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Abstract

Does distance matter for the volatility of international real and financial transactions? We show that it does, in addition to its well-established relevance for the level of trade. A simple model of trade with endogenous markups shows that demand shocks have a larger impact on trade between more distant countries. We test this implication in two steps, relying on a broad range of real and financial transactions measures, as well as several different metrics of distance (physical, linguistic, and internet). We first show that during the Great Trade Collapse of 2007-09 international transactions fell more between countries that are more distant along the various metrics, and find that the different distance measures magnify each other's respective impacts. We then focus on a longer panel analysis of trade in goods and show that trade is more volatile between more distant countries, with again a magnification pattern across metrics of distance.

Key words: distance, gravity, volatility, international trade, international finance, Great Trade Collapse

JEL classification: F10, F30

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Non-technical summary

The “gravity” result that the level of international real and financial trade is negatively impacted by distance between countries is a well-established fact in international macroeconomics. However, policymakers care at least as much (if not more) about the volatility of international trade, since it is a powerful channel of transmission of economic shocks and policies. Does distance also matter for the volatility of international real and financial transactions? The effect is ambiguous a priori. A “footloose” view is that exporters faced with challenging conditions pull back more from markets that are distant. An opposite “beachhead” view is that because gaining market share in a distant country is hard, exporters do not abandon these markets easily.

This paper contributes to our understanding of the impact of distance on the volatility of trade in several ways.

We present a simple model of trade with endogenous markups that shows that demand shocks have a larger impact on trade between more distant countries. Intuitively, the reduction in demand weighs on profits and leads some exporters to exit the market. This raises the market power of the remaining firms and their markups, especially when there are initially few exporters owing to high trading costs to distant destinations. The larger increase in markups for more distant countries leads to a larger contraction of trade.

We take this prediction to the data by conducting a cross-sectional event study on bilateral linkages between 186 countries during the Great Trade Collapse of 2007-09. Our measures of bilateral international linkages cover a broad array of real and financial transactions, including trade in goods, services, portfolio investment, banking etc. We consider alternative metrics of distance, including physical distance, virtual (or internet) distance, and linguistic distance. On top of their direct impact, we test whether the different metrics of distance amplify each other’s marginal effects. Finally, we derive evidence from a long panel of country-pair observations on bilateral trade in goods from 1950 to 2015.

Our findings support the model’s prediction. During the Great Trade Collapse of 2007-09 international transactions fell more between countries that are more distant along the various metrics, in line with the “footloose” view. The various measures of

distance also interact, with virtual distance amplifying the marginal impact of physical distance (and vice-versa).

The effect of distance is economically substantial. By our estimates, an increase in physical distance between two countries by one standard deviation decreased trade in goods by 23% during the Great Trade Collapse; the corresponding decreases for virtual and linguistic distances are 15% and 5%, respectively. But while physical distance has received the bulk of attention in the literature, it is not always the measure with the largest effects. For instance, virtual distance had larger impacts for transactions in services or in portfolio investments.

Moreover, the impact of the various distance measures is not limited to the Global Crisis. Our panel analysis of trade in goods between 1950 and 2015 confirms indeed that physical and virtual distances matter, with trade being generally more volatile between countries that are farther away. Again, the two metrics of distance magnify each other's impacts.

These findings are relevant for policy. Policy makers have long been concerned about the international spillovers of growth through trade and financial linkages. Our findings suggest that these concerns apply particularly to more distant trading partners.

1. Introduction

The “gravity” result that the level of international real and financial trade is inversely proportional to the distance between countries is a well-established fact in international macroeconomics.[1] Leamer (2007, p. 11) calls it “the only important finding” having withstood “the scrutiny of time and the onslaught of economic techniques” in international economics.

Aside from the level of international linkages, policymakers care at least as much (if not more) about the volatility of these linkages. International real and financial connections are powerful channels of transmission of economic shocks and policies. Does distance also matter for the volatility of linkages? The effect is ambiguous a priori. A first “footloose” view is that exporters faced with challenging conditions pull back more from markets that are distant. An opposite “beachhead” view is that because gaining a market share in a distant country is hard, exporters do not abandon these markets easily.[2]

This paper contributes to our understanding of the impact of distance on volatility in several ways. We first develop a theoretical model for the role of distance, and then show the empirical relevance of distance during the Global Crisis as well as over a longer time horizon. The analysis takes a broad view of both international trade and financial linkages as well as of metrics of distance.

We present a simple model with varying exporters’ markups, building on Atkeson and Burstein (2008). The model shows that a decline in foreign demand reduces trade flows disproportionately more in country pairs that are more distant, in line with the “footloose” view. Intuitively, the reduction in demand weighs on profits and leads some exporters to exit the market. This raises the market power of the remaining firms and their markups, especially when there are initially few exporters because of high trading costs to distant destinations. The larger increase in markups for more distant country-pairs leads to a larger contraction of trade.

We take this prediction to the data by conducting a cross-sectional event study on the bilateral linkages between 186 countries during the Great Trade Collapse of 2007-

[1] See Anderson and van Wincoop (2004), (2003) or Head and Mayer (2014) for a recent survey, as well as Tinbergen (1962) or Krugman (1997) for earlier discussions.

[2] There is an old tradition in the theory of international trade on the role of “beachhead” or “hysteresis” effects (see e.g. Baldwin (1988), Baldwin and Krugman (1989) and Dixit (1989)).

09.[3] Our measures of bilateral international linkages cover trade in goods, trade in services, portfolio investment in bonds and in equities, foreign direct investments, and stocks and flows of bank loans and deposits. We consider alternative metrics of distance, including physical distance, virtual (or internet) distance, and linguistic distance. In addition to their direct impact, we test whether different metrics of distance amplify each other's marginal effects.[4] We also derive evidence from a long panel of dyadic (country-pair) observations on bilateral trade in goods from 1950 to 2015.

We find that distance matters for volatility, and does so in a diverse way. During the Global Crisis of 2007-09, international real and financial linkages contracted disproportionately more for distant country-pairs. While physical distance clearly mattered – as can be expected – we also find a robust role for linguistic distance and virtual distance. The various measures of distance also interact, with virtual distance amplifying the marginal impact of physical distance (and vice-versa). The impact of distance is quite heterogeneous across various forms of international linkages. In particular, FDI and banking activity are less sensitive to the measures of distance. This suggests that local presence through plants, offices or branches allows firms to obtain more accurate information on destination markets, while at the same time making a pull-back from the destinations in question less likely due to the fixed costs incurred in setting up local operations.

The effect of distance is economically substantial. By our estimates, an increase in physical distance between two countries by one standard deviation decreased trade in goods by 23% during the Great Trade Collapse; the corresponding decreases for virtual

[3] The Great Trade Collapse refers to the sizeable decline in international trade that accompanied the global financial crisis and the global recession of 2007-09 (see e.g. Ahn et al. (2011) or Bems et al. (2013)). Although many papers have been written on the collapse in question, it is still not fully understood. Most papers have focused on demand conditions in the destination countries or supply effects in the source countries (see also e.g. Bussière et al. (2013) on the role of the composition of demand). Evidence that brings both dimensions together via e.g. distance between source and destination countries, is more limited, however.

[4] Linguistic distance is considered in e.g. Isphording and Otten (2013) or Melitz and Toubal (2014). Virtual distance or internet connectedness is considered in e.g. Freund and Weinhold (2004), Blum and Goldfarb (2006), Chung (2011) or Hellmanzik and Schmitz (2017). In exploratory work we also considered a measure of genetic distance between the populations of two nations in the spirit of Spolaore and Wacziarg (2016). Giuliano, Spilimbergo and Tonon (2013) as well as Fensore, Legge and Schmid (2016) examined the impact of genetic distance on bilateral trade levels, for instance. However, we did not succeed in obtaining consistent results on the impact of this measure on the volatility of trade and hence chose not to report them here. But the results in question are available from the authors upon request.

and linguistic distances are 15% and 5%, respectively. But while physical distance has received the bulk of attention in the literature, it is not always the measure with the largest effects. For instance, virtual distance had larger impacts for transactions in services or in portfolio investments.

The impact of the various measures of distance is not limited to the Global Crisis. Our panel analysis of trade in goods over the time period 1950 to 2015 similarly shows that physical and virtual distances matter, with trade being more volatile between countries that are farther away. In addition the two metrics of distance again magnify each other.

The rest of the paper is set out as follows. Section 2 reviews the related streams of literature. Section 3 presents our simple model of heterogeneous trade adjustment. Section 4 discusses our empirical approach and presents the data. The empirical results are presented in Section 5. Section 6 concludes.

2. Literature

The impact of distance on international trade rests on well-established theoretical foundations emerging naturally from models with monopolistic competition and iceberg costs of trading (see for instance Anderson and van Wincoop ((2004), (2003)).[5] A large body of research has assessed the impact of distance in international finance. Empirical studies find that distance matters for the level of bilateral financial investment, in particular for information sensitive assets such as equities (see e.g. Portes, Rey and Oh (2001), Portes and Rey (2005), Aviat and Coeurdacier (2007), Brei and von Peter (2017)). Ozawa and van Wincoop (2012), however, caution that the theoretical underpinnings for the distance effect are more fragile for international financial transactions than for trade in goods and services. Brüggeman, Kleinert and Prieto (2011) derive a gravity equation for bank lending, but Niepman (2015) shows that such a specification is sensitive to the specifics of the model (such as the heterogeneity of banking sector efficiency across countries).

[5] They relate bilateral trade to nations' economic size, trade barriers (including distance), and multilateral resistance (e.g. distance with respect to all nations other than the two nations in the trading pair or other unobserved effects). Empirically, multilateral resistance terms are estimated by importer and exporter fixed effects (see Head and Mayer (2014)).

While the literature on the effect of distance on the level of international trade is voluminous, there are fewer studies on the effect of distance on the *volatility* of international trade. There is evidence that distance matters for changes in international trade flows. Berman et al. (2013) show that the adverse impact of financial crises on trade is especially strong for destinations with longer time to ship. Geographical distance also helped to explaining the pattern of adjustment in bilateral portfolio investment positions during the global financial crisis (Galtsyan and Lane (2013)). Moreover, Békés et al. (2017) examine how exporting firms adapt to the uncertainty stemming from demand volatility using customs data from France. They show inter alia that firms send less frequent, larger shipments to more uncertain markets, and that the effect of demand volatility is magnified on markets with longer-time-to-ship.

A systematic examination of the effect of distance on the volatility of international trade is, however, still lacking. This is an important issue both from a research perspective, e.g. for the design of open-economy macro models, and from a policy perspective, insofar as the volatility of trade matters at least as much for policy-makers as its level.[6]

The debate between the "footloose" or "beachhead" views is well established in international trade. For instance, Japanese firms that entered US markets in the early 1980s when the dollar was strong did not abandon their sunk investments when the dollar fell in the wake of the Plaza agreement of 1985. Once firms had invested in marketing, R&D, reputation, distribution networks, etc., they found it profitable to remain in US markets even at a lower exchange rate (Dixit (1989)).

Our work is also related to the studies considering various proxies for distance. A first set of measures is aimed at how similar the various countries are. One metric focuses on how close various languages are with each other (Isphording and Otten (2013), Melitz and Toubal (2014), Otten (2013)). A second approach focuses on the genetic distance between various populations (Fensore, Legge and Schmid (2016), Giuliano, Spilimbergo and Tonon (2013), Spolaore and Wacziarg (2016)). Still another set of measures pertains to the extent of information flows. While earlier studies focused on volumes of phone calls, the measures have recently been broadened with a focus on the impact of the

[6] For instance, G20 Heads of State and Governments have sought to take actions to increase the resilience of their economies to "volatile capital flows" at their Cannes summit of 2011 (Group of Twenty (2011)).

internet (Blum and Goldfarb (2006), Chung (2011), Freund and Weinhold (2004), Hellmanzik and Schmitz (2017)).

3. A Simple Model of Heterogeneous Trade Adjustment

3.1 *General Approach*

Existing contributions have shown that the impact of financial crises on trade is related to distance. Schmidt-Eisenlohr (2013) shows that trade finance is a central element of the overall contract between exporters and importers, the more so for more distant destinations as goods remain for longer in transit. Berman and al. (2013) test the relevance of time to ship in the contraction of trade during the global crisis. Trade finance is provided by banks that are exposed to risk as long as the shipment is on its way. A banking crisis leads banks to reduce their risk exposure, and thus reduce trade finance more strongly for distant destinations. Berman and al. (2013) show that during the global crisis trade fell more for origin-destination pairs that entailed longer shipments.

The role of time to ship focuses on shocks that affect the transaction costs of trade, such as iceberg costs. A shock that raises these costs will naturally depress trade more substantially for flows with a higher transaction costs. While there is clear evidence for this channel, it relies on shocks affecting the entities that finance trade, and can thus be limited to times of financial crises. We instead consider a more general approach where shocks do not directly bear on the transaction costs. Our model thus applies more broadly to periods of standard economic fluctuations rather than just to times of financial crises.

Our approach emphasizes the presence of heterogeneous elasticities of substitution between goods, building on the work by Atkeson and Burstein (2008). They consider a nested Constant Elasticity of Substitution (CES) model of sectors and brands within sectors, with the elasticity across brands being larger than the one across sectors. When firms are not atomistic, a firm's market share in its sector of activity affects the price elasticity of demand that it faces, and hence its markup. Specifically, a firm with a small market share competes against other firms in its sector and faces a relatively high elasticity of demand. This limits the changes in its prices following a shock, out of concern of losing customers to other firms. By contrast, a firm with a high market share competes more against firms in other sectors, and faces a lower elasticity of demand.

We consider a model where exporters face fixed and variable exporting costs. The number of firms is limited and when setting prices an individual exporter in a specific sector takes account of her impact on the sectoral price index. The number of firms then affects the elasticity of demand, which in turn impacts profits. With free entry, the number of firms is endogenously determined by a zero profit condition. Under the assumption that more distant destinations entail larger trade costs, the impact of distance operates through the equilibrium number of firms.

3.2 *Key Elements*

3.2.1 *Demand*

We keep the model complexity to a minimum, and focus on the main points.[7] We consider a static model where exporters sell to a market where they face domestic competition. The consumers in the market minimize the expenditure required to fund a consumption basket C which consists of sub-baskets of domestic brands C^D and imported brands C^I:

$$C = \left[(C^D)^{(\eta-1)/\eta} + (C^I)^{(\eta-1)/\eta}\right]^{\eta/(\eta-1)}$$

where η is the elasticity of substitution between domestic and imported sub-baskets. Each in turn consists of a discrete number of brands (n^D and n^I for domestic and imported brands, respectively):

$$C^D = \left[\sum_{k=1}^{n^D} (C_k^D)^{(\rho-1)/\rho}\right]^{\rho/(\rho-1)} \qquad C^I = \left[\sum_{k=1}^{n^I} (C_k^I)^{(\rho-1)/\rho}\right]^{\rho/(\rho-1)}$$

where ρ is the elasticity of substitution between brands. Following Atkeson and Burstein (2008), we make the standard assumption that brands are more easily substitutable than sub-baskets, i.e. $\rho > \eta$.[8] The difference between the two elasticities is a central element of the model.

The consumers' optimization leads to a standard demand function for an individual brand. It reflects overall demand for domestic and imported brands, the price of the brand in question, the price of its respective sub-basket (domestic or imported), and the price of the overall consumption basket. Specifically, the demands for individual domestic and imported brands are:

[7] The detailed derivations are presented in an appendix available on request.

[8] We also make the standard assumption that $\infty > \rho > 1$.

$$C_k^D = (P_k^D)^{-\rho}(P^D)^{\rho-\eta}P^\eta C \qquad ; \qquad C_k^I = (P_k^I)^{-\rho}(P^I)^{\rho-\eta}P^\eta C \tag{1}$$

where the price index of the overall basket is $P = [(P^D)^{1-\eta} + (P^I)^{1-\eta}]^{1/(1-\eta)}$ and the price indices for the sub-baskets of domestic and imported goods are:

$$P^D = \left[\sum_{k=1}^{n^D}(P_k^D)^{1-\rho}\right]^{1/(1-\rho)} \qquad P^I = \left[\sum_{k=1}^{n^I}(P_k^I)^{1-\rho}\right]^{1/(1-\rho)}$$

An important element is that these baskets are treated as endogenous by firms. As the number of firms is limited, an individual firm takes the impact of its price P_k^I on the index P^I into account. In the remainder of this section, we focus on the optimization problem of exporting firms. The overall demand C in (1) is the source of shocks in the analysis.

3.2.2 *Technology, profits and pricing*

We assume that an exporter *k* produces using an amount N_k^I of labor with a technology displaying decreasing returns to scale: $Y_k^I = \alpha^{-\alpha}(N_k^I)^\alpha$ where $\alpha \leq 1$. The exporter faces two costs, namely a standard iceberg trading cost τ that reduces the income from sales, and a fixed cost F^I. The profits of the exporter are then:

$$\Pi_k^I = (1-\tau)P_k^I Y_k^I - W^I N_k^I - F^I C \tag{2}$$

The marginal cost reflects the wage and output (the latter reflecting decreasing returns to scale):

$$MC_k^I = \partial(W^I N_k^I + F^I)/\partial Y_k^I = W^I (Y_k^I)^{(1-\alpha)/\alpha}$$

The exporter sets price P_k^I to maximize profits, taking account of the demand it faces as well as its impact on sub-basket price P^I. Profit maximization implies that the price is set as a markup over marginal cost:

$$P_k^I = \frac{\varepsilon_k^I}{\varepsilon_k^I - 1}\frac{MC_k^I}{1-\tau} = \left(\frac{\varepsilon_k^I}{\varepsilon_k^I - 1}\frac{W^I}{1-\tau}\right)^{\frac{\alpha}{\alpha+\eta(1-\alpha)}}\left((s_k^I)^{\frac{\rho-\eta}{\rho-1}}P^\eta C\right)^{\frac{1-\alpha}{\alpha+\eta(1-\alpha)}} \tag{3}$$

The elasticity of demand ε_k^I faced by the exporter is a weighted average of the elasticities ρ and η where weights reflect the exporter's market share s_k^I:

$$\varepsilon_k^I = \rho - (\rho-\eta)s_k^I \qquad ; \qquad s_k^I = \frac{P_k^I Y_k^I}{\sum_{h=1}^{n^I} P_h^I Y_h^I} = \left(\frac{P_k^I}{P^I}\right)^{1-\rho} \tag{4}$$

Using optimal price (3), profits can be written as a function of the elasticity and market shares (4).[9]

As all firms are identical, the market share of an individual exporter simply reflects the number of firms in equilibrium: $s_k^I = 1/n^I$. We can show that the profits (2) are a decreasing function of the number of firms. Intuitively, a larger number of firms reduces the market share of each one, leading to a higher elasticity of demand ε_k^I. Faced with a higher elasticity, firms set lower markups and receive lower profits.

We consider free entry and exit of exporters. The number of firms n^I is then such that variable profits offset the fixed cost.[10] Higher fixed or variables costs from trade lower profits, and thus lead to a smaller number of firms in equilibrium. If we assume that trade costs increase with distance, the number of exporters is lower for destinations that are farther away.

3.2.3 *Numerical Illustration*

We illustrate the implications of our model by setting the elasticities at $\rho = 6$ and $\eta = 2$, the iceberg cost at $\tau = 0.1$ and considering constant returns to scale: $\alpha = 1$. Without loss of generality we set the wage, aggregate price and consumption to unity; $W^I = P = C = 1$. We consider a range of values for the number of exporters n^I between 2 and 10, and compute the implied fixed cost F^I for each of them.

We present the impact of an exogenous fall in demand of the destination country, with C decreasing by 20%.[11] We hold fixed cost F^I unchanged at the value corresponding to the initial number of exporters, and compute the new equilibrium number of exporters which brings profits to zero given the fixed cost and lower demand.[12] The new number of firms in turn gives price P_k^I reflecting the new individual

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[9] Specifically, profits are:

$$\Pi_k^I = \left[\left(\frac{\varepsilon_k^I}{\varepsilon_k^I - 1}\right)^{\frac{\alpha(1-\eta)}{\alpha+\eta(1-\alpha)}} - \alpha\left(\frac{\varepsilon_k^I}{\varepsilon_k^I - 1}\right)^{\frac{-\eta}{\alpha+\eta(1-\alpha)}}\right] \times \left[(1-\tau)^\eta (W^I)^{\alpha(1-\eta)} (s_k^I)^{\frac{\rho-\eta}{\rho-1}} P^\eta C\right]^{\frac{1}{\alpha+\eta(1-\alpha)}} - F^I$$

[10] For brevity we take the number of domestic firms n^D as given. It could be set endogenously along similar lines.

[11] We hold the overall price index unchanged. Our analysis of the movements in the price of imported brands should thus be understood in terms of relative prices.

[12] For clarity of presentation of the results, we do not impose that the new number of firms is an integer. Doing so would only amplify the magnitude of our results.

market share, and the volume and value of exports for an individual firm, Y_k^I and $P_k^I Y_k^I$, as well as across all exporters, $\sum_{h=1}^{n^I} Y_h^I$ and $\sum_{h=1}^{n^I} P_h^I Y_h^I$.[13]

Figure 1 shows the impact of the contraction in foreign demand for different values of the initial number of exporting firms. The lower demand reduces profits, leading to a contraction in the number of firms to restore the zero-profit-condition (top left panel of Figure 1). The surviving firms have a higher market share and thus face a lower elasticity of demand ε_k^I. This leads them to increase their markup and price (top right panel), which in turn lowers real exports of each individual firm. The overall volume of trade falls even more as the number of firms decreases (bottom left panel). In terms of overall export values, there is a tension between higher prices and lower volumes. If the increase in price is moderate enough, the shift in volume dominates and the value of overall exports falls (bottom right panel).

The impact of distance can be read by contrasting different values of the initial number of exporting firms. More distant destinations are associated with a smaller number of exporters, as trade to these destination entails higher fixed or variable costs. Exports to distant destinations thus correspond to points towards the left in each panel. The figure clearly shows that a given decrease in foreign demand leads to a larger contraction of trade for distant destinations with a limited number of firms. The model hence predicts that distance magnifies trade volatility, in line with the "footloose" hypothesis.

[Figure 1 about here]

[13] That mechanism echoes the evidence of Corsetti, Dedola and Trezzi (2017) in a domestic economy context whereby negative house price shocks across US regions between 2008 and 2013 led to relative increases in the price of services which – in light of standard price Phillips curve models– also points to a potentially important role for adjustment in firms' mark-ups.

3.2.4 *Sensitivity Analysis*

We assess the sensitivity of our results to alternative calibrations. Figure 2 presents the impact of the foreign demand contraction on the total volume of trade (left panel) and its value (right panel). The solid line corresponds to our baseline calibration of Figure 1.

Our results are not sensitive to the extent of returns to scale. Figure 2 shows that considering decreasing returns ($\alpha = 0.75$, dashed lines) only has a limited impact.

The results are more sensitive to the elasticities of substitution. When brands are closer substitutes that in our baseline ($\rho = 10$, dotted line), the trade contraction is less pronounced. The pattern of a larger contraction for more distant destinations with fewer firms still remains, consistent with the "footloose" hypothesis. The contraction of trade following an adverse demand shock is also dampened when domestic and imported goods are not as substitutable as in our baseline ($\eta = 1$, lines with crosses). While the pattern of a larger contraction for more distant destinations remains in terms of trade volume, it is not present any longer in terms of value as the unit elasticity implies that price and volume movements offset each other.

[Figure 2 about here]

We explore the sensitivity to elasticities further in Figure 3, focusing on whether the trade contraction is more pronounced when the initial number of exporters is limited. Specifically, we consider three possible values for each elasticity: $\rho = 6, 8, 10$ and $\eta = 1, 3, 5$, for a total of nine combinations. For each combination we compute the impact of a 20% reduction in demand C. We first do so for a small initial number of firms ($n^I = 2$, with the associated fixed cost), and then repeat the exercise for a larger number of firms ($n^I = 5$, with a different fixed cost). Comparing the trade decrease for low and high numbers of firms gives us the extent to which trade contracts more for more distant destinations.

Figure 3 illustrates the effect of distance for the contraction of overall trade in terms of volume (left panel) and value (right panel). Each panel shows the nine combinations of elasticities. For each combination, the bar shows by how much more trade contracts for distant destinations (2 firms instead of 5). For instance, when $\rho = 8$ and $\eta = 5$, the total value of trade falls by 44.8 percent when there are initially 2 firms and 41.1 percent when there are 5 firms. The difference of 3.7 percentage points is depicted by the middle bar in the last row in the right panel. The stripped bars correspond to the combinations of elasticities where the gap between ρ and η is held at 5.

[Figure 3 about here]

The impact of elasticities is varied and reflects not only the difference between ρ and η but also their levels. The additional trade contraction for more distant destination is more pronounced when brands cannot easily be substitutable (low ρ for a given η) or when imports and domestic goods are more easily substitutable (high η for a given ρ).

The impact is also increasing with the value of the elasticities holding the gap constant ($\rho - \eta = 5$). One can therefore not make inferences solely based on one of the two elasticities. For instance, we should not expect that easier substitution between brands (a higher ρ) necessarily reduces the extra volatility of trade to more distant destinations. In fact, if substituting between imports and domestic goods also becomes easier (a higher η) the impact of distance will be more pronounced. One may have expected an opposite pattern a priori. When elasticities are high, a given difference in absolute terms represents a smaller one in relative terms.[14] One might thus expect to get closer to the case of identical elasticities, for which the number of firms is irrelevant. Our results show that this conjecture is misguided.

4. An Empirical Test of the Impact of Distance(s)

4.1 *Econometric Specifications*

This section provides a broad test of whether trade is more volatile with distance, consistently with the "footloose" pattern predicted by our model. We test this for various measures of international linkages, including financial ones in addition to trade ones, and various measures of distances, as detailed below. In addition to assessing the patterns during the Global Crisis we consider whether it is also observed generally in more

[14] When the absolute difference is held at $\rho - \eta = 5$, the relative difference $(\rho - \eta)/\eta$ is equal to 5 when $\eta = 1$, to 1.67 when $\eta = 3$ and to 1 when $\eta = 5$.

normal times over a long time series (with a focus on trade in goods due to data availability).

Our first test consists of a cross-sectional analysis of bilateral linkages between up to 186 countries during the global financial crisis of 2007-09, which represents a major shock to international linkages. Following Galstyan and Lane (2013) we estimate the following specification:

$$\ln(Y)_{i,j,2009} - \ln(Y)_{i,j,2007} = \sum_{k} \alpha_k Dist(k)_{i,j} + \sum_{h}\sum_{k} \beta_{k,h} Dist(k)_{i,j} Dist(h)_{i,j} + \gamma'\mathbf{X}_{\mathbf{i,j,2007}} + \delta \ln(Y)_{i,j,2007} + FE_i + FE_j + \varepsilon_{i,j} \quad (5)$$

Where Y is a measure of real or financial bilateral trade between countries i and j detailed below (trade in goods or in services, bilateral portfolio investment positions, bilateral foreign direct investment positions or bilateral banking positions and flows),[15] *Dist* is a measure of distance indexed by k between the two countries detailed below (physical, linguistic or virtual distance), **X** is a vector of gravity controls measured in 2007, and FE_i and FE_j are country-source and country-destination fixed effects. [16] Our estimates also control for the pre-crisis level of bilateral trade and investment positions. We estimate (5) using OLS with standard errors robust to heteroscedasticity.

Our specification (5) looks at the impact of various measures of distance on their own, as well as their interaction. From our model we expect that the decline during the crisis was larger for more distant countries ($\alpha_k < 0$). An additional question is whether the various measures of distance amplify each other. Two distinct metrics of distance k and h are complements when the marginal impact of one metric is larger when the other metric is high, i.e. $\beta_{k,h} < 0$. Otherwise the metrics are substitutes.

Our second test consists of a panel approach across dyadic (country pair) observations on bilateral trade in goods from 1950 to 2015 (our focus on trade in goods is driven by data limitations). We specifically link the volatility of trade to our measures of distance and controls:

[15] For cross-border banking, data on bilateral *transactions* are available, which we include in equation (5) as detailed below.

[16] Equation (5) is a generalization of the model estimated by Galstyan and Lane (2013) who restricted their attention to changes in bilateral portfolio investment positions and the role of physical distance.

$$SD(Y)_{ij,t} = \sum_k \alpha_k Dist(k)_{ij} + \sum_h \sum_k \beta_{k,h} Dist(k)_{ij} Dist(h)_{ij} + \boldsymbol{\gamma}'\mathbf{X_{i,j,t}} + FE_{i,t} + FE_{j,t} + \varepsilon_{i,j,t} \quad (6)$$

The periods indexed by *t* are non-overlapping 5-year windows. $SD(Y)_{ij,t}$ is the standard deviation of the annual log difference in bilateral imports of goods over the 5 years corresponding to each window. The remaining variables and parameters are defined as in Equation (5). $FE_{i,t}$ and $FE_{j,t}$ are time-varying country-source and country-destination fixed effects.

Given the high dimensionality of the time-varying fixed effects, we use the method developed by Guimaraes and Portugal (2010), which draws on an iterative (Gauss-Seidel) approach to fit linear regression models with two or more high-dimensional fixed effects under minimal memory requirements. We cluster the standard errors by dyad.

4.2 *The Data*

4.2.1 *Measures of International Linkages*

We consider an array of bilateral linkages at annual frequencies. We consider annual totals for flow data (trade in goods and services, financial flows) and year-end values for stock data (holdings of debt, equity and banking positions).

We consider two measures of trade, namely imports of goods (in value) taken from the IMF's Direction of Trade Statistics, and imports of services taken from several sources.[17] We rely on the standard "mirror data approach" if one country does not report bilateral transactions with a partner country, and use the data reported by the partner-country in question instead.

We consider five measures of international financial linkages. The first two are bilateral portfolio investment holdings of debt (short and long maturity) and equities (listed shares and investment funds), both taken from the IMF's Coordinated Portfolio

[17] The sources in question include Eurostat, the OECD statistics on international trade in services, and the United Nations' Services Trade database. We consider total cross-border transactions in services, which include transportation, tourism, construction, insurance, financial, communication, computer and information services, royalties and license fees, personal, government and other business services.

Investment Survey (CPIS).[18] The third measure is bilateral foreign direct investment positions (FDI), taken from the OECD's FDI statistics.[19] Our final two measures pertain to international bank linkages from the BIS locational banking statistics.[20] They consist of bilateral banking positions (loans and deposits), and the corresponding banking flows adjusted for valuation effects arising from exchange rates movements.[21]

4.2.2 *Metrics of Distance*

We consider three alternative metrics of distance. The first measure, physical distance, is standard, and defined as the logarithm of the kilometer distance between two nations' capital cities (using the latitudes and longitudes of the cities and question as well as the great circle formula), taken from CEPII's GeoDist data base.[22]

Our second measure is bilateral virtual distance, following Hellmanzik and Schmitz (2017). It captures the extent of internet connections between two nations and is the inverse of the measure of virtual proximity of Chung (2011). Chung relies on bilateral inter-domain hyperlinks connecting webpages for 87 countries.[23] The data cover the entire universe of websites registered on Yahoo in 2009, hence mitigating sampling bias.

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[18] The CPIS database is a standard source in the literature on international financial integration (see e.g. Lane and Milesi-Ferretti (2008)).

[19] According to the 3rd OECD benchmark definition of foreign direct investment (BMD3).

[20] Our results are robust to using BIS consolidated banking positions.

[21] In the case of banking flows, we use annual bilateral transactions. If these are negative (indicating a retrenchment), we take the logarithm of the absolute value and multiply it with -1 to remain in line with a gravity model specification.

[22] See Mayer and Zignago (2011).

[23] Chung's data were constructed in May 2009 using Yahoo's search function and LexiURL Searcher, a social science web analysis tool developed by Thelwall (2009). Yahoo index covered about 47 billion websites, with more than 9.3 billion hyperlinks included in 33.8 billion sites from 273 different top-level domains (so-called ccTLDs, such as ".de" for Germany or ".it" for Italy). Due to the bidirectional nature of the data, bilateral hyperlinks are the number of links from websites with domain.xx (i.e. from the country with domain.xx) to domain.yy (i.e. to the country with domain.yy) and vice versa. Classifying source and host countries is a relatively easy task as long as one uses country top-level domains (ccTLD). It is more challenging for non-national domain names, such as ".org" or ".edu" or ".com". Chung (2011) developed an attribution method to identify the host country of such non-national domain names. It relies on webcrawling on the 20,000 most visited webpages to allocate web traffic to the ".com" domain to a specific host country (correcting for repeated visits). As website visits in the sample follow a power law, the webcrawling results are extrapolated for webpages with less traffic. This allocation of the large ".com" domain to specific countries makes the data much richer.

We take the logarithm of his measure, and multiply it by -1 so that higher values indicate countries that are more distant in virtual terms.[24]

Our third metric is the bilateral linguistic distance, taken from Melitz and Toubal (2014). It is based on an index of linguistic proximity capturing several dimensions, including whether a dyad has a common official language, or spoken language, or native language and whether their respective language is considered by linguists as close. The index takes values between zero and one, with higher values indicating closer linguistic proximity. We transform the measure by taking the logarithm of (1 plus the index), and multiply it by -1 so that higher values indicate countries that are more distant in linguistic terms.

The three distance measures are standardized to facilitate comparison of the economic magnitude of their estimated effects on international linkages.

4.2.3 *Control Variables*

The vector **X** of control variables in (5) and (6) includes the measures typically used in gravity models insofar as they are known to influence the geography of international trade and finance. The controls include binary dummy variables equal to 1 if two countries are contiguous (common border), share a common legal system (common law), share a currency (common currency), and were ever in a colonial relationship (common colony).[25] These variables aim at capturing transaction costs or information asymmetries that affect trade and financial relations between nations; they are sometimes described as picking up "familiarity" or "connectivity" frictions. The data are from CEPII's GeoDist data base.[26] We also include as control variables the index of religious proximity of Melitz and Toubal (2014), a dummy equal to 1 if the countries have a trade agreement, and time zone differences.

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[24] For inclusion in our panel analysis, we estimate a time series of virtual distance for a set of 34 countries over 1998 to 2014 (the time series in question are available upon request). We regress in a log-log specification 2009 bilateral hyperlinks on the number of internet hosts within a dyad, as reported in the OECD Digital Economy Outlook 2015. With the obtained elasticities we can backcast a full time-series of bilateral hyperlinks.

[25] See e.g. Portes and Rey (2005) and Aviat and Coeurdacier (2007) for earlier discussions of these variables.

[26] See Mayer and Zignago (2011).

5. Econometric Results

5.1 *Distance and the Global Crisis*

5.1.1 *Baseline results*

Table 1 presents the estimated coefficients of model equation (5), with the dependent variable being the log difference in bilateral linkages between 2009 and 2007, so that a negative value represents a larger contraction. The table presents the estimated coefficient for our three metrics of distance, without any interactions between them. For brevity the coefficients on the initial level of bilateral linkage, the gravity controls and source- and destination-country fixed effects are not reported.

Our findings support the "footloose" pattern predicted by the model, with larger contraction for more distant country pairs. The effect of distance displays heterogeneity across metrics of distance and different types of international linkages.

Physical and linguistic distances have robust impacts, with negative and statistically significant coefficients across all forms of linkages (except portfolio equity holdings and bank flows for physical distance). The specific estimates for bond and equity investments are close to those of Galstyan and Lane (2013). Virtual distance also matters for trade in goods and services, as well as portfolio investment. FDI and banking linkages are however not sensitive to virtual distance, a pattern which we also find in other specifications below.

Our results show that physical distance, while clearly relevant, is not the whole story. Even after controlling for it, ease of communication matters. Countries that do not have similar languages or do not share many internet connections experienced a larger pullback in linkages during the crisis. This indicates that linkages between countries that share higher information flows proved more robust in the crisis.

FDI and banking linkages are not as robustly affected by distance as other linkages. In particular, virtual distance has no significant effect. One interpretation is that multinational firms and banks often have local operations in the destination country, in the form of local production, offices, affiliates or subsidiaries. This presence allows them to have a more comprehensive understanding of local conditions, even in countries that are far away. An alternative, albeit related, interpretation is that the local operations of the multinational and banks in question imply larger fixed costs. The presence then indicates a long term commitment from the firms and banks to the country, making them less likely to take a short-sighted view and to pull back in challenging times.

[Table 1 about here]

The effect of distance is economically substantial. The estimates of column 1 show that an increase in physical distance between two countries by one standard deviation decreased trade in goods by 23% during the Great Trade Collapse; the corresponding decreases for virtual and linguistic distances are 15% and 5%, respectively. But while physical distance has received the bulk of attention in the literature, it is not always the measure with the largest effects. For instance, virtual distance had larger impacts for transactions in services or in portfolio investments (columns 2 to 4).[27]

We undertake several robustness checks. We first replace the dependent variable by the log change of international linkages between 2008 and 2009 (instead of 2007 and 2009). The estimates in Appendix Table A1 show that the effect of distances on trade in goods and services as well as on portfolio investments remains robust, albeit somewhat weaker in economic magnitude. [28] We again find that that the effect of distance on FDI and banking is mostly insignificant.

We also compute separate estimates across country groups. Specifically we split the country pairs in three groups to focus on linkages between (i) advanced economies only, (ii) emerging market economies only, (iii) advanced economies and emerging market economies.[29] The results are reported in Panels A, B and C of Appendix Table A2). The effect of distance is weakest (mainly statistically insignificant) for linkages between advanced economies and strongest for linkages between advanced economies and emerging market economies. This is not surprising. Over half of the advanced

[27] In line with Galstyan and Lane (2013), we find a significantly negative coefficient on the pre-crisis level of real and financial trade, thus indicating that the pull back during the crisis was stronger in percentage terms for country-pairs with more intensive pre-crisis trade. This holds in particular for portfolio investment, which is in line with “reversion to the mean” behavior of investors scaling back “overweight” pre-crisis positions.

[28] The coefficient estimates on the distance measures lose statistical significance in some cases. This is likely due to the fact that 2008 observations are affected by developments following the collapse of Lehman Brothers, while this is not the case for 2007 observations.

[29] The classification between advanced and emerging economies follows the IMF’s definition.

economies are located in Europe and much closer to each other in terms of the various distance measures than they are to emerging market economies.

5.1.2 *Do Different Distances Magnify Each Other?*

We assess the extent to which our alternative measures of distance complement or substitute each other in Table 2. In addition to the direct impact of the three measures, the table also includes the interaction between physical and virtual distance. Compared to Table 1, we observe that the direct effects of physical and linguistic distances remain significantly negative for all linkages, with the exception of banking connections that are not sensitive to physical distance any longer.

The interaction between physical and virtual distance is significantly negative for trade in goods and services and portfolio investment. This shows that these two distance metrics are complements: the marginal impact of physical distance is larger in countries that are also distant in terms of internet linkages. FDI and banking positions on the other hand are not affected.

The amplification effect of physical and virtual distances is robust to including other interactions, such as the product of physical distance with linguistic distance (Appendix Table A3).[30] The latter interaction, in contrast, is mostly insignificant, thereby suggesting that physical distance and linguistic distances are neither complements nor substitutes.

[Table 2 about here]

Our results thus show that distance mattered during the crisis. International linkages contracted by more between countries that are far apart, have limited internet linkages, and have limited language commonality. The effect is more pronounced for trade in goods and services and portfolio investment, while FDI and bank positions are less sensitive. Physical and virtual distances also amplify each other.

[30] The interacted effect on FDI and banking transactions is again statistically insignificant.

5.2 *Panel Estimates*

5.2.1 *Baseline results*

Our results so far apply to a large but exceptional episode. The question remains as to whether distances generally matter for movements in international linkages, i.e. also in more normal times. We address this with the panel model described in Equation (6) for trade in goods, with the dependent variable being the standard deviation of the annual growth rate in bilateral imports over 5-year windows.

Distances matter, in a heterogeneous way, as shown in Table 3, which for brevity again presents only the coefficients on the distance measures.[31] When considering all measures (column (1)), we find the physical and linguistic distances play no role, while virtual distance leads to more volatile trade flows. A caveat is that virtual distance is only available in recent years and for a smaller set of countries, which reduces the sample by a factor of four. Abstracting from virtual distance (column (2)) we find that physical distance matters for trade volatility, as does linguistic distance (marginally). The impact of distance is thus not confined to the Global Crisis period.

Our results point out that while gravity applies to both the level and changes of trade flows, it can do so in different ways. A long-standing literature has shown that physical distance matters for the level of trade flows. We find that it also matters for the volatility of trade flows. Our results over the shorter sample, however, suggest that fluctuations reflect the effect of information frictions alongside those of physical distance on transaction costs.

As a robustness check we obtained estimates excluding the global financial crisis of 2007-09 to make sure that the results are not dominated by the significant surge in volatility that occurred in this period. The results are broadly unchanged (Appendix Table A4). We also consider trade volatility over 10 year windows. Appendix Table A5 shows that the results are broadly unchanged.

Finally it could be argued that volatility of trade is a function of its level. We take up this issue in Table A6 where we use a coefficient of variation measure as our

[31] The regressions include the control variables of model equation (5) as well as time-varying source- and destination-country fixed effects.

dependent variable.[32] We find again evidence that distance amplifies trade volatility (see columns 1 to 4). As yet another robustness check we use our basic dependent variable and control for lagged average bilateral trade; that distance amplifies trade volatility comes out again strongly from the estimates (see columns 5 to 8).[33]

[Table 3 about here]

5.2.2 *Amplification*

We now assess whether the metrics of distance amplify each other in terms of their impact on trade volatility. Table 4 presents the results including interactions between our various metrics. Interactions are included jointly in column (1) and individually in columns (2) to (4).

The results confirm the finding from the Global Crisis sample that alternative distance metrics are complements rather than substitutes. Specifically, virtual distance amplifies the impact of physical and linguistic distances.[34] When all direct and interacted effects are included at the same time (column (1)), we find no evidence that distance directly amplify trade volatility. If anything, virtual distance dampens it. There is, however, an effect in terms of interactions. Countries that are further apart in terms of geography or language face more volatile trade flows, provided that they are also apart in terms of virtual distance.

We also consider interactions one by one. The magnification effect of virtual distance is robust to this alternative specification, as shown in columns (2) and (4). We find no evidence of any amplification between language and physical distance, even

[32] In other words, we scale the standard deviation of the annual growth rate in bilateral imports of goods over non-overlapping 5-year windows of observations by the average level of bilateral trade during this period.

[33] We do not control in this specification for the standard gravity covariates as they are obviously correlated with lagged average trade; but we use time-varying exporter and importer fixed-effects throughout.

[34] The joint effect of physical and linguistic distances is statistically insignificant, in contrast (see columns (1) and (3) of Table 4).

when allowing for this only interaction, which allows us to use the longer sample (column 3).

Our results are robust to considering windows of 10 years instead of 5 for the computation of trade volatility, as shown in Appendix Table A.7.

[Table 4 about here]

6. Conclusion

This paper considers whether distance impacts the volatility of international real and financial trade beyond its well-established relevance for the level of trade. A simple model points out that trade can be more sensitive to demand shocks between more distant countries, due to differences in reaction in exporters' markups. This is in line with the "footloose" hypothesis that transactions between more distant countries are less resilient. We test this implication of the model by looking at a broad range of international linkages and metrics of distance. We first show that linkages contracted disproportionately more during the Great Trade Collapse of 2007-09 for countries that are more distant in terms of geography, language, and internet connections, and that the different metrics of distance amplify each other. We then show that distance is associated with more volatile trade flows when considering a panel approach on a longer sample.

These findings are relevant for future research and policy. Policymakers have long been concerned about international spillovers of growth through trade and financial linkages. Our findings suggest that these concerns apply particularly to more distant partners. We also showed that the "distance effect" is heterogeneous across types of linkages and types of distances. The role of virtual distance, for instance, suggests that strengthening information linkages can limit volatility, both directly and by reducing the impact of physical distance.

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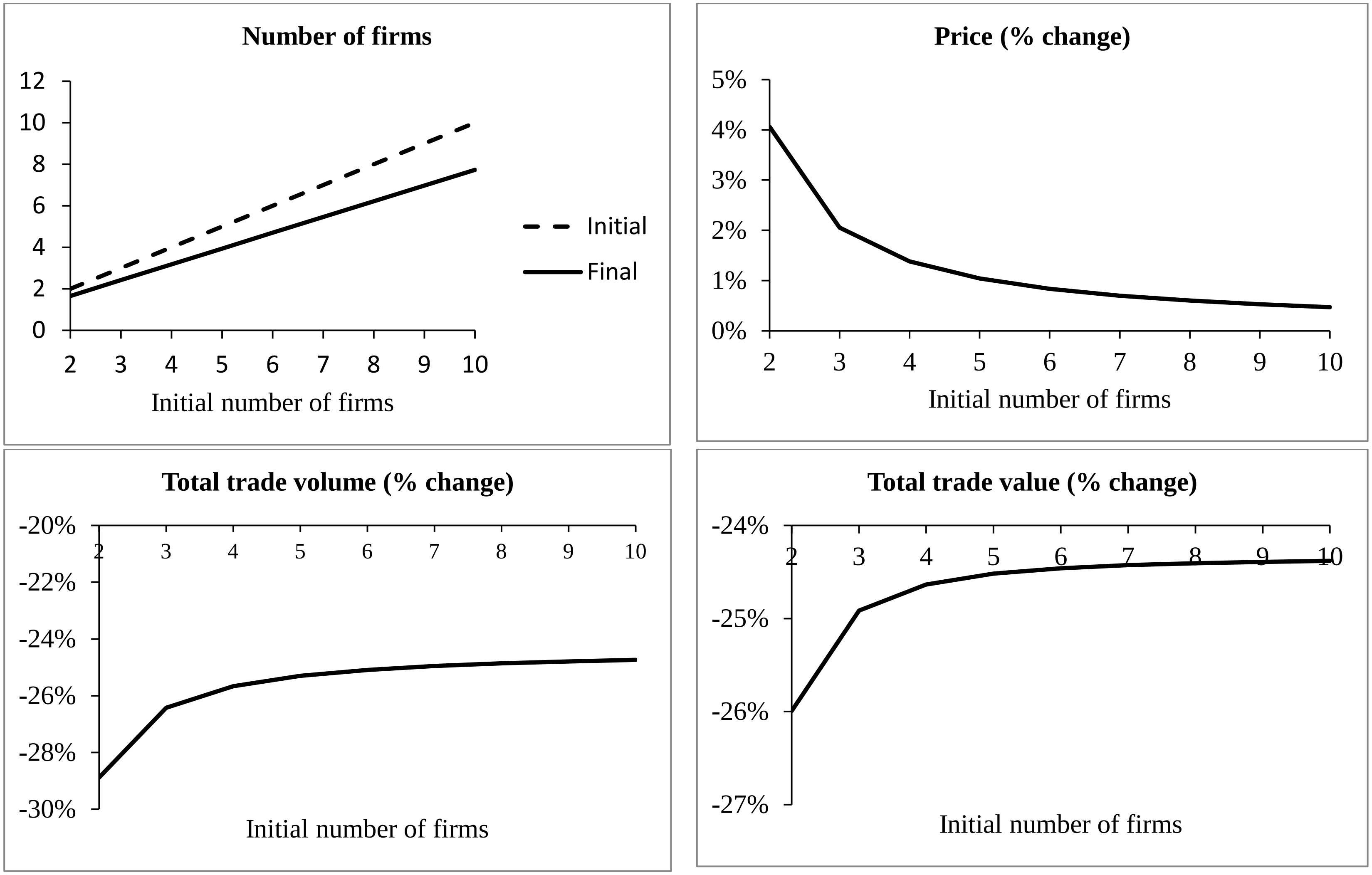
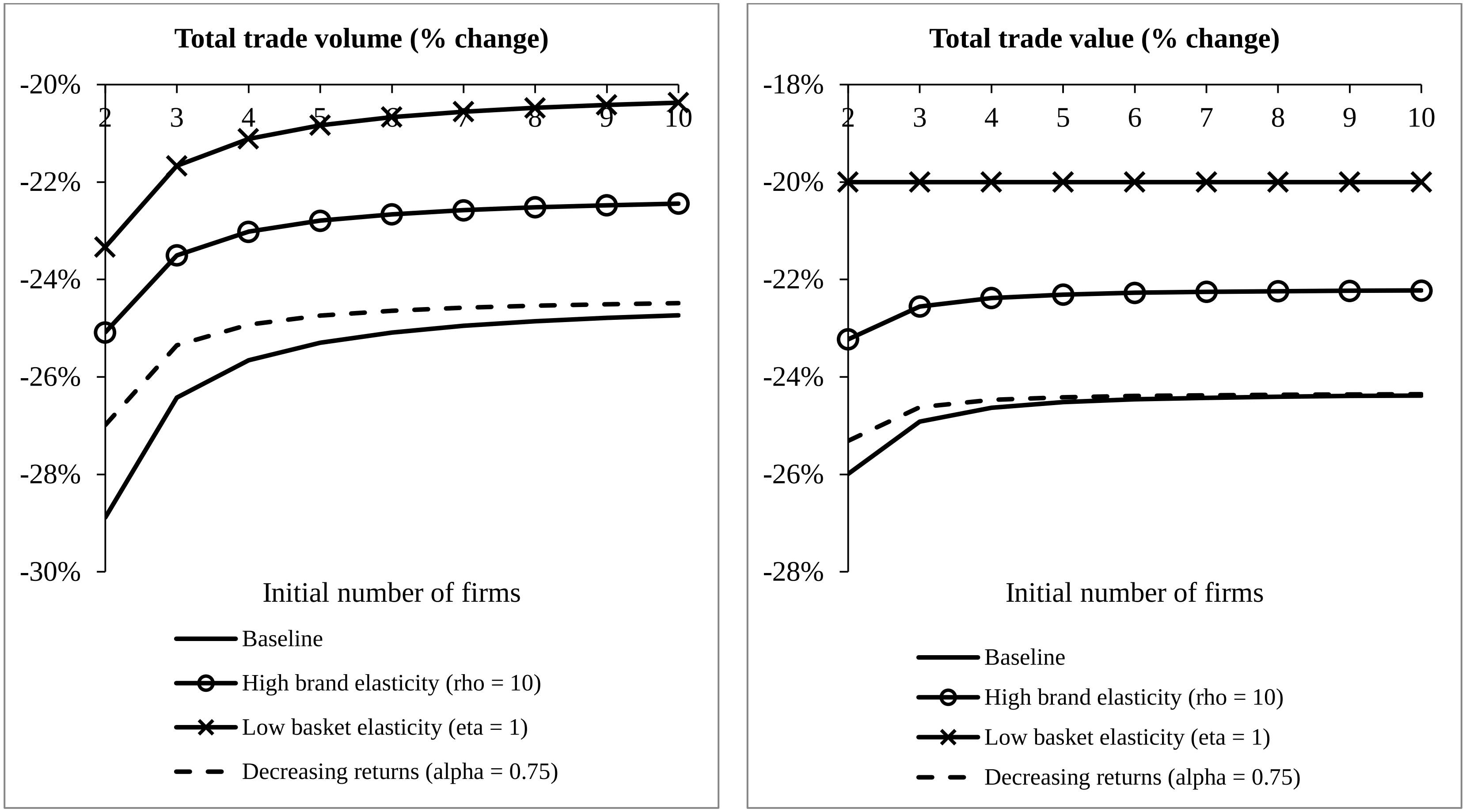
Figure 1: Impact of a Decline in Foreign Demand



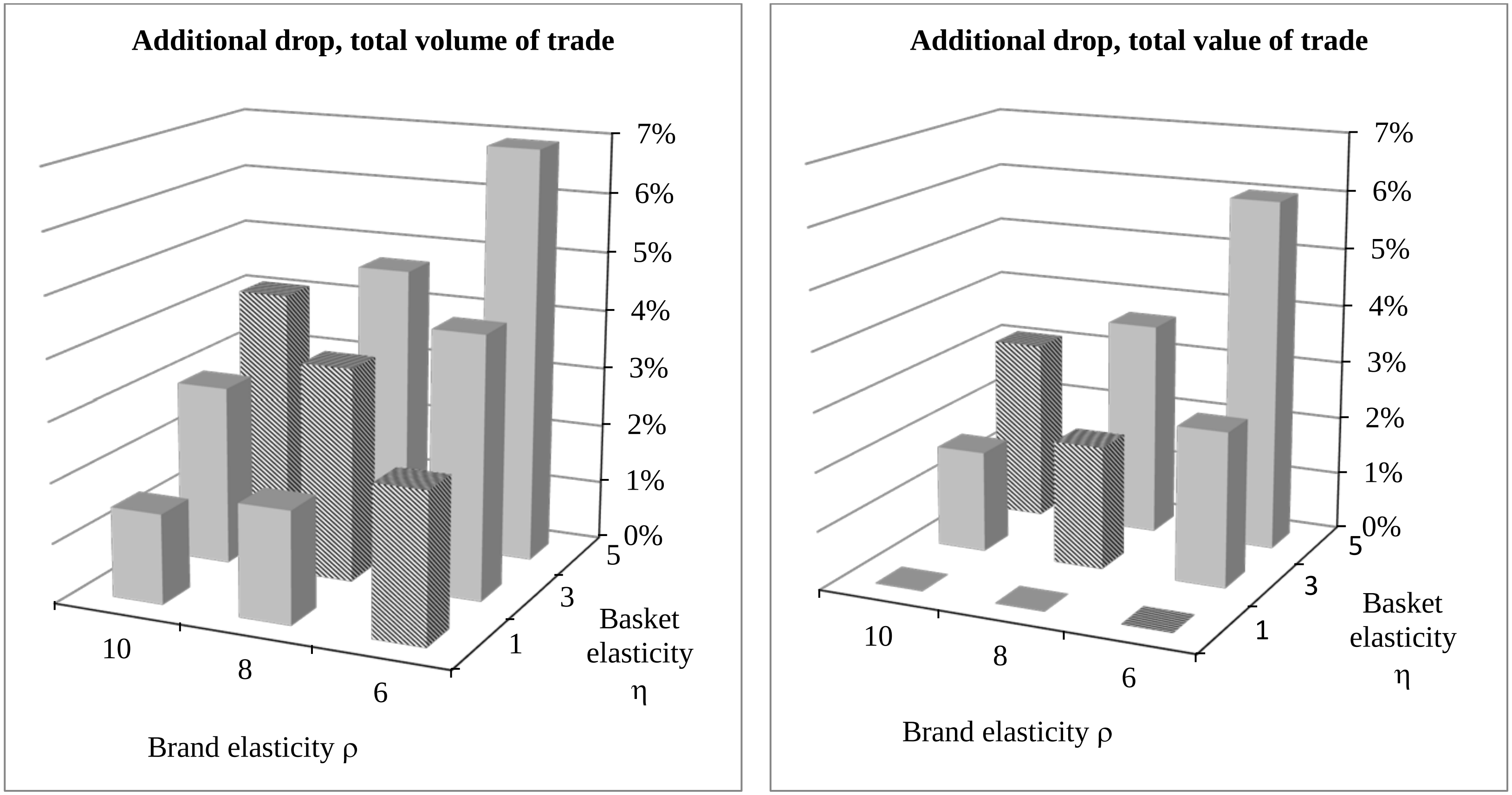
Notes: the figures show the impact of a 20 % decrease in foreign demand (C) under the following parameterization: $\rho = 6$, $\eta = 2$, $\alpha = 1$. The panels shows the initial and post-shock number of firms (top left), the impact on the price (top right), the impact on total exports in volume (bottom left) and value (bottom right). All effects are shownfor various values of the initial number of firms (horizontal axis).

Figure 2: Sensitivity Analysis



Notes: the figure shows the sensitivity of the results to alternative calibrations. It depicts the baseline calibration (solid line), the case of decreasing returns to scale ($\alpha = 0.75$, dotted line), the case of high elasticity of substitution between imported brands ($\rho = 10$, rounded line) and the case of low elasticity of substitution between imported and domestic baskets ($\eta = 1$, crossed line). The panels show the impact of a drop in foreign demand on total exports in volume (left panel) and value (right panel). All effects are shown for various values of the initial number of firms (horizontal axis).

Figure 3: Sensitivity to Elasticities



Notes: the figure shows the sensitivity to the elasticities of substitution between imported brands (ρ, left horizontal axis) and between imported and domestic baskets (η, right horizontal axis). The bars show the additional percentage fall in total exports in volume (left panel) and value (right panel) when there are few firms ($n^I = 2$) compared to when there are more firms ($n^I = 5$), with positive values indicating a larger contraction of trade when there are few firms. The stripped bars corresponds to the combination where the elasticity difference is set at $\rho - \eta = 5$.

Table 1: Event Study – Basic Estimates

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(phyiscal distance)	-0.235***	-0.152***	-0.077	-0.145***	-0.140***	-0.187***	0.393
	(0.029)	(0.028)	(0.053)	(0.054)	(0.041)	(0.064)	(0.345)
ln(virtual distance)	-0.148**	-0.361***	-0.509***	-0.335**	-0.025	0.087	-0.848
	(0.064)	(0.084)	(0.165)	(0.140)	(0.117)	(0.180)	(0.919)
ln(1+language distance)	-0.049***	-0.035**	-0.127***	-0.063*	-0.061**	-0.103**	-0.579**
	(0.018)	(0.016)	(0.036)	(0.038)	(0.027)	(0.044)	(0.249)
Observations	6,566	2,935	1,631	1,800	1,288	1,509	1,576
R^2	0.194	0.211	0.385	0.316	0.300	0.235	0.165
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (5) obtained by OLS where the log change in bilateral cross-border transactions over 2007-2009 is the dependent variable. Each measure of bilateral cross-border transactions is regressed on the three alternative measures of distance, the pre-crisis levels of the transactions in question, the gravity controls and source- and destination-country fixed-effects. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** p<0.01, ** p<0.05, * p<0.1.

Table 2: Event Study – Complementarities between Distance Measures

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(physical distance) × ln(virtual distance)	-0.051***	-0.070***	-0.172***	-0.106***	-0.043	-0.011	-0.457*
	(0.016)	(0.023)	(0.038)	(0.038)	(0.029)	(0.046)	(0.247)
ln(physical distance)	-0.393***	-0.407***	-0.708***	-0.535***	-0.302**	-0.230	-1.346
	(0.064)	(0.091)	(0.160)	(0.158)	(0.120)	(0.200)	(0.950)
ln(virtual distance)	0.413**	0.384	1.367***	0.874*	0.436	0.209	4.164
	(0.193)	(0.242)	(0.453)	(0.460)	(0.329)	(0.536)	(2.785)
ln(1+language distance)	-0.041**	-0.038**	-0.120***	-0.060	-0.064**	-0.103**	-0.589**
	(0.018)	(0.016)	(0.036)	(0.038)	(0.027)	(0.044)	(0.248)
Observations	6,566	2,935	1,631	1,800	1,288	1,509	1,576
R^2	0.196	0.213	0.393	0.319	0.301	0.235	0.167
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade / positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (5) obtained by OLS where the log change in bilateral cross-border transactions over 2007-2009 is the dependent variable. Each measure of bilateral cross-border transactions is regressed on the interaction of physical distance and virtual distance, as well as on the three alternative measures of distance, the pre-crisis levels of the transactions in question, the gravity controls and source- and destination-country fixed-effects. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Panel Estimates

	(1)	(2)
ln(physical distance)	-0.001	0.030***
	(0.008)	(0.010)
ln(virtual distance)	0.006***	
	(0.001)	
ln(1+language distance)	-0.002	0.009+
	(0.005)	(0.006)
Observations	6,599	27,367
R^2	0.232	0.253
Time-varying exporter fixed effects	yes	yes
Time-varying importer fixed effects	yes	yes
Other gravity controls	yes	yes

Notes: the table reports panel estimates of model equation (6) where the standard deviation of the annual log change in bilateral imports of goods between countries measured over non-overlapping 5-year windows of observations is the dependent variable. The three measures of distance are entered jointly as explanatory variables in the specification of column (1), while virtual distance (for which data availability is poorer) is excluded from the specification of column (2). The regressions include the remaining control variables as in model equation (5); country-time fixed effects are also included throughout. Given the high dimensionality of the fixed effects in question, we use the method developed by Guimaraes and Portugal (2010). Standard errors are clustered by dyads; *** p<0.01, ** p<0.05, * p<0.1, $^+$ p<0.15.

Table 4: Panel Estimates – Complementarities between Distance Measures

	(1)	(2)	(3)	(4)
ln(physical distance) × ln(virtual distance)	0.002***	0.002***		
	(0.000)	(0.000)		
ln(physical distance) × ln(language distance)	-0.000		0.001	
	(0.003)		(0.003)	
ln(language distance) × ln(virtual distance)	0.002***			0.002***
	(0.000)			(0.000)
ln(physical distance)	0.006	0.006	0.033***	
	(0.010)	(0.008)	(0.012)	
ln(virtual distance)	-0.010**	-0.015***		0.010***
	(0.004)	(0.004)		(0.001)
ln(1+language distance)	0.005		-0.005	0.006
	(0.025)		(0.031)	(0.006)
Observations	6,599	6,599	27,367	6,599
R^2	0.239	0.236	0.253	0.235
Time-varying exporter fixed effects	yes	yes	yes	yes
Time-varying importer fixed effects	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes

Notes: the table reports panel estimates of model equation (6) where the standard deviation of the annual log change in bilateral imports of goods between countries measured over non-overlapping 5-year windows of observations is the dependent variable. The regressions include the measures of distance and their interacted effects, which are included jointly in the specification of column (1) and individually in the specifications of columns (2) to (4). The regressions include the remaining control variables as in model equation (5); country-time fixed effects are also included throughout. Given the high dimensionality of the fixed effects in question, we use the method developed by Guimaraes and Portugal (2010). Standard errors are clustered by dyads.

ONLINE APPENDIX: NOT FOR PUBLICATION

Table A1: Event Study – Estimates for 2008-2009

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(phyiscal distance)	-0.190***	-0.084***	-0.037	-0.066	-0.069*	-0.041	0.861***
	(0.025)	(0.023)	(0.049)	(0.047)	(0.041)	(0.049)	(0.323)
ln(virtual distance)	-0.104**	-0.074	-0.530***	-0.290**	0.018	-0.036	0.065
	(0.047)	(0.069)	(0.153)	(0.123)	(0.121)	(0.161)	(0.828)
ln(1+language distance)	-0.052***	-0.035**	-0.073**	-0.057	-0.028	-0.017	-0.147
	(0.014)	(0.014)	(0.031)	(0.035)	(0.022)	(0.029)	(0.235)
Observations	6,607	3,017	1,676	1,785	1,413	1,538	1,578
R^2	0.154	0.172	0.272	0.283	0.133	0.182	0.189
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (5) obtained by OLS where the log change in bilateral cross-border transactions over 2008-2009 is the dependent variable. Each measure of bilateral cross-border transactions is regressed on the three alternative measures of distance, the pre-crisis levels of the transactions in question, the gravity controls and source- and destination-country fixed-effects. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A2: Event Study – Estimates by Country Groups

A. ***Only Advanced Economies***

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(phyiscal distance)	-0.028	-0.072***	-0.127*	0.017	-0.050	-0.085	0.702
	(0.025)	(0.025)	(0.068)	(0.076)	(0.055)	(0.111)	(1.018)
ln(virtual distance)	-0.141	-0.324***	-0.646***	0.001	0.029	-1.040***	-6.181*
	(0.093)	(0.104)	(0.224)	(0.287)	(0.182)	(0.372)	(3.412)
ln(1+language distance)	-0.024*	-0.016	0.062	-0.037	0.003	-0.098	-0.729
	(0.014)	(0.015)	(0.043)	(0.048)	(0.043)	(0.078)	(0.703)
Observations	525	525	503	457	474	382	334
R^2	0.347	0.347	0.324	0.435	0.539	0.253	0.282
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

B. ***Only Emerging Market Economies***

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(phyiscal distance)	-0.361***	-0.371***	-0.357**	-0.235	-0.296	-0.040	1.775*
	(0.053)	(0.085)	(0.162)	(0.149)	(0.248)	(0.240)	(0.916)
ln(virtual distance)	-0.160	-0.686***	0.346	-0.379	0.187	0.188	-1.229
	(0.103)	(0.261)	(0.411)	(0.393)	(0.423)	(0.536)	(1.833)
ln(1+language distance)	-0.071**	-0.105**	-0.159	-0.230	0.153	-0.068	0.351
	(0.031)	(0.054)	(0.115)	(0.142)	(0.162)	(0.178)	(0.675)
Observations	3,138	667	248	274	137	212	230
R^2	0.213	0.392	0.616	0.540	0.655	0.566	0.428
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

C. *Advanced Economies to/from Emerging Market Economies*

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(phyiscal distance)	-0.210***	-0.193***	-0.134	-0.264***	-0.259***	-0.379***	-1.038**
	(0.043)	(0.039)	(0.095)	(0.102)	(0.082)	(0.126)	(0.507)
ln(virtual distance)	-0.121	-0.291***	-0.648**	-0.400*	0.030	0.174	-1.661
	(0.101)	(0.100)	(0.279)	(0.225)	(0.155)	(0.226)	(1.102)
ln(1+language distance)	-0.063**	-0.072***	-0.169**	-0.212***	-0.109**	-0.149*	-0.686**
	(0.026)	(0.027)	(0.073)	(0.080)	(0.047)	(0.078)	(0.279)
Observations	2,855	1,750	924	1,040	766	952	998
R^2	0.292	0.260	0.466	0.398	0.330	0.277	0.234
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (5) obtained by OLS where the log change in bilateral cross-border transactions over 2008-2009 is the dependent variable and the estimates are restricted to three country groups: (i) advanced economies only (Panel A); (ii) emerging market economies only (Panel B); (iii) advanced economies to/from emerging market economies (Panel C). Each measure of bilateral cross-border transactions is regressed on the three alternative measures of distance, the pre-crisis levels of the transactions in question, the gravity controls and source- and destination-country fixed-effects. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** p<0.01, ** p<0.05, * p<0.1.

Table A3: Event Study – Robustness Check on Complementarities

	(1) Goods imports	(2) Services imports	(3) Portfolio Equity	(4) Portfolio Debt	(5) FDI	(6) Bank loans (stocks)	(7) Bank loans (flows)
ln(physical distance) × ln(virtual distance)	-0.050***	-0.069***	-0.170***	-0.102***	-0.042	0.015	-0.328
	(0.016)	(0.023)	(0.038)	(0.038)	(0.029)	(0.049)	(0.260)
ln(physical distance) × ln(language distance)	0.014*	-0.001	-0.008	-0.025	-0.001	-0.044**	-0.257
	(0.009)	(0.008)	(0.017)	(0.019)	(0.013)	(0.021)	(0.162)
ln(physical distance)	-0.363***	-0.407***	-0.716***	-0.569***	-0.302**	-0.215	-1.357
	(0.068)	(0.091)	(0.162)	(0.161)	(0.120)	(0.201)	(0.959)
ln(virtual distance)	0.414**	0.378	1.336***	0.806*	0.428	-0.114	2.528
	(0.193)	(0.247)	(0.458)	(0.460)	(0.339)	(0.572)	(2.972)
ln(1+language distance)	-0.185**	-0.027	-0.039	0.194	-0.051	0.360	2.127
	(0.086)	(0.080)	(0.174)	(0.190)	(0.125)	(0.222)	(1.799)
Observations	6,566	2,935	1,631	1,800	1,288	1,509	1,576
R^2	0.196	0.213	0.393	0.320	0.301	0.237	0.169
Exporter fixed effects	yes	yes	yes	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
Pre-crisis trade / positions	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (5) obtained by OLS where the log change in bilateral cross-border transactions over 2007-2009 is the dependent variable. Each measure of bilateral cross-border transactions is regressed on two interactions (physical distance and virtual distance as well as physical distance and language distance), the three alternative measures of distance, the pre-crisis levels of the transactions in question, the gravity controls and source- and destination-country fixed-effects. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** p<0.01, ** p<0.05, * p<0.1.

Table A4: Panel Estimates – Excluding the Global Financial Crisis

	(1)	(2)
ln(physical distance)	-0.001	0.024**
	(0.009)	(0.010)
ln(virtual distance)	0.008***	
	(0.001)	
ln(1+language distance)	-0.003	0.008#
	(0.006)	(0.006)
Observations	5,653	23,319
R^2	0.243	0.248
Time-varying exporter fixed effects	yes	yes
Time-varying importer fixed effects	yes	yes
Other gravity controls	yes	yes

Notes: the table reports panel estimates of model equation (6) where the standard deviation of the annual log change in bilateral imports of goods between countries measured over non-overlapping 5-year windows of observations is the dependent variable, excluding the 2007-09 global financial crisis period. The three measures of distance are entered jointly as explanatory variables in the specification of column (1), while virtual distance (for which data availability is poorer) is excluded from the specification of column (2). The regressions include the remaining control variables as in model equation (5); country-time fixed effects are also included throughout. Given the high dimensionality of the fixed effects in question, we use the method developed by Guimaraes and Portugal (2010). Standard errors are clustered by dyads; *** p<0.01, ** p<0.05, * p<0.1, $^{+}$ p<0.15, $^{\#}$ p<0.20.

Table A5: Panel Estimates – 10-year Windows

	(1)	(2)
ln(physical distance)	-0.009	0.023**
	(0.008)	(0.011)
ln(virtual distance)	0.005***	
	(0.001)	
ln(1+language distance)	0.001	0.008#
	(0.005)	(0.006)
Observations	3,779	15,961
R^2	0.296	0.319
Time-varying exporter fixed effects	yes	yes
Time-varying importer fixed effects	yes	yes
Other gravity controls	yes	yes

Notes: the table reports panel estimates of model equation (6) where the standard deviation of the annual log change in bilateral imports of goods between countries measured over non-overlapping 10-year windows of observations is the dependent variable. The three measures of distance are entered jointly as explanatory variables in the specification of column (1), while virtual distance (for which data availability is poorer) is excluded from the specification of column (2). The regressions include the remaining control variables as in model equation (5); country-time fixed effects are also included throughout. Given the high dimensionality of the fixed effects in question, we use the method developed by Guimaraes and Portugal (2010). Standard errors are clustered by dyads; *** p<0.01, ** p<0.05, * p<0.1, $^{+}$ p<0.15, $^{\#}$ p<0.20.

Table A6: Panel Estimates – Controlling for Average Level of Trade (5-year Windows)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ln(physical distance)	0.002**	0.002***			0.010*	0.011**		
	(0.001)	(0.001)			(0.005)	(0.005)		
ln(virtual distance)			0.001***				-0.005***	
			(0.000)				(0.000)	
ln(1+language distance)	0.001+			0.001**	0.003			0.007*
	(0.000)			(0.000)	(0.004)			(0.004)
Lagged average trade					-0.053***	-0.054***	-0.036***	-0.055***
					(0.002)	(0.002)	(0.002)	(0.002)
Observations	27,367	28,204	6,599	27,367	25,195	25,964	6,125	25,195
R^2	0.242	0.241	0.233	0.241	0.315	0.313	0.345	0.315
Time-varying exporter fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Time-varying importer fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes	no	no	no	no

Notes: the table reports panel estimates of model equation (6) where the standard deviation of the annual log change in bilateral imports of goods over non-overlapping 5-year windows is scaled by the average level of bilateral trade during this period in columns (1) to (4); the standard deviation of the annual log change in bilateral imports of goods between countries measured over non-overlapping 5-year windows of observations is the dependent variable in columns (5) to (8). The regressions include the remaining control variables as in model equation (5) in the first four columns but not in the remaining ones where lagged average trade is used as control variable; country-time fixed effects are also included throughout. Given the high dimensionality of the fixed effects in question, we use the method developed by Guimaraes and Portugal (2010). Standard errors are clustered by dyads.

Table A7: Panel Estimates – Complementarities between Distance Measures (10-year Windows)

	(1)	(2)	(3)	(4)
ln(physical distance) × ln(virtual distance)	0.002***	0.003***		
	(0.000)	(0.000)		
ln(physical distance) × ln(language distance)	0.001		0.003	
	(0.003)		(0.003)	
ln(language distance) × ln(virtual distance)	0.002***			0.002***
	(0.000)			(0.000)
ln(physical distance)	0.003	0.003	0.030**	
	(0.011)	(0.008)	(0.013)	
ln(virtual distance)	-0.017***	-0.022***		0.009***
	(0.004)	(0.004)		(0.001)
ln(1+language distance)	0.001		-0.023	0.009*
	(0.024)		(0.033)	(0.006)
Observations	3,779	3,779	15,961	3,779
R^2	0.307	0.305	0.319	0.300
Time-varying exporter fixed effects	yes	yes	yes	yes
Time-varying importer fixed effects	yes	yes	yes	yes
Other gravity controls	yes	yes	yes	yes

Notes: the table reports panel estimates of model equation (6) where the standard deviation of the annual log change in bilateral imports of goods between countries measured over non-overlapping 10-year windows of observations is the dependent variable. The regressions include the measures of distance and their interacted effects, which are included jointly in the specification of column (1) and individually in the specifications of columns (2) to (4). The regressions include the remaining control variables as in model equation (5); country-time fixed effects are also included throughout. Given the high dimensionality of the fixed effects in question, we use the method developed by Guimaraes and Portugal (2010). Standard errors are clustered by dyads.