CYP	0.0002	-0.0009	-0.0012
Czech Republic	CZE	-0.0014	-0.0003	0.0000
Germany	DEU	0.0010	-0.0003	-0.0008
Djibouti	DJI	0.0000	0.0004	-0.0014
Dominica	DMA	0.0009	-0.0043	-0.0062
Denmark	DNK	0.0008	-0.0007	-0.0007
Dominican Republic	DOM	-0.0001	-0.0011	-0.0021
Algeria	DZA	0.0002	0.0006	-0.0000
Ecuador	ECU	-0.0020	-0.0004	0.0005
Egypt, Arab Rep.	EGY	0.0022	0.0031	0.0004
Spain	ESP	0.0021	0.0010	-0.0005
Estonia	EST	-0.0012	-0.0002	-0.0015
Ethiopia	ETH	0.0111	-0.0016	0.0008
Finland	FIN	0.0024	0.0007	-0.0009
Fiji	FJI	0.0000	0.0014	-0.0030
France	FRA	0.0020	-0.0008	-0.0009
Faeroe Islands	FRO	0.0013	-0.0025	-0.0013
Gabon	GAB	-0.0022	-0.0016	0.0006
United Kingdom	GBR	0.0005	-0.0008	-0.0002
Georgia	GEO	-0.0008	-0.0037	-0.0005
Ghana	GHA	-0.0016	0.0017	-0.0004
Guinea	GIN	0.0027	0.0012	-0.0011
Gambia, The	GMB	0.0045	0.0035	-0.0002
Guinea-Bissau	GNB	-0.0006	-0.0139	0.0089
Equatorial Guinea	GNQ	-0.0100	0.0037	-0.0056
Greece	GRC	0.0028	0.0011	-0.0002
Grenada	GRD	0.0026	-0.0053	-0.0001
Greenland	GRL	-0.0022	-0.0007	-0.0066
Guatemala	GTM	0.0012	-0.0024	0.0007
Guyana	GUY	-0.0021	0.0023	0.0026
Hong Kong SAR, China	HKG	-0.0004	0.0003	0.0003

Country	ISO	$\lambda^{US}_{h,1992}$	$\lambda^{US}_{h,2002}$	$\lambda^{US}_{h,2012}$
Honduras	HND	0.0012	-0.0021	-0.0007
Croatia	HRV	0.0017	0.0014	0.0002
Haiti	HTI	0.0105	0.0010	-0.0004
Hungary	HUN	-0.0045	-0.0009	0.0014
Indonesia	IDN	-0.0025	0.0000	-0.0003
India	IND	0.0033	-0.0009	-0.0032
Ireland	IRL	0.0028	-0.0009	-0.0014
Iran, Islamic Rep.	IRN	-0.0007	0.0021	0.0007
Iraq	IRQ	-0.0044	-0.0019	0.0023
Iceland	ISL	0.0048	0.0020	-0.0013
Israel	ISR	0.0019	0.0004	-0.0016
Italy	ITA	-0.0011	-0.0020	-0.0009
Jamaica	JAM	0.0013	-0.0009	-0.0022
Jordan	JOR	0.0043	-0.0002	0.0003
Japan	JPN	0.0010	-0.0009	-0.0007
Kazakhstan	KAZ	-0.0015	-0.0009	-0.0017
Kenya	KEN	-0.0001	0.0004	0.0011
Kyrgyz Republic	KGZ	-0.0388	-0.0032	-0.0003
Cambodia	KHM	-0.0006	0.0048	0.0021
St. Kitts and Nevis	KNA	-0.0154	-0.0003	-0.0092
Korea, Rep.	KOR	0.0006	-0.0006	-0.0005
Kuwait	KWT	-0.0033	0.0001	-0.0015
Lao PDR	LAO	0.0015	-0.0027	-0.0010
Lebanon	LBN	-0.0030	-0.0002	-0.0017
Liberia	LBR	0.0248	0.0021	-0.0013
Libya	LBY	-0.0004	0.0003	-0.0008
St. Lucia	LCA	-0.0027	0.0031	0.0254
Sri Lanka	LKA	0.0012	0.0029	-0.0005
Lithuania	LTU	0.0024	0.0016	-0.0019
Luxembourg	LUX	0.0011	-0.0029	-0.0036
Latvia	LVA	-0.0031	-0.0009	-0.0009
Macao SAR, China	MAC	-0.0008	0.0025	0.0016
Morocco	MAR	0.0015	0.0008	-0.0004
Moldova	MDA	0.0014	-0.0000	-0.0013
Madagascar	MDG	0.0088	0.0028	-0.0003
Maldives	MDV	-0.0044	-0.0016	-0.0009
Mexico	MEX	0.0012	-0.0003	0.0001
Macedonia, FYR	MKD	0.0013	-0.0029	0.0001
Mali	MLI	0.0021	0.0017	0.0006
Malta	MLT	0.0035	-0.0025	-0.0042
Myanmar	MMR	0.0109	-0.0011	0.0003
Montenegro	MNE	0.0028	-0.0004	-0.0023
Mongolia	MNG	-0.0006	-0.0046	-0.0017
Mozambique	MOZ	-0.0029	0.0028	-0.0000
Mauritania	MRT	-0.0042	-0.0038	-0.0021
Mauritius	MUS	-0.0024	-0.0000	-0.0007
Malawi	MWI	-0.0031	-0.0002	-0.0018
Malaysia	MYS	0.0007	-0.0009	-0.0014
New Caledonia	NCL	0.0013	-0.0022	0.0005
Niger	NER	-0.0029	0.0055	0.0010
Nigeria	NGA	0.0023	-0.0002	-0.0011
Nicaragua	NIC	0.0025	-0.0012	0.0001
Netherlands	NLD	0.0001	-0.0005	-0.0016
Norway	NOR	-0.0001	0.0000	-0.0021
Nepal	NPL	-0.0010	0.0037	-0.0003
New Zealand	NZL	-0.0002	-0.0015	-0.0028
Oman	OMN	0.0002	0.0013	0.0014
Pakistan	PAK	-0.0012	-0.0019	-0.0021
Panama	PAN	0.0015	0.0009	0.0013
Peru	PER	-0.0005	0.0004	-0.0012
Philippines	PHL	-0.0001	0.0002	0.0004
Papua New Guinea	PNG	0.0025	-0.0037	-0.0012
Poland	POL	-0.0038	-0.0001	-0.0005
Portugal	PRT	0.0025	-0.0024	0.0000
Paraguay	PRY	-0.0100	-0.0013	-0.0002
Qatar	QAT	0.0019	0.0004	0.0012
Romania	ROM	-0.0026	-0.0007	-0.0007
Russian Federation	RUS	-0.0010	-0.0006	-0.0017
Rwanda	RWA	-0.0040	0.0006	-0.0023
Saudi Arabia	SAU	0.0014	0.0004	-0.0006

Country	ISO	$\lambda^{US}_{h,1992}$	$\lambda^{US}_{h,2002}$	$\lambda^{US}_{h,2012}$
Sudan	SDN	0.0034	-0.0013	0.0018
Senegal	SEN	0.0009	0.0007	-0.0038
Singapore	SGP	0.0002	-0.0008	0.0001
Solomon Islands	SLB	-0.0001	0.0006	0.0022
Sierra Leone	SLE	0.0023	0.0090	0.0001
El Salvador	SLV	0.0009	-0.0014	0.0016
Somalia	SOM	0.0030	-0.0024	-0.0007
Serbia	SRB	0.0022	-0.0004	-0.0006
Sao Tome and Principe	STP	0.0068	0.0405	0.0026
Suriname	SUR	-0.0025	-0.0005	0.0003
Slovak Republic	SVK	-0.0016	0.0012	0.0002
Slovenia	SVN	0.0009	0.0000	0.0002
Sweden	SWE	0.0008	-0.0048	-0.0013
Seychelles	SYC	-0.0322	-0.0046	0.0056
Syrian Arab Republic	SYR	0.0047	-0.0021	-0.0010
Chad	TCD	0.0027	0.0047	0.0026
Togo	TGO	-0.0001	-0.0060	0.0046
Thailand	THA	0.0006	-0.0031	-0.0002
Tajikistan	TJK	0.0003	-0.0029	-0.0021
Turkmenistan	TKM	-0.0001	0.0034	0.0006
Tonga	TON	0.0041	-0.0010	-0.0066
Trinidad and Tobago	TTO	-0.0026	0.0038	-0.0024
Tunisia	TUN	0.0013	-0.0013	-0.0011
Turkey	TUR	0.0012	-0.0007	-0.0015
Tanzania	TZA	0.0024	0.0010	-0.0000
Uganda	UGA	0.0013	-0.0013	-0.0016
Ukraine	UKR	-0.0003	-0.0027	0.0003
Uruguay	URY	0.0028	-0.0041	-0.0013
United States	USA	0.0010	0.0006	-0.0010
Uzbekistan	UZB	0.0019	-0.0041	-0.0017
St. Vincent and the Grenadines	VCT	-0.0057	-0.0062	-0.0053
Venezuela, RB	VEN	0.0013	-0.0026	-0.0028
Vietnam	VNM	-0.0037	-0.0012	-0.0014
Vanuatu	VUT	-0.0158	-0.0144	-0.0514
Samoa	WSM	0.0030	0.0170	0.0047
Yemen, Rep.	YEM	0.0002	0.0022	-0.0013
South Africa	ZAF	0.0017	-0.0011	-0.0004
Congo, Dem. Rep.	ZAR	-0.0012	-0.0027	-0.0018
Zambia	ZMB	-0.0015	-0.0006	-0.0039
Zimbabwe	ZWE	0.0034	0.0034	-0.0052

Table A.4: Parameter estimates of linear SDF models

Model: Test assets:	CAPM 25 FF pfs.	FF four factor model 49 industry portfolios
$\boldsymbol{\zeta}_{US}$	1	1
	[119]	[76.7]
γ_{US}	-3.77	-4.22
	[-2.7]	[-2.3]
γ_{US}^{SMB}		3.21
		[1.13]
γ_{US}^{RMW}		-7.92
		[-1.24]
γ_{US}^{CMA}		4.57
		[.74]
# Moment Conditions	26	50
# Observations	450	450
# Parameters	2	5
Test of joint signific.: χ_e^2	131	1853
$\mathrm{P}(\chi_2^2 > \chi_e^2)$	0	0
J-Test: J-Stat	131	67
$\mathrm{P}(\chi_{M-k}^2 > J)$	0	.02

Results from first-stage GMM. Time period: 1977M1–2014M6. t-statistics in brackets. Column (1) uses Fama and French (1993)'s 25 Benchmark portfolios (and the risk-free rate) as test assets. Column (2) based on Fama and French (2015)'s four-factor model and 49 value-weighted industry portfolios. k denotes # parameters and M # of moment conditions.

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

Export data	Description	# Obs.	# Groups	Mean	Std. Dev.	Min	Max	Source, notes
Value		3,360,036		663,239	25,086,817	0	1.56e+10	US Census, FTD; cp.
Quantity	in kg.	3,360,036		353,605	31,107,200	0	2.75e+10	Pierce and Schott (2012a)
# Years		3,360,036	3			1992	2012	
# Markets		3,360,036	169					
# Products	time consistent HS10 digits or derived codes	3,360,036	6916					cp. Pierce and Schott (2012b)
Markets p. product	with positive sales	787,696		59	30	1	167	
Products p. market	with positive sales	787,696		3,160	1,466	2	5,829	
Quantity p. market	excl. zeros, in kg.	787,696		1,508,356	2,147,572	5,957	9,845,392	
Airshare	share of kg. shipped by air	787,696		.38	.45	0	1	
Exports by vessel								
Markets p. product	with positive sales	562,317		47	26	1	153	
Quantity p. market	excl. zeros, in kg.	562,317		2,101,473	3,778,704	14,781	55,127,272	
Exports by air								
Markets p. product	with positive sales	497,536		51	31	1	167	
Quantity p. market	excl. zeros, in kg.	497,536		12,927	12,624	326	49,382	
Country data								
λ								own computations
Import	by country × year	3,360,036	490	-0.0004	0.0050	-0.0514	0.0405	IMF DOTS
Industrial Production	by country × year	664,130	97	-0.00004	0.0004	-0.0013	0.0011	OECD MEI, IMF IFS
Retail Sales	by country × year	702,754	103	-0.0001	0.0004	-0.0025	0.0009	OECD MEI
GDP	by country × year	3,360,036	490	1.90e+11	5.51e+11	1.08e+8	4.71e+12	WDI, PWT
CGDP	by country × year	3,360,036	490	10,069	14,940	114	79,782	WDI, PWT
RTA	by country × year	3,360,036	490	0.05	0.22	0	1	WTA RTA database
FreightCost	by country × year, ad valorem	3,360,036	490	0.07	0.04	0.01	0.59	US Census, FTD (import data)
by air	by country × year, ad valorem	3,360,036	490	0.08	0.06	0.01	0.57	US Census, FTD (import data)
by vessel	by country × year, ad valorem	3,360,036	490	0.07	0.07	0.00	0.99	US Census, FTD (import data)
FreightCost p. kg.	by country × year, per kg.	3,360,036	490	1.45	1.33	0.02	11.27	US Census, FTD (import data)
Tariff	by HS 6 × country × year, ad valorem (%)	1,728,233	901,580	9.58	21.07	0	3000	WITS
Sector data								
UpfrontInvestment	by NAICS 6 digit × year	3,010,047	1,437	-0.12	5.58	-93.16	33.51	Compustat; cp. Rajan and Zingales (1998)

For the country data, # Groups refers country × year (× HS6) groups. The number of countries in the baseline regression using λ based on industrial production (retail sales) growth is 35 (42).

Table A.6: Gravity estimations with risk premia

Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q^{Ves}_{jh,t}$	$\ln q^{Air}_{jh,t}$	$\ln q^{m}_{jh,t}$	$\ln q^{m}_{jh,t}$	$\ln q^{m}_{jh,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln *GDP*	0.374	0.308	0.240	0.431**	0.337*	0.337*	
	(0.268)	(0.266)	(0.221)	(0.198)	(0.204)	(0.204)	
ln *CGDP*	0.122	0.103	0.100	0.024	0.062	0.062	
	(0.280)	(0.285)	(0.238)	(0.227)	(0.227)	(0.227)	
RTA	0.332***	0.349***	0.424***	0.130	0.276***	0.276***	
	(0.096)	(0.100)	(0.114)	(0.081)	(0.073)	(0.073)	
FreightCost	-0.788	-0.495	-0.074	-0.435	-0.276	-0.270	-0.389**
	(0.963)	(0.898)	(0.237)	(0.367)	(0.289)	(0.285)	(0.194)
$\ln(1+\lambda)$	0.033**	0.033**	0.029**	0.013	0.021*	0.031**	
	(0.015)	(0.017)	(0.013)	(0.011)	(0.011)	(0.013)	
× *Air*						-0.019**	-0.019*
						(0.010)	(0.010)
× *UpfrontInv*		0.0003*					
		(0.0002)					
Fixed effects	prd×yr prd×cty	prd×yr prd×cty	prd×yr prd×cty	prd×yr prd×cty	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air prd×cty×yr
Observations	3,360,036	3,094,634	3,360,036	3,360,036	6,720,072	6,720,072	6,720,072
Adjusted R^2	0.645	0.649	0.599	0.629	0.612	0.612	0.228

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable $\ln q_{jh,t}$ denotes export quantity (in kg.) by product, destination, and time. $\ln q^{m}_{jh,t}$ denotes total export quantity (in kg.) by product, destination, time, and transport mode. $\ln q^{Ves}_{jh,t}$ ($\ln q^{Air}_{jh,t}$) denotes the quantity shipped by vessel (air). Estimates based on years 1992,2002,2012.

Table A.7: Robustness of gravity estimations

Robustness test:	5 yrs ($\Delta = 5$)	21 yrs ($\Delta = 1$)	p. kg. Freight Cost	Lagged GDP	Quantity Units		Export value			
Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}^{Units,HS10}$	$\ln q_{jh,t}^{HS10}$	$\ln s_{jh,t}$	$\ln s_{jh,t}$	$\ln s_{jh,t}^{HS1}$	$\ln s_{h,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ln *GDP*	0.454*	0.405	0.400		0.384*	0.408*	0.441	0.485	1.500***	1.009***
	(0.264)	(0.266)	(0.265)		(0.216)	(0.246)	(0.356)	(0.349)	(0.522)	(0.258)
ln *CGDP*	0.049	-0.043	0.104		0.031	0.056	0.217	-0.008	-0.510	-0.442*
	(0.275)	(0.278)	(0.283)		(0.223)	(0.255)	(0.370)	(0.364)	(0.514)	(0.263)
RTA	0.216***	0.150**	0.329***	0.332***	0.277***	0.307***	0.446***	0.228***	-0.377***	-0.025
	(0.077)	(0.073)	(0.097)	(0.098)	(0.085)	(0.094)	(0.116)	(0.086)	(0.131)	(0.078)
FreightCost	-0.617	-0.877*	0.008	-0.913	-0.717	-0.839	-1.057	-1.121*	-3.982	-1.604*
	(0.607)	(0.461)	(0.034)	(0.976)	(0.735)	(0.866)	(1.317)	(0.610)	(2.355)	(0.883)
$\ln(1+\lambda)$	0.025*	0.016**	0.034**	0.028**	0.033***	0.036***	0.047**	0.023**	0.117***	0.037*
	(0.013)	(0.008)	(0.015)	(0.014)	(0.011)	(0.013)	(0.021)	(0.011)	(0.033)	(0.020)
ln L.*GDP*				0.289						
				(0.286)						
ln L.*CGDP*				0.044						
				(0.299)						
Fixed effects	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	yr
	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	cty
Observations	5,718,219	24,418,154	3,360,036	3,332,734	4,186,753	4,209,512	3,360,036	24,418,154	71,720	3,586
Adjusted R^2	0.669	0.693	0.645	0.646	0.616	0.589	0.667	0.710	0.816	0.955

S.e. (in parentheses) robust to two-way clusters on product and country (on country) level in Columns (1)-(9) (in Column 10). Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable $\ln q_{jh,t}$ ($\ln s_{jh,t}$) denotes total export quantity in kg. (value in USD) by product, destination, and time. $\ln s_{h,t}$ denotes export value in USD by destination and time. $\ln q_{jh,t}^{Units}$ denote export quantity in units. Superscripts $HS10$, $HS1$ denote level of aggregation of product groups (respectively, HS 10-digits and highest level of aggregation of the HS1992 classification). Column (1) is based on years 1992,1997,2002,2007,2012, Columns (2),(8)-(10) are based on annual data between 1992 and 2012, and Columns (3)-(7) are based on years 1992,2002,2012.

Table A.8: Robustness of gravity estimations: Zeros

Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q^{Ves}_{jh,t}$	$\ln q^{Air}_{jh,t}$	$\ln q^{m}_{jh,t}$	$\ln q^{m}_{jh,t}$	$\ln q^{m}_{jh,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
ln *GDP*	1.359**	1.302**	1.024**	1.284***	1.166***	1.166***	
	(0.543)	(0.541)	(0.478)	(0.337)	(0.393)	(0.393)	
ln *CGDP*	0.051	0.079	0.075	-0.088	-0.011	-0.011	
	(0.571)	(0.564)	(0.525)	(0.372)	(0.438)	(0.438)	
RTA	-0.084	-0.088	0.189	-0.120	0.031	0.031	
	(0.187)	(0.188)	(0.206)	(0.101)	(0.121)	(0.121)	
FreightCost	-13.748***	-13.891***	-4.053*	-5.930***	-5.302***	-5.307***	-3.681***
	(4.084)	(4.132)	(2.112)	(1.126)	(1.353)	(1.348)	(1.310)
$\ln(1+\lambda)$	0.085**	0.087**	0.071**	0.012	0.074*	0.126**	
	(0.035)	(0.035)	(0.033)	(0.023)	(0.041)	(0.059)	
× *UpfrontInv*		0.003					
		(0.002)					
× *Air*						-0.104*	-0.103*
						(0.060)	(0.059)
Fixed effects	prd×yr prd×cty	prd×yr prd×cty	prd×yr prd×cty	prd×yr prd×cty	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air prd×cty×yr
Observations	1,212,161	1,119,830	1,212,161	1,212,161	2,424,322	2,424,322	2,424,322
Adjusted R^2	0.394	0.649	0.451	0.533	0.495	0.495	.0429

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable $\ln q_{jh,t}$ denotes export quantity (in kg.) by product, destination, and time. $\ln q^{m}_{jh,t}$ denotes total export quantity (in kg.) by product, destination, time, and transport mode. $\ln q^{Ves}_{jh,t}$ ($\ln q^{Air}_{jh,t}$) denotes the quantity shipped by vessel (air). Estimates based on years 1992,2002,2012.

Table A.9: Robustness of gravity estimations: Tariffs

Robustness test:	21 yrs ($\Delta = 1$)	21 yrs ($\Delta = 1$)	5 yrs ($\Delta = 5$)	5 yrs ($\Delta = 5$)	3 yrs ($\Delta = 10$)	3 yrs ($\Delta = 10$)
Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
ln *GDP*	0.526**	0.534**	0.630***	0.640***	0.524**	0.520**
	(0.224)	(0.225)	(0.222)	(0.222)	(0.253)	(0.253)
ln *CGDP*	0.196	0.198	0.295	0.306	0.450	0.457
	(0.212)	(0.213)	(0.216)	(0.215)	(0.310)	(0.310)
RTA	0.118**	0.127**	0.178***	0.190***	0.282*	0.291**
	(0.051)	(0.051)	(0.063)	(0.062)	(0.143)	(0.141)
FreightCost	-1.804**	-1.845**	-2.130*	-2.210*	-2.823*	-2.887*
	(0.757)	(0.758)	(1.239)	(1.262)	(1.673)	(1.684)
$\ln(1+\lambda)$	0.026*	0.025*	0.050*	0.049*	0.042	0.042
	(0.015)	(0.015)	(0.028)	(0.028)	(0.030)	(0.030)
ln *Tariff*	-0.300**		-0.440*		-0.150	
	(0.136)		(0.264)		(0.243)	
Fixed effects	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr
	prd×cty	prd×cty	prd×cty	prd×yr	prd×cty	prd×cty
Observations	16,317,097	16,317,097	3,760,735	3,760,735	1,727,233	1,727,233
Adjusted R^2	0.675	0.675	0.638	0.638	0.608	0.608

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable $\ln q_{jh,t}$ denotes export quantity in kg. by product, destination, and time. Columns (1) and (2) are based on annual data between 1992 and 2012, Columns (3) and (4) are based on years 1992,1997,2002,2007,2012, Columns (5) and (6) are based on years 1992,2002,2012. ln *Tariff* denotes 1+t/100, where t equals the ad-valorem (equivalent of) tariff by destination, time, and HS 6-digit product category.

Table A.10: Robustness of gravity estimations: Alternative estimates of λ

Robustness test:	25 FF pfs	four FF factors	Industrial production			Retail sales		
Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q^{Ves}_{jh,t}$	$\ln q^{Air}_{jh,t}$	$\ln q_{jh,t}$	$\ln q^{Ves}_{jh,t}$	$\ln q^{Air}_{jh,t}$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln *GDP*	0.373	0.395	0.185	0.600	0.191	-0.432	-0.009	0.059
	(0.268)	(0.268)	(0.636)	(0.752)	(0.510)	(0.657)	(0.662)	(0.564)
ln *CGDP*	0.122	0.120	0.964	0.293	0.876	1.755***	1.042*	1.157**
	(0.280)	(0.277)	(0.609)	(0.701)	(0.530)	(0.568)	(0.585)	(0.547)
RTA	0.332***	0.326***	0.038	0.148	0.009	0.008	0.044	0.008
	(0.096)	(0.096)	(0.120)	(0.123)	(0.057)	(0.153)	(0.187)	(0.071)
FreightCost	-0.788	-0.771	-20.025***	-15.072***	-5.895**	-10.879***	-8.584**	-3.823**
	(0.963)	(0.961)	(4.265)	(4.769)	(2.170)	(3.247)	(3.886)	(1.861)
$\ln(1+\lambda)$	0.033**	0.043***	0.044*	0.048**	0.011	0.031	0.048**	0.014
	(0.015)	(0.016)	(0.023)	(0.022)	(0.015)	(0.023)	(0.022)	(0.016)
Fixed effects	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr
	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty
Observations	3,360,036	3,360,036	4,931,783	4,931,783	4,931,783	5,462,048	5,462,048	5,462,048
Adjusted R^2	0.645	0.645	0.690	0.651	0.691	0.706	0.667	0.699

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable $\ln q_{jh,t}$ denotes total export quantity (in kg.) by product, destination, and time. $\ln q^{Ves}_{jh,t}$ ($\ln q^{Air}_{jh,t}$) denotes the quantity shipped by vessel (air). Columns (1) and (2) are based on years 1992,2002,2012. Columns (3)-(8) are based on annual data between 1992 and 2012.

Table A.11: Robustness of gravity estimations, continued

Robustness test:	$\ln(\sigma^{\hat{Y}})$		excl. CAN & MEX		$(q^{Ves}_{jh,t} + q^{Air}_{jh,t})/q_{jh,t} > .9$	
Dep. Var.:	$\ln q^m_{jh,t}$	$\ln q^m_{jh,t}$	$\ln q^m_{jh,t}$	$\ln q^m_{jh,t}$	$\ln q^m_{jh,t}$	$\ln q^m_{jh,t}$
	(1)	(2)	(3)	(4)	(5)	(6)
ln *GDP*	0.338*	0.338*	0.330	0.332	0.330	0.332
	(0.204)	(0.204)	(0.203)	(0.204)	(0.200)	(0.201)
ln *CGDP*	0.069	0.069	0.063	0.070	0.057	0.064
	(0.226)	(0.226)	(0.227)	(0.226)	(0.224)	(0.223)
RTA	0.278***	0.278***	0.265***	0.266***	0.267***	0.268***
	(0.072)	(0.072)	(0.077)	(0.076)	(0.076)	(0.076)
FreightCost	-0.287	-0.285	-0.243	-0.258	-0.232	-0.247
	(0.292)	(0.290)	(0.278)	(0.283)	(0.274)	(0.279)
$\ln(1+\lambda)$	0.023**	0.032**	0.030**	0.032**	0.029**	0.032**
	(0.010)	(0.013)	(0.013)	(0.013)	(0.013)	(0.012)
$\times$ *Air*		-0.017	-0.018*	-0.017*	-0.018*	-0.017
		(0.010)	(0.009)	(0.010)	(0.009)	(0.010)
$\ln(\sigma^{\hat{Y}})$	0.031	0.019		0.027		0.030
	(0.030)	(0.038)		(0.038)		(0.037)
$\times$ *Air*		0.023		0.015		0.013
		(0.034)		(0.033)		(0.033)
Fixed effects	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air	prd×yr×air prd×cty×air
Observations	6,720,072	6,720,072	6,637,744	6,637,744	6,576,614	6,576,614
Adjusted R^2	0.612	0.612	0.612	0.612	0.607	0.607

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. $\ln q^m_{jh,t}$ denotes total export quantity (in kg.) by product, destination, time, and transport mode. Estimates are based on years 1992,2002,2012.