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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

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JEL Classification: F15, F36, F44, G11

Keywords: international trade, structural gravity, Global Risk Sharing

Inga Heiland - inga.heiland@econ.uio.no
University of Oslo and CEPR

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Inga Heiland†

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

1 Introduction

Exporting not only provides firms with profit opportunities, but can also provide for risk diversification if is demand is stochastic and shocks are imperfectly correlated across countries. However, international financial market integration provides firm owners with an alternative means to engage in global risk sharing. So do risk-diversification concerns shape the pattern of trade? The extant literature on trade under uncertainty is inconclusive. In seminal contributions, Helpman and Razin (1978), Anderson (1981) and Helpman (1988) show that in the presence of complete financial markets, trade patterns under production uncertainty are fully predictable by traditional sources of comparative advantage (CA), that is, endowment differences or productivity differences. In these models, capital is allocated under uncertainty about productivity, while trade patterns are determined after the uncertainty has been resolved. In contrast, the literature on exports under demand uncertainty studies firms that make market-specific choices before demand is known and finds that trade patterns are influenced by the cross-country correlation patterns of shocks (see, e.g., Maloney and Azevedo 1995; Riaño 2011; Esposito 2019). Yet, this literature considers risk-averse firms concerned with the diversification of firm-specific risk in the absence of financial markets.

To shed light on the importance of a risk-diversification motive for goods trade in the presence of asset trade, I analyze export patterns under demand uncertainty in a setting with complete and potentially globally integrated financial markets. I develop a tractable general equilibrium model of global trade in goods and assets, which yields three novel results. First, idiosyncratic risk is diversified through asset trade but aggregate risk influences exporting decisions. Second, the distribution of demand shocks across countries endows export destinations where demand is relatively high in times when demand is low in other popular export markets with a demand-based comparative advantage. Third, the risk-diversification motive for trade persists even if financial markets are complete and integrated internationally. Moreover, I provide new empirical evidence for the impact of demand risk on goods trade based on a structural risk-augmented "gravity" equation for international goods trade and three decades of data on bilateral trade flows. Finally, I quantify the importance of demand-risk-based CA (henceforth, "DRCA") for global trade patterns by means of a counterfactual experiment based on a model calibration that targets global trade and production patterns between 2005 and 2014.

In a nutshell, the link between trade flows and the cross-country covariances of demand shocks established in this paper is as follows. Consider a risk-averse shareholder who owns a global portfolio of firms and dislikes consumption volatility stemming from a volatile portfolio return. This shareholder values more any firm whose profits covary negatively with the portfolio return, conditional on the expected value of profits. Suppose further that the portfolio return covaries strongly with demand fluctuations in some countries, for example, because many firms in the portfolio are based there and sell a lot domestically or are based elsewhere but export a lot to these markets. Then, conditional on the expected value of any firm's profits, the shareholder will value the firm more if it diverts some of its activity to markets where demand covaries less or even negatively with her total portfolio return. Hence, shareholder-value-maximizing firms are incentivized to deviate from the first-best quantity under risk neutrality and take into account to which extent the volatility of profits in a given market contributes to or reduces the volatility of their representative investor's portfolio. Survey evidence confirms the empirical relevancy of this concept of shareholder value, established by Modigliani and Miller (1958). Based on the responses of 392 chief financial officers (CFOs) to a survey conducted among U.S. firms in 1999, Graham and Harvey (2001) report that to evaluate the profitability of an investment, more than 70% use discount factors that account for the covariance of returns with movements in investors' total wealth. 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 overseas.

Investors seeking to reduce the variance of their portfolio may, of course, also do so by adjusting the portfolio composition in favour of firms with lower exposure to risky markets. A key theoretical result of this paper is that in a canonical trade model augmented with demand risk and financial markets, both margins of diversification, portfolio choice on the part of shareholders and export choices on the part of firms, are used in equilibrium. Moreover, I show that this result does not hinge on any notion of financial market incompleteness.

In the model, production of tradable intermediate goods is described by a classic monopolistic competition model of international trade. The key novel elements are twofold. First, at the time intermediate goods producers choose how much to produce for final goods producers in a specific country, they face uncertainty about the price at which they are going to sell.[1] This assumption turns export-market-specific choices into a de-facto investment problem. Price uncertainty for intermediate goods producers derives from preference shocks that may shift the global demand for final goods produced in a given country. Second, intermediate goods producers compete for the capital of risk-averse in-

[1] There is ample evidence that exporters face significant time lags between production and sales of their goods, exposing them to uncertainty about demand conditions at the time of production. Djankov et al. (2010) report that export goods spend from 10 to 116 days in transit after leaving the factory gate before reaching the vessel, depending on the country of origin. Hummels and Schaur (2010) document that shipping to the United States by vessel takes another 24 days on average.

vestors, who trade firm shares and a risk-free bond in a financial market. Capital is the only primary factor of production, hence equity investment today fully determines the resource base available for production of final goods in the second period. Two additional, albeit standard, model characteristics are essential for the novel predictions of this paper. A well-defined optimal firm size and a motive for firms to serve multiple markets that is independent of diversification considerations. Without these two firm characteristics, a global investor could replicate the optimal allocation by choosing the corresponding units of domestically-selling firms in all countries. In the model, the optimal firm size and the export motive are rooted in the New Trade Theory assumptions of increasing returns to scale at the firm level, product differentiation, and love-for-variety preferences. Investors' portfolio choices then determine the number of firms in each country whereas firms decide upon the sales per market. Optimality requires that the risk-return trade-off for both investment problems be identical at the margin.

The model encompasses different degrees of global financial market integration: nationally segregated, regionally segregated, and globally integrated financial markets. The three scenarios permit investors to own, respectively, domestic firms only, firms from a set of countries whose financial markets are integrated, or firms residing anywhere in the world. In any of the settings, shareholder-value maximization incentivizes firms to, ceteris paribus, ship smaller quantities to markets whose shocks carry more aggregate risk, reflected in a larger covariance between demand shocks and the total income of their investors. Equilibrium trade flows follow a gravity equation featuring a bilateral risk premium on top of trade costs. The risk premium captures a destination market's aggregate risk contribution and is endogenously determined in the financial market equilibrium, which is described by the Capital Asset Pricing Model (CAPM). Equilibrium risk premia are large for countries that are popular export destinations according to non-risk-related determinants of trade (for example, trade costs and market size), and feature shocks that are positively correlated with those of other popular export markets. Low covariances with demand shocks in popular destinations for exports thus endow countries with a CA.

In the empirical part of the paper, I present descriptive statistics of the correlation pattern between aggregate stock market returns and demand shocks in export destinations. Moreover, I show that the model does a strikingly good job at predicting these moments of the joint distribution of national stock returns and demand growth in other countries based on trade data only. Then, I use data on bilateral trade flows covering the years 1985 to 2015 to provide reduced-form empirical evidence for the hypothesis that diversification concerns shape the global pattern of trade. I estimate the risk-augmented gravity equation and find that exports are larger in destination markets where demand shocks covary less with stock market returns or consumption growth in the exporting country, conditional on market size and trade costs. Additional reduced-form evidence lends support to the model assumption that exposure to demand uncertainty is due to a time lag between production and sales: Exploiting variation across products and country pairs, I find that larger covariances of demand shocks with consumption growth or stock returns in the exporting country are more detrimental to trade if products are shipped over long distances and by slow means of transportation.

To quantify the importance of DRCA, I calibrate the model to the world economy and conduct a counterfactual analysis. The counterfactual experiment is designed to reveal how global trade flows would change if all countries' shocks became perfectly correlated such that all diversification possibilities were eliminated. In the counterfactual equilibrium, global trade is 4.6% lower. Country-level exports are affected vastly differently, depending on the initial degree of a country's DRCA and on the degree of risk aversion: Exports in the counterfactual equilibrium deviate from the baseline by -13% to +10%. Welfare losses range between .4% and 16%.

The notion of CA across states of nature entertained in this paper goes back to Svensson (1988), who shows how it shapes global capital flows. The theoretical contribution of my paper is to show that CA deriving from differences in relative demand across states of nature also shapes global goods trade flows and, importantly, that this can be true even if global financial markets are perfectly integrated.[2] Key to this result is the fact that insurance against *aggregate* risk, here, the common component of countries' shocks, is costly even in a complete financial market that provides for costless diversification of *idiosyncratic* risk. As long as insurance against aggregate risk is costly, it is optimal for firms to sacrifice some expected return in order to reduce investors' exposure to the aggregate risk implied by their exporting decisions.

In an international trade context, the concept of real investment decisions based on expected payoffs *and* aggregate risk is prevalent in the literature on international trade and investment under productivity uncertainty following Helpman and Razin (1978) and in the small strand of literature modeling market entry choices of firms owned by asset-trading shareholders.[3] Yet, to date, it has not made its way into the literature studying

[2] A related strand of literature following Turnovsky (1974) and Helpman and Razin (1978) analyzes whether financial market incompleteness prevents countries from specializing according to their sectoral CA of the traditional kind (see, for example, Koren 2004; di Giovanni and Levchenko 2011; Islamaj 2014; Kucheryavyy 2017). Another related strand of literature addresses the question of whether trade increases or lowers income volatility (see, for example, Caselli et al. 2019 for a recent contribution and an overview of the previous literature). Neither of the two strands explores the implications of CA across states of nature, which is central to this paper.

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

risk diversification as a motive for trade, which has analyzed demand uncertainty from the point of view of risk-averse firms acting in the absence of financial markets.[4] In this setting, exporters engage in diversification of firm-specific risk by exploiting imperfectly correlated demand shocks in foreign markets. In contrast, in my setting with financial markets and risk-averse shareholders, idiosyncratic risk is diversified through asset trade and only aggregate risk influences exporting decisions. While financial markets add a layer of complexity to the model, their presence greatly simplify one dimension of the problem of the firm. As Esposito (2019) shows, the problem of a firm choosing expected sales across markets in order to optimize a trade-off between expected profits and the variance of firm-level profits is non-trivial, because sales in one destination affect the marginal benefit of sales in another destination if profits are correlated across markets. In contrast, when firm-specific risks are diversified through asset trade, the marginal impact of exposure to demand volatility in any market on the value of the firm is determined outside the firm. Financial market equilibrium determines a common equilibrium risk premium per unit of any asset's exposure to the shocks in any given destination, reflecting this market's contribution to *aggregate* volatility. From the point of view of the individual firm, these risk premia are given and, hence, it may choose optimal expected sales independently for each market. Applying standard logic from the asset pricing literature, I show that the risk premium is in fact identical to the price of an insurance that insulates a unit of sales in a given market from fluctuations in the price. Hence, the optimal choice of the shareholder-value-maximizing firm is identical to the problem of a firm that purchases insurance against price fluctuations in all destinations for a market-determined price and then maximizes profits.

A sizeable literature documents that investors care about aggregate risk exposure through firms' operations in foreign markets.[5] Fillat and Garetto (2015) find that U.S. investors demand compensation in the form of higher returns for holding shares of internationally active U.S. firms. Fillat et al. (2015) provide evidence that those excess returns are systematically related to the correlation of demand shocks in destination markets with the consumption growth of U.S. investors and develop a dynamic model that rationalizes the relationship between firms' internationalization choices and their stock returns. However, little is known about whether firms actually internalize investors' desire for consumption smoothing in their internationalization choices and to what extent

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

[5]See, for example, Rowland and Tesar (2004), Ramondo and Rappoport (2010), Fillat et al. (2015), and Fillat and Garetto (2015).

demand risk shapes the global pattern of goods trade. My paper provides novel empirical and quantitative evidence for the impact of the global distribution of demand shocks on goods trade to fill that void. Moreover, in contrast to the model developed by Fillat et al. (2015), which treats consumption growth as exogenous, I endogenize the joint distribution of the stochastic discount factor and firm profits. This step requires sacrificing dynamic aspects of the firm's problem for the sake of tractability. However, it allows me to map the underlying distribution of demand shocks into equilibrium risk premia through which DRCA shapes trade patterns even in a static setup, and to study the quantitative importance of this mechanism in a multi-country general equilibrium model.

Thereby, my paper relates to the literature on international asset pricing building on Stulz (1981) and to the literature on general equilibrium models of asset pricing following Jermann (1998), which models the supply and demand for equity by linking both firms' investment returns and investors' consumption to the same volatile economic fundamentals, such as productivity shocks. Based on a model with country-specific and sector-specific productivity shocks and production linkages, Richmond (2019) has shown that trade network centrality helps explain the cross-country pattern of currency risk premia. To the best of my knowledge, my paper is the first to link stock returns and the pricing kernel to country-specific demand shocks with the help of a general equilibrium trade model. The model provides a microfoundation for a linear factor model featuring country-specific demand shocks as factors. Moreover, the model delivers microfounded exposures ("betas") of firms to these country-specific shocks that derive from a gravity model of trade, and endogenous factor prices. It predicts that the correlation between destination-market-specific shocks and domestic stock returns can to a large extent be explained by the level of trade with the destination country and the level of trade with other countries exhibiting correlated shocks. In fact, I find that the model-predicted country-risk premia constructed with trade data only align well with stock market data–based risk premia for country shocks. Risk premia are higher for countries which are central in the trade network, either for being large or for being geographically close to many other countries, making it harder to diversify their shocks.

Finally, my paper extends the literature that provides microfoundations for the theoretical gravity equation of international trade (for a comprehensive survey of this literature, see Costinot and Rodriguez-Clare 2014). I show that the cross-country correlations of demand volatility alter the cross-sectional predictions of standard gravity models. Moreover, the model rationalizes and endogenizes current account deficits and thereby addresses an issue that severely constrains counterfactual analysis based on static quantitative trade models (see, e.g., Ossa 2014, 2016).

The paper proceeds as follows. Section 2 develops the model, Section 3 provides stylized facts and empirical evidence and Section 4 presents the counterfactual analysis. Section 5 concludes.

2 Theory

Consider a world consisting of J countries indexed by $i, j \in \mathcal{J}$. Each country is part of a region $r \in \mathcal{R}$. The set of countries forming region r is $\mathcal{J}_r$. Individuals in all countries live for two periods, derive utility from consumption of an aggregate good, and earn income from the ownership and trade of assets whose returns are stochastic. Preferences are of the von Neumann-Morgenstern type with concave periodic utility functions, and individuals hold identical beliefs about the probabilities with which uncertain events occur. Within regions, financial markets are complete. That is, there are no frictions to trading assets within regional financial markets and idiosyncratic risks can be eliminated through diversification. Under these assumptions, aggregate investment and consumption patterns of a region resulting in the decentralized equilibrium can be described by the optimal choices of a representative investor for every region who possesses the sum of all individuals' wealth (see Constantinides 1982).[6] The set of assets available to investor r consists of a globally traded risk-free bond and shares of the firms in her region that produce differentiated intermediate goods.[7] The model comprises the special cases of financial autarky, where each country is a separate region, $\mathcal{R} = \mathcal{J}$, and global financial market integration, where there is a single region spanning all countries, $\mathcal{J}_r = \mathcal{J}$. Firms are homogenous within countries and indexed to their home country i.

The amount of investment today determines the expected level of consumption tomorrow. Intermediate producers use the shareholders' capital, the only primary input in the model, to produce differentiated varieties that are sold to domestic and foreign final goods producers. Production and shipping of intermediate goods takes time so that varieties produced in period zero become available for the production of final goods and

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

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

the aggregate consumption good in period one. Moreover, global demand for final goods in period one is subject to origin-country-specific taste shocks, which perfectly competitive final goods producers pass on upstream in the form of higher or lower prices paid for the intermediate inputs. Hence, intermediate goods producers' profits are stochastic at time zero, implying stochastic returns to investments in firm shares and a stochastic consumption level for the representative investor in period one.

2.1 Utility, Consumption, and Investment

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

$$U_r = u_r(C_r) + \delta \mathrm{E}\left[u_r(\widetilde{C}_r^1)\right] \qquad \text{with} \qquad u_r'(\cdot) > 0,\ u_r''(\cdot) < 0, \tag{1}$$

where δ is the time preference rate, C_r denotes consumption in period zero, and $\widetilde{C}_r^1$ denotes consumption in period one.[8] Let W_r denote the investor's initial endowment with units of the investment and consumption good (numéraire). In period zero, W_r is split between consumption C_r, investment a_r^f in the risk-free bond that yields a certain gross return R^f in period one, and risky investments a_{ri} in shares of firms from country $i \in \mathcal{J}_r$ that yield a stochastic gross return $\widetilde{R}_i$ in period one. In the special case of autarkic financial markets, $\mathcal{J}_r$ contains only the homogenous domestic firms. In the case of a globally integrated financial market, $\mathcal{J}_r$ contains firms from all countries. The budget constraint in period zero is given by

$$W_r = a_r^f + A_r + C_r \qquad \text{with} \qquad A_r = \sum_{i \in \mathcal{J}_r} a_{ri}. \tag{2}$$

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

$$\widetilde{C}_r^1 = a_r^f R^f + A_r \widetilde{R}_r^M \qquad \text{with} \qquad \widetilde{R}_r^M = \sum_{i \in \mathcal{J}_r} \frac{a_{ri}}{A_r} \widetilde{R}_i, \tag{3}$$

where $\widetilde{R}_r^M$ denotes the gross return to the risky portfolio.

The investor chooses investments a_r^f and $\boldsymbol{a}_r = [a_{r1} ... a_{ri} ... a_{rJ_r}]$, where J_r is the number of distinct assets (equalling the number of countries) in $\mathcal{J}_r$, to maximize (1) subject to (2) and (3). Optimal investments observe the Euler equations

$$\mathrm{E}\left[\widetilde{m}_r\right] R^f = 1 \qquad \text{and} \qquad \mathrm{E}\left[\widetilde{m}_r \widetilde{R}_i\right] = 1 \quad \forall\, i \in \mathcal{J}_r \tag{4}$$

[8] I use a tilda to denote stochastic variables whose period-one realizations are uncertain in period zero.

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

$$\widetilde{m}_r := \delta \frac{u_r'(\widetilde{C}_r^1)}{u_r'(C_r)} \tag{5}$$

denotes the investor's expected marginal utility growth, commonly referred to as the stochastic discount factor (SDF). Asset returns in this two-period setting are given by the firms' stochastic sales over the price of their equity, $\widetilde{R}_i = \frac{\tilde{s}_i}{v_i}$. The Euler equations (4) determine the equilibrium market value of firm i's equity in period zero as the investor's willingness to pay for the ownership of firm i's sales value in the next period:

$$v_i = \mathrm{E}\left[\widetilde{m}_r \tilde{s}_i\right] = \frac{\mathrm{E}\left[\tilde{s}_i\right]}{R^f} + \mathrm{Cov}\left[\widetilde{m}_r, \tilde{s}_i\right]. \tag{6}$$

Accordingly, the investor's willingness to pay for an asset with stochastic payoff $\tilde{s}_i$ is determined not only by the asset's expected payoff discounted at the risk-free rate, but also by the payoff's covariance with the investor's SDF, an inverse measure of change in the investor's well-being. Eq. (6) states that assets whose payoffs tend to be high in times when expected marginal utility is high are more valuable to the investor and trade at higher prices in equilibrium. Note that the variance of asset i has no bearing on its price. This owes to the assumption of financial market completeness that facilitates perfect and costless diversification of *idiosyncratic* risk. The only risk that remains is *aggregate* risk, reflected in the volatility of the representative investor's SDF. Assets are priced according to their aggregate risk content, reflected in the covariance with the SDF. The distribution of the SDF is endogenous to the investor's investment choices and so are the covariances of assets with the SDF. Any investment lowers consumption today and thus lowers expected marginal utility growth. Moreover, as a given asset's share in the investor's total portfolio increases, the asset's return becomes more correlated with the investor's total wealth. Hence, it becomes less attractive as a means of consumption smoothing and the investor's willingness to pay declines.

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

2.2 Final Demand with Taste Shocks

In period one, the representative investor spends the realized return on her investments, $a_r^f R^f + A_r R_r^M$, on the aggregate consumption good, which is composed of quantities C_{rj}^1

of all countries' final goods according to

$$C_r^1 = \sum_{j \in \mathcal{J}} \psi_j C_{rj}^1. \tag{7}$$

ψ_j is the realization of $\widetilde{\psi}_j$, a stochastic taste or quality-shift parameter for final goods from country j. $\widetilde{\psi}_j$ is the (sole) source of uncertainty in the model. It is common across consumers from all regions, that is, it reflects a shock to *global* demand for final goods from country j.

Final goods are freely traded. Maximization of (7) over C_{rj}^1 subject to the budget constraint $C_r^1 = \sum_{j \in \mathcal{J}} P_j C_{rj}^1$ implies that the price of country j's final good in units of the aggregate consumption good in period one obeys $P_j = \psi_j$. At time zero, final goods prices in period one are therefore stochastic:

$$\widetilde{P}_j = \widetilde{\psi}_j. \tag{8}$$

Likewise, global expenditure for country j's final good in period one is stochastic from the point of view of period zero and equal to

$$\widetilde{Y}_j = \widetilde{P}_j \sum_{r \in \mathcal{R}} \widetilde{C}_{rj}^1 = \widetilde{P}_j Q_j, \tag{9}$$

where Q_j is final goods output from country j. The second equality imposes market clearing. Since, as will be detailed below, all investment and production decisions determining the supply of inputs into final goods production in country j are made in period zero, Q_j is predetermined in period one. Taste shocks $\widetilde{\psi}_j$ are thus passed through to $\widetilde{Y}_j$ fully and exclusively via $\widetilde{P}_j$.

2.3 Production

Production involves two stages. Each country produces varieties of a differentiated intermediate good in period zero and a final good in period one. The final good in country $j \in \mathcal{J}$ is produced with a nested constant elasticity of substitution production function that combines imported and domestically produced varieties of the intermediate good:

$$Q_j = \left(\sum_{i \in \mathcal{J}} Q_{ij}^{\frac{\varepsilon-1}{\varepsilon}} \right)^{\frac{\varepsilon}{\varepsilon-1}} \qquad \text{with} \qquad Q_{ij} = \left(\sum_{\omega \in \Omega_i} q_{ij}(\omega)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}}, \tag{10}$$

where $\varepsilon > 1$ is the elasticity of substitution between composites of varieties from different countries i, and $\theta > 1$ is the elasticity of substitution between varieties from the same country. Ω_i is the set of varieties produced in country i. I assume that varieties from the same country are closer substitutes than varieties from different countries are, that is, $\varepsilon < \theta$. Perfectly competitive final goods producers choose optimal inputs $q_{ij}(\omega)$ so as to maximize profits $P_j Q_j - \sum_i \sum_{\omega \in \Omega_i} p_{ij}(\omega) q_{ij}(\omega)$, where $p_{ij}(\omega)$ is the price of variety ω from country i in country j. The number of firms in the final goods sector is normalized to one. Anticipating symmetry among varieties from the same country, inverse demand for a typical variety from country i results as

$$p_{ij} = \left(\frac{Q_{ij}}{Q_j}\right)^{\frac{\varepsilon-1}{\varepsilon}} \left(\frac{q_{ij}}{Q_{ij}}\right)^{\frac{\theta-1}{\theta}} \frac{Y_j}{q_{ij}}. \tag{11}$$

In the intermediate goods sector, firms from country $i \in \mathcal{J}$ produce varieties using c_i units of the composite good per unit of output. When shipping goods to country j, they face iceberg-type trade costs $\tau_{ij} \geq 1$. To set up production, firms pay fixed costs α_i. There is free entry and N_i denotes the number of intermediate goods producers from country i. Variety producers must decide on the optimal output quantity for every market j in period zero, that is, *before* Y_j is known, because production and shipping take time. Hence, at time zero they choose the quantity q_{ij} to be sold in period one and they base this decision on expectations about the global demand for country j's final goods, $\widetilde{Y}_j$, which will determine the sales price in period one. In accordance with (11) and (10), stochastic sales per market are

$$\tilde{s}_{ij} = \tilde{p}_{ij} q_{ij} = \left(\frac{Q_{ij}}{Q_j}\right)^{\frac{\varepsilon-1}{\varepsilon}} \left(\frac{q_{ij}}{Q_{ij}}\right)^{\frac{\theta-1}{\theta}} \widetilde{Y}_j. \tag{12}$$

Firm i's total sales are $\tilde{s}_i(\boldsymbol{q}_i) = \sum_{j \in \mathcal{J}} \tilde{s}_{ij}(q_{ij})$, where $\boldsymbol{q}_i = [q_{i1} ... q_{ij} ... q_{iJ}]$. The assumption that firms fix quantities but not prices is less restrictive than it may appear at first sight. Firms do implicitly fix prices in units of country j's final goods when quantity decisions are made. Uncertainty, however, prevails regarding the exchange rate of country j's final good against the global investment and consumption good, measured by $\widetilde{P}_j$. This problem is akin to the problem of a firm that engages in local currency pricing in the presence of nominal exchange rate uncertainty.

In period zero, firm i sets $\boldsymbol{q}_i$ to maximize its net present value in accordance with (6):

$$\max_{\boldsymbol{q}_i \geq 0} V_i = \mathrm{E}\left[\widetilde{m}_r \tilde{s}_i(\boldsymbol{q}_i)\right] - \sum_{j \in \mathcal{J}} c_i \tau_{ij} q_{ij} - \alpha_i. \tag{13}$$

As prescribed by Modigliani and Miller (1958), the shareholder-value-maximizing firm uses the representative investor's SDF to discount expected sales, taking the distribution of $\widetilde{m}_r$

as a given.[9] This discounting is central to the results of this paper because it incentivizes the firm to take into account how risky any given destination market is from the point of view of a representative investor when deciding upon optimal export quantities. The influence of the SDF on the firm's problem can be seen immediately by noting that the value of firm i is equal to the value of a portfolio of J assets yielding risky payoffs $\tilde{s}_{ij}$, respectively. In accordance with (6), we can split the value of such a portfolio into a discounted expected payoff and a risk adjustment equal to the covariance of $\widetilde{m}_r$ and $\tilde{s}_{ij}$:

$$v_i = \mathrm{E}\left[\widetilde{m}_r \widetilde{s}_i\right] = \sum_{j \in \mathcal{J}} \left[\frac{\mathrm{E}\left[\tilde{s}_{ij}\right]}{R^f} + \mathrm{Cov}\left[\widetilde{m}_r, \tilde{s}_{ij}\right]\right] = \sum_{j \in \mathcal{J}} \left[\frac{1-\lambda_{rj}}{R^f} \mathrm{E}\left[\tilde{s}_{ij}\right]\right], \tag{14}$$

where the last equality uses the fact that $\tilde{s}_{ij}/\mathrm{E}\left[\tilde{s}_{ij}\right] = \widetilde{Y}_j/\mathrm{E}[\widetilde{Y}_j]$ following (11) and

$$\lambda_{rj} := -R^f \mathrm{Cov}\left[\widetilde{m}_r, \widetilde{y}_j\right] \qquad \text{with} \qquad \widetilde{y}_j := \frac{\widetilde{Y}_j}{\mathrm{E}[\widetilde{Y}_j]}. \tag{15}$$

λ_{rj} is the "risk premium" of market j determined in region r's financial market. It is positive for markets that are risky in the sense that demand shocks on these markets are positively correlated with investor r's consumption, and negative otherwise. According to the pricing equation (6), λ_{rj}/R^f is equal to the equilibrium price of an asset with a stochastic return of $\frac{\mathrm{E}[\widetilde{Y}_j]-\widetilde{Y}_j}{\mathrm{E}[\widetilde{Y}_j]}$, that is, an asset which perfectly insures the owner against shocks in market j.[10] Hence, the value of firm i in (14) is equal to firm i's discounted expected sales in every market minus the value of a portfolio of insurance assets that neutralizes the demand risk in each market.[11] The value of the firm is larger if it sells relatively more to markets for which insurance is cheap, that is, if λ_{rj} is small or even negative.[12]

The first-order condition of the firm's problem in (13) yields an optimal quantity for

[9]As described by Fisher (1930) and Hirshleifer (1965), complete financial markets facilitate separation of investors' consumption and portfolio choices from firms' optimal decisions on productive investments.

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

[11]The fact that the firm can take the distribution of the SDF and hence the "insurance prices" λ_{rj} as given greatly simplifies its problem compared to models where the firm is risk averse as, e.g., in Esposito (2019), since it breaks the interdependence of market-specific choices.

[12]The problem of the firm in (13) can equivalently be stated as $\max_{\boldsymbol{q}_i \geq 0} V_i = \mathrm{E}\left[\tilde{s}_i\right]/R^f - \mathrm{E}[\widetilde{R}_i]/R^f \left(\sum_{j \in \mathcal{J}} c_i \tau_{ij} q_{ij} + \alpha_i\right)$, where $\mathrm{E}[\widetilde{R}_i]/R^f = \left(1 - \sum_{j \in \mathcal{J}} \mathrm{E}\left[\tilde{s}_{ij}\right]/\mathrm{E}\left[\tilde{s}_i\right] \lambda_{rj}\right)^{-1}$ is firm i's weighted average cost of capital. Importantly, the firm acknowledges the dependency of its weighted average cost of capital on its market-specific choices. In particular, it takes into account that placing greater quantities in markets where the value of sales covaries positively with m_r lowers the riskiness of the firm from the point of view of its representative investor and thus brings down its capital cost.

every market j equal to

$$q_{ij}^* = \frac{\Theta N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{rj})^{\varepsilon} \left(c_i \tau_{ij} R^f\right)^{-\varepsilon}}{\sum_{r\in\mathcal{R}} \sum_{i\in\mathcal{J}_r} N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{rj})^{\varepsilon-1} \left(c_i \tau_{ij} R^f\right)^{1-\varepsilon}} \frac{\mathrm{E}[\widetilde{Y}_j]}{N_i}, \tag{16}$$

where $\Theta = \frac{\theta-1}{\theta}$. Eq. (16) states that firms ship larger quantities to markets with lower trade costs and higher expected demand. They ship less in times of high interest rates, that is, when current consumption is highly valued over consumption tomorrow, because production costs and trade costs accrue today, while revenue is obtained tomorrow. Moreover, firms ship more to those markets where demand growth is positively correlated with their investors' SDF, reflected in a smaller risk premium λ_{rj}. This is the central prediction of the model, which is subjected to an empirical test in Section (3).

Optimal quantities as in (16) imply that expected prices feature a constant markup $1/\Theta$ over marginal costs, which include the bilateral risk premium: $\mathrm{E}\left[\tilde{p}_{ij}\right] = \frac{c_i \tau_{ij}}{\Theta} \frac{R^f}{1-\lambda_{rj}}$. Once the demand uncertainty is resolved, the firm's revenue in market j is

$$s_{ij}(q_{ij}^*) = \phi_{ij} Y_j \qquad \text{with} \qquad \phi_{ij} = \frac{N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{rj})^{\varepsilon-1} \left(c_i \tau_{ij} R^f\right)^{1-\varepsilon}}{\Pi^{1-\varepsilon}} \frac{1}{N_i} \tag{17}$$

and $\Pi_j = \left(\sum_{r\in R} \sum_{i\in\mathcal{J}_r} N_i^{\frac{1-\varepsilon}{1-\theta}} (1-\lambda_{rj})^{\varepsilon-1} \left(c_i \tau_{ij} R^f\right)^{1-\varepsilon}\right)^{\frac{1}{1-\varepsilon}}$. ϕ_{ij} denotes firm i's trade share in market j, that is, the share of country j's real expenditure devoted to a variety from country i. Eq. (17) is a gravity equation with bilateral trade costs augmented by a bilateral risk premium. There are a number of special cases under which sales predicted by the model follow the standard law of gravity. Suppose, first, that the time lag between production and sales is eliminated. Then, demand volatility becomes irrelevant because firms can always optimally adjust quantities to the current demand level ($\mathrm{E}[\widetilde{Y}_j] = Y_j$). Next, suppose that investors are risk neutral, so that marginal utility is constant. Then, the SDF does not vary over time and hence has a zero covariance with demand shocks. In this case, (17) will differ from the standard gravity equation only because of the presence of the time lag, which introduces the risk-free rate as an additional cost parameter. The same relationship obtains if demand growth is deterministic. Moreover, full integration of international financial markets implies a common SDF and common λs across source countries. Hence, the covariance terms cancel each other out in the trade share equation. Note, however, that in this case, risk premia still influence optimal quantities, as given by (16). Firms still ship larger quantities to countries with smaller λs and investors value these firms more, but since all their competitors from other countries behave accordingly, trade *shares* are independent of λ. Finally, the covariances could be set to zero *endogenously*, provided that an investment strategy that equalizes consumption across all possible states is feasible and deemed optimal by the investor. Generally, however, the investor is willing to trade some volatility for a higher expected return, implying non-zero covariances in (15).

2.3.1 Firm Entry, Market Clearing and Equilibrium

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

$$V_i^* = 0 \qquad \Leftrightarrow \qquad v_i = \mathrm{E}\left[\widetilde{m}_r \tilde{s}_{ij}\right] \equiv \sum_{j \in \mathcal{J}} c_i \tau_{ij} q_{ij}^* + \alpha_i. \tag{18}$$

Hence, variety producers enter until the investor's willingness to pay for shares of their type is equal to the firm's demand for capital. Without loss of generality, the number of shares per firm is set to one. Combining (16) and (18) shows that capital demand per firm and thus equilibrium share prices are constant

$$v_i = \frac{\alpha_i}{1-\theta}. \tag{19}$$

Market clearing conditions for each type of equity imply

$$N_i v_i = a_{ri}. \tag{20}$$

Global market clearing for the risk-free bond pins down the equilibrium risk-free rate:

$$\sum_{r \in \mathcal{R}} a_r^f = 0. \tag{21}$$

Equilibrium. An equilibrium is described by investment and consumption choices maximizing (1) subject to (2) and (3), optimal firm-level output as in (16), share prices, final goods output and a number of firms in each country consistent with (19), (18), and (20), a risk-free rate determined by (21), and country-risk premia as described in (15).

2.4 The Stochastic Discount Factor and Country Risk Premia

In this section I describe how the equilibrium distribution of the SDF is derived from the distribution of country-specific demand shocks and how, accordingly, the country risk premia λ_{rj} are determined. To that end, note first that with sales determined by (17), the return on a share of firm i depends linearly on demand shocks in the destination markets:

$$\widetilde{R}_i = \frac{\tilde{s}_i}{v_i} = \sum_{j\in\mathcal{J}} \beta_{ij}\widetilde{y}_j \qquad \text{with} \qquad \beta_{ij} := \frac{\phi_{ij}\mathrm{E}[\widetilde{Y}_j]}{v_i}. \tag{22}$$

Every market is weighted by a firm-market-specific factor β_{ij} that equals the share of expected sales in market j in the total value of the firm. It follows that the total return on the risky portfolio can be written as a linear combination of country shocks, $\widetilde{R}_r^M = \boldsymbol{\beta_r'}\widetilde{\boldsymbol{y}}$, where $\boldsymbol{\beta_r} = [\beta_{r1}...\beta_{rj}...\beta_{rJ}]$ with typical element $\beta_{rj} = \sum_{i\in\mathcal{J}_r}\frac{a_{ri}}{A_r}\beta_{ij}$ and $\widetilde{\boldsymbol{y}} = [\widetilde{y}_1...\widetilde{y}_j...\widetilde{y}_J]$.

Combining (5) and (3), the SDF can be written as a function of the stochastic return on the wealth portfolio and of variables determined at time zero only, and can then be approximated by a first-order Taylor expansion around $\mathrm{E}[\widetilde{R}_r^M]$ as

$$\widetilde{m}_r = \delta\frac{u_r'(a_r^f R^f + A_r\widetilde{R}_r^M)}{u_r'(C_r)} \approx \bar{\zeta}_r - \zeta_r\widetilde{R}_r^M, \tag{23}$$

where $\bar{\zeta}_r = \delta\frac{u_r'\left(\mathrm{E}[\widetilde{C}_r^1]\right)}{u_r'(C_r)} + \zeta_r\mathrm{E}[\widetilde{R}_r^M]$ and $\zeta_r = -\delta\frac{u''\left(\mathrm{E}[\widetilde{C}_r^1]\right)}{u'(C_r)}A_r > 0$. Accordingly, the country risk premia follow as

$$\frac{\lambda_{rj}}{R^f} = -\mathrm{Cov}\left[\widetilde{m}_r, \widetilde{y}_j\right] = \zeta_r\mathrm{Cov}\left[\widetilde{R}_r^M, \widetilde{y}_j\right]. \tag{24}$$

Using $\widetilde{R}_r^M = \boldsymbol{\beta_r'}\widetilde{\boldsymbol{y}}$ to rewrite (24) as

$$\frac{\lambda_{rj}}{R^f} = b_{rj}\sigma_{\widetilde{y}_j}^2 + \sum_{k\neq j} b_{rk}\sigma_{\widetilde{y}_j\widetilde{y}_k} \qquad \text{with} \qquad b_{rj} = \zeta_r\sum_{i\in\mathcal{J}_r}\frac{a_{ri}}{A_r}\beta_{ij} \tag{25}$$

reveals the dependency of the equilibrium risk premia on the global trade and investment pattern. b_{rj} measures investor r's direct exposure to shocks in market j through her ownership of firms from countries $i \in \mathcal{J}_r$, measured by portfolio shares $\frac{a_{ri}}{A_r}$, and these firms' exposure to shocks in j through exports (or domestic sales), measured by $\beta_{ij} = \frac{\phi_{ij}\mathrm{E}[\widetilde{Y}_j]}{v_i}$. In addition to the direct exposure to $\sigma_{\widetilde{y}_j}^2$ through b_{rj}, investor r is indirectly affected by shocks in market j due to exposure b_{rk} to other markets $k \neq j$, featuring shocks that are correlated with market j as measured by $\sigma_{\widetilde{y}_j\widetilde{y}_k}$.

The exogenous pattern of demand shock correlations across countries, $\sigma_{\widetilde{y}_j\widetilde{y}_k}$, constitutes a source of CA: Conditional on the bilateral exposure b_{rj}, countries featuring shocks that are negatively correlated with shocks in most other countries contribute less to aggregate risk.[13] While being independent of traditional sources of CA, DRCA interacts

[13]A decomposition of the variance of $\widetilde{m}_r$ gives $\sigma_{\widetilde{m}_r}^2 = \zeta_r^2\sigma_{\widetilde{R}_r^M}^2 = \sum_{j\in\mathcal{J}} b_{rj}\lambda_{r,j}$ and shows that $b_{rj}\lambda_{rj}$ measures the contribution of shocks in a given market j to aggregate risk in terms of SDF volatility

in important ways with other determinants of trade, such as trade cost and market size. Moreover, as will be discussed below, its impact on trade depends in intuitive ways on the degree of financial market integration.

The link between risk premia and other determinants of bilateral trade is particularly visible when financial markets are autarkic ($\mathcal{J}_r = \{i\}$). In this special case, investors own only domestic firms. All exposure to foreign markets is through trade, $b_{rj} = \zeta_r \beta_{ij}$, and

$$\frac{\lambda_{rj}}{R^f} = \zeta_r \text{Cov}\left[\widetilde{R}_i^M, \widetilde{y}_j\right] = \zeta_r \frac{N_i \phi_{ij} \text{E}[\widetilde{Y}_j]}{A_r} \sigma^2_{\widetilde{y}_j} + \zeta_r \sum_{k \neq j} \frac{N_i \phi_{ik} \text{E}[\widetilde{Y}_k]}{A_r} \sigma_{\widetilde{y}_j \widetilde{y}_k}. \tag{26}$$

Note first that the direct exposure to market j through the expected volume of bilateral trade, $N_i \phi_{ij} \text{E}[\widetilde{Y}_j]$ always contributes positively to the aggregate risk faced by investor r since $\sigma^2_{\widetilde{y}_j} > 0$. Hence, destination markets that are attractive either because of sheer size ($\text{E}[\widetilde{Y}_j]$) or relatively low market access cost for exporters from i (reflected in a large ϕ_{ij}) will command higher risk premia. Given the negative impact of λ_{rj} on bilateral trade as established above, uncertainty about Y_j thus weakens the impact of other sources of CA on trade. The last term in (26) shows that country j's risk premium is low (or even negative) if shocks in j covary negatively with shocks in those particular destinations k that are most attractive for exporters from i, again reflected in large expected export volumns thanks to market access (ϕ_{ik}) or market size ($\text{E}[\widetilde{Y}_k]$). Lastly, note that the disproportionate importance of domestic sales over export sales observed in the data implies that $\sigma_{\widetilde{y}_j \widetilde{y}_i}$, the covariance of shocks in j with the firm's home market i, is a quantitatively important determinant of λ_{rj}.

Under partially integrated financial markets where firm shares are freely traded within regions, the same basic mechanisms are at work. Albeit, investment patterns also come into play. Returning to the general expression for λ in (25), the first term shows that now the direct trade exposure of exporting firms from all countries where the investor is invested in matters. Each of these countries trade exposure is weighted by the share of the investor's portfolio its firms are accounting for, a_{ri}/A_r. Analogously, the second term implies that market j is less risky if its demand shocks covary negatively with the demand shocks in markets that are popular destinations for firms from countries where investor r is more heavily invested in. With domestic markets accounting for the largest share of firm sales, market j will be attractive from a diversification point of view if it lies outside of region r and/or if its shocks covary negatively with shocks in markets within region r.

Hence, trade and investment are substitutes from a diversification point of view. Im-

faced by investor r.

portantly, however, investment can only partially substitute for diversification through trade, even when global financial markets are perfect. This can be seen from analyzing the country risk premia in a globally integrated financial market, where $A_r = A = \sum_{j \in \mathcal{J}} a_{rj}$. Market j's risk premium then obtains as

$$\lambda_j = \zeta \frac{\mathrm{E}[\widetilde{Y}_j]}{A} \sigma^2_{\widetilde{y}_j} + \zeta \sum_{k \neq j} \frac{\mathrm{E}[\widetilde{Y}_k]}{A} \sigma_{\widetilde{y}_j \widetilde{y}_k}, \tag{27}$$

since $\sum_{i \in \mathcal{J}} N_i \phi_{ij} = 1$. In the global financial market, efficient risk sharing implies that marginal utility grows in lockstep everywhere. Accordingly, the contribution of country-specific shocks to aggregate risk are the same everywhere and, hence, λ_j is no longer a bilateral quantity. Differential market access of different origins becomes irrelevant, since the globally representative investor is entitled to receipts from sales in j originating anywhere.[14] Risky countries from the global investor's point of view are the popular global export destinations, and especially so if they feature volatile shocks and shocks that are positively correlated with other popular export markets. It is apparent from (27) that even in the globally integrated financial market, risk related to demand shocks is generally not eliminated and will affect firms' export quantity choices based on (13).

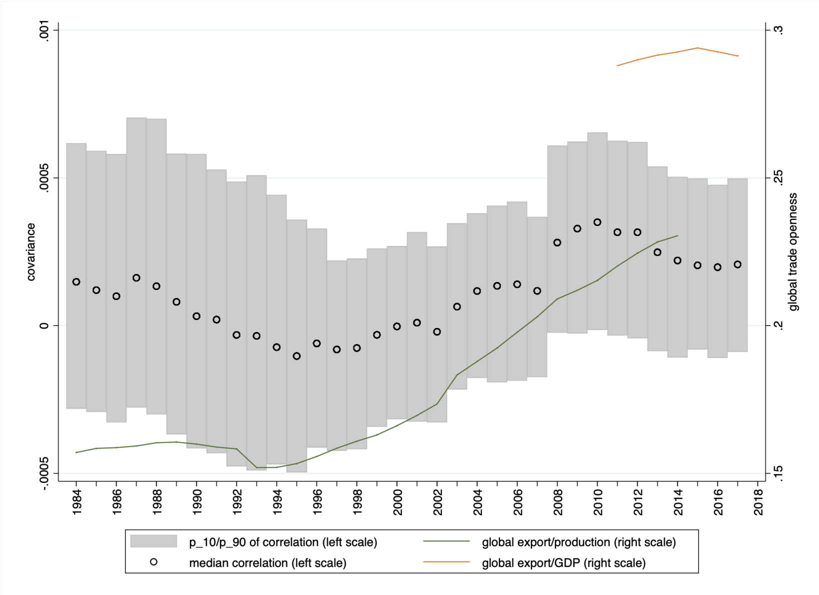
How does DRCA materialize in trade flows? Recall from above that λ_{ri}/R^f equals the equilibrium price at which an insurance insulating a unit of revenue in market j from demand-driven price fluctuations trades in the financial market of region r. Hence, market j's CA materializes in lower prices of insurances against its demand shocks in region r. In view of Equation (14), this means lower risk discounts of the value of firms selling to market j. Equivalently, it means lower capital cost of exporters from region r selling to market j. Following Cochrane (2005), we may employ the linear SDF model (23) to solve (14) for firm i's capital cost, that is, the equilibrium average return on its equity that investors demand for holding a share, as

$$\mathrm{E}[\widetilde{R}_i] = R^f + \sum_{j \in \mathcal{J}} \beta_{rj} \lambda_{rj}.$$

Conditional on the firm's export pattern reflected in β_{rj}, lower risk premia λ_{rj} imply lower capital cost for firm $i \in \mathcal{J}_r$.

[14]It is noteworthy, though, that $\mathrm{E}[\widetilde{Y}_j]$ depends on *global* access to market j.

Figure 1: Distribution of covariances over countries and time, and openness



The figure shows the distribution of covariances between demand shocks with aggregate stock returns for 810 country pairs together with the ratio of global exports over production (GDP), computed for each point in time as average over the past 10 years. Gray bars indicate the 10th to 90th percentile range of the distribution of covariances across country pairs.

3 Empirics

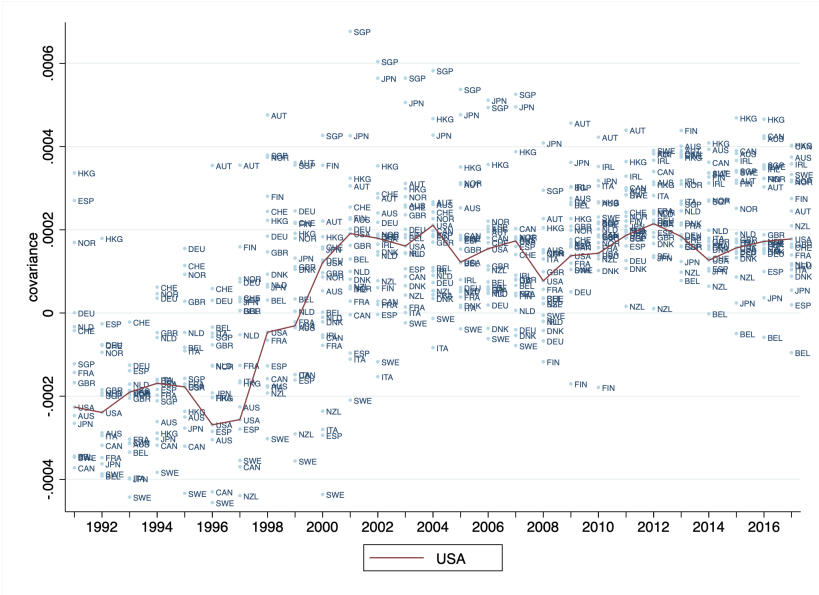
This section assesses the empirical performance of the model's central prediction, that is, the augmented gravity equation with country-risk premia. First, however, I present stylized facts on the covariances between countries' stock returns and demand shocks in export markets to demonstrate that there is considerable variation across markets and time. Moreover, this section presents evidence in support of the hypothesis enshrined in (26) that stock returns covary with foreign demand shocks because of export linkages.

3.1 Covariances of Stock Returns and Demand Shocks

Data and computations. To compute $\text{Cov}[\widetilde{R}_i^M, \widetilde{y}_j]$, I use growth in total seasonally adjusted monthly imports by country obtained from the IMF's *Direction Of Trade Statistics* to proxy demand growth $\widetilde{y}_{j,t}$. For $R_{i,t}^M$, I use the aggregate national stock market return in the exporting country obtained from *Kenneth R. French's data library.* Data on $R_{i,t}^M$ is available for 21 mostly industrialized countries.[15] To capture variation across time, I compute covariances for rolling time windows of a ten-year length. The result is a set of covariances for 21 exporters and 175 destination markets for every year from 1984

[15]Appendix A.1 provides additional details on all datasets and variable definitions and country coverage.

Figure 2: Covariances with China across exporters



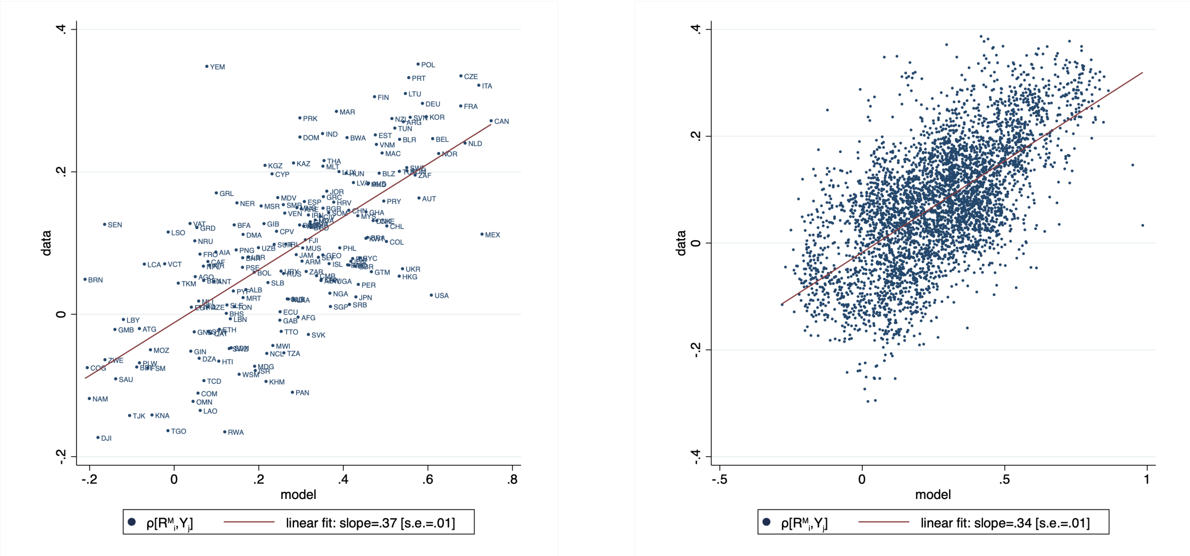
The figure shows the covariances of demand shocks in China with aggregate stock returns in 21 countries.

to 2017, each based on monthly data from the 10 most recent years.

Stylized facts. Fig. 1 presents an overview of the covariances. To filter out the effect of changes in the sample composition, the figure plots the changes in the distribution over time for the subsample of country pairs present in the dataset as of 1984. Three trends emerge from this picture: Covariances were declining until the mid nineties, increasing or stable until 2012 and declining since then. Fig. A.1 in the Appendix shows similar developments for later cohorts of country pairs. Fig. 1 also shows that the trends in the covariances commensurate approximately with the trends in trade openness, measured by the share of world exports in world production (or world GDP).[16] Fig. 2 focuses on China. It plots the covariances of all 21 countries' stock markets in the sample with respect to demand shocks in China. Consistent with the implication of Eqn. (26) that a higher degree of trade integration goes hand in hand with a more positive covariance, the figure shows that countries closer to China have higher covariances. Similarly, the positive upward trend of all countries' covariances starting in the mid-90ies is consistent with China's deepening integration into the world economy.

[16]For data availability reasons I supplement the export over production ratio with exports over GDP in recent years. Since the covariance measures are backward-looking (based on the most recent ten years), for each point in time, the openness measure in Fig. 1 reflects the average over the past ten years.

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



(a) U.S.

(b) All

The figure plots scaled covariances between domestic aggregate stock returns and demand shocks in other countries constructed from bilateral trade data, in line with the model, on the horizontal axis, against the same scaled covariance computed using actual stock returns on the vertical axis. The left panel shows the correlations for the U.S. as exporter, the right panel shows the correlation for 21 exporters for which national stock return data is available. Time period: 2003–2012.

Model vs. data. How well does the model predict actual correlations of country shocks with stock market returns? Fig. 3 plots $\rho_{\widetilde{R}_i^M,\widetilde{y}_j} = \frac{\mathrm{Cov}[\widetilde{R}_i^M,\widetilde{y}_j]}{\sigma_{\widetilde{R}_i^M}\sigma_{\widetilde{y}_j}}$, the correlation coefficient between country-level stock market returns and demand shocks computed using actual stock-market data on the vertical axis against its model-based equivalent computed using trade data only on the horizontal axis.[17] The model-based correlation coefficients reproduce the actual cross-section of the covariances between stock returns and demand shocks strikingly well, lending strong support to the relationship between the global pattern of (unconditional) trade flows, demand shocks, and stock returns as predicted by (26).

[17]The model-based correlation coefficient is obtained by combining (26) with $\sigma^2_{\widetilde{R}_i^M} = \sum_{j\in\mathcal{J}}\sum_{h\in\mathcal{J}} N_i\phi_{ij}\mathrm{E}[\widetilde{Y}_j]\sigma_{\widetilde{y}_j\widetilde{y}_h}N_i\phi_{ih}\mathrm{E}[\widetilde{Y}_h]$ and results as

$$\frac{\mathrm{Cov}[\widetilde{R}_i^M,\widetilde{y}_j]}{\sigma_{\widetilde{R}_i^M}\sigma_{\widetilde{y}_j}} = \sum_{k\in\mathcal{J}} \frac{N_i\phi_{ik}\mathrm{E}[\widetilde{Y}_k]}{\sqrt{\sum_{j\in\mathcal{J}}\sum_{h\in\mathcal{J}} N_i\phi_{ij}\mathrm{E}[\widetilde{Y}_j]\sigma_{\widetilde{y}_j\widetilde{y}_h}N_i\phi_{ih}\mathrm{E}[\widetilde{Y}_h]}}\frac{\sigma_{\widetilde{y}_j\widetilde{y}_k}}{\sigma_{\widetilde{y}_j}}.$$

$\sigma_{\widetilde{y}_j,\widetilde{y}_h}$, $\sigma_{\widetilde{y}_j}$ are computed based on ten years of monthly data. I use average annual trade flows over the same period for bilateral trade flows $N_i\phi_{ih}\mathrm{E}[\widetilde{Y}_h]$ obtained from *Comtrade*. For lack of domestic sales data, the trade-data-based correlation coefficient can only be approximated.

3.2 The Gravity Equation with Risk Premia

Next, I turn to an empirical assessment of the model's prediction of a negative relationship between trade flows and country-risk premia *conditional* on trade cost and market size. Moreover, I provide empirical evidence in support of the key assumption behind this prediction, that is, the relevancy of a time lag between production and sales.

3.2.1 Empirical model and data.

To assess if and how risk premia affect trade, I estimate the log-linear gravity equation for export quantities, derived from firms' first-order condition (16),[18] at the product-level:

$$\ln q_{pij,t} = \beta_1 \lambda_{rj,t} + \boldsymbol{\beta} \boldsymbol{Z}_{ij,t} + d_{pi,t} + d_{pj,t} + d_{pij} + u_{pij,t}. \tag{28}$$

The dependent variable is the quantity (in kilograms) of product p shipped from country i to j in year t.[19] The data, sourced from UN Comtrade, is disaggregated into 766 products (defined by the 4-digit level of the SITC classification, Rev. 2). I use four equally spaced time periods between 1985 and 2015.[20]

On the right-hand side of (28), importer-product-time and exporter-product-time fixed effects ($d_{pj,t}$ and $d_{pi,t}$, respectively) capture expected demand in the destination market and the importer's price index (also known as "multilateral resistance"), the exporter's production costs, and time-varying trade costs specific to the exporter or the importer. Country-pair-product fixed effects (d_{pij}) and a vector of dummy variables for joint membership in the EU or a free trade agreement (FTA), $\boldsymbol{Z}_{ij,t}$, control for bilateral trade costs.[21] Tab. A.6 summarizes the estimation sample and provides details regarding data sources and variable definitions.

As regards the risk premia on the right-hand side, note first that the structural interpretation of β_1 is $-\varepsilon < 0$, that is, higher risk premia imply lower trade ceteris paribus. As empirical measure for the risk premia, I use the covariance of demand shocks in j with the aggregate stock market return in i described in the previous section. In line

[18] To map the natural logarithm of (16) into the log linear specification (28), I use the fact that $\varepsilon \ln(1 - \lambda_{rj}) \approx -\varepsilon \lambda_{rj}$ for small values of the risk premia.

[19] See Head and Mayer (2014) for a summary of the history and applications of the gravity equation.

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

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

with (25), these covariances approximate λ_{rj} up to a positive factor of proportionality given by $\zeta_r R^f > 0$ if stock ownership is primarily local. A negative coefficient estimate for $\text{Cov}[\widetilde{R}_i^M, \widetilde{y}_j]$ in the empirical gravity model will thus lend support to the hypothesis that higher risk premia reduce trade, conditional on trade cost and market size. As an alternative measure for the risk premia, I compute covariances of demand shocks in export markets with consumption growth in the exporting country.[22] The use of consumption growth as alternative proxy for movements in the SDF relies neither on the assumption that the representative investor for firms from i is invested primarily in domestic firms, nor does it rely on the (model-inherent) assumption that consumption fluctuations driving volatility in marginal utility are exclusively due to volatile stock returns.

The coefficient on the covariance is identified using variation within country pairs over time only. A potential concern about omitted variables bias is due to bilateral time-varying factors, such as unobserved trade barriers or demand and supply shocks, affecting both product-level trade and the bilateral covariance. In fact, due to the positive dependency of the bilateral risk premia on bilateral trade established in (25), any omitted variable affecting the left-hand side will be correlated with the bilateral covariances as well. Yet, omitted variables that correlate positively (negatively) with trade on the left-hand side will also be positively (negatively) correlated with $\text{Cov}[\widetilde{R}_i^M, \widetilde{y}_j]$. Hence, the coefficient estimate for $\text{Cov}[\widetilde{R}_i^M, \widetilde{y}_j]$ may be interpreted as an upper bound. I explore this reasoning below, where I run multiple specifications, with stricter trade costs and demand controls added subsequently. Even without omitted variables, there remains a concern about reverse causality due to product-level exports being positively correlated with aggregate exports. However, for the same reason as outlined before, reverse causality leads to an upward bias of the estimate. Moreover, the concern is ameliorated by the fact that product-level exports on the left-hand side make up only a small part of aggregate exports.

In additional regressions, I analyze the heterogeneity of the effect of $\text{Cov}[\widetilde{R}_i^M, \tilde{y}_j]$ across products and markets to test the presumption that the negative effect of the covariance on exports is due to a time lag between production and sales. If firms could immediately adjust quantities to the current demand level, they would still exhibit volatile profits and thus expose their investors to risk, yet current sales would be perfectly explained by the current level of demand and the covariances should not matter. Trade relationships that are subject to longer time lags are therefore expected to be more affected by the dampening effect of positively correlated shocks. To test for the relevancy of a time lag, I interact the covariances with the distance between the exporter and the importer, presuming that

[22] I use ten-year windows of data on quarterly seasonally adjusted growth rates of consumption with respect to the previous period and quarterly import growth to compute time-varying covariances.

Table 1: Gravity estimations with covariance

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	Vessel	Air	All	All
$\mathrm{Cov}\left(\widetilde{R}^M, \widetilde{y}\right)$	-0.012*	0.140*	0.241***	-0.032	-0.050	
	(0.007)	(0.074)	(0.077)	(0.086)	(0.089)	
$\times$ ln *Dist*		-0.018**	-0.030***	0.002	0.004	
		(0.009)	(0.009)	(0.010)	(0.010)	
$\times$ Vessel					-0.035***	-0.031***
					(0.009)	(0.008)
$\times$ Vessel					0.299***	0.269***
					(0.074)	(0.071)
N	2,080,695	2,080,695	1,316,842	763,853	2,080,695	2,080,346

All columns include importer-product-time, exporter-product-time, and country-pair-product fixed effects. Cols. 1–5 include binary indicators for joint membership in the EU or an FTA, and two five-year-spaced lags thereof. Col. 6 includes country-pair-time fixed effects. S.e. (in parentheses) are robust to two-way clusters at the product and country-pair levels. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Dependent variable: log export quantity (in kg) by product, country pair, and time. Col. 3 (4) is based on a subsample of products shipped primarily by vessel/ground transportation (air) only. Estimates are based on years 1985, 1995, 2005, 2015. $\mathrm{Cov}(\widetilde{R}^M, \widetilde{y})$ is the standardized covariance between the monthly aggregate stock market return in the exporting country and aggregate import growth in the destination.

distance correlates with shipping time. To further tease out the role of the time lag, I split the sample into goods shipped primarily by vessel (or ground transportation) rather than by air, presuming that shipping over long distances implies a significant time lag only if the goods are not transported by air. Product-specific indicators for the primary transport mode (vessel/air) are computed using product-level shipments to and from the U.S. which are recorded by mode of transport; see Appendix A.1 for details. I then re-run the specification that includes the covariances interacted with distance in both subsamples. Alternatively, I include a triple interaction $\mathrm{Cov}[\widetilde{R}_i^M, \widetilde{y}_j]$ $\times$ ln *Dist* $\times$ *Vessel* in an estimation based on the full sample, for the same effect. Since the triple interaction term varies by country pair, time, and product, it can also be identified when country-pair-time fixed effects are included.

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

3.2.2 Results

Col. 1 of Tab. 1 shows parameter estimates from the baseline specification (28). I find that a higher covariance has a significantly negative effect on export quantities. The estimates in Col. 1 imply that a unit increase in the covariance goes along with a decrease in exports of about 34%.[23] In terms of economic magnitude, the coefficient estimate implies, for example, that the .0004-unit increase in the covariance of demand shocks in China with the U.S. stock market between 1992 and 2004 (see Fig. 2) was associated with 1.4% lower exports compared to exports in a counterfactual world where covariances do not influence firms' exporting decisions. In other words, the coefficient estimate suggests that the aggregate increase in U.S. exports to China in that period was slowed down by 1.4% due to a corresponding increase in the bilateral covariance. Arguably, the economic magnitude of the effect of covariances on trade seems modest. However, as discussed above, the estimate must be interpreted as an upper bound on the negative effect. Moreover, there is substantial heterogeneity of the effect across country pairs and products that is relevant for assessing the economic importance of the diversification motive.

As Col. 2 of Tab. 1 shows, the effect of the covariance on trade varies with the distance between exporter and importer. Higher covariances impede trade more if countries are more distant. As argued above, this supports the hypothesis that the impact of the correlation of shocks on trade is due to the presence of a time lag between production and sales. Cols. 3 and 4 lend further support to this hypothesis, showing the interaction with distance separately for the subsample of products that are shipped primarily by vessel or by air, respectively. Distance matters only if goods are shipped by vessel, that is, when a larger distance actually implies significantly longer shipping times. This is confirmed by the results presented in Col. 5, which is based on the full sample and features a triple interaction of the covariance, distance, and the binary indicator for goods shipped by vessel. Col. 6 shows that the inclusion of country-pair-time fixed effects, which absorb unobserved bilateral time-varying trade costs, does not impair this result.

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

3.2.3 Robustness and Discussion

I conduct various tests to analyze the robustness of my results with regard to changes in the exact specification of Eq. (28). Results are collected in Tabs. A.7 and A.8. Covariances based on consumption growth instead of stock returns yield very similar results; see

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

Tab. A.8, upper panel, Cols. 1–3. Proxying demand growth in the destination market with growth in industrial production or retail sales rather than import growth produces qualitatively similar effects (Cols. 4–7), in spite of the fact that such data is available only for a subset of destination countries (less than 40). Significance, however, is weaker. As additional robustness checks, discussed in Appendix A.2, I analyze more years of data, export sales as dependent variable, different aggregation levels of the dependent variable, and the inclusion of tariffs as a control variable. None of these changes affects the conclusions drawn from the main specification.

Finally, I analyze the potential for omitted variables bias using observable trade cost variables and fixed effects. Tab. A.7 shows that the coefficient of the covariances shrinks and eventually turns negative and significant as trade cost controls are added successively, thus supporting the model-based rationale that bias caused by omitted variables, if present, will drag the coefficient towards the positive range.

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

4 Counterfactual Analysis

How important is DRCA for trade? To answer this question, I compare actual trade flows to trade flows in a counterfactual equilibrium where all countries' shocks are perfectly correlated. To isolate the effect on trade and, at the same time, to keep the problem tractable, I consider a counterfactual equilibrium where expected global expenditure on each countries' final good is held constant. The counterfactual equilibrium can be found with the help of "hat algebra", outlined in the following. But first the general equilibrium comparative statics require two additional assumptions: Specifying the representative investors' utility function and specifying the distribution of shocks. Regarding the latter, I assume multivariate normality:

$$\widetilde{\boldsymbol{y}} \sim MVN(\mathbf{1}, \Sigma_{\widetilde{y}})\,. \tag{29}$$

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

$$u_r(C_r) = -e^{-\gamma_r C_r} \qquad \text{with} \qquad \gamma_r > 0.$$

With these preferences, investor r's optimal investment choices in line with (4) observe

$$\boldsymbol{a}_r = \Sigma^{-1}_{\widetilde{R}_r} \frac{\mathrm{E}[\widetilde{\boldsymbol{R}}_r] - \boldsymbol{R^f}}{\gamma_r} \qquad \Rightarrow \qquad A_r = \frac{\mathrm{E}[\widetilde{R}^M_r] - R^f}{\gamma_r \sigma^2_{\widetilde{R}_r}} \tag{30}$$

$$a^f_r = \frac{W_r}{R^f+1} - A_r \frac{\mathrm{E}[\widetilde{R}^M_r]+1}{R^f+1} + \frac{\gamma_r}{2} \frac{A^2_r \sigma^2_{\widetilde{R}_r}}{R^f+1} + \frac{\ln\left(\delta R^f\right)}{\gamma_r (R^f+1)}, \tag{31}$$

where $\Sigma_{\widetilde{R}_r}$ and $\mathrm{E}[\widetilde{\boldsymbol{R}}_r]$ denote, respectively, the covariance matrix and the vector of expected values of $\widetilde{R}_i \ \forall\, i \in \mathcal{J}_r$ and $\sigma^2_{\widetilde{R}_r} = \frac{1}{A^2_r} \boldsymbol{a}_r \Sigma_{\widetilde{R}_r} \boldsymbol{a}'_r$ is the variance of investor r's portfolio. Thanks to the linear relationship between demand shocks and returns, (29) implies normality of $\widetilde{\boldsymbol{R}}_r$ and $\widetilde{R}^M_r$. Hence, the linear SDF satisfying (4) is given by[24]

$$m_r = \bar{\zeta}_r - \zeta_r \widetilde{R}^M_r \qquad \text{with} \qquad \zeta_r = \frac{\gamma_r A_r}{R^f} \qquad \text{and} \qquad \bar{\zeta}_r = \frac{1}{R^f} + \zeta_r \mathrm{E}[\widetilde{R}^M_r]. \tag{32}$$

With normality of $\widetilde{R}^M_r$ and exponential utility, the expected lifetime utility equals

$$U_r = -e^{-\gamma_r \left(a^f_r R^f + A_r \mathrm{E}[\widetilde{R}^M_r]\right) + \frac{\gamma^2_r}{2} \sigma_{\widetilde{R}_r} A^2_r}. \tag{33}$$

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

Let x' denote the counterfactual value of any variable x, and let $\hat{x} = x'/x$. Consider a change in the distribution of taste shocks $\widetilde{\boldsymbol{\psi}}$ such that $\sigma'_{\widetilde{y}_j \widetilde{y}_k} \lesseqgtr \sigma_{\widetilde{y}_j \widetilde{y}_k}$ subject to $\mathrm{E}[y_j]' = \mathrm{E}[y_j]$. Then, recalling (25), the counterfactual risk premia observe

$$\lambda'_{rj} = \zeta'_r R^{f\prime} \sum_{k \in \mathcal{J}} \beta'_{rk} \sigma'_{\widetilde{y}_j \widetilde{y}_k}. \tag{34}$$

The changes in risk premia induce changes in bilateral trade shares equal to

$$\widehat{\phi}_{ij} = \left(\frac{\widehat{1-\lambda_{rj}}}{\widehat{R}_f} \right)^{\varepsilon-1} \frac{\widehat{N}_i^{\frac{\theta-\varepsilon}{1-\theta}}}{\widehat{\Pi}_j^{1-\varepsilon}} \quad \text{where} \quad \widehat{\Pi}_j^{1-\varepsilon} = \sum_{r \in \mathcal{R}} \sum_{i \in \mathcal{J}_r} N_i \phi_{ij} \widehat{N}_i^{\frac{1-\varepsilon}{1-\theta}} \left(\frac{\widehat{1-\lambda_{rj}}}{\widehat{R}_f} \right)^{\varepsilon-1}. \tag{35}$$

The change in the number of firms follows from the free-entry condition (18) as

$$\widehat{N}_i = \left[\frac{1}{N_i v_i} \sum_{j \in \mathcal{J}} \frac{1-\lambda_{rj}}{R^f} \left(\frac{\widehat{1-\lambda_{rj}}}{\widehat{R}_f} \right)^{\varepsilon} N_i \phi_{ij} \mathrm{E}\left[Y_j\right] \frac{1}{\widehat{\Pi}^{1-\varepsilon}} \right]^{\frac{1-\theta}{\varepsilon-\theta}}. \tag{36}$$

[24] Details of the derivation can be found in Cochrane (2005), p. 155. Note that with normally distributed returns, the linear relationship between $\widetilde{m}$ and $\widetilde{R}^M$ displayed in (23) is exact rather than approximate.

Using (20), new trade exposures obtain as

$$\beta'_{rj} = \frac{\sum_{i\in\mathcal{J}_r} \widehat{N}_i \widehat{\phi}_{ij} N_i \phi_{ij} \mathrm{E}[\widetilde{Y}_j]}{\widehat{A}_r A_r} \qquad \text{with} \qquad \widehat{A}_r = \frac{\sum_{i\in\mathcal{J}_r} a_{ri} \widehat{N}_i}{A_r}. \tag{37}$$

To complete the description of the changes in trade patterns, first note that $\widehat{\zeta}_r = \widehat{A}_r / \widehat{R}^f$ according to (32). It remains to be shown how the global risk-free rate R^f changes because of the new portfolio choices of the representative investors from all regions. From (21) and (31) it follows that $R^{f\prime}$ solves

$$\sum_{r\in\mathcal{R}} a_r^{f\prime} = 0 \qquad \text{where}$$

$$a_r^{f\prime} = \frac{W_r}{R^{f\prime}+1} - A'_r \frac{\mathrm{E}[\widetilde{R}_r^M]'+1}{R^{f\prime}+1} + \frac{\gamma_r}{2}\frac{\left(A'_r\right)^2 \sigma^{2\prime}_{\widetilde{R}_r}}{R^{f\prime}+1} + \frac{\ln\left(\delta R^{f\prime}\right)}{\gamma_r(R^{f\prime}+1)}, \tag{38}$$

$$\mathrm{E}[\widetilde{R}_r^M]' = \sum_{j\in\mathcal{J}} \beta'_{rj}, \qquad \text{and} \qquad \sigma^{2\prime}_{\widetilde{R}_r} = \sum_{j\in\mathcal{J}}\sum_{k\in\mathcal{J}} \beta'_{rj}\sigma'_{\widetilde{y}_j\widetilde{y}_k}\beta'_{rk}. \tag{39}$$

With $a_r^{f\prime}, A'_r, \mathrm{E}[\widetilde{R}_r^M]'$, and $\sigma^{2\prime}_{\widetilde{R}_r}$ determined, utility in the counterfactual equilibrium is readily obtained from (33).

4.2 Calibration

I calibrate the model to the world economy using data for the period 2005–2014. I split the world into 12 regions. The industrialized economies of Europe and North America (consisting of 32 individual countries) form one region (henceforth referred to as EUNA), and the 10 remaining individual countries and the rest-of-the-world aggregate (ROW) from the World Input Output Database (WIOD) all form individual regions.[25] By assumption, equity markets are fully integrated *within* regions, but strictly segmented *across*. Only the risk-free asset is globally traded.

The calibration requires specifying four structural parameters, $\varepsilon, \theta, \delta, \gamma_r$ and a set of observable moments, namely, bilateral trade shares $N_i\phi_{ij}$, investment levels at the regional level A_r, a_r^f, expected expenditure by country $\mathrm{E}[\widetilde{Y}_j]$, the covariance matrix of demand shocks $\Sigma_{\widetilde{y}}$ and the global risk-free rate R^f. Of the four structural parameters, γ_r is internally calibrated, and so are the remaining moments of the baseline equilibrium: W_r for all regions, $\frac{a_{ri}}{A_r}$ for the countries within EUNA, and $\mathrm{E}[\widetilde{R}_i]$ and $\sigma^2_{\widetilde{R}_i}$ for all countries. To calibrate A_r, I use the total value of inputs in production plus fixed costs, as implied

[25] Appendix A.1 lists all the countries. The choice of regional groupings is informed by the results of Fitzgerald (2012), Bekaert et al. (2011), and Callen et al. (2015), who provide evidence in favor of financial market integration within the industrialized world, but not beyond.

Table 2: Calibration overview

Targeted moments		mean	min	max	source	note
ϕ_{ij}	bilateral trade shares	.02	1.2e-7	.93	WIOD[a]	avg. 2005-2014
$\mathrm{E}[\widetilde{Y}_j]$	expected expenditure	2.7e+6	2.1e+4	2.4e+7	WIOD[a]	avg. 2005-2014
A_r	interm. inputs + wage bill + gross fixed cap. formation	8.8e+6	9.5e+5	5.2e+7	WIOD[a]	avg. 2005-2014
a_r^f	net foreign asset position	0	-4.6e+6	3.3e+6	IMF IIP[b]	avg. 2005-2014
$\Sigma_{\widetilde{y}}$	cov. of trend-adjusted growth in total expenditure	.008	-.002	.03	WIOD[a]	2005-2014
R^f	global risk-free rate (%)	.87	.87	.87	multiple[d]	w.avg. 2005-2014[e]

Internally calibrated moments/parameters		mean	min	max	external data mean	external data correlation
γ_r	Eq. (30)	4.7e-6	2.1e-8	1.5e-5		
a_{ri}	Eq. (30)	2.5e+6	1.8e+4	2.2e+7	2.1e+6[a]	1[a]
W_r	Eq. (31)	1.8e+7	1.5e+6	9.8e+7		
$\mathrm{E}[\widetilde{R}_i]$	Eq. (22)	1.2	1.01	1.3	1.1[c]	.13[c]
$\sigma^2_{\widetilde{R}_i}$	$\sum_j \sum_k \beta_{ij}\sigma_{\widetilde{y}_j\widetilde{y}_k}\beta_{ik}$	.01	0.002	0.05	.08[c]	.58[c]

Structural parameters	value	source/note
ε	5	Costinot and Rodriguez-Clare (2014)
θ	6	robustness checks: $\theta = 8, 10$
δ	.96	Gourinchas and Parker (2002)

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

by the free-entry condition (18). Accordingly, A_r is calibrated to match total expenditure on inputs, excluding capital, plus expenditures for fixed capital formation of a region. Hence, the bridge between the data and the model featuring only capital as input is built on the assumption that capital is used to pay for other production factors and fixed costs at the time of production, and then remunerated with the stochastic sales value in the next period. Tab. 2 summarizes the calibration, Appendix A.3 contains details.

As regards the non-targeted moments, the model does a good job at replicating a_{ri}, the within-region distribution of risky investments for the 29 countries forming the region EUNA. As regards the first and second moments of the aggregate risky return at the country level, the model underpredicts the variance of stock returns and overpredicts the mean when compared to observed total stock market returns for the same period. Yet, it does a fairly good job at replicating the cross-country variation, as shown by the correlation coefficients in the last column of Tab. 2. Fig. A.2 shows that the model performs better in explaining the cross-section of average stock returns if only the dividend part of the observed returns is considered. Tab. A.9 lists a set of baseline moments at the regional level that will be useful for interpreting the results.

Table 3: Counterfactual changes at the regional level

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

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

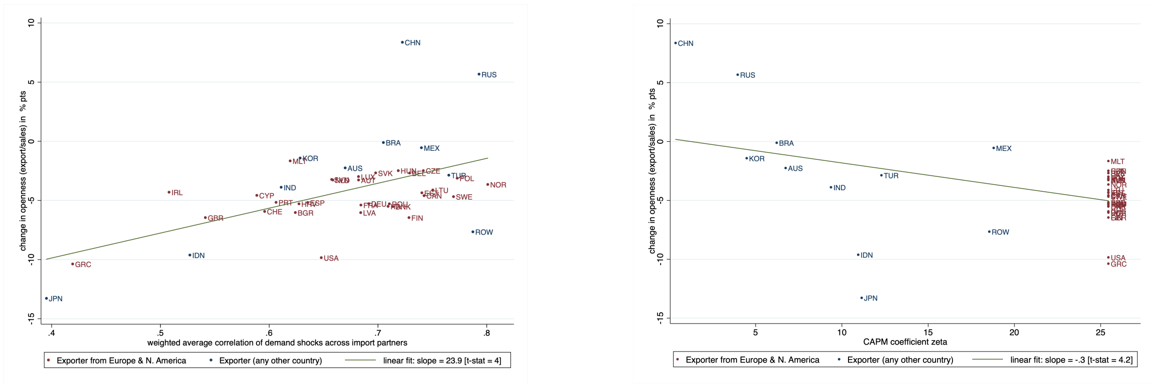
4.3 Counterfactual Equilibrium with Perfectly Correlated Shocks

The counterfactual experiment is implemented through a change in the distribution of country-specific demand shocks. The counterfactual covariance matrix of shocks features perfect correlations. That is, the counterfactual value of $\sigma_{\widetilde{y}_j\widetilde{y}_k} = \rho_{jk}\sigma_{\widetilde{y}_j}\sigma_{\widetilde{y}_j}$, a typical element of $\Sigma_{\widetilde{y}}$, features $\rho'_{jk} = 1$ and is thus given by $\sigma'_{\widetilde{y}_j\widetilde{y}_k} = \sigma_{\widetilde{y}_j}\sigma_{\widetilde{y}_j}$. Moreover, I assume that $\mathrm{E}[\widetilde{Y}_j]' = \mathrm{E}[\widetilde{Y}_j]\ \forall\ j$. Note that $\Sigma_{\widetilde{y}}$ and $\mathrm{E}[\widetilde{Y}_j]$ are endogenous variables, depending crucially but not exclusively on the joint distribution of the taste shocks $\widetilde{\boldsymbol{\psi}}$ (see Eq. 9). The counterfactual change is thus to be understood as an implicitly determined change in the distribution of $\widetilde{\boldsymbol{\psi}}$ that produces the desired counterfactual values of $\Sigma_{\widetilde{y}}$ and $\mathrm{E}[\widetilde{Y}_j]$, conditional on constant values of all other exogenous model parameters. This counterfactual experiment allows me to analyze what global trade patterns would look like if all countries' shocks were perfectly correlated. Comparing these counterfactual trade flows with observed trade flows that constitute the baseline equilibrium reveals how DRCA shapes trade patterns.

Tab. 3 presents the results for the main variables at the regional level.[26] DRCA accounts for 4.6% of global trade; see Col. 3. By construction, total expected world

[26] Tab. A.10 presents the changes at the country level. Tab. A.11 shows the general equilibrium changes at the regional level using alternative values of θ. The results are only marginally different.

Figure 4: Counterfactual changes in openness



(a) Changes in openness vs. initial correlations

(b) Changes in openness vs. ζ

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

sales in the counterfactual equilibrium is the same as in the baseline equilibrium. At the country level, trade and total sales effects are very heterogeneous, ranging from -13% to +10% for the former and -5% to +4% for the latter. What explains the stark heterogeneity? Intuitively, it is that the exporters with the largest DRCA suffer most. A key determinant of DRCA is the correlation pattern of shocks across trade partners, with low correlations implying stronger DRCA and, ceteris paribus, smaller risk premia. Fig. 4 Panel (a) plots the predicted change in openness (exports over sales) against the weighted average correlation of shocks across import partners, exhibiting a strong positive relationship. Countries with low average correlations reduce trade the most as DRCAs erode. Panel (b) inspects the role of the parameter ζ_r. Technically, $\zeta_r = -\frac{\partial m_r}{\partial R_r^M}$ measures to what extent investor r's marginal utility growth fluctuates with the return to the risky portfolio. The smaller ζ_r is, the less the investor is bothered by the volatility of her portfolio, implying smaller risk premia, ceteris paribus. Eq. (32) shows that, intuitively, ζ_r depends on the degree of risk aversion and the absolute size of the risky investment. In view of the counterfactual change in the distribution of shocks, which increases the portfolio variance everywhere, a low ζ_r is beneficial. China and Russia, the countries that gain most in terms of exports, are the countries with the smallest ζ_r. Countries from EUNA, in contrast, start out with the largest ζ_r and end up with the largest losses. Tab. 4 shows the results from regressions of export growth and the change in openness on the initial average correlation and ζ_r. Both variables are individually significant predictors and together explain 68% and 47% of the variation in the counterfactual changes, respectively.

In addition to having a large initial ζ_r, the countries from EUNA also lose their advantage of being part of an integrated financial market. In the baseline equilibrium, risk

Table 4: Counterfactual changes in exports and openness

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

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

diversification in this region takes place not only through trade but also through cross-border investment (within the region), which is reflected in a portfolio variance that is significantly smaller than the portfolio variance of most of the other individual countries; see Col. 1 of Tab. A.9. In the counterfactual equilibrium, the advantage of financial market integration gets fully eliminated, as all countries within a region feature exactly the same correlation pattern of shocks. Col. 1 of Tab. 3 shows that the initial effect (before any of the endogenous variables adjust) is a huge increase in the portfolio variance of the representative investor from EUNA compared to the portfolio variance of the representative investors from the other countries. As a consequence, investment in the risky asset decreases in EUNA; see Col. 2. This decrease leads to firm exit in all countries in this region in the range of -11% to -1%, and to a decline in total sales (Col. 4). Firm exit in EUNA ameliorates competition in all sales markets, allowing other countries to increase production and expected sales despite the initial increase in volatility.

Tab. 5 looks at bilateral trade changes and confirms that the initial degree of correlation is a strong predictor of trade changes also at the bilateral level. Col. 1 shows that the correlation alone explains 14% of the variation in the log changes in trade shares. Next, I analyze whether geography matters for which country pairs' trade is affected more. Cols. 2 and 3 present the results of regressions of the trade share changes on bilateral distance and on bilateral trade shares predicted with geographic variables.[27] Cols. 2 and 3 show that trade growth is bigger for country pairs enjoying favorable geographic characteristics,

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

Table 5: Counterfactual changes in bilateral trade

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

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

such as short distances or a common border, highlighting that the erosion of one source of CA strengthens the relative importance of other determinants of trade. Cols. 4 and 5 show that both the initial correlation and the geographic characteristics have independent explanatory power for the trade share changes, even though they are not uncorrelated. Cols. 6 and 7 show that the previous result is robust to the inclusion of importer and exporter fixed effects.

Finally, I turn to the welfare effects presented in Tab. 3, Col. 5. In the counterfactual equilibrium with no diversification opportunities, utility is lower everywhere. All countries are negatively affected by the initial increase in the portfolio variance. The disproportional decline in competitiveness of EUNA adds to the losses of this region but ameliorates the impact on the other countries. Countries and regions are also disproportionately affected by the change in the risk-free rate, which drops by 2.1 percentage points as a consequence of the increase in global demand for the risk-free asset that accompanies the increase in global volatility. The lower risk-free rate affects negatively the initial lenders (identified by shares below one in Col. 2, Tab. A.9): China, Japan, and ROW. For China, however, the relative gain in competitiveness moderates the losses. To summarize, the counterfactual analysis shows that DRCA accounts for a sizeable share of global trade and significantly impacts the cross-country pattern of production and trade.

5 Conclusions

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

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

Using panel data on bilateral trade, stock returns, and consumption, I provide evidence in support of the model's key hypothesis: Trade is larger with markets where demand shocks covary less with the exporter's investors' income or consumption, conditional on market size and trade costs. A counterfactual analysis reveals the quantitative importance of this mechanism: Without diversification possibilities, global trade would be 4.6% smaller. I conclude from this analysis that the distribution of demand shocks constitutes a hitherto unexplored source of CA that exerts a sizeable impact on the global pattern of trade.

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Appendix

A.1 Data Used in Section 3

Stock returns. Data on monthly total stock market returns by country is obtained from *Kenneth R. French's data library.* Countries included: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, United Kingdom, Hong Kong, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Singapore, Sweden, United States.

Import growth. I use total monthly imports by country obtained from the IMF's *Direction of Trade Statistics* to measure demand growth. Imports are converted to constant U.S. dollars using the Bureau of Labor Statistics' monthly consumer price index (series CUUR0000SA0). Growth is measured with respect to the previous month and rates are seasonally adjusted using the U.S. Census Bureau's X-13ARIMA-SEATS Seasonal Adjustment Program. The earliest observation used to estimate the risk premia is January 1975. To obtain continuous import series for countries evolving from the break-up of larger states or country aggregates defined by the IMF, I use a proportionality assumption to split imports reported for country groups. In particular, I use each country's share in the total group's imports in the year succeeding the break-up to split imports among country group members in all years before the break-up. These adjustments concern member countries of the former USSR, Serbia and Montenegro, the Socialist Federal Republic of Yugoslavia, Belgium and Luxembourg, former Czechoslovakia, and the South African Common Customs Area. Moreover, I aggregate China and Taiwan, the West Bank and Gaza, and Serbia and Kosovo in order to accommodate the reporting levels of other data used in the analysis.

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

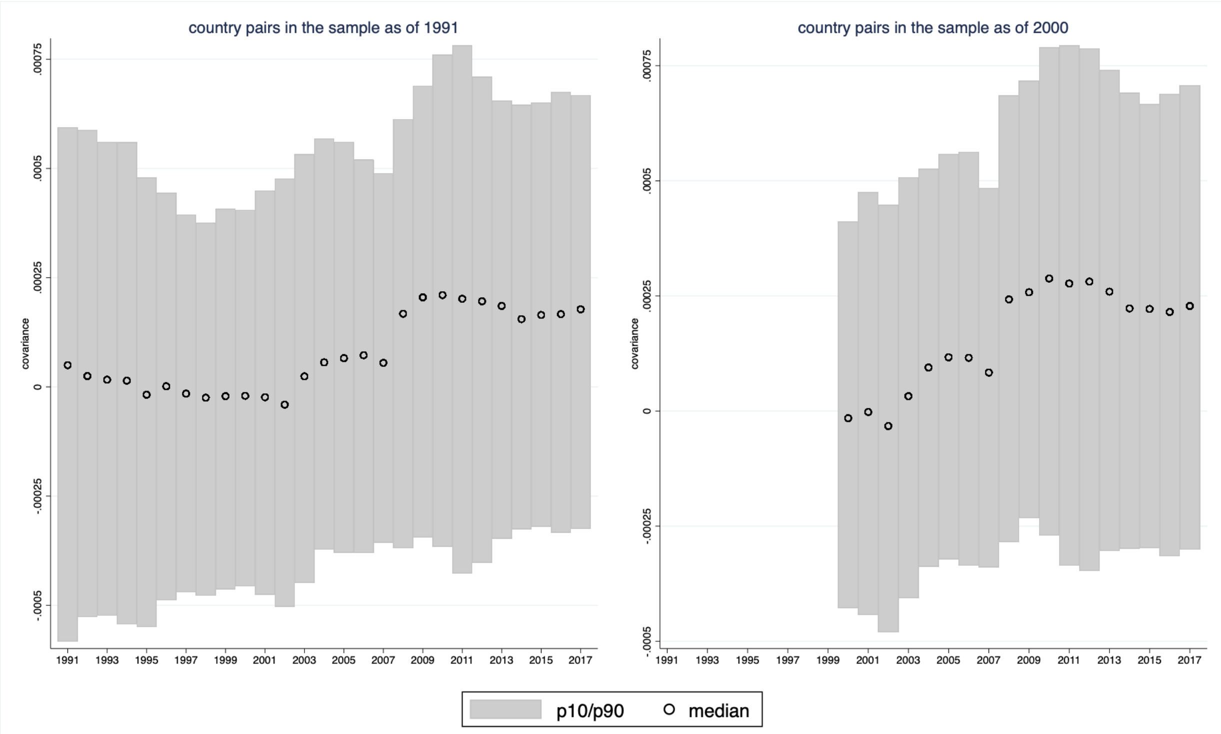
Retail sales. The third proxy for demand shocks is growth of the monthly (seasonally adjusted) index of retail sales volume taken from the OECD *Monthly Economic Indicators* (MEI) Database. It is available for 37 destination countries, over varying lengths of time.

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

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

Primary transport mode. Source: U.S. Census Bureau FTD. I use the dataset pro-

Figure A.1: Distribution of risk premia over countries and time: 1991 & 2000 cohort



The figure shows the distribution of covariances across country pairs. Gray bars denote the range of the distribution between the 10th and 90th percentile.

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

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

Table A.6: Summary statistics of the estimation sample

Variables/Categories	Description	# Obs.	# Groups	Mean	Std. Dev.	Min	Max
Value	> 0, in thsd. USD	2,080,695		7,132,654	1.20e+08	1	4.97e+10
Quantity	> 0, in kg.	2,080,695		4,735,109	5.15e+08	1	6.54e+11
$\ln Dist$	(log) bilateral distance in km	2,080,695		8.2	1.0	4.1	9.9
Contiguity	binary common border indicator	2,080,695		.05	.22	0	1
Comm. Language	binary common offic. language indicator	2,080,695		.15	.36	0	1
EU	binary joint EU membership indicator	2,080,695		.19	.39	0	1
FTA	binary joint FTA membership indicator	2,080,695		.39	.49	0	1
$\mathrm{Cov}_t\,(R, y)$	bilateral covariance, main specification	2,080,695		.0001	.0003	-.0033	.0041
$\mathrm{Cov}_t\,(R, y)$ (IP)	bilateral covariance, based on *industrial production* growth	782,291		.00004	.0002	-.0009	.001
$\mathrm{Cov}_t\,(R, y)$ (RS)	bilateral covariance, based on *retail sales* growth	683,900		.00004	.0001	-.0007	.0007
$\mathrm{Cov}_t\,(C, y)$ (CG)	bilateral covariance, based on *consumption* growth	1,746,827		.00003	.0001	-.0012	.0009
$\ln(1 + Tariff)$	bilateral tariff	1,768,077		.06	.10	0	3.43
Vessel	binary indicator for primary shipment mode = vessel	2,080,695		.63	.48	0	1
# Exporters		2,080,695	21				
# Importers		2,080,695	175				
# Products	SITC rev. 2 4-digit codes	2,080,695	766				
# Years		2,080,695	4			1985	2015
Exporters p. product	with positive sales		766	19	3.5	2	21
Importers p. product	with positive sales		766	110	48	2	175
Years p. product-cty-pair	with positive sales		752,901	2.8	.8	2	4

A.2 Reduced-form Results: Robustness Analysis

Table A.7: Gravity estimations with covariances: The role of omitted bilateral factors

	(1) All	(2) All	(3) All	(4) All	(5) Tariffs	(6) Tariffs
$\text{Cov}\left(\widetilde{R}^M, \widetilde{y}\right)$	0.126***	0.006	0.003	-0.012*	-0.015*	-0.015*
	(0.025)	(0.013)	(0.013)	(0.007)	(0.008)	(0.008)
ln *Dist*		-1.745***	-1.684***			
		(0.039)	(0.046)			
Contiguity		0.478***	0.501***			
		(0.114)	(0.111)			
Comm. Language		0.853***	0.850***			
		(0.065)	(0.064)			
EU			0.146*	0.099*	0.068	0.065
			(0.081)	(0.054)	(0.080)	(0.080)
L5.*EU*			0.566***	0.308***	0.289***	0.288***
			(0.103)	(0.056)	(0.068)	(0.068)
L10.*EU*			-0.777***	-0.032	-0.005	0.001
			(0.108)	(0.056)	(0.061)	(0.061)
FTA			0.205***	0.043	-0.004	-0.008
			(0.059)	(0.032)	(0.032)	(0.032)
L5.*FTA*			-0.073	0.070*	0.073**	0.070*
			(0.082)	(0.039)	(0.036)	(0.036)
L10.*FTA*			0.126*	0.065**	0.042	0.039
			(0.068)	(0.031)	(0.032)	(0.032)
ln *Tariff*						-0.252***
						(0.080)
Fixed Effects						
Imp/Exp×prd×yr	YES	YES	YES	YES	YES	YES
Cty-pair×prd	NO	NO	NO	YES	YES	YES
N	2,080,695	2,080,695	2,080,695	2,080,695	1,716,482	1,716,482

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

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

Dependent variable and aggregation level. The main empirical specification uses export quantities rather than values. Quantities are fixed by the time production starts, whereas the value of sales depends on the realization of the demand shock. On average, export values registered at customs should still be negatively related to the bilateral covariances. Cols. 8 and 9 of Tab. A.8, upper panel, show that the negative effect of higher covariances prevails when considering export values, and so does the interaction with distance and the vessel indicator. Cols. 10 and 11 show the importance of the aggregation level of the product classification. The coefficient estimate for $\text{Cov}[\widetilde{R}_i^M, \tilde{y}_j]$ at the 2-digit level (1-digit level) becomes smaller in absolute terms (positive) and insignificant, which is in line with the argument made above that a lower level of aggregation mitigates upward bias due to a reverse influence of exports on the covariance.

Sample years. My sample spans 1984–2017 and the baseline estimation uses data for the years 1985, 1995, 2005, 2015. Since the covariances are based on data reaching ten years into the past, ten-year-spaced trade data is the preferred choice. It avoids overlap and thus systematic correlations in the error term. The choice of the starting year 1985 is somewhat arbitrary. Cols. 1–6 of Tab. A.8, lower panel, show that using alternative starting years, 1984, 1986, or 1987, produces similar effects, except for the direct effect in the first and second specifications being insignificant. Moreover, I re-estimate Eq. (28) using five-year-spaced data and covariances computed using the five most recent years (Cols. 7 and 8) or all available years of data (Cols. 9 and 10), with the latter in particular producing remarkably similar effects.

Tariffs. Cols. 5 and 6 of Tab. A.7 explore the effect of adding tariffs. The tariff data is available at the product level, but time and country coverage is very patchy. Hence, I lose a significant number of observations. Col. 5 shows that in this smaller sample, the effect of the covariance is still significant. Col. 6 shows that adding tariffs does not affect this estimate.

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

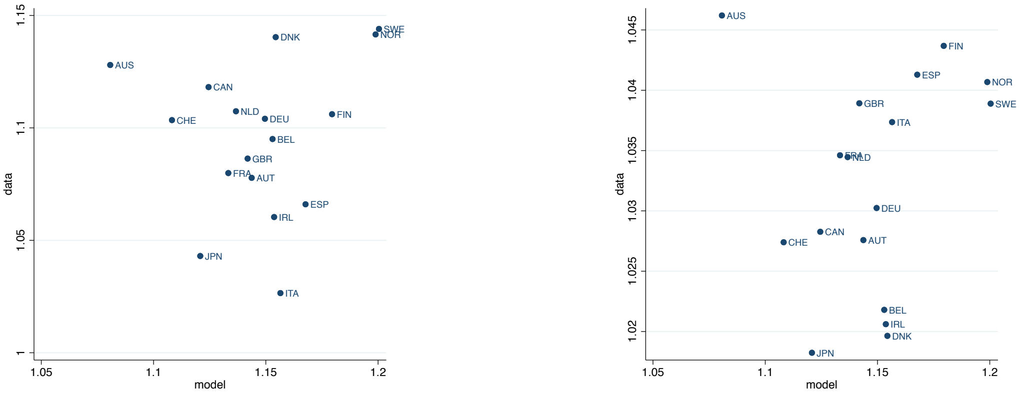
Table A.8: Gravity estimations with risk premia: Robustness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Robustness check:	*Consumption growth* 1985-2015, $\Delta = 10$			*Industrial production* 1984-2017, $\Delta = 1$		*Retails Sales* 1984-2017, $\Delta = 1$		*Dependent Variable:* ln *Exp. Value*, 1985-2015, $\Delta = 10$ SITC 4-digit		SITC 2-digit	SITC 1-digit
$\text{Cov}\left(\widetilde{R}^M, \widetilde{y}\right)$	-0.015**	-0.262***		-0.014*	-0.044	-0.003	0.045	-0.017**	-0.090	-0.011	0.002
	(0.007)	(0.080)		(0.007)	(0.048)	(0.005)	(0.031)	(0.007)	(0.069)	(0.009)	(0.015)
× ln *Dist*		0.029***			0.004		-0.006		0.008		
		(0.009)			(0.006)		(0.004)		(0.008)		
× Vessel		-0.038***	-0.037***		-0.001		-0.015***		-0.022***		
		(0.008)	(0.007)		(0.005)		(0.004)		(0.007)		
× Vessel		0.324***	0.321***		0.010		0.117***		0.187***		
		(0.065)	(0.063)		(0.041)		(0.032)		(0.057)		
N	1,699,404	1,699,404	1,699,160	7,303,953	7,303,953	6,321,376	6,321,376	2,281,127	2,281,127	401,632	85,010

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Time Spacing	1984-2014 $\Delta = 10$		1986-2016 $\Delta = 10$		1987-2017 $\Delta = 10$		1985-2015 $\Delta = 5$		1984-2017 $\Delta = 1$	
$\text{Cov}\left(\widetilde{R}^M, \widetilde{y}\right)$	-0.010	-0.041	-0.009	-0.020	-0.015**	-0.120	-0.009**	0.002	-0.012***	-0.044
	(0.007)	(0.087)	(0.007)	(0.078)	(0.007)	(0.075)	(0.004)	(0.043)	(0.004)	(0.056)
× ln *Dist*		0.003		0.001		0.013		-0.001		0.004
		(0.010)		(0.009)		(0.009)		(0.005)		(0.007)
× Vessel		-0.033***		-0.017**		-0.024***		-0.008*		-0.034***
		(0.008)		(0.008)		(0.008)		(0.004)		(0.005)
× Vessel		0.283***		0.142**		0.196***		0.058		0.287***
		(0.071)		(0.070)		(0.070)		(0.037)		(0.047)
N	2,039,752	2,039,752	2,141,349	2,141,349	1,960,372	1,960,372	4,580,341	4,580,341	21,427,053	21,427,053

All estimations include binary indicators for joint EU or FTA membership, and two 5-year-spaced lags of the latter, importer-product-time, exporter-product-time and country-pair-product fixed effects. S.e. (in parentheses) are robust to two-way clusters at the product and country-pair levels. Significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The dependent variable is log export quantity in kg. by product, country pair, and time unless indicated otherwise. *Spacing* $\Delta = 10(5,1)$ indicates that the sample consists of 10 (5,1)-year-spaced time windows spanned by the period denoted by *Time*. In Cols. 4 and 5 (6 and 7) $\text{Cov}(\widetilde{R}^M, \widetilde{y})$ is based on growth in a monthly, seasonally adjusted quantity index of industrial production (retails sales) rather than aggregate imports.

Figure A.2: Model fit: Average stock returns



(a) Total return

(b) Dividends only

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

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

A.3.1 Data and Variable Definitions

Unless stated otherwise, all data is obtained from the World Input Output Database (WIOD, Release 2016). Current price levels are converted to 2005 USD using the U.S. GDP deflator from the World Development Indicators database (series NY.GDP.DEFL.ZS). China and Taiwan are aggregated for lack of specific data from other sources. **Bilateral trade shares** are matched to average trade shares over the period 2005–2014. **Expected expenditure** is matched with average expenditure during 2005–2014. Intermediate input expenditure and gross fixed capital formation for the construction of **risky investments** are taken out of WIOD directly, labor costs are obtained from the supplementary Socioeconomic Accounts Data provided by WIOD. Labor costs are not available for the ROW aggregate. I construct them using the average share of intermediate goods and labor expenditure in total production for five developing and emerging economies in my sample: China, Indonesia, India, Mexico, Turkey. This share is then applied to the output of ROW. For EUNA, the aggregate risky investment of the region is matched. Country-level risky investments within EUNA are internally calibrated using (30). **Risk-free investments** are matched with the net international investment position (series IFR_BP6_USD) from the IMF's *Balance of Payments and International Investment Positions Statistics Database*. Demand shocks used to construct Σ_y are obtained as the residuals of the regression

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

where $Y_{j,t}$ equals the annual total expenditure of country j at time t. $Y_{j,t}$ is taken from WIOD directly and the covariance matrix of residuals is computed over the period 2005–2014. The **global risk-free rate** is computed as weighted average over all countries'

Table A.9: Baseline values at the regional level

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

A_r is in million 2005 USD.

annualized government bond rates net of inflation using country size (total expenditure) as weights. The primary source of government bond rates is the IMF's *International Financial Statistics Database*, missing data is supplemented with rates from the OECD's *Key Economic Indicators*, and the ECB's *Statistical Data Warehouse*. Consumer price inflation rates for all countries are obtained from the *BIS Statistics Warehouse*.

A.3.2 Solution Method

The numerical solution algorithm starts with guessing $R^{f'}$ and $\boldsymbol{\lambda'}$. First, it iterates over (35), (36), (37) for a given $R^{f'}$ until the risk premia in (34) converge, producing intermediate solutions for the changes in the number of firms $\widehat{\boldsymbol{N}}(R^{f'})$, trade shares $\widehat{\boldsymbol{\psi}}(R^{f'})$, and risk premia $\widehat{\boldsymbol{\lambda}}(R^{f'})$, and intermediate solutions for the covariance matrix $\Sigma'_{R_i}(R^{f'})$ and expected values of individual and portfolio returns $\boldsymbol{R}'(R^{f'})$ in accordance with (39). Second, the algorithm iterates over $R^{f'}$ until the global surplus in demand for the risk-free asset, in accordance with (38), is zero.

A.3.3 Additional Results

Table A.10: Counterfactual changes at the country level

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

Table A.11: Counterfactual changes at the regional level: Alternative θs

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