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

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Preliminary

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 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 values 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. To test this 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. 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 stakeholders 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 stakeholders' 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 shareholders care not only about the level of expected profits, but also about the distribution of payoffs over good states and bad states. Survey evidence confirms this conjecture. 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. While the concept of optimal decision-making

[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 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.

based on expected payoffs *and* risk characteristics 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 uncertainty, which typically assumes risk-neutral behavior of firms.[5] This paper addresses that 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 characterized by idiosyncratic and common shocks. Using product-level export data from the United States, I find that export shipments are larger to those markets where expected profits correlate negatively with the income of U.S. investors, conditional on market size and trade cost. I thus provide evidence that exporting firms are actively engaged in global risk sharing by virtue of shareholder-value maximization.

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* the level of demand is known. There is ample evidence that exporters face significant time lags between production and sales of their goods.[6] Moreover, a sizable literature documents that investors care about firms' operations in foreign markets and their potential 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 serve specific markets through exports, and what this means for the pattern of aggre-

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

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

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

[6]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.

gate bilateral trade and the degree of global risk sharing. Here lies the contribution of my paper. I show that introducing risk-averse investors and a time lag between production and sales in an otherwise standard monopolistic competition setup leads to a firm-level gravity equation that includes a novel determinant of bilateral trade flows: the model predicts that, ceteris paribus, firms ship more to countries where demand shocks are more positively correlated with the marginal utility of firms' investors. I provide empirical support for this hypothesis based on a panel of product-level exports from the United States to 175 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. In addition to the direct bilateral exposure of investors to a given destination country through ownership of firms selling to this market, these covariances also reflect indirect exposure through firms' sales to markets with correlated shocks. Building 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 175 destination markets.

With those estimated covariances at hand, I 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). Moreover, I 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.

Those 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 besides 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. Figure A.5 in the appendix shows the share of respondents who answered that they always or almost always adjust discount rates or cashflows for the given risk factor. 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 micro-foundations 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.[7] 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 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 country. 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

[7] 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 country shocks plays no role if investors are risk neutral or if demand growth is deterministic.

is solely in the hand of investors, I argue that there is a role for internationally active firms to engage in diversification, in addition to profit maximization. The key assumption I make in this regard is market specificity of goods, 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 have 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.[8]

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 excess returns for holding shares of internationally active firms and provide evidence that those excess returns are systematically related to the correlation of demand

[8] 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 that offers 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.

shocks in destination markets with the consumption growth of investors in the firms' home country. In the model developed by these authors, 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 abstract from entry cost and instead consider the implications of longer time lags between production and foreign sales, which do have an impact on the intensive margin of firms' optimal exports. My paper is similar to these authors' work in that I also develop a structural model linking firm values to country shocks and to the distribution of marginal utility growth. However, Fillat and Garetto (2015) and Fillat et al. (2015) analyze asset returns conditional on firms choices, whereas my focus lies on the optimal choices themselves. Moreover, thanks to the 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 thus also related to the literature on firm investment under uncertainty, specifically the strand 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. This literature began with testing and rejecting the asset pricing implications of a standard real business cycle models (see Jermann, 1998). 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 cost. 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.

The extant literature shows that demand volatility in conjunction with time lags due to shipping impacts various decision margins of exporters and importers, including order size and the timing of international transactions (Alessandria et al., 2010), as well as the choice of an optimal transportation mode (Aizenman, 2004; Hummels and Schaur, 2010). In this literature, agents are risk neutral and demand volatility 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. I 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 and, therefore, changes the willingness to bear a particular market's specific risk. Even though the model ignores the possibility of hedging risk by means of inventory holdings or fast transport, it implies that optimal market-specific hedging choices will be affected by investors' perception of costliness.[9]

3 Theory

Consider a world consisting of I countries inhabited by individuals who derive utility from consumption of a final good and earn income from the ownership of firms producing differentiated intermediate goods. Intermediate goods are sold to domestic and foreign final goods producers whose output is subject to a country-specific stochastic technology.

[9]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, for example, Khan and Thomas, 2007).

3.1 Utility, Consumption, and Investment

The expected utility that an infinitely-lived representative risk-averse agent $i \in \iota$ derives from lifetime consumption $\{C_{i,t+s}\}_{s=0}^{\infty}$ is given by

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

where ρ is his time preference rate. The agent is endowed with wealth $W_{i,t}$ which he consumes or invests into $a_{ij,t}$ shares of firms $j \in \mathcal{J}_{i,t}$ that sell at price $v_{j,t}$ and into $a_{i,t}^f$ units of a risk-free asset. All prices are denoted in units of the aggregate consumption good. Wealth thus observes

$$W_{i,t} = A_{i,t} + C_{i,t} \quad \text{where} \quad A_{i,t} = \sum_{j \in \mathcal{J}_{i,t}} a_{ij,t} v_{j,t} + a_{i,t}^f. \tag{2}$$

Every period the agent receives interest $r_{i,t}^f$ on his investment in the risk-free asset and a dividend per share that corresponds to a fraction δ_j of firm j's profit $\pi_{j,t}$. Without loss of generality, I set $\delta_j = 1$. Moreover, the agent makes net investments $\mathrm{d}a_{ij,t} = a_{ij,t} - a_{ij,t-1} \lesseqgtr 0$ in risky assets (firm shares) and the safe asset ($\mathrm{d}a_{i,t}^f$), so that his per-period budget constraint reads

$$C_{i,t} = \sum_{j \in \mathcal{J}_{i,t-1}} a_{ij,t-1} \pi_{j,t} + a_{i,t-1}^f r_{i,t}^f - \sum_{j \in \mathcal{J}_{i,t}} \mathrm{d}a_{ij,t} v_{i,t} - \mathrm{d}a_{i,t}^f. \tag{3}$$

The agent's wealth thus evolves over time according to

$$\begin{aligned} W_{i,t+1} &= \sum_{j \in \mathcal{J}_{i,t}} a_{ij,t} v_{j,t} + a_{i,t}^f + \sum_{j \in \mathcal{J}_{i,t}} a_{ij,t} \left(\mathrm{d}v_{j,t+1} + \pi_{j,t+1} \right) + a_{i,t}^f r_{i,t+1}^f \\ &= R_{i,t+1}^W \left(W_{i,t} - C_{i,t} \right) \quad \text{where} \quad R_{i,t+1}^W = \sum_{j \in \mathcal{J}_{i,t}} \frac{a_{ij,t} v_{j,t}}{A_{i,t}} R_{j,t+1} + \frac{a_{i,t}^f}{A_{i,t}} R_{i,t+1}^f. \end{aligned} \tag{4}$$

$R_{i,t+1}^W$ denotes the gross return to the wealth portfolio $A_{i,t}$, $R_{i,t+1}^f = 1 + r_{i,t+1}^f$ is the exogenously given gross interest rate earned by the risk-free asset. Gross returns to risky assets, $R_{j,t+1} = \frac{\pi_{j,t+1} + v_{j,t+1}}{v_{j,t}}$, will be determined by firms' choices. The investor chooses optimal investment levels by maximizing utility in Equation (1) with respect to $a_{ij,t}, a^f_{i,t}$ and subject to Equations (2), (3), (4), and the no-Ponzi-game condition $0 = \lim_{s\to\infty} \frac{A_{i,t+s}}{\mathrm{E}_t\left[R^W_{i,t+s}\right]}$. His first-order conditions yield an Euler equation for the risk-free asset,

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

and Euler equations for the risky assets,

$$v_{j,t} = \mathrm{E}_t\left[\rho \frac{u_i'(C_{i,t+1})}{u_i'(C_{i,t})}(\pi_{j,t+1} + v_{j,t+1})\right] \quad \forall\, j, t. \tag{6}$$

The Euler equations describe the consumption-investment tradeoff: investment (disinvestment) occurs while the price paid today is smaller (larger) than the marginal return tomorrow, where the return tomorrow is scaled by the time preference rate and expected marginal utility growth. This scaling factor is commonly referred to as the stochastic discount factor (SDF).

The Euler equations also describe the tradeoff between investing in different types of assets. Chaining together Equation (6) and using Equation (5) yields

$$v_{j,t} = \mathrm{E}_t \sum_{s=1}^{\infty} \rho^s \frac{u_i'(C_{i,t+s})}{u_i'(C_{i,t})}\pi_{j,t+s} = \sum_{s=1}^{\infty} \frac{\mathrm{E}_t\left[\pi_{j,t+s}\right]}{R^f_{i,t+s}} + \sum_{s=1}^{\infty} \mathrm{Cov}_t\left[\rho^s \frac{u_i'(C_{i,t+s})}{u_i'(C_{i,t})}, \pi_{j,t+s}\right]. \tag{7}$$

The right-hand side of Equation (7) shows that an investor's willingness to pay for a share of firm j, which promises a risky dividend stream $\{\pi_{i,t+s}\}_{s=1}^{\infty}$, is determined not only by the expected value (discounted with the risk-free interest rate), but also by the payoff's correlation with

$$m_{i,t+s} := \rho^s \frac{u_i'(C_{i,t+s})}{u_i'(C_{i,t})}, \tag{8}$$

the investor's SDF. The SDF is an inverse measure of 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 expected consumption is small and marginal utility is high. Equation

(6) states that stocks that pay high dividends in times when expected marginal utility is high are more valuable to an investor.[10] The investor buys risky assets ($\mathrm{d}a_{ij,t} > 0$) while his willingness to pay exceeds the price $v_{j,t}$. He thus increases expected consumption tomorrow at the expense of consumption today so that expected growth in marginal utility falls. Equation (5) then commands that he partly disinvest the risk-free asset. Moreover, as the share of asset j in the investor's total portfolio, $\frac{a_{ij,t}v_{j,t}}{A_{i,t}}$, increases, its return becomes more correlated with the return on total wealth and, therefore, asset j becomes less attractive as a means of consumption smoothing. Hence, the investor's willingness to pay for additional units of this asset decreases.

The assumption of a representative investor is innocuous in an economy where individuals have identical beliefs about the probabilities with which uncertain events occur, the financial market is complete, and individuals' preferences are of the von Neumann-Morgenstern type as described in Equation (1) (see Constantinides, 1982). Completeness of financial markets means that trading and creating state contingent assets is unrestricted and costless and hence idiosyncratic risks are insurable. Constantinides (1982) shows that under those conditions, equilibrium outcomes in an economy characterized by optimal choices of investors exhibiting heterogeneous per-period utility functions and heterogeneous levels of wealth are identical to the case where a "composite" investor owning the sum of all inviduals' wealth makes optimal decisions. Moreover, he shows that the composite investor's preferences inherit the von Neumann-Morgenstern property and the concavity of individuals' utility functions.

The above setup of the financial market then encompasses three cases of financial market integration. Let $\mathcal{I}_i \subseteq \mathcal{I}$ with $i = 1, ..., \iota$ denote mutually exclusive and collectively exhaustive sets of countries among which asset trade is unrestricted. Then $\iota = I$ denotes the case where all countries are in financial autarky, so that there is one representative

[10]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.

investor for every single country in $\mathcal{I}$ and the set of available assets $\mathcal{J}_{i,t}$ is restricted to the set of domestic firms. The case of $I > \iota > 1$ describes partially integrated international asset markets, where investor i is representative for every country in $\mathcal{I}_i$ and $\mathcal{J}_{i,t}$ comprises the firms from all countries in $\mathcal{I}_i$. Finally, $\iota = 1$ denotes the case of complete integrated international market, where investor i is representative for all countries and has unrestricted access to shares of all firms.

Note that the creation and trade of other "financial" assets within a complete market, that is, creation and trade of assets like derivatives, options, or futures, which are in zero net supply, has no bearing on the representative investor's optimal consumption or investment decisions.[11] This does not mean that none of those assets are traded; in fact, they are essential for eliminating idiosyncratic risk in the first place and facilitating a description of the equilibrium by means of a representative investor. However, since by definition they must be in zero net supply, they cannot play a role in mitigating aggregate risk and thus their presence does not have any impact on the tradeoff between risky assets and the risk-free investment, nor do they have any bearing on the consumption-investment tradeoff.

The Euler equations describe the demand side of the asset market and determine the equilibrium price for a given number of available shares with specific stochastic properties. The supply of such assets and their stochastic properties 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 with an exogenously given return $R^f_{i,t}$.

[11] 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.

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

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

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 one and 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.[12] The distribution is known to all agents of the model.

Inverse demand for any individual variety of the differentiated good follows as

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

where $p_{jh,t}$ is the price of variety j in country h. In the differentiated goods sector, firms produce varieties using c_j units of the composite good per unit of output and, when shipping goods to country h, they face iceberg-type trade costs $\tau_{jh} \geq 1$. Moreover, each period, firms pay a fixed cost α_j.[13] I assume that firms within each country are homogeneous with respect to cost, but every firm produces a distinct variety. Since I

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

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

will be considering a representative firm for a given country, I subsume the home country index in the firm index j. The number of firms and varieties from country j is $N_{j,t}$.

Demand for a firm's variety in any destination market h is volatile because it depends on the destination country's stochastic state of productivity $\psi_{h,t}$. I assume that variety producers have to decide on the optimal output quantity for a given market *before* the productivity of the destination country is known because production and shipping take time. Hence, at time t they choose the quantity $q_{jh,t} = \bar{q}_{jh,t+1}$ to be sold in $t+1$ and they base this decision on the expected level of demand.[14] Consequently, the amount of the composite good at time t is also determined a period in advance and follows as $\bar{Q}_{h,t+1} = Q_{h,t} = \left(\sum_{j\in\mathcal{I}} N_{j,t} \left(q_{jh,t}\right)^{\frac{\varepsilon-1}{\varepsilon}}\right)^{\frac{\varepsilon}{\varepsilon-1}}$.

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

$$\mathrm{E}_t\left[p_{jh,t+1}\right] = \eta \left(\frac{q_{jh,t}}{Q_{h,t}}\right)^{-\frac{1}{\varepsilon}} Q_{h,t}^{\eta-1} \mathrm{E}_t\left[\psi_{h,t+1}\right] = \eta \left(\frac{\tilde{q}_{jh,t}}{Q_{h,t}}\right)^{-\frac{1}{\varepsilon}} \frac{\mathrm{E}_t\left[Y_{h,t+1}\right]}{Q_{h,t}} \tag{10}$$

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

$$\mathrm{E}_t\left[\pi_{jh,t+1}\right] = \mathrm{E}_t\left[p_{jh,t+1}(q_{jh,t}) \cdot q_{jh,t} - c_j \tau_{jh} q_{jh,t+1}\right] \tag{11}$$

Note that current revenue depends on the quantity produced at time t, while current cost depend on the quantity produced in $t+1$. Total profits are $\pi_{j,t+1} = \sum_{h\in\mathcal{I}} \pi_{jh,t+1} - \alpha_j$.

Firm j 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. As discussed above, firm j may obtain financing from investors in multiple countries, depending on the degree of financial market integration. Lets assume, without loss of generality, that the firm's home country j is part of the set of countries $\mathcal{I}_i$ whose

[14] I have thus implicitly assumed that firms cannot reallocate quantities across markets once the uncertainty about demand has been resolved, and that they do not hold inventory in destination countries.

asset markets are fully integrated. Then, the relevant discount factor for firm j is $m^j_{t+s} = m_{i,t+s}$. The firm takes the distribution of the SDF as given; hence, its optimization problem reads

$$\max_{[q_{jh,t+s}\geq 0]_{s=0}^{\infty}\ \forall h} \quad V_{j,t} = \mathrm{E}_t\left[\sum_{s=0}^{\infty} m^j_{t+s}\cdot\pi_{j,t+s}\right].$$

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

$$\max_{q_{jh,t}\geq 0\ \forall h} \quad \mathrm{E}_t\left[m^j_{t+1}\cdot\sum_{h\in\mathcal{I}} p_{jh,t+1}(q_{jh,t})\cdot q_{jh,t}\right] - \sum_{h\in\mathcal{I}} c_j\tau_{jh}q_{jh,t} - \alpha_j$$

$$= \sum_{h\in\mathcal{I}} \eta\left(\frac{q_{jh,t}}{Q_{h,t}}\right)^{\frac{\varepsilon-1}{\varepsilon}}\left(\mathrm{E}_t\left[Y_{h,t+1}\right]\mathrm{E}_t\left[m^j_{t+1}\right] + \mathrm{Cov}_t\left[m^j_{t+1}, Y_{h,t+1}\right]\right) - \sum_{h\in\mathcal{I}} c_j\tau_{jh}q_{jh,t} - \alpha_j.$$

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

$$q^*_{jh,t} = \frac{\theta(1+\lambda^j_{h,t})^{\varepsilon}\left(R^f_{j,t+1}c_j\tau_{jh}\right)^{-\varepsilon}}{\sum_{j\in\mathcal{I}} N_{j,t}(1+\lambda^j_{h,t})^{\varepsilon-1}\left(R^f_{j,t+1}c_j\tau_{jh}\right)^{1-\varepsilon}}\cdot\mathrm{E}_t\left[Y_{h,t+1}\right], \tag{12}$$

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

$$\lambda^j_{h,t} := R^f_{j,t+1}\mathrm{Cov}_t\left[m^j_{t+1}, \frac{Y_{h,t+1}}{\mathrm{E}_t\left[Y_{h,t+1}\right]}\right].$$

To arrive at Equation (12), I used $Q_{h,t}^{\frac{\varepsilon-1}{\varepsilon}} = \sum_{j\in\mathcal{I}} N_{j,t}(q^*_{jh,t})^{\frac{\varepsilon-1}{\varepsilon}}$ and Equation (5) to substitute for the expected value of the SDF. I call $\lambda^j_{h,t}$ 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. Equation (9) implies that demand growth comoves one to one with the country-specific productivity shocks $\mathrm{E}_t\left[\psi_{h,t+1}\right]/\psi_{h,t+1}$.

Equation (12) 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 will be subjected to empirical testing in Section 4. First, however, I relate the model's predictions to the standard gravity framework and close the model to show how the risk premia are determined in general equilibrium and how they can be estimated. I also show that they will be zero only under special circumstances, namely, if the exogenous distribution of productivity shocks and financial market integration permit complete elimination of *aggregate* risk, and if investors, trading off risk against returns, endogenously choose to do so.

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

$$p_{jh,t+1}(q^*_{jh,t})q^*_{jh,t} = \phi_{jh,t} Y_{h,t+1}, \tag{13}$$

where

$$\phi_{jh,t} = \left(\frac{q^*_{jh,t}}{Q_{jh,t}}\right)^{\frac{\varepsilon-1}{\varepsilon}} = \frac{(1+\lambda^j_{h,t})^{\varepsilon-1}\left(R^f_{j,t+1}c_j\tau_{jh}\right)^{1-\varepsilon}}{\sum_{j\in\mathcal{I}} N_{j,t}(1+\lambda^j_{h,t})^{\varepsilon-1}\left(R^f_{j,t+1}c_j\tau_{jh}\right)^{1-\varepsilon}}$$

denotes firm j's trade share in market h, that is, the share of country h's real expenditure devoted to firm j. Equation (13) is a firm-level gravity equation with bilateral trade cost augmented by a risk-adjusted interest rate. Note that Equation (13) nests the Armington gravity equation as a special case. 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

($\mathrm{E}_t[Y_{h,t}] = Y_{h,t}$). Next, suppose that investors are risk neutral, so that marginal utility is constant. Then, the SDF does not vary over time and hence has a zero covariance with demand shocks. In this case, Equation (13) will differ from the Armington 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 (12). Firms still ship larger quantities to countries with positive λs and investors value these firms more, but since all their competitors from other countries behave accordingly, trade *shares* are independent of λ. Finally, covariances could be set to zero *endogenously*, a possible but unlikely case, as I will discuss in more detail below.

Firm j's maximum net present value is given by

$$
\begin{aligned}
V^*_{j,t} &= \sum_{h \in \mathcal{I}} \left(\mathrm{E}_t \left[m^j_{t+1} \cdot p_{jh,t+1}(q^*_{jh,t}) q^*_{jh,t} \right] - c_j \tau_{jh} q^*_{jh,t} \right) - \alpha_j \\
&= \sum_{h \in \mathcal{I}} (1-\theta) \frac{1+\lambda^j_{h,t}}{R^f_{j,t+1}} \phi_{jh,t} \mathrm{E}_t \left[Y_{h,t+1} \right] - \alpha_j,
\end{aligned}
\tag{14}
$$

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.

3.3 Model Closure

3.3.1 Firm Entry and Asset Market Clearing

Firm entry governs the supply of assets from every country. I assume that there are no barriers to entry; hence, firms enter as long as their net present value is non-negative. In view of Equation (14), this implies that in equilibrium

$$V_{j,t}^{*} = 0 \qquad \Leftrightarrow \qquad \mathrm{E}_t \left[m_{t+1}^{j} \cdot \sum_{h \in \mathcal{I}} p_{jh,t+1}(q_{jh,t}^{*}) q_{jh,t}^{*} \right] = \sum_{h \in \mathcal{I}} c_j \tau_{jh} q_{jh,t}^{*} + \alpha_j. \tag{15}$$

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.[15] Moreover, entry of additional firms from country j 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, $V_{j,t}^{*}$ is driven down to zero as new firms enter. Equation (15) determines the number of firms and thus the supply of assets from every country. Asset market clearing implies

$$N_{j,t} = a_{ij,t} \qquad \forall\ j \in \mathcal{I}_i, \tag{16}$$

that is, the number of variety producers in country j is equal to the representative investor i's demand for shares of this particular type.[16] Remember that depending on the degree of financial market integration, the representative investor's demand equals the composite demand of all individuals from country j or from (a subset of) all countries.

Combining the entry condition (15) with the Euler equation (6) that governs asset demand and substituting $\sum_{h \in \mathcal{I}} p_{jh,t+1}(q_{jh,t}^{*}) \cdot q_{jh,t}^{*} = \pi_{j,t+1} + \sum_{h \in \mathcal{I}} c_j \tau_{jh} q_{jh,t+1}^{*} + \alpha_j$ implies that the equilibrium asset price equals the cost of setting up a new firm, that is,

$$v_{j,t} = \sum_{h \in \mathcal{I}} c_j \tau_{jh} q_{jh,t}^{*} + \alpha_j. \tag{17}$$

With asset prices and profits determined, the returns to holding firm shares can be described in terms of country-specific demand growth, which, by Equation (9), correlates

[15] There is a countervailing positive effect of firm entry on incumbents' profits arising from the love of variety inherent to 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 for variety.

[16] Remember that I have normalized the number of shares per firm to unity.

perfectly with the productivity shocks. Using Equations (13), I obtain

$$R_{j,t+1} = \frac{\pi_{j,t+1} + v_{j,t+1}}{v_{j,t}} = \sum_{h \in \mathcal{I}} \frac{\phi_{jh,t} \mathrm{E}_t \left[Y_{h,t+1}\right]}{v_{j,t}} \left(\frac{Y_{h,t+1}}{\mathrm{E}_t \left[Y_{h,t+1}\right]} \right) \tag{18}$$

as the gross return of a share of firm j. Returns are linear combinations of demand growth in the destination markets, where markets are weighted by the share of expected sales in the total discounted value of the firm.

3.3.2 Equilibrium

Let $\boldsymbol{N}_t$, $\boldsymbol{\psi}_{t+1}$, $\boldsymbol{q}_{j,t}$ denote $(I \times 1)$ vectors collecting, respectively, the number of firms, the productivity levels, and firm j's optimal quantity in each country $h = 1, ..., I$. Then $\boldsymbol{q}_t = \left[\boldsymbol{q}'_{1,t}, ..., \boldsymbol{q}'_{i,t}, ..., \boldsymbol{q}'_{I,t}\right]$ is a $(I \times I)$ matrix of all firms' sales across all markets. Moreover, let $\boldsymbol{a}_{i,t}$ denote the $(I_i \times 1)$ vector of investor i's optimally chosen number of shares of all representative firms $j \in \mathcal{I}_i$, where I_i is the number of countries in $\mathcal{I}_i$. $\widetilde{\boldsymbol{\pi}}^i_{t+1}$ and $\boldsymbol{v}^i_t$ denote $(I_i \times 1)$ vectors of these firms' profits and share prices, respectively. I use a tilde to indicate random variables defined by a conditional density function. For example, $\widetilde{\boldsymbol{\psi}}_{t+1}$ describes the joint distribution of the productivity levels $f(\boldsymbol{\psi}_{t+1}|\boldsymbol{\Psi}_t)$ conditional on the history of realized productivity shocks. Then, the set of equilibrium conditions determining the endogenous variables $\boldsymbol{q}_t$, $\boldsymbol{N}_t$, $\{\boldsymbol{a}_{i,t}\}_{i=1}^{\iota}$, $\{a^f_{i,t}\}_{i=1}^{\iota}$, $\{\boldsymbol{v}^i_t\}_{i=1}^{\iota}$, $\{C_{i,t}\}_{i=1}^{\iota}$, and, for all $s = 1, ..., \infty$, $\widetilde{\boldsymbol{q}}_{t+s}$, $\widetilde{\boldsymbol{N}}_{t+s}$, $\{\widetilde{\boldsymbol{a}}_{i,t}\}_{i=1}^{\iota}$, $\{\widetilde{a}^f_{i,t+s}\}_{i=1}^{\iota}$, $\{\widetilde{\boldsymbol{\pi}}^i_{t+s}\}_{i=1}^{\iota}$, $\{\widetilde{\boldsymbol{v}}^i_{t+s}\}_{i=1}^{\iota}$, $\{\widetilde{m}_{i,t+s}\}_{i=1}^{\iota}$, $\{\widetilde{C}_{i,t+s}\}_{i=1}^{\iota}$ is given by

Investors' first-order conditions (5) and (6):

$$a^f_{i,t}\left[\widetilde{m}_{i,t+1}; R^f_{i,t+1}\right] \quad \text{and} \quad a_{ij,t}\left[v_{j,t}, \widetilde{\pi}_{j,t+1}, \widetilde{m}_{i,t+1}\right] \qquad \forall\ j \in \mathcal{I}_i \text{ and } i = 1, ..., \iota$$

Firms' first-order conditions (12): $\boldsymbol{q}_{j,t}\left[\boldsymbol{q}_t, \boldsymbol{N}_t, \widetilde{m}_{i,t+1}; \widetilde{\boldsymbol{\psi}}_{t+1}\right] \quad \forall\ j \in \mathcal{I}_i$ and $i = 1, ..., \iota$

Profits (11): $\widetilde{\pi}_{j,t+1}\left[\boldsymbol{q}_t, \boldsymbol{N}_t; \widetilde{\boldsymbol{\psi}}_{t+1}\right] \quad \forall\ j \in \mathcal{I}_i$ and $i = 1, ..., \iota$

Free entry condition (15): $N_{j,t}\left[v_{j,t}, \boldsymbol{q}_t, \boldsymbol{N}_t, \widetilde{m}_{i,t+1}; \widetilde{\boldsymbol{\psi}}_{t+1}\right] \quad \forall\ j \in \mathcal{I}_i$ and $i = 1, ..., \iota$

Asset market clearing (16): $a_{ij,t}\left[N_{j,t}\right]$ $\forall\ j \in \mathcal{I}_i$ and $i = 1, ..., \iota$

Stochastic discount factor (8): $\widetilde{m}_{i,t+1}\left[C_{i,t}, \widetilde{C}_{i,t+1}\right]$ $\forall\ i = 1, ..., \iota$

Budget constraint (3): $C_{i,t}\left[a^f_{i,t}, \boldsymbol{a}_{i,t}, \boldsymbol{v}^i_t; W_{i,t}\right]$ and

$$\widetilde{C}_{i,t+1}\left[a^f_{i,t}, \boldsymbol{a}_{i,t}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, \widetilde{\boldsymbol{v}}^i_{t+1}; R^f_{i,t+1}\right] \qquad \forall\ i = 1, ..., \iota$$

and the no-Ponzi-game condition $0 = \lim_{s\to\infty} \frac{A_{i,t+s}}{\mathrm{E}_t\left[R^W_{i,t+s}\right]}$ $\forall\ i = 1, ..., \iota$.[17]

This describes the equilibrium from the point of view of the representative investors for the ι subsets of countries. If financial markets are partially or fully integrated ($\iota > 1$), the equilibrium values for investment and consumption describe aggregates of all countries in $\mathcal{I}_i$. Hence, consumption or investment on the national level, as well as bilateral financial flows, are not determined at this point. To pin down those values in the case of (partially) integrated international financial markets, further assumptions on the distribution of wealth and the utility functions are needed. Note that up 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.2, I show how countries' current accounts can be derived once country-level consumption and bilateral investment flows are determined.[18]

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[17] I include a subset of the exogenous or predetermined variables, separated by a semicolon, wherever this seems conducive to conveying the intuition behind the conditions. Also, remember that I use superscript j on the variables m, R^f, and λ to denote the SDF, the risk-free rate, and the risk premia relevant to firm j and subscript i to denote the SDF, the risk-free rate, and the risk premia of investors from country i. For all $j \in \mathcal{I}_i, m^j_{t+1} = m_{i,t+1}$, $\lambda^j_{h,t} = \lambda_{ih,t}\ \forall\ h \in \mathcal{I}$, and $R^f_{j,t+1} = R^f_{i,t+1}$.

[18] Country-level (or even individual-level) consumption and bilateral investment flows can, for example, easily be determined under the assumption that individuals' preference exhibit identical degrees of *constant relative risk aversion*, that is, all individuals per-period utility functions observe $u(c_{i,t}) = c_{i,t}^{(1-\gamma)}/(1-\gamma)$ for $\gamma > 1$ or $u(c_{i,t}) = \ln c_{i,t}$. 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 consumption of the representative investor, depending, again, only on the individual's share in total wealth (see Rubinstein, 1974 and Grossman and Razin, 1984). It follows that for all countries k, j in I_i, country-level consumption $C_{k,t}$ and bilateral investment $a_{kj,t}$

3.3.3 The Stochastic Discount Factor and Country Risk Premia

This section shows how the distribution of the SDF derives from the distribution of country-specific productivity shocks in order to understand how the country risk premia $\lambda_{ih,t} = R^f_{i,t+1}\mathrm{Cov}_t\left[\widetilde{m}_{i,t+1}, \widetilde{\hat{Y}}_{h,t+1}\right]$ are determined and how they develop over time. 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 an additional assumption on the stochastic nature of the productivity levels. Specifically, I assume that the productivity levels are independently and identically distributed over time and follow a multivariate lognormal distribution. This assumption facilitates describing the SDF in terms of current consumption and next-period wealth, with the latter being directly affected by the country-specific productivity shocks through the profits of firms in the investor's portfolio.

Using the budget constraint (3) together with Equations (2) and (4), equilibrium consumption of the representative investor i can be expressed in terms of asset wealth and the return to the wealth portfolio. Substituting optimal consumption plans for $C_{i,t}$ and $\widetilde{C}_{i,t+1}$ in $\widetilde{m}_{i,t+1}$ yields $\widetilde{m}_{i,t+1} = f_i(A_{i,t-1}, R^W_{i,t}, A_{i,t}, \widetilde{R}^W_{i,t+1}, \widetilde{A}_{i,t+1})$. Moreover, $\widetilde{A}_{i,t+1}$ can be replaced by the sequence of optimal future investments, which depend on initial wealth and the evolution of asset prices and returns, to pin down the SDF as

$$m_{i,t+1} = f_i\left(A_{i,t-1}, R^W_{i,t}, A_{i,t}, \widetilde{R}^W_{i,t+1}, \{\widetilde{\boldsymbol{v}}^i_{t+s}\}_{s=1}^{\infty}, \{\widetilde{\boldsymbol{\pi}}^i_{t+s}\}_{s=1}^{\infty}, \{R^f_{i,t+s}\}_{s=1}^{\infty}\right), \tag{19}$$

a function of current wealth and investment and exogenous parameters (from the investor's point of view) only. See Appendix A.1 for details of the derivation.

Generally, the precise relationship $f_i(\cdot)$ depends crucially on two fundamentals; the nature of the stochastic processes guiding the distribution of returns and the functional

are proportional to the representative investor i's consumption C_i and investment into the firms from all countries in $\mathcal{I}_i$, $a_{ij,t}$, with the factor of proportionality equal to $W_{k,t}/W_{i,t}$ where $W_{i,t} = \sum_{k\in\mathcal{I}_i} W_{k,t}$.

form of $u_i(\cdot)$.[19] Fama (1970) showed that the multiperiod consumption choice problem can be reduced to a two-period problem of choosing between today's consumption and tomorrow's wealth if investment returns are independently and identically distributed over time, that is, if the set of investment opportunities is independent of the current state or past states of the economy. This implies, that $f_i(\cdot)$ can be written as $g_{i,t}(\widetilde{R}^W_{i,t+1})$, 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. Moreover, as the pioneers of the Capital Asset Pricing Model (CAPM) (Sharpe, 1964; Lintner, 1965; and Black, 1972) have shown, $g_{i,t}(\cdot)$ is *linear* in $\widetilde{R}^W_{i,t+1}$ if returns are normally distributed, *independently* of the functional form of $u_i(\cdot)$.

Let us assume that productivity levels are lognormally distributed with constant mean and variance, that is, $\forall\ t$

$$\widetilde{\boldsymbol{\psi}}_t \sim \mathit{Lognormal}\left(\boldsymbol{\mu}, \boldsymbol{\Sigma}\right). \tag{20}$$

Then, productivity shocks follow an approximate normal distribution $\widetilde{\hat{\boldsymbol{\psi}}}_t \underset{approx.}{\sim} N\left(\boldsymbol{\mu}^{\hat{\boldsymbol{\psi}}}, \boldsymbol{\Sigma}^{\hat{\boldsymbol{\psi}}}\right)$, where $\widetilde{\hat{\boldsymbol{\psi}}}_t = \left[\widetilde{\hat{\psi}}_{1,t}, ..., \widetilde{\hat{\psi}}_{h,t}, ..., \widetilde{\hat{\psi}}_{I,t}\right]'$ with typical element $\widetilde{\hat{\psi}}_{h,t} = \frac{\psi_{h,t} - \mathrm{E}_{t-1}\left[\psi_{h,t}\right]}{\mathrm{E}_{t-1}\left[\psi_{h,t}\right]}$. The approximation works best in the neighborhood of zero. Rewriting returns in Equation (18) using Equation (9) as

$$\widetilde{R}_{j,t+1} = \sum_{h\in\mathcal{I}} \frac{\phi_{jh,t} Q^{\eta}_{h,t} \mu_h}{v_{j,t}} \cdot \widetilde{\hat{\psi}}_{h,t+1}$$

shows that returns are linear combinations of productivity shocks. Hence, they inherit the approximate normal distribution. Moreover, from the investor's point of view at time

[19] If the shocks are independent over time, fluctuations in returns do not indicate changes in investment opportunities and do no affect total discounted future wealth of the infinitely lived agent. In contrast, if returns are non-stationary, changes in returns do imply changes in investors' total wealth and changes in the set of investment opportunities and, therefore, may affect long-run consumption plans. How quickly investors return to the their steady long-run consumption level after a temporary shock crucially depends on the elasticity of intertemporal substitution, a feature inherent to $u(\cdot)$. If shocks are permanent, $u(\cdot)$ determines whether income effects of higher expected returns in the future on current consumption dominate substitution effects from changes in the incentive to invest.

t, future returns follow i.i.d. distributions as well if he does not expect changes in ϕ_{jh}, Q_h, and v_j in any future period $t+s$ to be systematically related to realizations of $\widetilde{\boldsymbol{\psi}}$.[20] Under those assumptions, I can apply the results of Fama (1970) and the CAPM literature to obtain

$$\widetilde{m}_{i,t+1} = \zeta_{i,t} + \gamma_{i,t} \widetilde{R}^W_{i,t+1} \quad \text{where} \quad \gamma_{i,t} < 0. \tag{21}$$

For details of the derivation, which in parts follows Cochrane (2005), Chapter 9, see Appendix A.1.

The linear model for the SDF facilitates deriving an explicit expression for $\boldsymbol{\lambda}'_{i,t} = [\lambda_{i1,t}, ..., \lambda_{ih,t}, ..., \lambda_{i\mathcal{I},t}]$, the covariances of the SDF with the country-specific productivity shocks. To ease notation, I henceforth drop the tilde symbol for random variables. Using Equation (18) together with the expression for $R^W_{i,t+1}$ in Equation (4), I can write the SDF as a linear function of asset returns:

$$m_{i,t+1} = \zeta_{i,t} + \gamma_{i,t} \sum_{j \in \mathcal{J}_{i,t}} \frac{a_{ij,t}}{A_{i,t}} \sum_{h} \phi_{jh,t} \mathrm{E}_t \left[Y_{h,t+1}\right] \left(\frac{Y_{h,t+1}}{\mathrm{E}_t \left[Y_{h,t+1}\right]} \right). \tag{22}$$

Equation (22) implies that *partial* covariances of $m_{i,t+1}$ with demand growth in any country h are given by the coefficients from a linear regression of the form $m_{i,t+1} = b_{i0,t} + \boldsymbol{b}'_{i,t} \hat{\boldsymbol{Y}}_{\boldsymbol{t+1}}$ with $\boldsymbol{b}'_{i,t} = [b_{i1,t}, ..., b_{ih,t}, ..., b_{iH,t}]$ and $\hat{\boldsymbol{Y}}'_t = \left[\hat{Y}_{1,t}, ..., \hat{Y}_{h,t}, ..., \hat{Y}_{\mathcal{I},t}\right]$, where

$$b_{ih,t} = \gamma_{i,t} \sum_{j \in \mathcal{J}_{i,t}} \frac{a_{ij,t}}{A_{i,t}} \phi_{jh,t} \mathrm{E}_t \left[Y_{h,t+1}\right]. \tag{23}$$

Equation (23) shows that the partial correlation of the SDF with country h's demand growth is a weighted sum of exports by all firms in the investor's portfolio, where each

[20]This requires a certain degree of myopia on the part of investors. Specifically, it requires assuming that investors do not take into account general equilibrium adjustments in the number of firms and their market-specific profit opportunities following a specific realization of global productivity levels at any future date. This assumption is needed only in the case where financial markets are imperfectly integrated. It owes to the fact that with imperfectly integrated financial markets, profit opportunities and thus returns and share prices depend on the distribution of wealth across countries due to the general equilibrium adjustments in the number of firms per country.

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. What matters for investors' perception of riskiness, however, is not the partial correlation, 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

$$\boldsymbol{\lambda}_{i,t} = R^f_{i,t+1}\mathrm{Cov}_t\left[m_{i,t+1}, \hat{\boldsymbol{Y}}_{t+1}\right] = R^f_{i,t+1}\mathrm{Cov}_t\left[\hat{\boldsymbol{Y}}_{t+1}, \hat{\boldsymbol{Y}}'_{t+1}\right]\boldsymbol{b}_{i,t}, \tag{24}$$

with hth element equal to

$$\lambda_{ih,t} = R^f_{i,t+1}\mathrm{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right] = R^f_{i,t+1}\left(\sigma_t^{\hat{Y}_h}\right)^2 b_{ih,t} + R^f_{i,t+1}\sum_{k\neq h}\sigma_t^{\hat{Y}_h,\hat{Y}_k} b_{ik,t}. \tag{25}$$

Note that the bs are themselves functions of the λs so that Equation (25) is an implicit expression for $\lambda_{ih,t}$.

Using the linear SDF from Equation (22) to rewrite the Euler equation (6) as

$$\mathrm{E}_t\left[R_{j,t+1}\right] - R^f_{i,t+1} = -\boldsymbol{\lambda}'_{i,t}\boldsymbol{\beta}_{j,t} \tag{26}$$

shows that the λs can be interpreted as monetary risk premia.[21] Equation (26) 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, $\beta_{jh,t}$, measures firm j's exposure to demand volatility in market h. More precisely, $\beta_{jh,t}$ is the elasticity of the firm's value with respect to demand growth in market h. According to Equation (18), it equals the share of expected sales in market h in the total present value of the firm, that is, $\beta_{jh,t} = \frac{\phi_{jh,t}\mathrm{E}_t\left[Y_{h,t+1}\right]}{v_{j,t}}$. The λs measure how much compensation in terms of

[21]See Appendix A.3 for details of the derivation.

average return in excess of the risk-free rate investors demand per unit of exposure $\beta_{jh,t}$ to volatility in market h.

3.4 Equilibrium Risk Premia and the Risk-Return Tradeoff

The risk premia obtaining in equilibrium are 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 have no role in mitigating 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 choices. Aggregate risk is absent if and only if consumption does not vary over time. Equation (22) shows that the volatility of the SDF derives from the volatility of the country-specific shocks, where the individual countries' contributions depend on firms' export choices $\phi_{jh,t}\mathrm{E}_t[Y_{h,t+1}]$ and investors' portfolio choices $a_{ij,t}$. It is apparent that the potential for eliminating consumption risk through portfolio management is constrained by the correlation pattern of country shocks. Unless some shocks are perfectly negatively correlated, the only way to set the variance of the SDF to zero is zero investment in risky assets. This means that no firm is active and investors put all their savings into the risk-free asset. All λs will then be zero. For this to be an equilibrium outcome, however, the value of creating a new firm must be zero.

Rewriting Equation (14) in terms of exogenous variables and λ only yields

$$V^*_{j,t} = \frac{1-\theta}{\theta^{\frac{\eta}{\eta-1}}} \sum_{h\in\mathcal{I}} \left(\frac{1+\lambda^j_{h,t}}{R^f_{j,t+1}}\right)^{\varepsilon} \frac{(c_j\tau_{jh})^{-\varepsilon}\mathrm{E}_t\left[\psi_{h,t+1}\right]^{\frac{\eta}{1-\eta}}}{\left(\sum_{j\in\mathcal{I}} N_j (c_j\tau_{jh}R^f_{j,t+1})^{1-\varepsilon}(1+\lambda^j_{h,t})^{\varepsilon-1}\right)^{\frac{\varepsilon-\eta\varepsilon-1}{(\varepsilon-1)(\eta-1)}}} - \alpha_j. \quad (27)$$

Since $\varepsilon - \eta\varepsilon - 1 > 0$, the value of creating a new firm goes to infinity as the number of firms approaches zero. This owes to the fact that 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 into 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 buying firms from the country with negatively correlated shocks. Or, more generally, by buying firms that sell a lot to this market. This is precisely what the Euler equation commands: the 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 lies again with 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 (27) 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 only 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 $\mathcal{I} = (i, h)$, $c_i = c_h = c, \alpha_i = \alpha_j = \alpha, \tau_{ih} =$

$\tau_{hi} = \tau, \tau_{ii} = \tau_{hh} = 1$. 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, $\rho^{\hat{Y}_i,\hat{Y}_h} = \frac{\sigma^{\hat{Y}_i,\hat{Y}_h}}{\sigma^{\hat{Y}_i}\sigma^{\hat{Y}_h}} = -1$. 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 $\mathrm{E}_t[\psi_{h,t+1}] \geq \mathrm{E}_t[\psi_{i,t+1}]$. 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 (25) jointly obey

$$
\begin{aligned}
\lambda_{k,\ell} = R^f_{k,t+1}\mathrm{Cov}_t\left[m_{k,t+1}, \hat{Y}_{\ell,t+1}\right] = 0 \quad \forall\, k,\ell = i,h \\
\Leftrightarrow \quad \mathrm{E}_t\left[Y_{\ell,t+1}\right]\left(a_{k\ell}\phi_{\ell\ell,t} + a_{kk}\phi_{k\ell,t}\right) = -\rho^{\hat{Y}_k,\hat{Y}_\ell}\cdot \mathrm{E}_t\left[Y_{k,t+1}\right]\left(a_{kk}\phi_{kk,t} + a_{k\ell}\phi_{\ell k,t}\right) \quad \forall\, k,\ell = i,h \\
\Leftrightarrow \qquad \mathrm{E}_t\left[Y_{h,t+1}\right] = \mathrm{E}_t\left[Y_{i,t+1}\right]. \qquad (28)
\end{aligned}
$$

The third step follows from the fact that with fully integrated international asset markets and constant and equal degrees of relative risk aversion, investors in both countries will own a share of the same international market portfolio. That is, $a_{ii,t} = \varphi N_{i,t}$, $a_{hi,t} = (1-\varphi)N_{i,t}$, $a_{ih,t} = \varphi N_{h,t}$, $a_{hh,t} = (1-\varphi)N_{h,t}$, where $\varphi/(1-\varphi) = A_{h,t}/A_{i,t}$. Equation (28) states that zero risk premia obtain if expected final goods production between the two countries is equalized. Note that Equation (28) together with $\mathrm{E}_t[\psi_{i,t+1}] \leq \mathrm{E}_t[\psi_{h,t+1}]$ implies $Q_{i,t} \geq Q_{h,t}$, that is, the output of the composite good is larger in the less productive market. This already suggests that an allocation yielding $\lambda_{ih} = 0$ is not efficient. To make this argument formally, I show in Appendix A.4 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 $\mathrm{E}_t[\psi_{h,t+1}] = \mathrm{E}_t[\psi_{i,t+1}]$.

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.

4 Empirics

4.1 Estimating λ

There are three challenges to estimating $\lambda_{ih,t}$. First, the SDF is not observed; hence, direct linear estimation as suggested by Equation (21) is not feasible. Second, the theory (see Subsection 3.3.3) suggests that the coefficients $\zeta_{i,t}, \gamma_{i,t}$ vary over time as investors make changes to their consumption plans depending on the current level of wealth. Third, as implied by Equation (22), bilateral exposures $b_{ih,t}$ change when investors change their portfolio and firms adjust their sales structure. I borrow methodology from the empirical asset pricing literature to address the first and second issue 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 (6) and (5) imply that $m_{i,t+1}$ prices every asset $j \in \mathcal{J}_{i,t}$. Hence, I obtain a moment condition of the form

$$1 = \mathrm{E}_t\left[m_{i,t+1} R_{j,t+1}\right] \qquad \text{where} \qquad m_{i,t+1} = \zeta_{i,t} + \gamma_{i,t} R^W_{i,t+1} \tag{29}$$

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:

$$\frac{1}{R^f_{i,t+1}} = \mathrm{E}_t\left[m_{i,t+1}\right]. \tag{30}$$

The moment conditions are functions of the parameters $\zeta_{i,t}, \gamma_{i,t}$ and data, namely, the return on the wealth portfolio. By the law of iterated expectations and under the assumption that $\zeta_{i,t}$ and $\gamma_{i,t}$ are uncorrelated with the return to the wealth portfolio, taking expectations over time, $1 = \mathrm{E}\left[\mathrm{E}_t\left[m_{i,t+1} R_{i,t+1}\right]\right]$, yields unconditional moments

$$1 = \mathrm{E}\left[\left(\zeta_i + \gamma_i R^W_{i,t}\right) R_{j,t+1}\right] \ \forall j \ \in \mathcal{J}_{i,t} \qquad \text{and} \qquad 1 = \mathrm{E}\left[\left(\zeta_i + \gamma_i R^W_{i,t}\right) R^f_{i,t+1}\right] \tag{31}$$

where $\zeta_i = E[\zeta_{i,t}]$ and $\gamma_i = E[\gamma_{i,t}]$. I estimate Equation (31) with GMM using data on $R^W_{i,t}$ and data on individual asset returns $R_{j,t}$. 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 $\mathrm{Cov}_t\left[m_{i,t+1}, \hat{Y}_{h,t+1}\right] = T^{-1}\sum_{s=0}^{T}\left[m_{i,t-s} \cdot \hat{Y}_{h,t-s}\right] - T^{-2}\sum_{s=0}^{T} m_{i,t-s} \cdot \sum_{s=0}^{T} \hat{Y}_{i,t-s}$.

4.2 Estimating λs for the U.S. Financial Market

I estimate risk premia with respect to 175 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. As discussed above, this is consistent with the cases where investors from (a subset of) all countries (including the United States) trade freely on a supranational asset market as well as with financial autarky. 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 data reaching back 10 years into the past. That is, I estimate the covariance of demand shocks and the mean of the risk-free rate based on the 10 most recent years.

Table 1: Summary statistic of return and import growth data

Return data	#Obs.	Mean	Std. Dev.	Min	Max
Time	450			1977M1	2014M6
r^f	450	0.41	0.29	0	1.35
r^W	450	1.02	4.49	-22.64	12.89
$\overline{R}^e$	49	.73	.17	.37	1.24
Import growth data					
Time	360			1983M1	2012M12
$\mu^{\hat{Y}}$	180	0.04	0.05	0.01	0.45
$\sigma^{\hat{Y}}$	180	0.27	0.35	0.06	2.61

Returns in %. $\overline{R}^e$ is the average excess return (gross return minus risk-free rate) of industry portfolios over time. $\mu^{\hat{Y}}$ ($\sigma^{\hat{Y}}$) denotes the mean (standard deviation) of country-specific demand shocks over time.

4.2.1 Data

For monthly asset returns I use 49 value-weighted industry portfolios provided by Kenneth R. French through his Data Library.[22] 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 (31). Figure A.2 in the Appendix plots the distribution of excess returns to the industry portfolios. A robustness check with regard to this choice of test assets will be provided. 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. Monthly data on the market portfolio and the risk-free rate are also from Kenneth R. French's Data Library.

I use total monthly imports by country obtained from the IMF's Direction of Trade

[22] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html

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. The data appendix A.5 gives details more details.

4.2.2 Results

Table 2 summarizes the results from GMM estimation of Equation (31). Column (1) shows parameter estimates based on the full sample period, which are strongly significant. As suggested by the theory, γ is negative; hence, the return to 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 (31), it is reassuring that the estimates barely change over time.

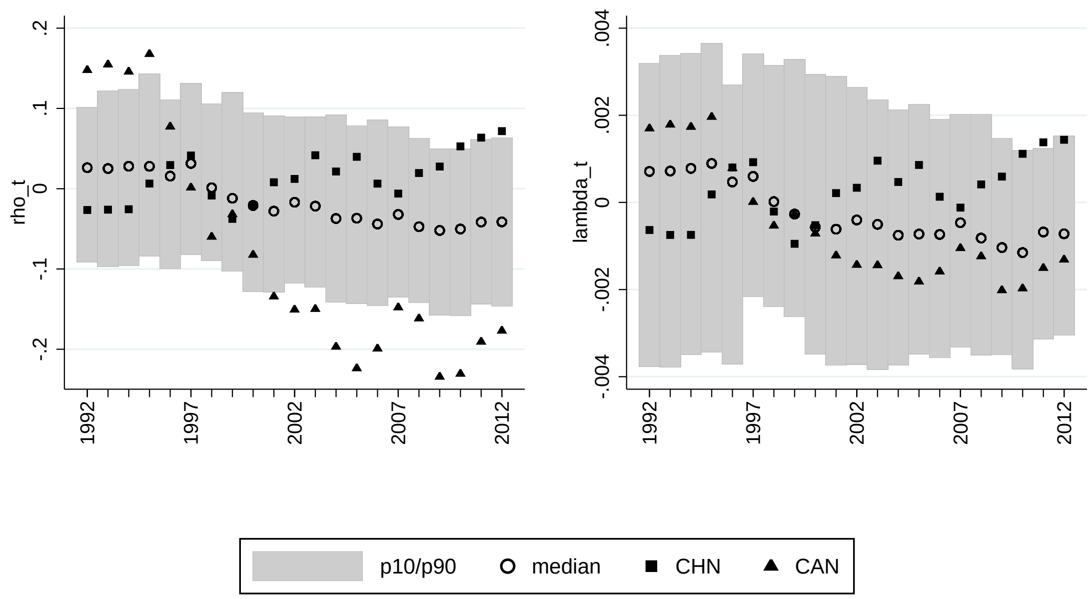
Table 2: Parameter estimates of the linear SDF model

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.

I use the estimates in Column (1) to predict a time series of the SDF in accordance with Equation (21) and then compute covariances with import growth scaled with the average risk-free rate as in Equation (25) 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

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



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

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 (25), this may be interpreted as the United States becoming more integrated with the rest of the world and taking advantage of the diversification benefits available in integrated international goods 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 exemplary 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.3 in the Appendix shows how other countries' risk premia have been developing 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, for example, also for Indonesia. Russia's risk premium exhibits barely any change. Table A.3 in the Appendix lists the risk premia for all countries in selected years.

4.3 Testing the Gravity Equation with Risk Premia

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 states that firms take into account the riskiness of markets for their investors when deciding how much to ship to a given market, as implied by Equation (12):

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

Note that I add 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 175 destination countries to test whether exports are, ceteris paribus, higher to countries exhibiting larger covariances with the SDF of U.S. investors.[23] The data are from the U.S. Census Bureau's Foreign Trade Division and cover the universe of U.S. exports. I use three equally spaced time periods between 1992 and 2012 to allow structural changes in risk-premia over time to come into effect. I consider more years of data in a robustness analysis. My main estimation equation is a log-linear version of Equation (12),

$$\ln q_{jh,t} = \varepsilon \ln(1+\lambda^j_{h,t}) - \varepsilon \ln \tau_{jh,t} - \varepsilon \ln\left(R^f_{j,t+1}c_{j,t}\right) + \ln\theta + \ln\,\mathrm{E}_t\left[Y_h\right] + \ln\Pi_{jh,t}, \quad (32)$$

[23] I observe 180 destination countries in the dataset, but only for 175 of them data on all relevant variables is available.

where $\Pi_{jh,t} = \sum_{j \in \mathcal{I}} N_{j,t}(1+\lambda^j_{h,t})^{\varepsilon-1} \left(R^f_{j,t+1} c_{j,t} \tau_{jh,t} \right)^{1-\varepsilon}$. In the empirical model, j now indicates a product and h is a 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. I use shipments by air or vessel only, which make up more than 90% of value shipped for about 98% of all observations; robustness checks with regard to this choice will be provided. Table A.4 summarizes all variables used in the gravity estimations and contains details regarding data sources and variable definitions. The data appendix A.5 provides further details.

On the right-hand side of Equation (32) I use logs of real GDP and real per capita GDP to proxy for expected demand in the destination country.[24] 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

[24] 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 hard to come by a better proxy. Besides the fact that exporters' expectation are unobserved, the exact point in time at which the expectation is 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 formed the relevant expectation much earlier. Some relief is provided 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 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 cost for U.S. exports, I use data on U.S. imports by product and country of origin, also from the U.S. Census Bureau's Foreign Trade Division, 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

$$\ln q_{j^{US}h,t} = \beta_1 \ln(1 + \lambda_{h,t}^{US}) + \beta_2 FreightCost_{h,t} + \beta_3 RTA_{h,t} + \beta_4 \ln GDP_{h,t} + \beta_5 \ln CGDP_{h,t} + d_{jh} + d_{j,t} + u_{jh,t}. \tag{33}$$

A potential omitted variables concern involves the fact 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 (33) with OLS relies on the assumption that the time-varying component of $\Pi_{jh,t}$, that ends up in the error term, 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 cannot be financed by 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 $\ln(1+\lambda_{h,t}^{US}) \times ExtFinDep_{s^j,t}$. s^j denotes the sector defined by the NAICS six-digit code to which product j belongs.[25]

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 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 (33) 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

$$\begin{aligned}\ln q^m_{j^{US}h,t} = {} & \beta_1 \ln(1+\lambda_{h,t}^{US}) + \beta_{11} \ln(1+\lambda_{h,t}^{US}) \times Air + \beta_2 FreightCost_{h,t} + \beta_3 RTA_{h,t} \\ & + \beta_4 \ln GDP_{h,t} + \beta_5 \ln CGDP_{h,t} + d_{jmh} + d_{jm,t} + u_{jmh,t} \qquad (34)\end{aligned}$$

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:

$$\ln q^m_{j^{US}h,t} = \beta_{11} \ln(1+\lambda_{h,t}^{US}) \times Air + d_{jmh} + d_{jm,t} + d_{jh,t} + u_{jmh,t} \qquad (35)$$

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.[26] Shipments by vessel, however, have

[25] There are a few products where the assignment to NAICS six-digit sectors is no longer unique after aggregating HS10 digits to time consistent product groups as described above. I use weighted averages of the *ExtFinDep* measure in those cases.

[26] Alternatively, one might consider a case where production does take time but quantities do not need

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 λ's, 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.

4.3.2 Results

Column (1) of Table A.5 shows parameter estimates from the baseline specification (33). Estimations are based on three years of data, equally spaced between 1992 and 2012, and rely on time 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. I standardized $\ln(1+\lambda)$ to make coefficients comparable across specifications. 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 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

to be customized to a specific market.

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. A implied trade cost elasticity of 5.6 places this estimate well inside the range typically found in the literature.[27]

In Column (2) I interact the risk premia with Rajan and Zingales's sectoral measure of external financial dependence. 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 investments 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 (33) 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 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 (34) and (35) based on the same data set, pooling shipments by air and vessel.[28] 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

[27] 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 should hence be interpreted with care.

[28] 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, respectively, by air, only.

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 Equation (33). Results are collected in Tables A.6 and A.7 in the Appendix. First, I include tariffs as additional trade cost variables. Tariff data are available on the HS six-digit level; for some products on higher levels of aggregation. Time and country coverage is very patchy, even after filling in missing values with lags or leads or weighted averages on higher levels of aggregation.[29] Hence, I lose a significant share of observations. Column (2) of Table A.6 shows that the effect of λ in this smaller sample is still positive and significant, but also larger. Including tariffs (Column 1) barely affects the coefficient estimate for λ. Next, I re-estimate Equation (33) using more of the available years of data: five equally spaced time windows between 1992 and 2012 in Column (3) and all 21 years in Column (4). 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

[29] I detail the procedures used to fill in missings in Appendix A.5.

time to phase in.

In Column (5) I use export values on the product-year-destination level as the dependent variable. I find a positive and significant effect of the risk premia as well. Note that in view of Equation (13), this suggests that financial markets are not fully integrated across countries; otherwise, trade shares would be independent of λ. I also estimate a gravity equation on the country level, aggregating values over all products, and I find again a positive and significant effect of the risk premia on exports (Column 6).

I also perform robustness checks with regard to choices made in the estimation of the risk premia. I use Fama and French's 25 benchmark assets as an alternative set of test assets to obtain estimates of γ^{US}, ζ^{US}. 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). This method of portfolio construction, described in detail in Fama and French (1993), has become the benchmark for measuring the performance of models in the empirical asset pricing literature. 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}), by profitability (R^{RMW}), and by investment levels (R^{CMA}) in addition to the return on the market portfolio to describe the SDF as

$$m_{i,t+1} = \zeta_{i,t} + \gamma_{i,t} R^{W}_{i,t} + \gamma^{SMB}_{i,t} R^{SMB}_{i,t} + \gamma^{RMW}_{i,t} R^{RMW}_{i,t} + \gamma^{CMA}_{i,t} R^{CMA}_{i,t}. \qquad (36)$$

This model is very successful in explaining the cross-section of mean asset returns, but it does not have a theoretical foundation. Table A.8 presents the parameter estimates using the alternative test assets or the alternative SDF model, obtained from GMM estimation as decribed in Subsection 4.1. Changing the test assets has only a small impact on the CAPM estimates. Similarly, adding the additional explanatory factors as prescribed by Equation (36) to the linear model of the SDF slightly increases the estimate of $\gamma_{i,t}$ but does not affect its significance. The other factors are not individually significant. I use those alternative parameter estimates to predict time series of the SDF and obtain alternative sets of country risk premia. Columns (7) and (8) of Table A.6 show that the results from the gravity estimation are robust to those variations.

Table A.7 contains some additional robustness tests. Column (1) shows 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. In Column (2) I dropped Canada and Mexico, since ground transportation is a relevant alternative shipping mode for contiguous countries. Shipments by vessel and air might reflect extraordinary circumstances. In Column (3) 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 magnitude or significance of the coefficient estimate for λ.

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 to 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 by the agents of the model 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-destination market 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.

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Appendix

A.1 Model Details

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

$$\begin{aligned}
\max_{\{\boldsymbol{a}_{i,t+s}, a^f_{i,t+s}\}_{s=0}^{\infty}} \quad & \mathrm{E}_t \sum_{s=0}^{\infty} \rho^s u_i(C_{i,t+s}) \\
\text{s.t.} \quad C_{i,t+s} &= W_{i,t+s} - A_{i,t+s} \\
W_{i,t+s} &= R^W_{t+s} A_{t+s-1} = \boldsymbol{a}'_{i,t+s-1}(\boldsymbol{\pi}^i_{t+s} + \boldsymbol{v}^i_{t+s}) + a^f_{i,t+s-1} R^f_{t+s} \\
A_{i,t+s} &= \boldsymbol{a}'_{i,t+s} \boldsymbol{v}^i_{t+s} + a^f_{i,t+s} \\
0 &= \lim_{s \to \infty} \frac{A_{i,t+s}}{\mathrm{E}_t \left[R^W_{i,t+s} \right]}
\end{aligned}$$

Inserting constraints (1)-(3) yields

$$\begin{aligned}
\max_{\{\boldsymbol{a}_{i,t+s}, a^f_{i,t+s}\}_{s=0}^{\infty}} \quad & \mathrm{E}_t \sum_{s=0}^{\infty} \rho^s u_i \left(\boldsymbol{a}'_{i,t+s-1}(\boldsymbol{\pi}^i_{t+s} + \boldsymbol{v}^i_{t+s}) + a^f_{i,t+s-1} R^f_{i,t+s} - \boldsymbol{a}'_{i,t+s} \boldsymbol{v}^i_{t+s} - a^f_{i,t+s} \right) \qquad \text{(A.1)} \\
\text{s.t.} \quad & 0 = \lim_{s \to \infty} \frac{A_{i,t+s}}{\mathrm{E}_t \left[R^W_{i,t+s} \right]}
\end{aligned}$$

The investor's FOCs with respect to investment (5) and (6) are readily derived from this expression.

Derivation of Equation (19). To derive Equation (19), I first restate the relevant equilibrium conditions for easier reference.

- Investors' first-order conditions (5) and (6):

$$a^f_{i,t} \left[\widetilde{m}_{i,t+1}, R^f_{i,t+1} \right] \quad \text{and} \quad a_{ij,t} \left[v_{j,t}, \widetilde{\pi}_{j,t+1}, \widetilde{m}_{i,t+1} \right] \qquad \forall\ j \in \mathcal{I}_i \text{ and } i = 1, ..., \iota$$

- Stochastic discount factor (8): $\quad \widetilde{m}_{i,t+1} \left[C_{i,t}, \widetilde{C}_{i,t+1} \right] \qquad \forall\ i = 1, ..., \iota$

- Budget constraint (3): $\quad C_{i,t} \left[a^f_{i,t}, \boldsymbol{a}_{i,t}, \boldsymbol{v}^i_t; W_{i,t} \right]$ and

$$\widetilde{C}_{i,t+1} \left[a^f_{i,t}, \boldsymbol{a}_{i,t}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, \widetilde{\boldsymbol{v}}^i_{t+1}, R^f_{i,t+1} \right] \qquad \forall\ i = 1, ..., \iota$$

Substituting $C_{i,t}, C_{i,t+1}$ in $m_{i,t+1}$ from the budget constraint yields

$$\widetilde{m}_{i,t+1} \left[a^f_{i,t}, \boldsymbol{a}_{i,t}, \boldsymbol{v}^i_t, \widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, W_{i,t}, R^f_{i,t+1} \right]$$

and substituting $\widetilde{m}_{i,t+1}$ in the Euler equations then gives

$$a^f_{i,t}\left[\boldsymbol{a}_{i,t}, \boldsymbol{v}^i_t, \widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, W_{i,t}, R^f_{i,t+1}\right] \qquad \text{and}$$
$$a_{ij,t}\left[a^f_{i,t}, \boldsymbol{a}_{i,t}, \boldsymbol{v}^i_t, \widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, W_{i,t}, R^f_{i,t+1}\right] \ \forall\ j \in \mathcal{I}_i.$$

This system of $I_i + 1$ equations can be used to eliminate $a^f_{i,t}, \boldsymbol{a}_{i,t}$ on the "right-hand side," so that

$$a^f_{i,t}\left[\boldsymbol{v}^i_t, \widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, W_{i,t}, R^f_{i,t+1}\right] \qquad \text{and}$$
$$a_{ij,t}\left[\boldsymbol{v}^i_t, \widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}, W_{i,t}, R^f_{i,t+1}\right] \ \forall\ j \in \mathcal{I}_i.$$

Updating $a^f_{i,t}, \boldsymbol{a}_{i,t}$ one period then gives

$$\widetilde{a}^f_{i,t+1}\left[\widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{v}}^i_{t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+2}, \widetilde{a}^f_{i,t+2}, \widetilde{\boldsymbol{a}}_{i,t+2}, \widetilde{W}_{i,t+1}, R^f_{i,t+2}\right] \quad \text{and}$$
$$\widetilde{a}_{ij,t+1}\left[\widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{v}}^i_{t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+2}, \widetilde{a}^f_{i,t+2}, \widetilde{\boldsymbol{a}}_{i,t+2}, \widetilde{W}_{i,t+1}, R^f_{i,t+2}\right] \ \forall\ j \in \mathcal{I}_i.$$

Replacing $\widetilde{W}_{i,t+1}$ with $a^f_{i,t}, \boldsymbol{a}_{i,t}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, R^f_{i,t+1}$ and using again the system of $I_i + 1$ equations to eliminate $a^f_{i,t}, \boldsymbol{a}_{i,t}$, I obtain

$$\widetilde{a}^f_{i,t+1}\left[\widetilde{\boldsymbol{v}}^i_{t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+2}, \widetilde{a}^f_{i,t+2}, \widetilde{\boldsymbol{a}}_{i,t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, R^f_{i,t+1}, R^f_{i,t+2}\right] \quad \text{and} \tag{A.2}$$
$$\widetilde{a}_{ij,t+1}\left[\widetilde{\boldsymbol{v}}^i_{t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+2}, \widetilde{a}^f_{i,t+2}, \widetilde{\boldsymbol{a}}_{i,t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, R^f_{i,t+1}, R^f_{i,t+2}\right] \ \forall\ j \in \mathcal{I}_i.$$

Inserting $a^f_{i,t}, \boldsymbol{a}_{i,t}, \widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}$ (before substituting for $\widetilde{W}_{i,t+1}$) into $\widetilde{m}_{i,t+1}$ then yields

$$\widetilde{m}_{i,t+1}\left[\widetilde{\boldsymbol{v}}^i_{t+1}, \widetilde{\boldsymbol{v}}^i_{t+2}, \widetilde{\boldsymbol{\pi}}^i_{t+1}, \widetilde{\boldsymbol{\pi}}^i_{t+2}, \widetilde{a}^f_{i,t+2}, \widetilde{\boldsymbol{a}}_{i,t+2}, W_{i,t}, \widetilde{W}_{i,t+1}, R^f_{i,t+1}, R^f_{i,t+2}\right]$$

Now, repeated substitution of $\widetilde{a}^f_{i,t+1}, \widetilde{\boldsymbol{a}}_{i,t+1}$ as in Equation (A.2) updated to period $t+s$ for $s = 2, ..., \infty$ in $\widetilde{m}_{i,t+1}$ gives

$$\widetilde{m}_{i,t+1}\left[W_{i,t}, \widetilde{W}_{i,t+1}, \{\widetilde{\boldsymbol{v}}^i_{t+s}\}^\infty_{s=1}, \{\widetilde{\boldsymbol{\pi}}^i_{t+s}\}^\infty_{s=1}, \{R^f_{i,t+s}\}^\infty_{s=1}\right]$$

which is equivalent to Equation (19) in the main text.

Derivation of Equation (21). Writing out in full the expection in Equation (A.1) at time t, I obtain

$$\max_{\left\{\boldsymbol{a}_{i,t+s}, a^f_{i,t+s}\right\}_{s=0}^{\infty}} \sum_{s=0}^{\infty} \rho^s \int_{\boldsymbol{\psi}_{t+s}} \int_{\boldsymbol{\Psi}_{t+s-1}} u\left(\boldsymbol{a}'_{i,t+s-1}\left(\boldsymbol{\pi}^i_{t+s}(\boldsymbol{\psi}_{t+s}) + \boldsymbol{v}^i_{t+s}(\boldsymbol{\psi}_{t+s})\right)\right. \tag{A.3}$$

$$\left. +a^f_{i,t+s-1} R^f_{i,t+s} - \boldsymbol{a}'_{i,t+s} \boldsymbol{v}^i_{t+s}(\boldsymbol{\psi}_{t+s}) - a^f_{i,t+s}\right) \mathrm{d}F(\boldsymbol{\psi}_{t+s}|\boldsymbol{\Psi}_{t+s-1}) \mathrm{d}F(\boldsymbol{\Psi}_{t+s-1})$$

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

where $\boldsymbol{\Psi}_{t+s}$ denotes the full history of realized productivity levels up to $t+s$. Note that at this point, no assumptions have been imposed on the distribution $\mathrm{d}F(\boldsymbol{\psi}_{t+s}|\boldsymbol{\Psi}_{t+s-1})$ other than finiteness of expected values and non-negative support. As Fama (1970) showed, the problem is greatly simplified if the random variables follow independent and identical distributions over time. The i.i.d. assumption implicit in Equation (20) implies that $F(\boldsymbol{\psi}_{t+s}|\boldsymbol{\Psi}_{t+s-1}) = F(\boldsymbol{\psi})$. Moreover, the assumption that the investor takes as given the number of firms and the prices of the currently available set of assets (including the risk-free rate) implies that $\{\boldsymbol{\pi}_{t+s}(\boldsymbol{\Psi})\}_{s=1}^{\infty} = \boldsymbol{\pi}_t(\boldsymbol{\psi})$, $\{\boldsymbol{v}^i_{t+s}(\boldsymbol{\Psi})\}_{s=1}^{\infty} = \boldsymbol{v}^i_t$, and $R^f_{t+s} = R^f_t \; \forall s = 1, ..., \infty$, that is, profits associated with a given realization of $\boldsymbol{\psi}$ and asset prices are expected not to change over time.[30] Then, given the current state of the economy t, the investor's optimization problem at any future date $t+s$ is identical to the problem faced at time t except for the level of wealth $W_{i,t+s}$ he is starting with. Let $G(W_{i,t})$ denote the maximum value of the optimization problem (A.3) as a function of the initial level of wealth. Then, (A.3) may be written as

$$\max_{\{\boldsymbol{a}_{i,t+s}\}_{s=0}^{\infty}} u_i(W_{i,t} - \boldsymbol{a}'_{i,t}\boldsymbol{v}_t - a^f_{i,t}) + \rho G(W_{i,t+1})$$

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

and the first-order conditions obtain as

$$1 = \mathrm{E}_t\left[\rho \frac{G'(W_{i,t+1})}{u'_i(C_{i,t})}\right] R^f_{i,t+1} \qquad \text{and} \qquad v_{j,t} = \mathrm{E}_t\left[\rho \frac{G'(W_{i,t+1})}{u'_i(C_{i,t})}(\pi_{j,t+1} + v_{j,t+1})\right] \quad \forall\, j, t.$$

Hence, the SDF observes

$$m_{i,t+1} = \rho \frac{G'(W_{i,t+1})}{u'_i(C_{i,t})} = \rho \frac{G'\left(R^W_{i,t+1}(W_{i,t} - C_{i,t})\right)}{u'_i(C_{i,t})} = g_{i,t}(R^W_{i,t+1}).$$

Under the lognormal assumption on productivity levels (Equation (20)), returns to firm

[30] Equation (A.3) implies that $\widetilde{\boldsymbol{\psi}}$ is the only source of uncertainty. However, including uncertainty about changes in exogenous variables as well does not affect the investor's choice problem if shocks are i.i.d. and independent of $\boldsymbol{\Psi}$.

shares as described in Equation (18) and the return to the wealth portfolio (Equation (4)) are approximately normally distributed. 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), Chapter 9.

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

$$1 = \mathrm{E}_t[m_{i,t+1}R_{j,t+1}] \quad \Leftrightarrow \quad 1 = \mathrm{E}_t[m_{i,t+1}]\mathrm{E}_t[R_{j,t+1}] + \mathrm{Cov}_t[m_{i,t+1}, R_{j,t+1}], \tag{A.4}$$

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.4) for all $j \in \mathcal{I}_i$.

A.2 Current Account and Balance of Payments

The current account of country $k \in \mathcal{I}_i$ defined as net exports plus net earnings from foreign investment obtains as the sum of final goods net exports $Y_{k,t} + a^f_{k,t-1}R^f_{k,t} - \left(C_{k,t} + \sum_{j\in\mathcal{I}_i} a_{kj,t}v_{j,t} + a^f_{k,t} + N_{k,t}v_{k,t}\right)$ (final goods output including savings minus domestic absorption), net domestic intermediate exports $N_{k,t-1}\sum_{h\in\mathcal{I}} \phi_{kh,t-1}Y_{h,t} - Y_{k,t}$ (exports by variety producers minus intermediate imports by final goods producers) and profits owned from investment in foreign assets $\sum_{j\in\mathcal{I}_i} a_{kj,t-1}\pi_{j,t}$ minus profits owned by foreign investors in the home country $N_{k,t-1}\pi_{k,t}$.[31] The current account is then

$$\begin{aligned} CA_{k,t} &= Y_{k,t} + a^f_{k,t-1}R^f_{k,t} - \left(C_{k,t} + \sum_{j\in\mathcal{I}_i} a_{kj,t}v_{j,t} + a^f_{k,t} + N_{k,t}v_{k,t}\right) \\ &\quad + N_{k,t-1}\sum_{h\in\mathcal{I}} \phi_{kh,t-1}Y_{h,t} - Y_{k,t} + \sum_{j\in\mathcal{I}_i} a_{kj,t-1}\pi_{j,t} - N_{k,t-1}\pi_{k,t} \\ &= -\sum_{j\in\mathcal{I}_i} \mathrm{d}a_{kj,t}v_{j,t} + \mathrm{d}N_k v_{k,t} \end{aligned}$$

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

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

A.3 Expected Return-Beta Representation

The structural equation of the SDF (22) falls into the class of *linear factor models*, which are commonly used in the asset pricing literature to analyse 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. 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 $j \in \mathcal{I}_i$ 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) Chapter 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 (24) 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.4 A Special Case of $\boldsymbol{\lambda} = 0$

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 (12) evaluated at $\boldsymbol{\lambda}_t = 0$:

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

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 $N_i c^{1-\varepsilon} + N_h (c\tau)^{1-\varepsilon} \geq N_i (c\tau)^{1-\varepsilon} + N_j c^{1-\varepsilon}$. This holds true if $N_i \geq N_h$ 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 (14) evaluated at $\boldsymbol{\lambda}_t = 0$, shows that

$$
\begin{aligned}
V^*_{h,t} - V^*_{i,t} &= \frac{\mathrm{E}_t\left[Y_{h,t+1}\right]}{R^f_{t+1}} \left(\psi_{hh,t} + \psi_{hi,t} - \psi_{ii,t} - \psi_{ih,t}\right) \\
&= \frac{\mathrm{E}_t\left[Y_{h,t+1}\right]}{R^f_{t+1}} (1-\tau^{1-\varepsilon}) \left(\frac{1}{N_i\tau^{1-\varepsilon} + N_j} - \frac{1}{N_i + N_j\tau^{1-\varepsilon}}\right) \geq 0. \qquad \text{(A.6)}
\end{aligned}
$$

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

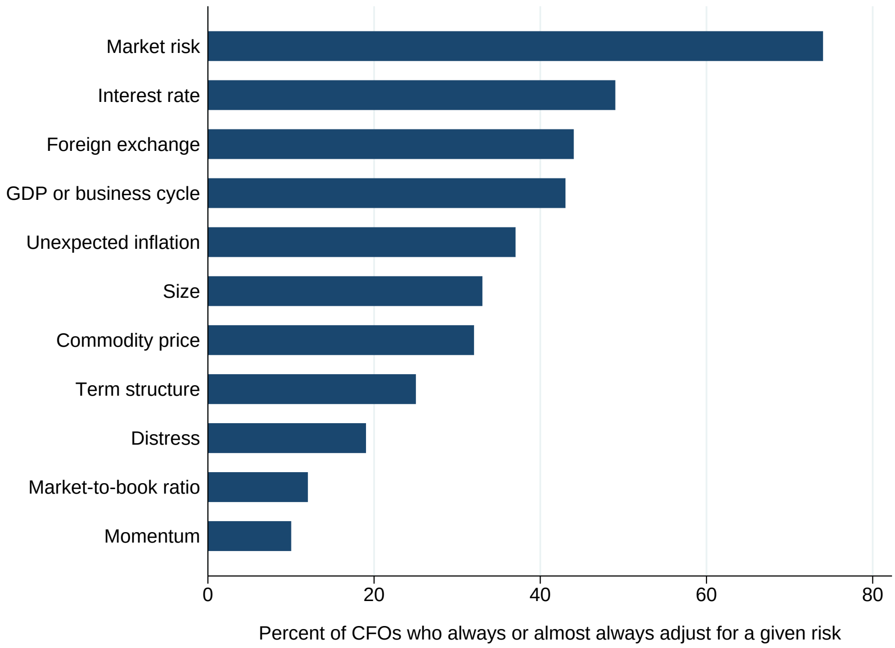
A.5 Data Appendix

Import growth. I use total monthly imports by country obtained from the IMF's *Direction of Trade Database* 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 covariance matrix of import growth across countries is January 1983. To obtain continous 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 import in the year succeding 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, Westbank and Gaza, as well as Serbia and Kosovo in order to accommodate the reporting levels of other data used in the analysis.

Tariffs. Source: WITS database. I use effectively applied tariffs including ad valorem equivalents of specific tariffs and quotas. Tariffs are provided mostly on HS six-digit level. I use trade weighted averages on the four-digit and two-digit levels to fill missing. Thereby, I obtain tariffs for 27% of all export observations. Filling missings with up to three lags or leads yields non-missing tariffs for another 15% of the sample. There are a few products where the assignment to HS six-digit sectors is no longer unique after aggregating HS ten-digits to time consistent product groups as described above. I use weighted averages of tariffs in those cases where weights correspond to the number of products in potentially different HS 6 groups.

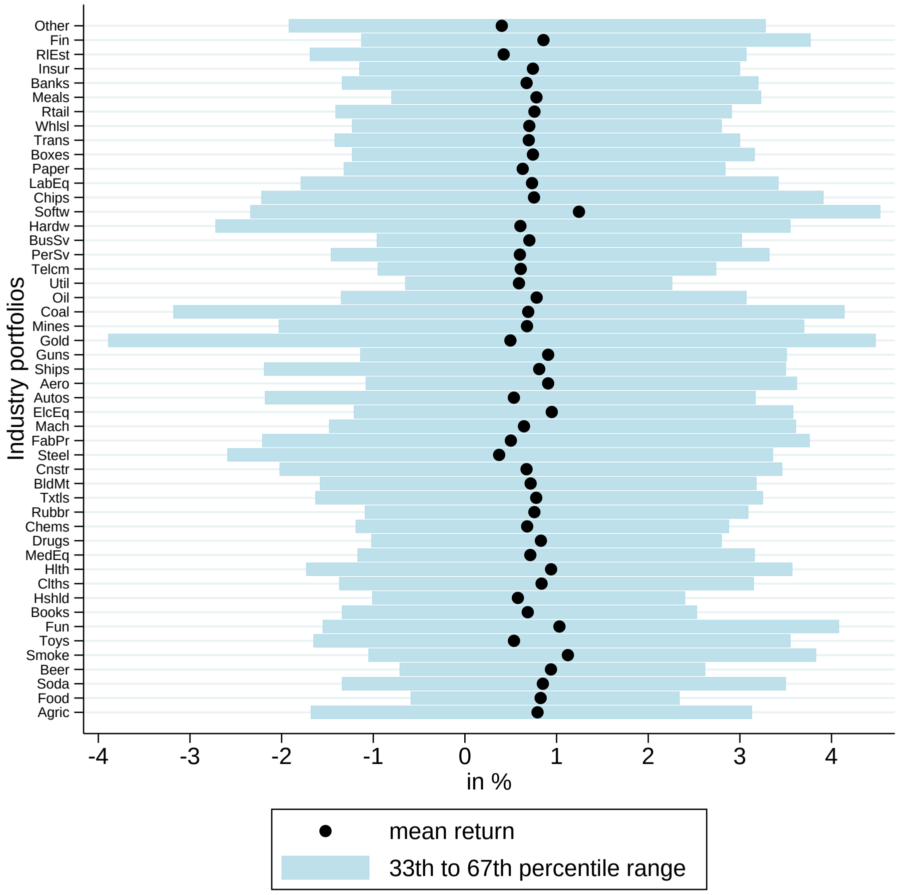
Freight costs. Source: U.S. Census FTD import data provided by Peter Schott through his website at *http://faculty.som.yale.edu/peterschott/sub_international.htm.* I compute median freight cost per unit value or per kg for total shipments and by mode of transportation on the country-year level.

Figure A.1: Common risk factors used to adjust cash flows or discount rates.



Source: Figure 4 in Graham and Harvey (2001)

Figure A.2: Mean excess return of 49 value-weighted portfolios



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

Figure A.3: Risk premia estimates for selected countries

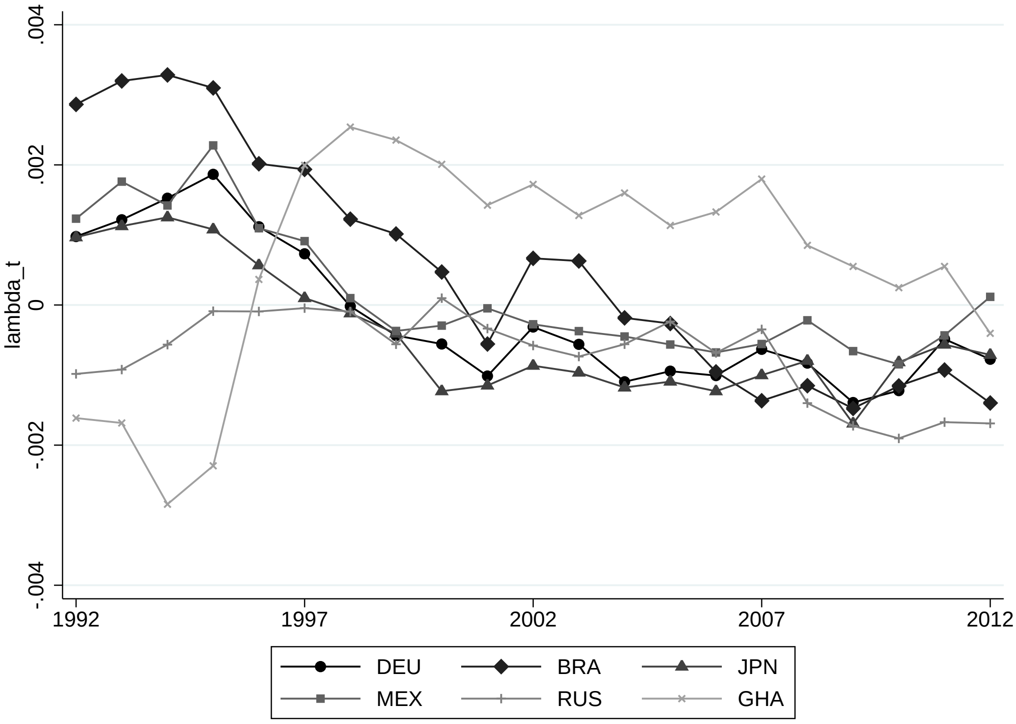


Table A.3: Estimated country risk premia for selected years

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: Summary statistics of variables used in the gravity estimations

Export data	Description	# Obs.	# Groups	Mean	Std. Dev.	Min	Max	Source, notes
Value		3,681,276		650,132	26,504,289	0	1.56e+10	US Census, FTD; cp.
Quantity	in kg.	3,681,276		339,153	30,258,985	0	2.75e+10	Pierce and Schott (2012a)
# Years		3,681,276	3			1992	2012	
# Markets		3,681,276	180					
# Products	time consistent HS10 digits or derived codes	3,681,276	7061					cp. Pierce and Schott (2012b)
Markets p. product	with positive sales	811,408		61	32	1	179	
Products p. market	with positive sales	811,408		3,150	1,480	2	5,831	
Quantity p. market	excl. zeros, in kg.	811,408		1,538,702	2,148,113	5,924	9,802,089	
Airshare		811,408		.38	.45	0	1	
Exports by vessel								
Markets p. product	with positive sales	3,681,276		28	24	0	166	
Quantity p. market	excl. zeros, in kg.	579,516		2,143,041	3,768,501	14,781	55113832	
Exports by air								
Markets p. product	with positive sales	509,459		52	33	1	178	
Quantity p. market	excl. zeros, in kg.	509,459		12,932	12,576	205	50,000	
Country data								
λ		3,681,276	533	-0.0004	0.0050	-0.0514	0.0405	
GDP		3,536,232	512	1.83e+11	5.40e+11	1.08e+8	4.71e+12	WDI, PWT
CGDP		3,536,232	512	9,746	14,703	114	79,782	WDI, PWT
RTA		3,681,276	533	0.05	0.21	0.00	1.00	WTA RTA database
FreightCost	by country, ad valorem $\times$ year	3,646,760	528	0.07	0.04	0.00	0.59	US Census, FTD (import data)
by air	by country $\times$ year, ad valorem	3,605,346	522	0.08	0.06	0.00	0.57	US Census, FTD (import data)
by vessel	by country $\times$ year, ad valorem	3,605,332	522	0.07	0.07	0.00	0.99	US Census, FTD (import data)
Tariff	by HS 6 $\times$ country $\times$ year, ad valorem	1,954,321	91,415	0.20	0.67	0.00	30.00	WITS
Sector data								
ExtFinDep	by NAICS 6 digit *times* year	3,296,991	1,437	-0.12	5.58	-93.16	33.51	Compustat; cp. Rajan and Zingales (1998)

Table A.5: Gravity estimations with risk premia

Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}^{Ves}$	$\ln q_{jh,t}^{Air}$	$\ln q_{jh,t}^{m}$	$\ln q_{jh,t}^{m}$	$\ln q_{jh,t}^{m}$
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)	
$\ln(1+\lambda)$	0.033**	0.033**	0.029**	0.013	0.021*	0.031**	
	(0.015)	(0.017)	(0.013)	(0.011)	(0.011)	(0.013)	
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)
× *Air*						-0.019**	-0.019*
						(0.010)	(0.010)
× *ExtFinDep*		0.0003*					
		(0.000)					
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: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.6: Gravity estimations with risk premia: Robustness

Robustness test:	Tariffs		5 yrs ($\Delta = 5$)	21 yrs ($\Delta = 1$)	Export value		25 FF pfs	FF four factors
Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln s_{jh,t}$	$\ln s_{h,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$
ln *GDP*	0.856**	0.881**	0.454*	0.405	0.441	1.009***	0.373	0.395
	(0.388)	(0.390)	(0.264)	(0.266)	(0.356)	(0.258)	(0.268)	(0.268)
ln *CGDP*	0.149	0.189	0.049	-0.043	0.217	-0.442*	0.122	0.120
	(0.398)	(0.398)	(0.275)	(0.278)	(0.370)	(0.263)	(0.280)	(0.277)
RTA	0.191	0.211*	0.216***	0.150**	0.446***	-0.025	0.332***	0.326***
	(0.122)	(0.125)	(0.077)	(0.073)	(0.116)	(0.078)	(0.096)	(0.096)
FreightCost	-1.912	-1.831	-0.617	-0.877*	-1.057	-1.604*	-0.788	-0.771
	(2.096)	(2.116)	(0.607)	(0.461)	(1.317)	(0.883)	(0.963)	(0.961)
$\ln(1+\lambda)$	0.080*	0.079*	0.025*	0.016**	0.047**	0.037*	0.033**	0.043***
	(0.045)	(0.045)	(0.013)	(0.008)	(0.021)	(0.020)	(0.015)	(0.016)
$ln(1+t)$	-0.886***							
	(0.317)							
Fixed effects	prd×yr	prd×yr	prd×yr	prd×yr	prd×yr	yr	prd×yr	prd×yr
	prd×cty	prd×cty	prd×cty	prd×cty	prd×cty	cty	prd×cty	prd×cty
Observations	1,725,578	1,725,578	5,718,219	24,418,154	3,360,036	3,586	3,360,036	3,360,036
Adjusted R^2	0.616	0.616	0.669	0.693	0.667	0.955	0.645	0.645

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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

Robustness test:	Air/Ves only	excl. CAN & MEX	p. kg. freight cost	lagged GDP
Dep. Var.:	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$	$\ln q_{jh,t}$
ln *GDP*	0.360	0.367	0.400	
	(0.264)	(0.267)	(0.265)	
ln *CGDP*	0.117	0.118	0.104	
	(0.277)	(0.279)	(0.283)	
ln *L.GDP*				0.289
				(0.286)
ln *L.CGDP*				0.044
				(0.299)
RTA	0.323***	0.321***	0.329***	0.332***
	(0.101)	(0.101)	(0.097)	(0.098)
FreightCost	-0.623	-0.692		-0.913
	(0.905)	(0.933)		(0.976)
FreightCost p. kg.			0.00764	
			(0.23)	
$\ln(1+\lambda)$	0.033**	0.033**	0.034**	0.028**
	(0.015)	(0.015)	(0.015)	(0.014)
Fixed effects	prd×yr	prd×yr	prd×yr	prd×yr
	prd×cty	prd×cty	prd×cty	prd×cty
Observations	3,288,307	3,318,872	3,360,036	3,332,734
Adjusted R^2	0.639	0.645	0.645	0.646

S.e. (in parentheses) robust to two-way clusters on product and country level. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A.8: Parameter estimates of linear SDF models

Model: Test assets:	CAPM 25 FF pfs.	FF four factor model 49 industry portfolios
ζ_{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.