Distance(s) and the volatility of international trade(s)

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Abstract

We show that distance matters for the volatility of international trade and finance beyond its well-known relevance for their level. A model of trade with endogenous markups shows that the effect of distance on the sensitivity of trade to demand shocks depends on the specific nature of entry and production costs. An empirical assessment using several measures of trade and financial transactions shows that they are more volatile for more distant country pairs. This pattern is observed for several forms of distance.

Key words: Distance, gravity, volatility, international trade, international finance, Great Trade Collapse, Covid-19 pandemic

JEL classification: F10, F30

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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, however, 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 international trade and financial 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 in the volatility of international trade. We then provide empirical relevance of the role of distance during the global financial crisis of 2007-09, the Covid-19 pandemic crisis of 2020 as well as over a longer time horizon. The analysis takes a broad view of international trade and financial transactions, on the one hand, and of metrics of distance, on the other hand.

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[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)).

Our simple model of trade with endogenous exporters' markups builds on the classic paper of Atkeson and Burstein (2008). We consider that firms have to pay a fixed cost of entering an export market before knowing the realization of demand, and a fixed cost of production if they decide to actually export, based on realized demand. Both costs are higher for exports to more distant destinations. Whether demand shocks have a larger impact on trade between more distant countries depends on the structure of fixed costs. A higher entry cost leads to a beachhead effect that dampens the effects of demand shocks on international trade with distant markets. Exporters that have had to pay a larger entry cost to enter more distant markets enjoy higher profit margins once that entry cost has been sunk. It then takes a larger decline in demand to trigger an exit of exporters in more distant markets. Higher production costs lead to an opposite footloose effect. Higher production costs imply a smaller number of exporters, with limited profits, in more distant markets. A fall in demand triggers the exit of exporters, which increases the market share of the surviving exporters, leading to higher markups and to an amplification of the adverse demand shock on international trade. This amplification is more pronounced when the initial number of exporters is limited, which is the case in more distant markets.

We undertake an empirical assessment by conducting a broad cross-sectional event study on the bilateral international trade transactions of 186 countries during the global financial crisis of 2007-09.[3] Our measures of bilateral international transactions cover trade in goods, trade in services, portfolio investment positions in bonds and equities, foreign direct investment positions, and both positions and

[3] The "Great Trade Collapse" refers to the sizeable decline in international trade that accompanied the global financial crisis and 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.

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 perform a similar cross-sectional analysis focused on bilateral trade in goods among the same countries during the Covid-19 pandemic of 2020. Finally, we consider 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 of international trade, and does so in a diverse way. During the global financial crisis of 2007-09, international real and financial linkages declined disproportionately more for distant country-pairs, in line with the footloose effect. 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 interacted, with virtual distance amplifying the marginal impact of physical distance (and vice-versa). The impact of distance is quite heterogeneous across the various forms of international trade transactions, however. In particular, foreign direct investment (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-entry costs incurred in setting up local operations.

[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.

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 international transactions in services or changes in cross-border portfolio investment positions.

The impact of the various measures of distance is not confined to the global financial crisis. Cross-sectional evidence for bilateral trade in goods during the Covid-19 pandemic of 2020 also suggests that international trade declined disproportionately more for distant country-pairs, even after controlling for integration in global value chains, also in line with a footloose effect. 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).

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 of 2007-09 (Galstyan 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

[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)).

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)).

Another related strand of literature focuses on the role of supply chains in the international transmission of shocks, which came back in the limelight with the Covid-19 pandemic.[7] Demand shocks in a country may be passed upstream through the global production network to input suppliers, with the initial shock being magnified by the "bullwhip effect" (Alessandria et al. (2011)), while supply disruptions can, in turn, be transmitted downstream.[8] In line with this interpretation, the marked decline in trade in goods in the wake of the Covid-19 pandemic has been largely ascribed to disruptions in global value chains further to the lockdown measures taken by many economies to combat the virus, among other factors. COVID-19 has struck value chains in Asia, Europe and the Americas, raising 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)).

[7] The complex network of supply linkages is potentially an important factor in the transmission of shocks across countries insofar as trade in intermediate goods accounts for more than 40% of world trade and more than 20% of world imports serve as inputs in domestic production processes and are embedded into goods which are subsequently re-exported.

[8] The "bullwhip effect" refers to situations in which a shock triggers disruption to demand for parts and components, which increases the further upstream a firm is located in the supply chain. Firms are induced to adjust their inventories along the supply chain to meet new expected levels of demand.

risk of a domino effect with feedback loops that could amplify the collapse in global trade (Cigna and Quaglietti (2020))

Finally, our work is 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 (e.g. Isphording and Otten (2013), Melitz and Toubal (2014)). A second approach focuses on the genetic distance between various populations (e.g. 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 internet (Blum and Goldfarb (2006), Chung (2011), Freund and Weinhold (2004), Hellmanzik and Schmitz (2017)).

3. Beachhead and footloose effects in a simple model of trade adjustment

3.1 *General approach*

Several mechanisms can lead trade fluctuations to depend on distance. If shocks directly affect the cost of exporting (fixed or proportional), we can expect them to have a larger impact for firms that face higher costs because they export to more distant markets. An example of this approach is Berman et al. (2013) where the trade cost is the time that a shipment takes to be delivered. The bank funding the trade transaction is exposed to risk while the shipment is on the way. A reduction in the bank's willingness to bear risk translates into a higher trade cost which especially affects shipments that require more time.

While shocks to trade costs are empirically relevant, their impact is quite immediate from a theoretical perspective. In addition, the relevance of these shocks may be concentrated in crisis times and be more limited otherwise. We take an alternative approach which focuses on the market structure in the importing country, following Atkeson and Burstein (2008). We consider a static model where several individual exporters sell to a destination market where they also compete against domestic firms. There is heterogeneous monopolistic competition: two brands of exported goods are relatively close substitutes, while exported and domestic goods are poorer substitutes. The number of exporters is limited, so an exporter's market share in export goods affects the price elasticity of the demand she faces, and thus her markup over marginal cost. Exporters face a fixed cost of production that determines the number of active exporters through a zero-profit condition. A reduction in aggregate demand in the destination market reduces profits and leads to a decrease in the number of exporters, which in turn affects markups, prices, trade volume and trade value.

Distance is reflected in the cost of exporting (fixed or variable), so we model exports to a more distant market as those facing higher costs. Our analysis shows how a given decrease in aggregate demand in the destination country impacts trade volume and value, and how this impact depends on the level of trade costs.

We first present the building blocks of the model, showing how the price elasticity of demand depends on the market structure. We then consider the equilibrium when exporters face a fixed cost of production, and show that the model leads to a footloose pattern. Specifically, a given decrease in demand leads to a larger decrease in aggregate trade (in volume and value) for a more distant market, characterized by larger trade costs and fewer exporters to start with. We show that this footloose pattern is a function of the elasticities of substitution between export brands and between exports and domestic good.

In the final section we augment the model by assuming that exporters must first incur an entry cost at the extensive margin. Their entry decision is based on expected demand. Once exporters have entered a destination market they observe realized aggregate demand and decide whether or not to produce, with production requiring an additional fixed cost. This extension leads to richer results. If trade costs take mainly the form of an iceberg cost or a fixed production cost, we get the footloose pattern. However, if they take mainly the form of a fixed entry cost, we get a beachhead pattern where a given decrease in demand leads to a smaller decrease in aggregate trade for a more distant market. Intuitively, the high entry cost implies that only a few exporters are present. Once the entry cost has been paid, they enjoy high margins and are willing to produce even if demand turns out to be lower than expected.

3.2 *Building blocks of the model*

3.2.1 *Demand*

We keep model complexity to a minimum, and focus on the main elements.[9] Consumers in the destination market purchase a CES basket C made of domestic brands C^D and imported brands C^I:

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

where η is the elasticity of substitution between the domestic and imported sub-baskets. Each of these in turn consists of a discrete number of brands. There are n^D domestic brands and n^I imported ones:

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

where ρ is the elasticity of substitution between brands. Following Atkeson and Burstein (2008), we make the standard assumption that brands are more easily

[9] The detailed results are available in an online appendix.

substitutable than sub-baskets: $\rho > \eta$.[10] The difference between these two elasticities is a central element of the model.

The optimal allocation of consumption gives the standard demand for an individual brand as a function of overall demand, the price of the brand, the price of the sub-basket, and the price of the overall basket.

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

where the price indices are:

$$P = [(P^D)^{1-\eta} + (P^I)^{1-\eta}]^{\frac{1}{1-\eta}}$$

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

Our analysis focuses on exporters, and we take the domestic index P^D and the aggregate index P as given. We consider that the number of exporters n^I is small, so an individual exporter takes the impact of her price P_k^I on the index P^I into account.

3.2.2 *Technology, profits and pricing*

Exporters use a technology with constant returns to scale where one unit of labor delivers one unit of output. Each exporter pays a real wage W^I (in terms of export good) and faces an iceberg cost τ. The variable profits (before any fixed cost) of exporter *k* are then:

$$\Pi_k^{I,Var} = \left((1-\tau)P_k^I - W^I\right)Y_k^I$$

where Y_k^I=C_k^I is the output.

[10] We also assume that there is monopoly power at the level of individual brands: $\infty > \rho > 1$.

The exporter sets her price P_k^I to maximize profits, taking account of the impact on the index P^I and demand Y_k^I from (1). The optimal price is a markup over marginal cost reflecting the price elasticity of demand faced by the exporter, ε_k^I:

$$P_k^I = \frac{\varepsilon_k^I}{\varepsilon_k^I - 1}\frac{W^I}{1-\tau} \qquad (2)$$

Due to the presence of two elasticities of substitution, and the limited number of exporters, the elasticity of demand ε_k^I is a combination of ρ and η depending on the firm's market share s_k^I:

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

As all exporters are identical in equilibrium, the market share is simply the inverse of the number of exporters: $s_k^I = 1/n^I$. Price (2) is then an inverse function of the number of exporters:[11]

$$P_k^I = \Omega^P(n^I)\frac{W^I}{1-\tau} \quad ; \quad \frac{\partial \Omega^P(n^I)}{\partial n^I} < 0 \qquad (3)$$

Intuitively a higher number of exporters implies that the market share of each of them is small and competition is mostly among exporters. Exporters therefore face a high elasticity of demand and charge a low markup. Using (3) we can solve for output and variable profits. A higher number of exporters leads to a reduction in variable profits as competition is then more intense: [12]

$$\Pi_k^{I,Var}(C,\tau,n^I) = \Omega^\Pi(n^I)(1-\tau)^\eta (W^I)^{1-\eta} P^\eta C \quad ; \quad \frac{\partial \Omega^\Pi(n^I)}{\partial n^I} < 0 \qquad (4)$$

3.3 *Equilibrium with a fixed cost of production*

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[11] Specifically $\Omega^P(n^I) = \frac{n^I\rho - (\rho-\eta)}{n^I(\rho-1)-(\rho-\eta)}$

[12] Specifically $\Omega^\Pi(n^I) = \frac{n^I}{n^I(\rho-1)-(\rho-\eta)}\left(\frac{n^I\rho-(\rho-\eta)}{n^I(\rho-1)-(\rho-\eta)}\right)^{-\eta}(n^I)^{-\frac{\rho-\eta}{\rho-1}}$

3.3.1 *Determination of the number of exporters*

Each exporter faces a fixed cost of production F^I. We consider free entry and exit of exporters, and the number of firms is then driven by the zero profit condition $\Pi_k^{I,Var}(C,\tau,n^I) = F^I$. As variable profits are inversely proportional to the number of exporters, this determines a unique solution for n^I.

The presence of a fixed cost is necessary to determine the number of exporters. Conditional on the fixed cost to be positive, the specific number reflects $F^I(1-\tau)^{-\eta}$ and can be driven by either a fixed cost of production or an iceberg cost.

3.3.2 *Impact of a contraction in demand*

We use the model to derive the impact of a decrease in aggregate demand C on trade flows. The lower demand reduces variable profits (4), and this leads to a reduction in the number of exporters to restore the zero profit condition. Specifically the elasticity of the number of firms to aggregate demand is:

$$\xi_{n^I} = \frac{\rho-1}{\rho-\eta}\left[1+\frac{n^I-1}{n^I\rho-(\rho-\eta)}\frac{(\rho-1)(\rho-\eta)}{n^I(\rho-1)-(\rho-\eta)}\right]^{-1} > 0 \qquad (5)$$

where we use the notation $\xi_x = (\partial x/\partial C)(C/x)$ for the elasticity of a variable x with respect to aggregate demand C.

The reduction in the number of exporters leads to an increase in price P_k^I. The demand shock therefore affects aggregate trade volume and value both directly and indirectly through its impact on the number of exporters and on prices. Taking all these channels into account, the elasticities of aggregate trade flows with respect to final demand are given by:

$$\xi_{n^I Y_k^I} = \frac{n^I[n^I\rho-(\rho-\eta)]}{\Phi}\frac{(\rho-1)^2}{\rho-\eta} > 0 \qquad (6)$$

$$\xi_{n^I P_k^I Y_k^I} = \frac{n^I[n^I(\rho-1)-(\rho-\eta)]}{\Phi}\frac{\rho(\rho-1)}{\rho-\eta} > 0 \tag{7}$$

where $\Phi = (n^I-1)(\rho-1)(\rho-\eta) + [n^I\rho-(\rho-\eta)][n^I(\rho-1)-(\rho-\eta)] > 0$.

The two elasticities of aggregate trade flows, $\xi_{n^I Y_k^I}$ and $\xi_{n^I P_k^I Y_k^I}$, are inversely proportional to the number of exporters:

$$\frac{\partial \xi_{n^I Y_k^I}}{\partial n^I} = -[\rho(n^I)^2 + (\eta + (2n^I-1)\rho)(\eta-1)]\frac{(\rho-1)^2}{\Phi^2} < 0 \tag{8}$$

$$\frac{\partial \xi_{n^I P_k^I Y_k^I}}{\partial n^I} = -(\eta-1)[(2n^I-1)(\rho-1)+(\eta-1)]\frac{\rho(\rho-1)}{\Phi^2} < 0 \tag{9}$$

When the number of exporters goes to infinity, both elasticities converge to $(\rho-1)/(\rho-\eta) > 1$

Our model shows that a contraction in aggregate demand leads to a more than proportional contraction in trade volumes and values, and that the sensitivity of trade flows is larger when the number of exporters is smaller, i.e. when trade costs (fixed or iceberg) are high. We therefore get a footloose pattern where trade is more sensitive to economic conditions in more distant markets, associated with larger trade costs. Intuitively, they are fewer exporters to more distant markets, and the departure of some of them has a stronger effect on the market share of the remaining ones, leading to a larger adjustment in markups that amplifies the initial shock.

3.3.3 *A numerical illustration*

We illustrate our results with a numerical example. We set the elasticities at $\rho = 6$ and $\eta = 2$, and abstract from the iceberg cost ($\tau = 0$). Without loss of generality we set the wage, aggregate price and consumption to unity: $W^I = P = C = 1$.

We compute the impact of a 20% decrease in demand C depending on the initial number of exporters n^I (between 2 and 10).[13] For each value of n^I we compute the corresponding fixed cost F^I from the zero profit condition. We then hold this cost unchanged and compute the new number of exporters that ensures zero profits at the lower level of demand.[14] We then solve for the new price, P_k^I, the trade flows for an individual exporter, Y_k^I and $P_k^I Y_k^I$, and the aggregate trade flows, $P_k^I Y_k^I$ and $n^I P_k^I Y_k^I$.

Figure 1 shows the impact of the shock. The lower profits lead to a decrease in the number of exporters to restore the zero profit condition (top left panel). The remaining exporters have a higher market share and a lower elasticity of demand ε_k^I. This leads them to increase their markup and their price (top right panel). The higher price amplifies the initial shock on the output of an individual exporter. The direct impact of the shock, along with the reduced number of exporters and the decrease in individual output leads to a contraction in the aggregate volume of exports (bottom left panel). The increase in prices is not strong enough to offset this, and overall exports also contract in value (bottom right panel).

[Figure 1 about here]

The indirect effect of the demand shock through the number of exporters and prices is larger when there are fewer exporters to start with (left part of the figures),

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[13] 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.

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

which corresponds to exports to more distant markets. The model therefore delivers a footloose pattern where a given demand shock leads to a larger decrease in aggregate trade flows between more distant country pairs.

3.3.4 *Sensitivity analysis*

To assess the sensitivity of our results, we consider the cases of a high brand elasticity ($\rho = 10$), and a low sub-basket elasticity, $\eta = 1$. Figure 2 shows the pattern for our baseline case (red line) and the two alternatives, in terms of aggregate volume of trade (left panel) and total value of trade (right panel).

[Figure 2 about here]

The elasticities of demand play a sizable role. A higher value of ρ (blue line) or a lower value of η (green line) dampens the impact of the shock on the total volume of trade. The footloose pattern of a larger impact for a limited number of exporters remains. In terms of the value of trade, the impact of the shock is reduced. The footloose pattern is dampened, and actually disappears when $\eta = 1$ as the increase in prices then exactly offsets the contraction in the overall trade volume.

We explore the role of the two elasticities further in Figure 3. We consider three possible values for each elasticity: $\rho = 6, 8, 10$ and $\eta = 1, 3, 5$, giving us 9 combinations. For each, we compute the impact of a 20 % reduction in demand C when the initial number of firms is set at $n^I = 2$ (with the associated fixed cost), focusing on the percentage reductions in the volume and value of aggregate trade. We repeat the exercise for $n^I = 5$. The last step takes the difference between the percent trade decrease when $n^I = 2$ and the percent trade decrease when $n^I = 5$, which provides us with a measure of the extent of the concavity of the curves shown in Figures 1 and 2. This additional trade decrease for a more distant country pair ($n^I = 2$ instead of $n^I = 5$) is shown in Figure 3 for each of the nine combinations of elasticities (a positive value indicates a larger decrease for countries that are more distant).

[Figure 3 about here]

The left panel shows that the additional decrease in the volume of trade for more distant destinations is increasing with the domestic-import elasticity η and decreasing with the brand elasticity ρ. Holding the gap between ρ and η at 5 (red diagonal bars), we see that the impact is increasing with the elasticities. A similar pattern is observed for the reduction in the value of aggregate trade (right panel).

Our analysis thus shows that the values of the elasticities of substitution matter in addition to the difference between them. In particular the additional impact on trade for more distant countries is larger when the elasticities are large (for a given elasticity difference). This is interesting, as when elasticities are high a given difference represents a smaller one in relative terms, and thus one may expect the situation to be close enough to identical elasticities.[15] Our results show that this is not the case.

3.4 *Equilibrium with a fixed cost of entry*

3.4.1 *Two decisions of exporters*

Our model so far generates a footloose pattern as exporters to more distant markets are limited in numbers, and thus face more substantial changes in their market share following a contraction in demand, leading to higher markup that amplify the initial demand shock. We now extend the model to allow for a reverse beachhead pattern where trade to more distant markets is less sensitive to demand shocks.

Exporters have to make two choices. They first decide on whether or not to enter the market. Entry entails a fixed cost F^E, and an exporter having entered the market has the option to then produce or not. Exporters take their entry decision based on the expected value of demand $\bar{C}$. We denote the number of entrants by $\bar{n}^I$.

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[15] 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 $\eta = 5$.

Once entry has taken place, exporters observe actual demand C and decide whether to actually produce or not. Production requires a fixed cost F^I and the number of exporters that produces is n^I, which cannot exceed $\bar{n}^I$.

3.4.2 *Determination of the number of exporters*

An exporter that enters the market, with the intention to produce, faces an expected value of variables profits $\Pi_k^{I,Var}(\bar{C},\tau,\bar{n}^I)$, with the form of this expression given by (4). Free entry drives the profits including fixed costs to zero, and $\bar{n}^I$ is implicitly given by $\Pi_k^{I,Var}(\bar{C},\tau,\bar{n}^I) = F^I + F^E$. The solution for $\bar{n}^I$ is computed along similar lines as the solution for n^I above, replacing C by $\bar{C}$ and F^I by $F^I + F^E$. More distant destinations are characterized by a higher overall fixed cost $F^I + F^E$, and fewer exporters are present in that market.

If demand C is higher than the expected value $\bar{C}$ all entrants produce and the number of exporters is equal to $\bar{n}^I$, with all of them making positive profits including the fixed costs. If demand is lower than expected, $C < \bar{C}$, the outcome depends on the magnitude of the demand shortfall.

A moderate shortfall of demand implies that variable profits cover the fixed cost of production even if all entrants produce: $\Pi_k^{I,Var}(C,\tau,\bar{n}^I) > F^I$. Producing is then profitable once the fixed entry cost has been sunk, and all entrants are active $n^I = \bar{n}^I$.

A more severe contraction of demand implies that variables profits are not sufficient to cover the production cost if all entrants are active: $\Pi_k^{I,Var}(C,\tau,\bar{n}^I) < F^I$. Some exporters choose not to produce, $n^I < \bar{n}^I$, and the number of active exporters is given by the zero-profit condition, as before: $\Pi_k^{I,Var}(C,\tau,n^I) = F^I$. We denote by C^{cut} the cutoff level of demand at which variables profits can just cover the fixed cost of production if all entrants are active: $\Pi_k^{I,Var}(C^{cut},\tau,\bar{n}^I) = F^I$. Using the zero profit condition at the entry stage and (4), the ratio between the cutoff level of demand and the expected level reflects the share of the fixed costs that consists of the production cost:

$$\frac{C^{cut}}{C} = \frac{F^I}{F^I + F^E} \tag{10}$$

Our prior analysis considered the case where $F^E = 0$.

3.4.3 *Sensitivity of trade to demand*

3.4.3.1 Elasticity above and below the demand cutoff

If $C < \bar{C}$ exports are reduced by the fall in demand, both for individual exporters and in aggregate terms, and both in terms of volume and values. As long as $C > C^{cut}$ the reduction of demand does not impact the number of producing exporters which is equal to $\bar{n}^I$. There is no indirect effect through market shares, markups and prices, and trade flows simply move in step with demand. The elasticity of trade to demand is then equal to one, both in real and nominal terms.

Once C falls below C^{cut}, the number of exporters is reduced by the fall in demand. This triggers the indirect effects via markup and prices, as shown above, and the elasticities of trade to demand increase: $\xi_{n^I Y_k^I} > 1$ and $\xi_{n^I P_k^I Y_k^I} > 1$.

Figure 4 shows exports as a function of demand. As above, we set $\rho = 6, \eta = 2$, $\tau = 0$, and $W^I = P = \bar{C} = 1$. We choose a number of entrants $\bar{n}^I = 3$ and set the overall fixed cost $F^I + F^E$ at the required value to ensure zero profits at the entry stage. We consider that the entry cost represents 20% of the overall fixed cost, which implies $C^{cut} = 0.8$.

[Figure 4 about here]

The left panel shows the exports for an individual exporter (blue lines) and in aggregate terms (red lines), both in terms of volumes (dashed lines) and values (solid lines). The right panel shows the elasticity of aggregate exports to demand, in terms of volumes (blue lines) and values (red lines). We present the marginal elasticity (impact of a change around the specific value of demand, solid lines) and the average elasticity (impact of the change of demand from $\bar{C}$ to C, dashed lines).[16] When $C > C^{cut}$ all export flows have a unit elasticity relative to demand. As C moves below C^{cut}, exports decrease further. The contraction is less pronounced for individual flows than in aggregate terms, reflecting the fact that the number of producing exporters falls. The elasticity of aggregate exports to demand rises above unity, and increases further as demand gets weaker.

We now discuss how the pattern shown in Figure 4 translates into different sensitivity of trade for exports to distant and nearby markets. Specifically, we compute the elasticities of trade to demand (as in the right panel of Figure 4) for a distant market where $\bar{n}^I = 3$ and a nearby market where $\bar{n}^I = 5$. Unless stated otherwise, all parameters are as in Figure 4.

3.4.3.2 Heterogeneity in entry cost

We first consider the case where the fixed cost of production F^I is the same for the distant and nearby markets. We set the entry cost F^E to account for 20% of the overall cost in the nearby market with $\bar{n}^I = 5$. As the overall cost is higher for the distant market where $\bar{n}^I = 3$, our assumption implies that the entry cost accounts for 51% of the total cost in that market. The cutoff C^{cut} is therefore much lower for the distant market.

Figure 5 illustrates the results, focusing on the elasticities of aggregate export flows to demand. The left panel presents the elasticity of trade in volume, while the elasticity of trade in value is shown in the right panel. In each panel the red lines correspond to the distant market and the blue lines to the nearby markets. As for

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[16] Specifically, for a value of demand $C < \bar{C} = 1$, the marginal elasticity of total exports in value is $\partial[n^I P_k^I Y_k^I(C)]/\partial C \times C/n^I P_k^I Y_k^I(C)$ where $n^I P_k^I Y_k^I(C)$ is the total value of exports when demand is equal to C. This corresponds to $\xi_{n^I P_k^I Y_k^I}$. The average elasticity of demand is computed in reference to $\bar{C}$ and is $[n^I P_k^I Y_k^I(C) - n^I P_k^I Y_k^I(\bar{C})]/[C - \bar{C}] \times \bar{C}/n^I P_k^I Y_k^I(\bar{C})$.

Figure 4, we show the marginal elasticity (solid line) and the average one (dashed line).

[Figure 5 about here]

The elasticities are equal to unity in both markets as long as demand is above the cutoff of the nearby market, i.e. 0.8. When demand falls below that level, but is still above the cutoff for the distant market, 0.51, the elasticities are higher in the nearby market and remain equal to one in the distant market. When demand falls below 0.51, elasticities are above one in both markets. The marginal elasticities are then identical in the two countries. This is because the number of exporters is then driven by the fixed cost of production for both, and that cost is the same for the two markets. At that point the fixed cost of entry becomes irrelevant.

The model generates a beachhead effect as the elasticity of exports to demand is higher for the nearby market (the blue lines are above the corresponding red lines). It takes a much larger fall in demand in a distant market to induce exporters to exit. Intuitively, entrants have paid a large entry cost to enter the distant market, and thus face high profit margins once the entry cost is sunk. It takes a larger fall in demand to drive profits net of production costs to zero.

3.4.3.3 Heterogeneity in production cost

We now consider the reverse case where the fixed cost of entry F^E is the same for the distant and nearby markets. We again set the entry cost F^E to account for 20% of the overall cost in the nearby market. As the overall cost is higher for the distant market, our assumption implies that the entry cost accounts for only 13% of the total cost in that market. The cutoff C^{cut} is much higher for the distant market.

Figure 6 shows the impact of lower demand on trade, and is built along similar lines as Figure 5. As demand is reduced, the distant market is the first one where the cutoff is reached and the elasticities increase, while they remain equal to one in the nearby market. Once demand falls below 0.8, the number of exporters also decreases in the nearby market and the elasticities rise. Even in the area below the cutoffs for both countries, we see that the elasticity is higher for the distant market. This is because the fixed production cost F^I is now the relevant one for the number of exporters, and that cost is higher in the distant market.

[Figure 6 about here]

We now have a footloose effect with exports being more sensitive to demand in the distant markets (the red lines are above the blue lines). Intuitively, the fixed cost of entry is proportionally less relevant in the distant market, and the entrants there face limited profits even when the entry cost is sunk, because they need to cover the higher production cost. A moderate fall in demand is enough to trigger the exit of exporters, which materially affects the market share of the few remaining ones, leading to higher markups and an amplification of the adverse demand shock.

3.4.3.4 Heterogeneity in both fixed costs

We finally consider the situation where the entry and production fixed costs are higher in the distant market than in the nearby one, but by the same factor. In other words, the entry cost accounts for 20% of the overall fixed costs for both markets.

Figure 7 shows the pattern in that case. The demand cutoff is now the same in both countries. Once demand falls below that point, the elasticities increase, but more so in the distant market. Intuitively, as they are few exporters in that market, the exit of some has a more material effect on their market share, markup and prices, than in the nearby market where there are more exporters. The amplification effect is thus more pronounced in the distant market, and we again get a footloose effect.

[Figure 7 about here]

3.4.3.5 Synthesis

Our simple model shows that whether more distant markets display a beachhead or footloose effect depends on the exact nature of the higher trade cost in that market. A higher fixed cost of production (or a higher iceberg cost) leads to a footloose effect as margins abstracting from the entry cost are limited and a reduction in demand quickly triggers a decrease in the number of exporters, which matters more for the market share of the surviving ones on a distant market.

On the other end, a higher fixed cost of entry leads to a beachhead effect. Exporters that are present in a distant market have incurred a substantial fixed cost, and their profit margins of production are relatively high. It then takes a big decrease in demand to trigger the exit of exporters from the distant market.

4. Empirical evidence on the impact of distance(s)

4.1 *Empirical specifications*

4.1.1. *General approach*

We test the predictions of this model using both cross-sectional and panel estimation methods. We do so for various measures of international trade, namely transactions in goods and services as well as for changes in cross-border financial positions, and various measures of distances (physical, linguistic and internet), as detailed below.

We consider the evidence from two major episodes of contraction in international linkages, namely the global financial crisis of 2007-09 and the Covid-19 pandemic of 2020, as well as long-term evidence from 1950 to 2015. The analysis focuses on trade in goods for the latter two exercises due to data availability.[17]

4.1.2. *Event studies*

Our first test consists of a broad cross-sectional analysis of bilateral trade linkages between up to 186 countries during the global financial crisis of 2007-09, which

[17] Global data on bilateral trade in services and in international financial positions are produced with a significant lag and were not available for the Covid-19 pandemic period yet. Moreover, those data do not go far back in time, which prevented us from obtaining similar panel estimates as for trade in goods on a long period.

represents a major shock to international linkages. Following Galstyan and Lane (2013) we estimate the following specification:

$$\ln(Y)_{i,j,2009} - \ln(Y)_{i,j,2007} = \sum_k \alpha_k Dist(k)_{i,j} + \sum_h \sum_k \beta_{k,h} Dist(k)_{i,j} Dist(h)_{i,j} + \boldsymbol{\gamma}'\mathbf{X}_{\mathbf{i,j,2007}} + \delta \ln(Y)_{i,j,2007} + FE_i + FE_j + \varepsilon_{i,j} \quad (11)$$

Where Y is a measure of real transactions or bilateral changes in cross-border financial positions 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),[18] *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 controls measured in 2007, and FE_i and FE_j are country-source and country-destination fixed effects.[19] Our estimates also control for the pre-crisis level of bilateral trade and investment positions. We estimate Equation (11) using OLS with standard errors robust to heteroscedasticity.

Our model specification (11) looks at the impact of various measures of distance on their own, as well as their interaction. We test whether the decline in the crisis was larger for more distant countries, in line with the footloose hypothesis (i.e. $\alpha_k < 0$) or smaller, in line with the beachhead hypothesis (i.e. $\alpha_k > 0$). 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

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[18] For cross-border banking, data on bilateral *transactions* are available, which we include in equation (6) as detailed below.

[19] Equation (11) is a generalization of the model estimated by Galstyan and Lane (2013), who restricted their attention to changes in bilateral portfolio investment positions and to the role of physical distance.

of one metric is larger when the other metric is high, i.e. $\beta_{k,h} < 0$. Otherwise the metrics are substitutes.

We conduct a similar test for the Covid-19 pandemic episode. The dependent variable is the difference in bilateral trade in goods between 2020 Q1 and 2019 Q1, which we regress on the full array of distance and control variables, also controlling for the level of trade in goods in 2019 Q1.

4.1.3. *Panel analysis*

Our final test consists of a panel estimates from dyadic (country pair) observations on bilateral trade in goods from 1950 to 2015. We specifically link the volatility of trade to our measures of distance and controls:

$$SD(Y)_{ij,t} = \sum_k \alpha_k Dist(k)_{ij} + \sum_h \sum_k \beta_{k,h} Dist(k)_{ij} Dist(h)_{ij} + \boldsymbol{\gamma}'\mathbf{X}_{\mathbf{i,j,t}} + FE_{i,t} + FE_{j,t} + \varepsilon_{i,j,t} \tag{12}$$

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 (11). $FE_{i,t}$ 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 estimation method of 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 *Data*

4.2.1 *Measures of international trade transactions*

We consider an array of bilateral international trade transactions 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.[20] 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 positions of debt (short and long maturity) and equities (listed shares and investment funds), both taken from the IMF's Coordinated Portfolio Investment Survey (CPIS).[21] The third measure is bilateral foreign direct investment positions (FDI), taken from the OECD's FDI statistics.[22] Our final two measures pertain to international bank linkages from the BIS locational banking statistics.[23] They consist of bilateral banking positions (loans and deposits), and the corresponding banking flows adjusted for valuation effects arising from exchange rates movements.[24]

[20] 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.

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

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

[23] Our results are robust when we use BIS consolidated banking positions instead.

[24] In the case of banking flows, we use annual bilateral transactions. If these are negative (indicating a retrenchment), we follow Levy Yeyati et al. (2007) and take the logarithm of the absolute value and multiply it with -1 to remain in line with a gravity model specification.

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.[25]

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.[26] The data cover the entire universe of websites registered on Yahoo in 2009, hence mitigating sampling bias. 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.[27]

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

[25] See Mayer and Zignago (2011).

[26] 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.

[27] 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.

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 (11) and (12) 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).[28] 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.[29] 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. Finally, for trade in goods we add to the event study analyses a measure of bilateral integration in global value chains (GVC) taken from the Eora Multi-Regional Input-Output (MRIO) database.[30] For instance, if our dependent variable is the change in

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

[29] See Mayer and Zignago (2011).

[30] This database provides data on input-output linkages between 189 countries and 26 sectors (including services) over the period 1990-2019 (see e.g. Ignatenko et al. (2019)).

bilateral German imports from the US, the GVC variable (in log level) measures the pre-crisis value-added produced by the US which is contained in German exports (i.e. German imports from the US in value-added terms which Germany uses in its exports).

5. Empirical results

5.1 *Cross-sectional evidence from the global financial crisis of 2007-09*

5.1.1 *Baseline estimates*

Table 1 presents the estimated coefficients of model equation (11), with the dependent variable being the log difference in international bilateral transactions 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 pre-crisis level of bilateral trade the gravity controls and source- and destination-country fixed effects are not reported.

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

Physical and linguistic distances have robust impacts, as suggested by the negative and statistically significant coefficients across all forms of transactions.[31] 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 for portfolio investment. However, FDI and banking linkages are not sensitive to virtual distance, a pattern which we also find in other specifications below.

[31] With the exception of portfolio equity holdings and bank flows for physical distance.

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 international trade transactions during the global financial crisis of 2007-09. This indicates that trade between countries that share higher information flows proved more robust in the crisis.

FDI and banking are not as robustly affected by distance as other linkages, which points in the direction of beachhead effects. 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 entry costs relative to production costs compared to other international trade transactions. In our model, that presence indicates that those firms and banks have paid large entry costs to enter distant markets, so that it would take a larger decline in demand to trigger exit from distant markets.

[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).[32]

We undertake several robustness checks. In the estimates for trade in goods, we first control for bilateral integration in global value chains (see Table 2). The estimates continue to robustly point to the existence of significant footloose effects. The coefficients on physical and linguistic distance are highly significant and with a negative sign, while the effect of virtual distance is no longer significant (see column 2 of Table 2). This suggests that participating in a value chain constitutes a source of information that offsets the limits on communication, as proxied by virtual distance. Excluding virtual distance from the estimation increases the number of observations substantially; the effects of physical and linguistic distance become stronger in turn, and strikingly close in economic magnitude to those of the basic estimates (see column 3).[33]

[Table 2 about here]

Next we replace the dependent variable by the log change of international linkages between 2008 and 2009 (instead of 2007 and 2009). The estimates in Table A1 reported in the Appendix show that the effect of distances on trade in goods and services as well as on portfolio investments remains robust, albeit somewhat weaker

[32] 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.

[33] Pre-crisis bilateral global value chain integration itself shows a significant positive signs indicating that larger bilateral integration was associated with a smaller decline in trade flows during the crisis. This may reflect that higher bilateral GVC integration is associated with a more stable bilateral trade relationship and thus more difficult to terminate during a crisis.

in economic magnitude.[34] 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.[35] The results are reported in Panels A, B and C of Table A2 reported in the Appendix). 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 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.

Next we control for the growth in international trade over the period 2005-07 to check whether our estimates would merely pick up a "payback" drop effect. The results remain largely robust (see Table A3). We explored whether the footloose effect is symmetric, i.e. whether distant pairs which experienced larger declines in the global financial crisis of 2007-09 were also those that experienced larger booms in trade post-crisis and find some evidence that this is the case for trade in goods, services and FDI (see Table A4).[36]

5.1.2 *Complementarities between distance measures*

We assess the extent to which our alternative measures of distance complement or substitute each other in Table 3. In addition to the direct impact of the three

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[34] 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.

[35] The classification between advanced and emerging economies follows the IMF's definitions.

[36] In banking, we still see crisis patterns, likely reflecting persistent banking deleveraging, in particular in Europe in line with Emter et al. (2019).

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 (see Table A5 in the Appendix).[37] The latter interaction, in contrast, is mostly insignificant, thereby suggesting that physical distance and linguistic distances are neither complements nor substitutes.

[Table 3 about here]

Our results thus show that distance mattered during the global financial crisis of 2007-09. International trade transactions contracted by more between countries that are far apart, have limited internet linkages, and have limited language commonality, in line with the footloose hypothesis. 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.

5.2 *Cross-sectional evidence from the Covid-19 pandemic*

Table 4 presents the estimated coefficients of model equation (6), with the dependent variable being the difference in bilateral trade in goods between 2020

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

Q1 and 2019 Q1, and initial trade the level of trade in goods 2019 Q1, thereby analyzing the initial impact of the Covid-19 pandemic on international trade flows.

The estimates again show that footloose effects are dominant. As in the global financial crisis episode, the coefficients on physical and linguistic distance are negative and highly significant, while the effect of virtual distance is not significant (see column 2 of Table 4). Excluding virtual distance from the estimation increases the number of observations substantially, and the effects of physical and linguistic distance become stronger and strikingly close in economic magnitude to those of the baseline estimates for the global financial crisis of 2007-09. The estimates are robust to controlling for the level of bilateral GVC integration measured in 2019, as in columns 3 and 4 of Table 4, although the economic magnitude of estimated effect of physical distance declines slightly in the estimates obtained without virtual distance (see column 4).[38]

[Table 4 about here]

5.3 *Panel estimates*

5.3.1 *Basic results*

Our results so far apply to large but exceptional episodes. The question remains as to whether distances generally matter for international trade transactions, i.e. also in more normal times. We address this with the panel model described in Equation (12) for trade in goods, with the dependent variable being the standard deviation of the annual growth rate in bilateral imports over 5-year windows.

Distance measures matter, in a heterogeneous way, as shown in Table 5, which for brevity again presents only the coefficients on the measures in question.[39]

[38] As in the global financial crisis episode, pre-Covid-19 global value chain integration itself shows a significant positive signs indicating that larger bilateral integration was associated with a smaller decline in trade flows.

[39] The regressions include the control variables of model equation (11) as well as time-varying source- and destination-country fixed effects.

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 (see 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 financial crisis and pandemic periods.

Our results suggest that while gravity applies to both the level and changes of international trade, it can do so in different ways. A long-standing literature has shown that physical distance matters for the level of international trade. We find that it also matters for its volatility. Our results over the shorter sample, however, suggest that this reflects 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 (see Table A6 in the Appendix). We also consider trade volatility over 10 year windows. Appendix Table A7 shows that the results are also broadly unchanged.

Finally it could be argued that volatility of trade is a function of its level. We take up this issue in Table A8 where we use as our dependent variable the coefficient of variation rather than the standard deviation of the annual log difference in bilateral imports of goods over each window.[40] 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

[40] 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.

average bilateral trade; that distance amplifies trade volatility comes out again strongly from the estimates (see columns 5 to 8).[41] In Table A9, we control for bilateral GDP growth correlations within time windows; although the sample size declines by about one-third, the results remain robust.

[Table 5 about here]

5.3.2 *Complementarities between distance measures*

We now assess whether the measures of distance amplify each other in terms of their impact on trade volatility. Table 6 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 financial crisis sample that alternative distance metrics are complements rather than substitutes. Specifically, virtual distance amplifies the impact of physical and linguistic distances. When all direct and interacted effects are included at the same time (see 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 interaction. 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 when allowing for this only interaction, which allows us to use the longer sample (column 3).

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[41] 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.

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

[Table 6 about here]

6. Conclusion

This paper considered whether distance impacts the volatility of international real and financial trade beyond its well-established relevance for the level of trade. A simple model shows that whether demand shocks have a larger impact on trade between more distant countries, and thereby produce a “beachhead” effect that dampens the effects of demand shocks on trade with distant markets, or an opposite “footloose” effect, depends on the specific structure of fixed costs.

We empirically assess the linkages between distance and trade volatility by looking at a broad range of international linkages and metrics of distance. We first showed that international trade in goods, services and finance, contracted disproportionately more during the global financial crisis 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 found similar evidence for trade in goods during the Covid-19 pandemic of 2020, and showed that distance is associated with more volatile trade flows when considering a panel of countries over a 65-year sample period.

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. A policy maker concerned about her country’s exposure to the global cycle should therefore not necessarily focus only on her main trading partners, which are likely to be nearby countries. Trade flows with smaller distant partners could prove more volatile in crisis times and thereby contribute to overall trade volatility as much as more stable flows from neighbouring countries. 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 20 % decrease in C
Baseline parameters: $\rho = 6, \eta = 2, \alpha = 1$

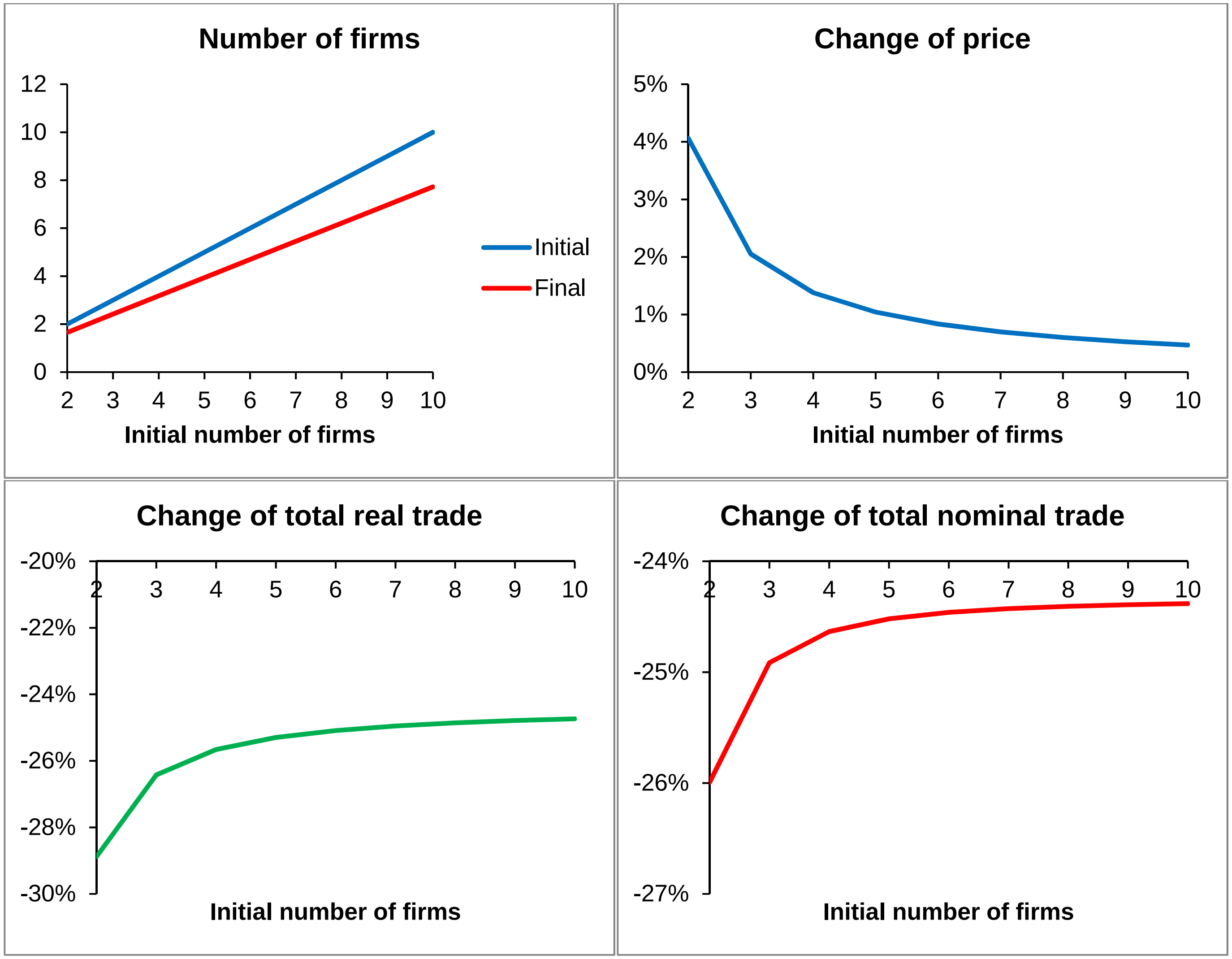

Figure 2: Sensitivity analysis

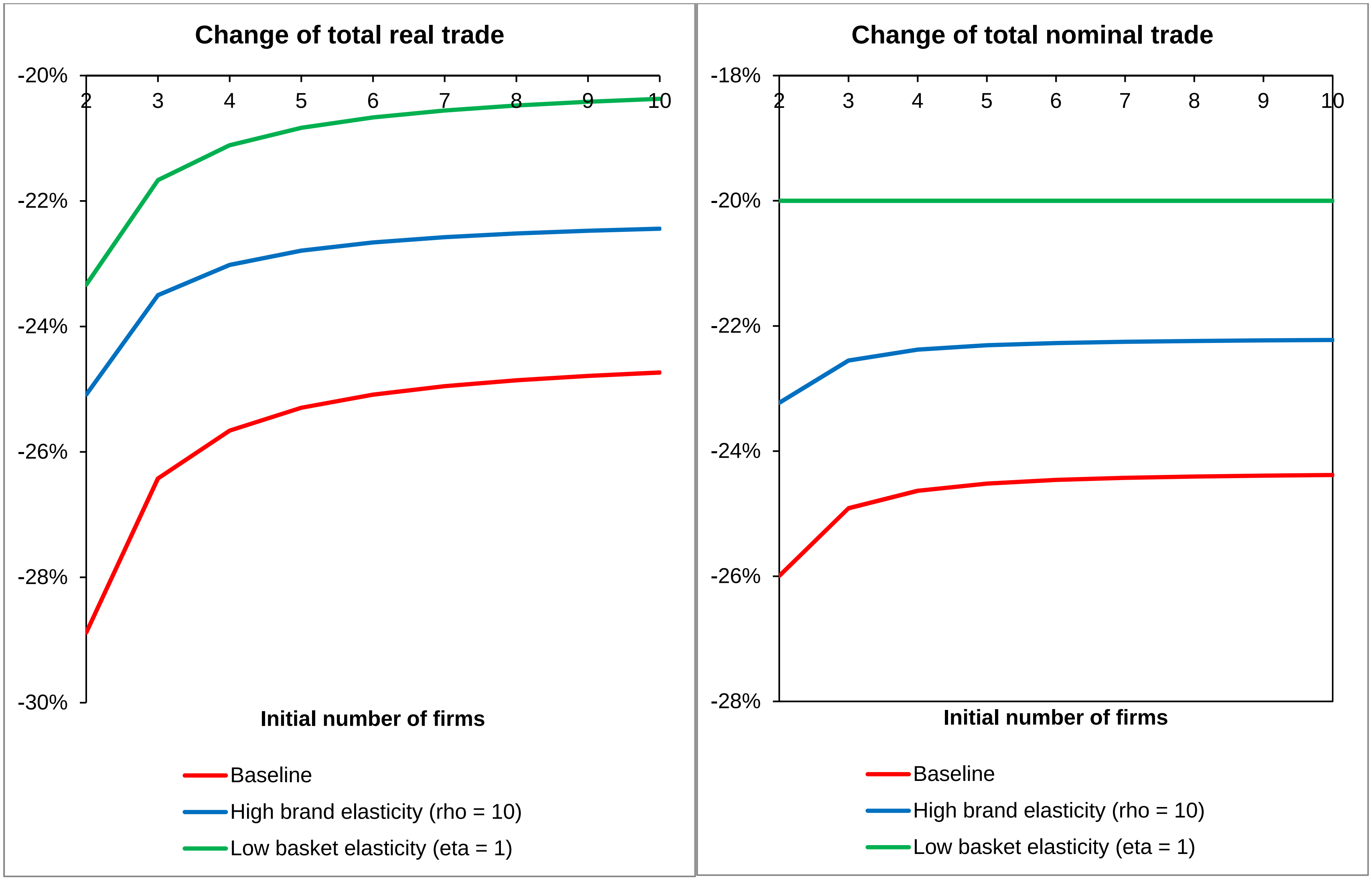

Figure 3: Role of elasticities

Additional percent fall when $n^I = 2$ compared to $n^I = 5$

The red bars corresponds to combinations where $\rho - \eta = 5$

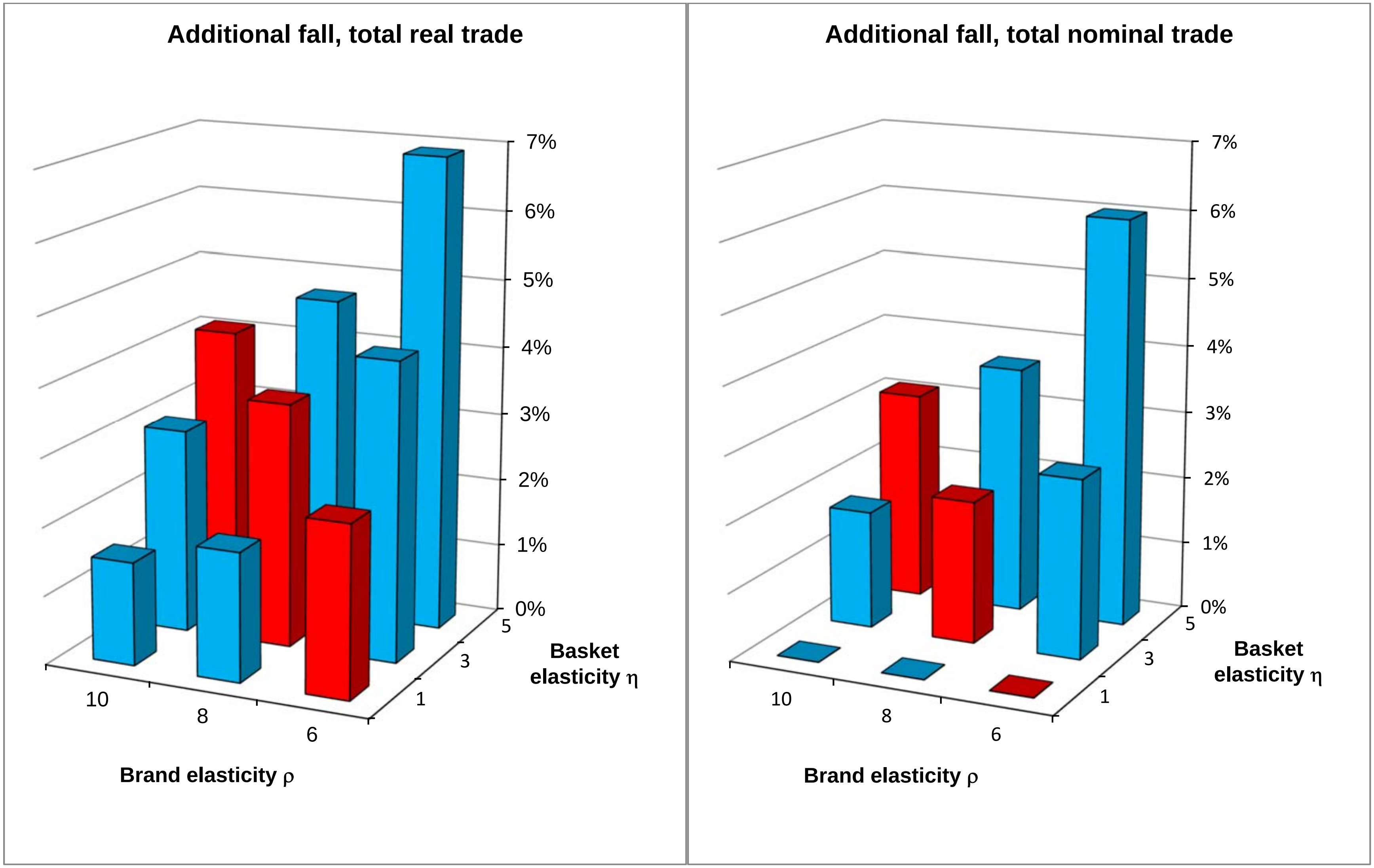

Figure 4: Impact of demand on exports with fixed entry cost

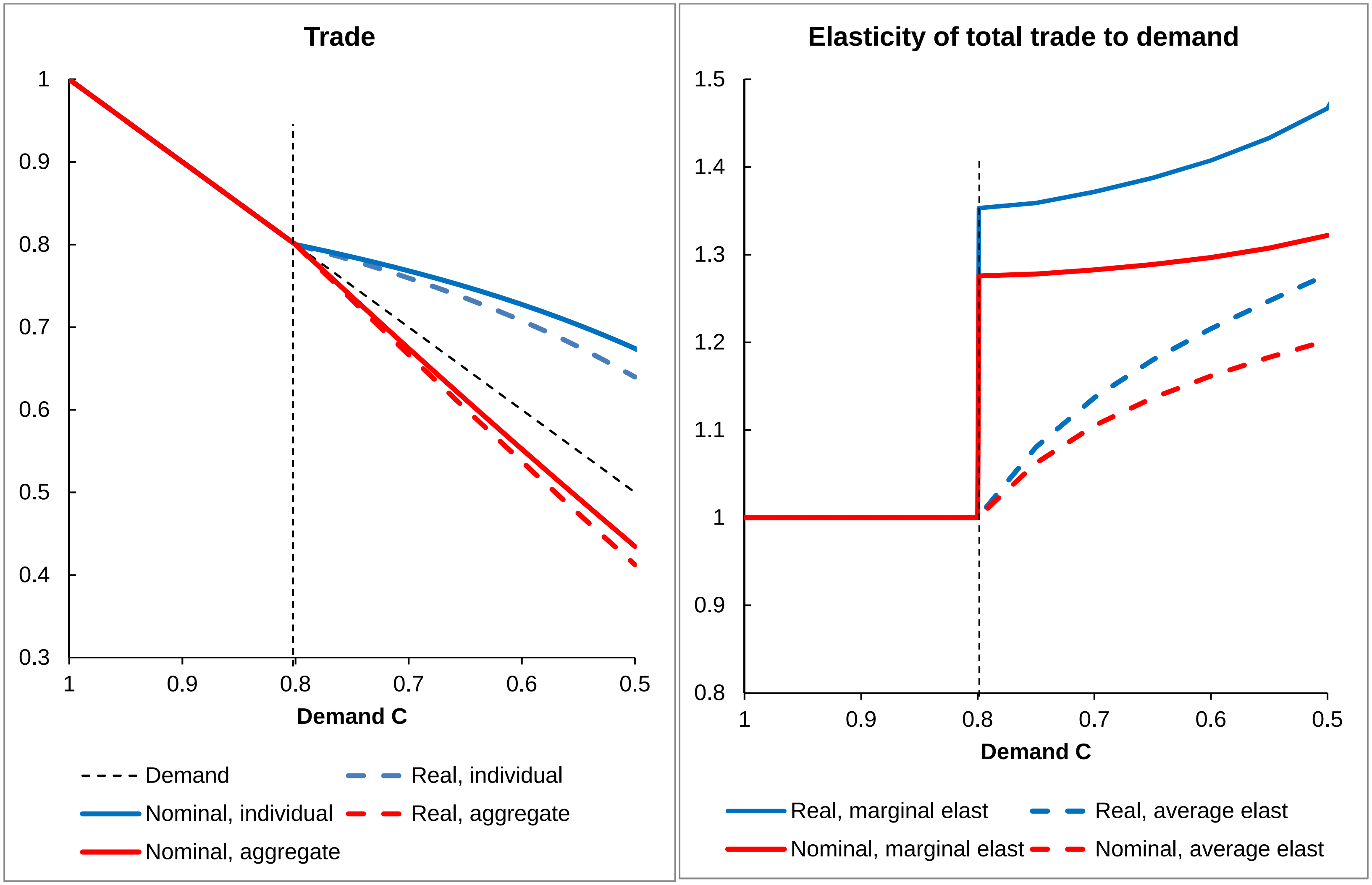

Figure 5: Elasticity of aggregate exports to demand

Different fixed costs of entry, identical fixed costs of production

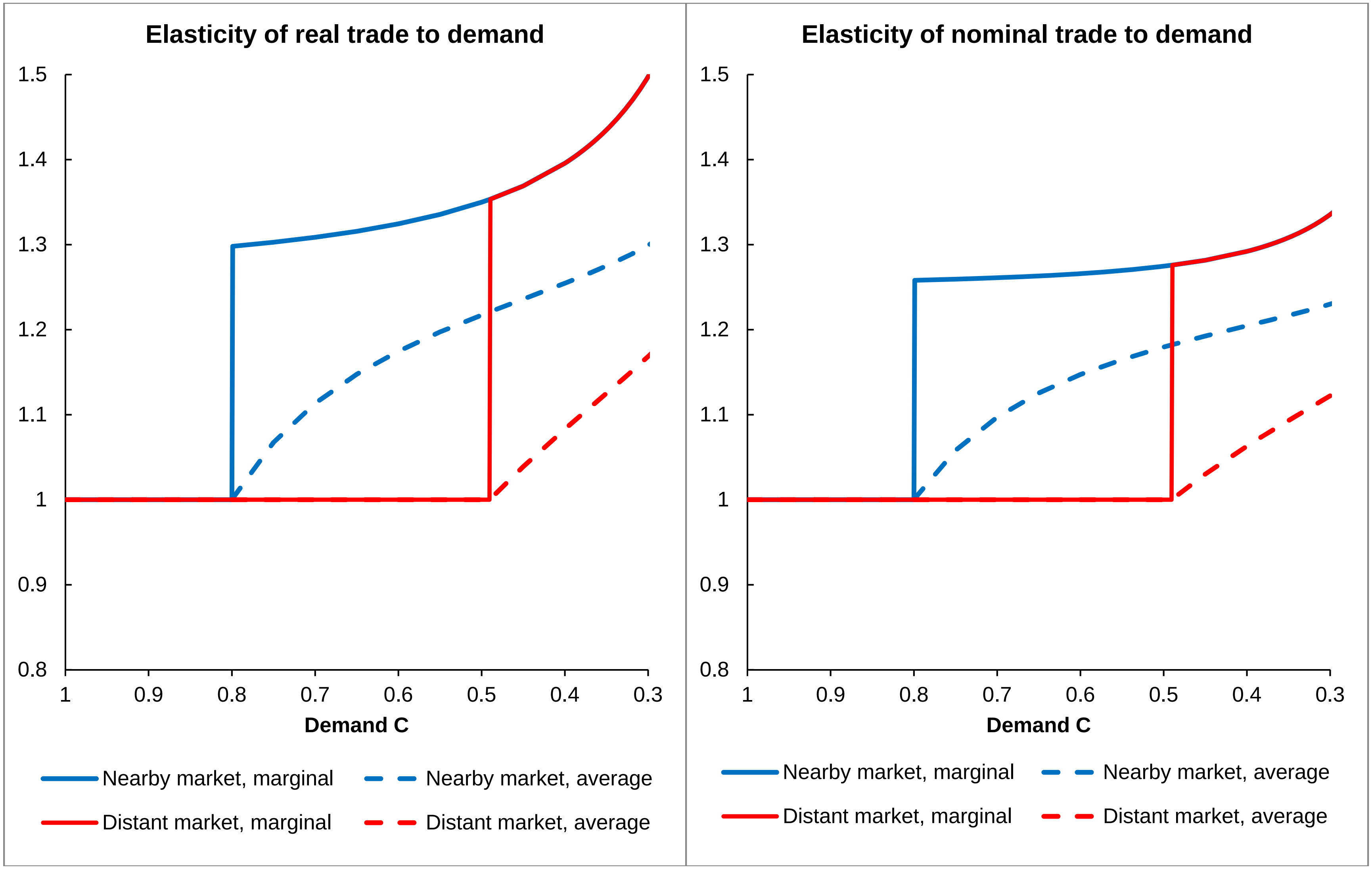

Figure 6: Elasticity of aggregate exports to demand
Different fixed cost of production, identical fixed costs of entry

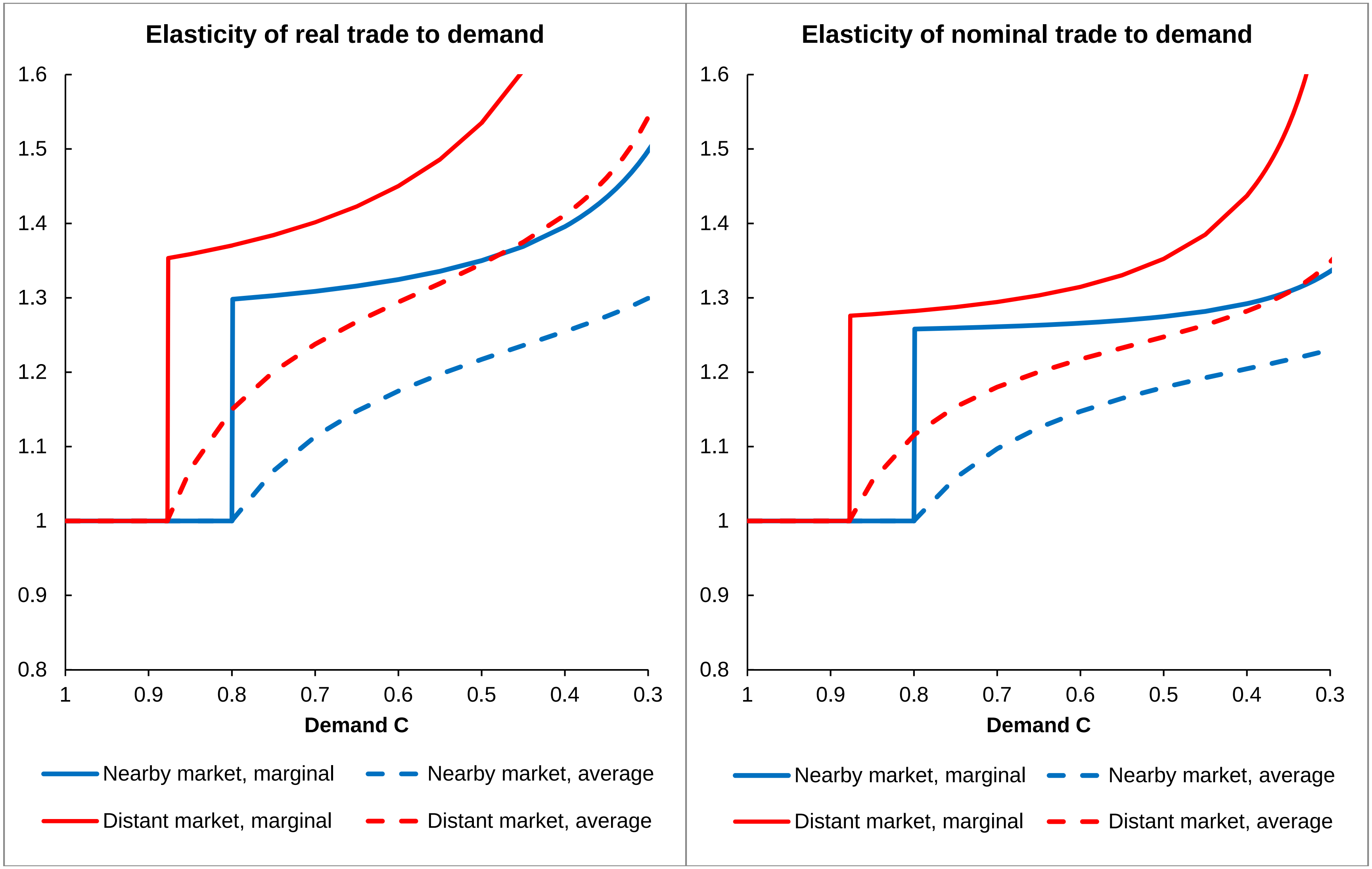

Figure 7: Elasticity of aggregate exports to demand

Different fixed costs of production and entry, identical ratio of fixed costs

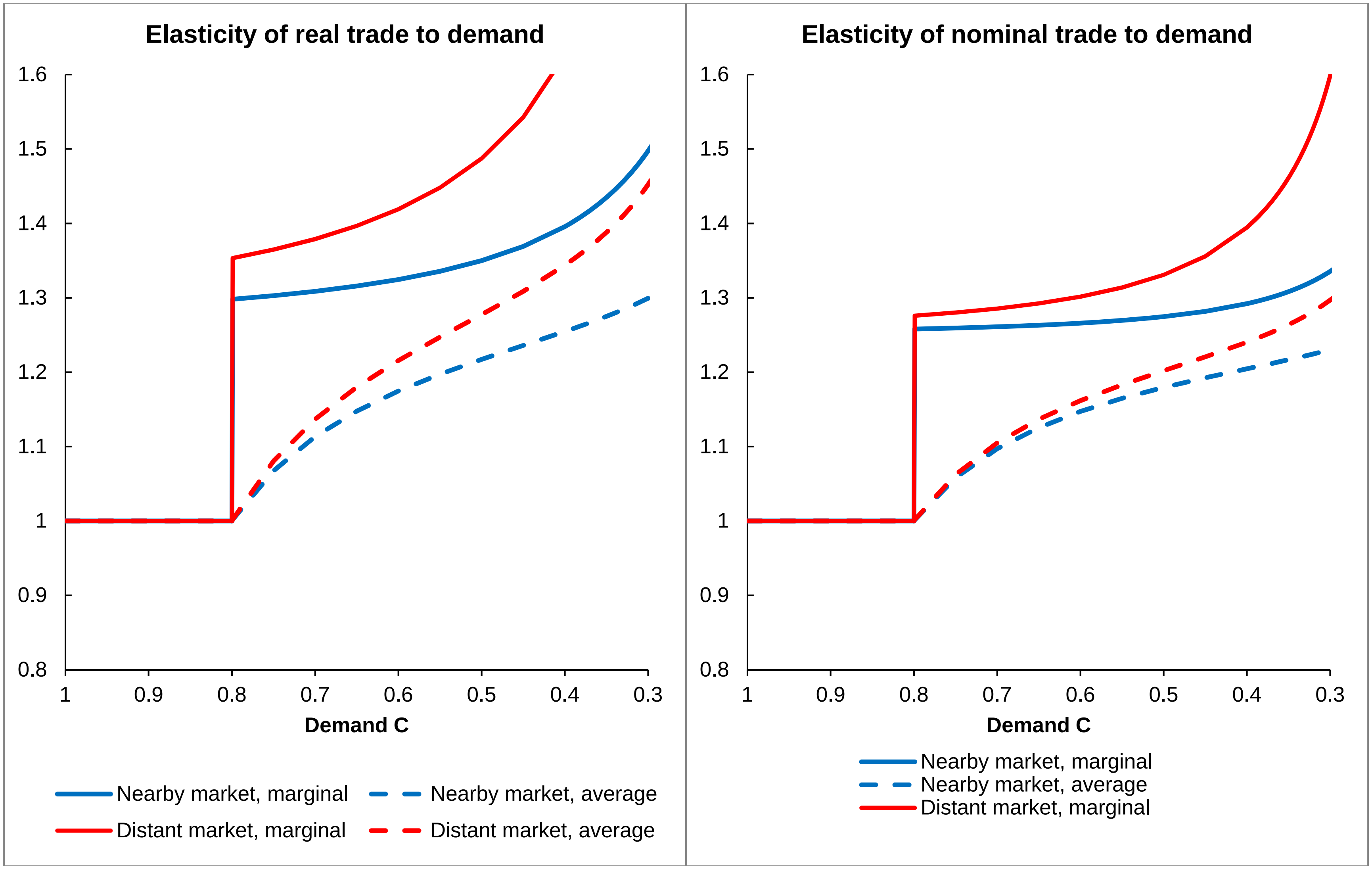

Table 1: Event study of the global financial crisis of 2007-09 – Basic cross-sectional estimates

	(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)	-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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions 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 of the global financial crisis of 2007-09– Controlling for global value chains

	(1) Goods imports	(2) Goods imports	(3) Goods imports
ln(physical distance)	-0.235***	-0.138***	-0.260***
	(0.029)	(0.029)	(0.023)
ln(virtual distance)	-0.148**	-0.056	
	(0.064)	(0.066)	
ln(1+language distance)	-0.049***	-0.054***	-0.064***
	(0.018)	(0.018)	(0.014)
Observations	6,566	6,348	15,672
R^2	0.194	0.212	0.226
Exporter fixed effects	yes	yes	yes
Importer fixed effects	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes
GVC integration	no	yes	yes
Other gravity controls	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (11) obtained by OLS where the log change in bilateral trade in goods over 2007-2009 is the dependent variable. Bilateral transactions in goods are regressed on the three alternative measures of distance, the pre-crisis levels of the trade in goods, the gravity controls and source- and destination-country fixed-effects as well as on pre-crisis bilateral integration in global value chains. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** p<0.01, ** p<0.05, * p<0.1.

Table 3: Event study of the global financial crisis of 2007-09 – 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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions 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 4: Event study of the Covid-19 pandemic of 2020– Cross-sectional estimates

	(1) Goods imports	(2) Goods imports	(3) Goods imports	(4) Goods imports
ln(physical distance)	-0.146***	-0.212***	-0.122***	-0.148***
	(0.027)	(0.020)	(0.026)	(0.021)
ln(virtual distance)	-0.062		-0.038	
	(0.057)		(0.059)	
ln(1+language distance)	-0.057***	-0.051***	-0.056***	-0.046***
	(0.018)	(0.013)	(0.018)	(0.013)
Observations	6,512	16,484	6,298	15,374
R^2	0.132	0.136	0.136	0.143
Exporter fixed effects	yes	yes	yes	yes
Importer fixed effects	yes	yes	yes	yes
Pre-crisis trade/positions	yes	yes	yes	yes
GVC integration	no	no	yes	yes
Other gravity controls	yes	yes	yes	yes

Notes: the table reports cross-sectional estimates of model equation (11) obtained by OLS where the log change in bilateral trade in goods between 2020 Q1 and 2019 Q1 is the dependent variable. Bilateral transactions in goods are regressed on the three alternative measures of distance, the 2019 Q1 level of trade in goods, the gravity controls, the 2019 level of bilateral integration in global value chains (columns 3 and 4) 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 5: Panel estimates on the 1950-2015 period

	(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 (12) 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 (11); 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 6: Panel estimates on the 1950-2015 period – 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 (12) 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 (11); 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 A1: Event study of the global financial crisis – Cross-sectional 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(physical 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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions 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 of the global financial crisis of 2007-09 – Cross-sectional 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(physical 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(physical 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(physical 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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions 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 of the global financial crisis of 2007-09 – Robustness check on "payback" drop bias

	(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)	-0.163***	-0.163***	-0.108***	-0.028	-0.101**	-0.150***	-0.140**
	(0.025)	(0.025)	(0.026)	(0.057)	(0.049)	(0.045)	(0.064)
ln(virtual distance)	-0.124**	-0.124**	-0.213***	-0.426**	-0.283*	-0.102	0.030
	(0.060)	(0.060)	(0.076)	(0.166)	(0.146)	(0.142)	(0.177)
ln(1+language distance)	-0.022	-0.022	-0.019	-0.072**	-0.047	-0.037	-0.120***
	(0.017)	(0.017)	(0.014)	(0.034)	(0.038)	(0.028)	(0.040)
Observations	6,459	6,459	2,791	1,396	1,585	1,034	1,406
R^2	0.267	0.267	0.257	0.423	0.339	0.321	0.261
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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions 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 as well as the change in the measure of cross-border transactions in questions over 2005-07 to capture any "payback" drop effects. The standard errors reported in parentheses are robust to autocorrelation and heteroskedasticity; *** p<0.01, ** p<0.05, * p<0.1.

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Table A4: Event study of the global financial crisis of 2007-09 – Robustness check on post-crisis recovery

	(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)	0.060**	0.060**	-0.033	-0.029	-0.072	0.036	-0.166**
	(0.030)	(0.030)	(0.027)	(0.075)	(0.069)	(0.046)	(0.069)
ln(virtual distance)	0.006	0.006	0.034	-0.089	0.382**	-0.082	-0.026
	(0.070)	(0.070)	(0.089)	(0.191)	(0.162)	(0.151)	(0.246)
ln(1+language distance)	0.015	0.015	0.026	0.033	-0.009	0.063*	-0.017
	(0.022)	(0.022)	(0.018)	(0.038)	(0.046)	(0.037)	(0.048)
R^2	6,614	6,614	2,966	1,714	1,816	1,362	1,543
Exporter fixed effects	0.096	0.096	0.173	0.258	0.258	0.232	0.256
Importer fixed effects	yes	yes	yes	yes	yes	yes	yes
2009 level of 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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions over 2009-2012 is the dependent variable. Each measure of bilateral cross-border transactions is regressed on the three alternative measures of distance, the 2009 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.

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Table A5: Event study of the global financial crisis of 2007-09 – 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 (11) obtained by OLS where the log change in bilateral cross-border transactions/positions 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 A6: Panel estimates on the 1950-2015 period – 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 (12) 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 (11); 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 A7: Panel estimates on the 1950-2015 period – 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 (12) 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 (11); 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 A8: Panel estimates on the 1950-2015 period – Controlling for the 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 (12) 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 (11) 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 A9: Panel estimates on the 1950-2015 period – Controlling for GDP growth correlations (5-year windows)

	(1)	(2)
ln(physical distance)	-0.004	0.024**
	(0.007)	(0.011)
ln(virtual distance)	0.003***	
	(0.001)	
ln(1+language distance)	-0.001	0.010+
	(0.004)	(0.007)
Observations	4,759	19,322
R^2	0.305	0.305
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 (12) 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 (11); country-time fixed effects are also included throughout, and control for bilateral GDP growth correlations. 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 A10: Panel estimates on the 1950-2015 period – 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 (12) 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 (11); 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.