OECD Economics Department Working Papers No. 610

# Have Developed Countries Escaped the Curse of Distance?

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https://dx.doi.org/10.1787/241705110254

OECD

**Unclassified** **ECO/WKP(2008)18**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

**15-May-2008**

**English - Or. English**

**ECONOMICS DEPARTMENT**

**ECO/WKP(2008)18**
**Unclassified**

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**By**

**Hervé Boulhol and Alain de Serres**

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**JT03245675**

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**English - Or. English**

## ABSTRACT/RÉSUMÉ


### Have developed countries escaped the curse of distance?

There is widespread evidence that a better access to markets contributes to raising income levels. However, no quantification of the impact of distance to markets has been made on the basis of a sample restricted to advanced — and therefore more homogeneous — countries. This paper applies the framework developed by Redding and Venables (2004) on a panel data covering 21 OECD countries over 1970-2004, and shows that, relative to the average OECD country, the cost of remoteness for countries such as Australia and New Zealand could be as high as 10% of GDP. Conversely, the benefit for centrally-located countries like Belgium and the Netherlands could be around 6-7%. Second, the paper explains why the key estimated parameter in the Redding-Venables model is biased upwards in cross-section samples that mix both developing and developed countries, because of the inability to adequately control for heterogeneity in technology levels across countries. The paper also provides a detailed discussion of the links between the “death-of-distance” hypothesis, the evolution of transport costs and that of the elasticity of trade to distance.



*JEL classification codes*: F12, F15, R11, R12

*Key words*: economic geography; market access; distance; transport costs


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### Les pays développés ont-ils échappé à la malédiction de la distance ?

De nombreuses études empiriques ont montré qu’un meilleur accès aux marchés contribue à augmenter les revenus. Cependant, aucune quantification de l’impact de la distance aux marchés n’a été effectuée à partir d’un échantillon homogène limité aux pays développés. Ce papier applique le cadre développé par Redding and Venables (2004) à des données de panel couvrant 21 pays de l’OCDE entre 1970 et 2004, et montre que, relativement à la moyenne des pays de l’OCDE, le coût de l’éloignement géographique pour des pays comme l’Australie et la Nouvelle Zélande s’élève à environ 10% de PIB. Réciproquement, le bénéfice que tirent les pays ayant une position centrale comme la Belgique et les Pays-Bas serait de l’ordre de 6-7%. Deuxièmement, cette étude explique pourquoi le paramètre-clé dans le modèle Redding-Venables est biaisé à la hausse dans des échantillons en coupe qui mêlent pays développés et en développement, en raison de l’incapacité à contrôler l’hétérogénéité des niveaux technologiques entre pays. Le papier propose également une discussion détaillée des liens entre l’hypothèse de la « fin de la distance », l’évolution des coûts de transport et celle de l’élasticité du commerce à la distance.



*Classification JEL* : F12, F15, R11, R12

*Mots-clés* : économie géographique ; accès aux marchés ; distance ; coûts de transport



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# HAVE DEVELOPED COUNTRIES ESCAPED THE CURSE OF DISTANCE? [1]

By Hervé Boulhol and Alain de Serres

## 1. Introduction

1. Everyone who has seen satellite pictures of earth at night has undoubtedly been struck by the clustering of economic activities as depicted by the concentration of city lighting across the globe. Such representations powerfully display agglomeration in a few locations and prompt the observer to wonder whether being surrounded by neighbours matter for a country's wealth. To what extent are countries remote from centres of economic activity hindered in their development process?

2. The impact of distance on income levels can materialise through various channels including trade, foreign investment, knowledge spillovers and technology diffusion, all of which are hampered by remoteness. Distance directly raises transport costs and thereby reduces trade in much the same way as a tax on exports or a tariff on imports, although without the benefits of tax receipts. By segmenting markets, distance also limits the extent to which domestic firms can operate on an efficient scale and, more generally, exploit increasing returns to scale. Also, by providing a natural shelter from foreign competition, the pressure on domestic companies to be efficient and innovate is weakened. Furthermore, the clustering of innovative activities suggests that there are extra benefits associated with such concentration.

3. There is widespread evidence that a better access to markets contributes to raising income levels. The model developed by Redding and Venables (2004) has led to a workhorse methodology to assess the impact of proximity to markets on income levels. It has been tested in different contexts and all of the studies find a strong relationship. Redding and Venables apply their framework to a cross-country sample of 101 countries, while Breinlich (2007), highlighting that regional income levels in the European Union display a strong core-periphery gradient, tests the impact of market access using a panel of European regions over 1975-1997. Head and Mayer (2006) conduct a similar exercise based on European sectoral data over a shorter period.[2]

4. The current paper brings three contributions. First, it investigates for the first time whether proximity to markets is a significant determinant of GDP per capita in a panel covering only developed countries. Access to markets varies widely between Australia and New Zealand, Japan, North America and

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1. The authors would like to thank numerous OECD colleagues, in particular Sveinbjörn Blöndal, Jørgen Elmeskov, Christian Gianella, David Haugh, Peter Hoeller, Vincent Koen, Jean-Luc Schneider and Andreas Wörgötter, for their valuable comments as well as Philippe Briard and Martine Levasseur for technical assistance and Caroline Abettan for editorial support. The paper has also benefited from comments by members of the Working party No. 1 of the OECD Economic Policy Committee, as well as the participants to 'The Gravity Model" Conference, Groningen, October 2007.

2. Concurrently, Hanson (2005) develops a model allowing for labour mobility and tests it using data covering US counties. Combes and Overman (2004) present a survey of studies for various European countries replicating Hanson's approach developed in an earlier version.

Europe. Even within the European Union, centrality to markets is very different between the core and periphery countries. Yet, in a broad sample covering both least and most developed countries, Australia and New Zealand come out as outliers in the relationship between distance to markets and GDP per capita, suggesting that they have overcome the tyranny of distance (Dolman, Parham and Zheng, 2007). In contrast, according to the results presented in this paper, remoteness from markets relative to the average country in the sample might contribute negatively to GDP per capita by as much as 10% in Australia and New Zealand. Conversely, the benefit from a favourable location might be as high as 6% of GDP in the case of Belgium and the Netherlands.

5. Second, the paper elucidates why the cross-section sample used by Redding and Venables leads to the false impression that developed countries have escaped the curse of distance. The reason is straightforward: a cross-section that mixes both low- and high-income countries cannot control satisfactorily for the wide differences in the level of technical efficiency, which drastically biases upwards the sensitivity of GDP per capita to proximity to markets. The bottom line is that focusing on a more homogenous group leads to more reliable estimates and, as the sample used in this study covers a large period between 1970 and 2004, the panel dimension can be used to control for national idiosyncrasies.

6. Third, the paper provides a detailed discussion of the links between the “death-of-distance” hypothesis, the evolution of transport costs and that of the elasticity of trade to distance. The discussion helps to shed some light on the persistence of differences in access to markets across countries due to the relative stability of this elasticity over time.

7. The remainder of the paper is organised as follows. The next section focuses on the construction of the indicators of access to markets, while Section 3 assesses their impact on GDP per capita. Section 4 discusses how these results relate to the “death-of-distance” hypothesis. Finally, Section 5 concludes.

## 2. Market and supplier access

### *2.1. Theoretical background*

8. Measuring access to markets is not a straightforward exercise. Market potential is a common measure of proximity to markets, which dates back to Harris (1954), and is defined as the sum of all countries’ GDP weighted by the inverse of the bilateral distance. Although it is an intuitive indicator of centrality, market potential is an ad-hoc way of capturing the influence of distance to markets. In particular, the weighting of markets in the market potential computation is based solely on distances, regardless of the true accessibility of these markets. Being closer to a large market is the more beneficial the more that country is open. In that respect, market *potential* is a very crude measure of market *access*. A better approach consists in looking not only at the *potential*, but rather at the *actual* accessibility to countries’ markets.

9. The new economic geography literature has revived the concept of proximity to markets and formalised the role of economic geography in determining income levels. Starting from a framework developed by Fujita, Krugman and Venables (1999), Redding and Venables (2004) have introduced two dimensions of proximity: market access refers to the access to final customers, while supplier access refers to the access of producers to intermediate goods. They show how better market and supplier access could raise the prices of the internationally immobile factors. The intuition for this result is the following and Annex 1 provides the details of this theoretical framework.

10. Based on a model with fixed costs of production and free entry under monopolistic competition, a firm which faces a large demand for its products is able to charge a higher price. Consequently, in equilibrium, this tends to boost labour demand and these firms pay higher wages. This is the market

(domestic and foreign) access effect. In addition, due to increased competition, prices of intermediates are lower in large markets. Firms having a favourable access to suppliers benefit from lower costs of inputs, which also leads to higher wages in equilibrium. This is the supplier (domestic and foreign) access effect. As summarised by Redding and Venables, "transport costs or other barriers to trade mean that more distant countries suffer a market access penalty on their sales and also face additional costs on imported inputs. As a consequence, firms in these countries can only afford to pay relatively low wages – even if, for example, their technologies are the same as those elsewhere".

11. The additional important insight of the Redding and Venables model consists of using trade data to *reveal* both observed and unobserved determinants of market and supplier access, $MA$ and $SA$ respectively. As discussed below, $MA$ and $SA$ are constructed using the estimates of a bilateral trade equation based on a gravity-like specification which relates bilateral trade flows to trade partners' characteristics and trade costs.

12. The effects of market and supplier access on wages, $w$, are captured in the following equation:

$$Log\ w_{it} = \frac{1}{\beta\,\sigma}\left[Log\ MA_{it} + \alpha\frac{\sigma}{\sigma-1}Log\ SA_{it}\right] + \frac{1}{\beta}Log\ a_{it} + constant_t + \varepsilon_{it} \qquad (1)$$

where $\alpha$ and $\beta$ are the intermediate input and labour shares in gross output respectively, $\sigma$, greater than 1, is the elasticity of substitution between the different varieties and $a_{it}$ is the level of technical efficiency. Note that the impact of supplier access is directly related to the share of intermediates. Also, wages are more sensitive to access conditions when the labour share is low because, in that case, wages react more to changes in prices.

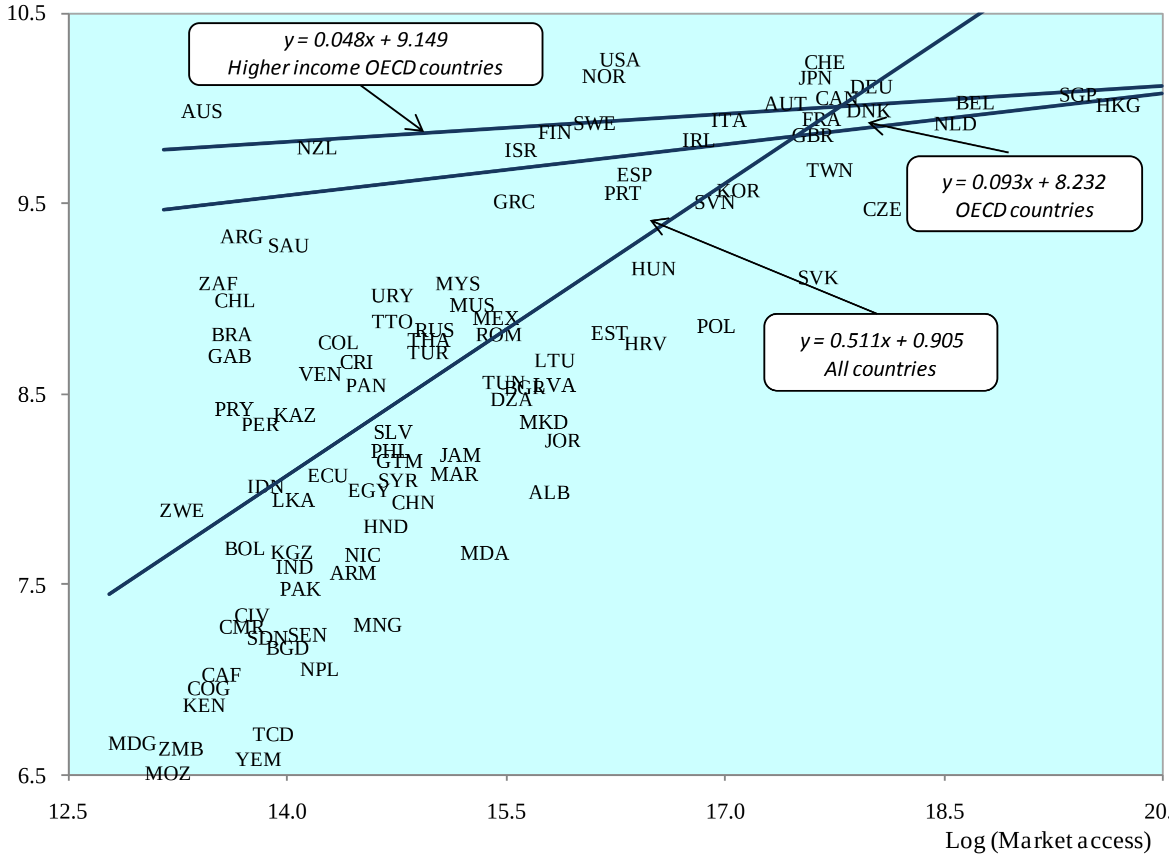
### 2.2. Importance of the sample

13. The level of technical efficiency, $a_{it}$, is a critical component in the relationship linking the access variables to income levels, *i.e.* equation 1. Since it is not directly observable, failure to adequately control for technical efficiency might bias the key parameters of interests. This issue is similar to the one highlighted by Hall and Jones (1999), among others, in the growth literature, since differences in technology are generally treated as residuals giving rise to omitted variable bias. This issue is likely to be serious in cross-section analysis, while panel data enables to introduce the whole battery of country and year fixed effects, as well as country specific time trends.

14. In order to illustrate this issue, Figure 1 reproduces Fig. 3 in Redding and Venables (2004) and adds three trend lines.[3] The log of market access appears on the x-axis, while the log of GDP per capita is represented on the y-axis, both in 1994. The steepest trend line mainly captures the relation identified by Redding and Venables. The slope is 0.51 and, with the best efforts to add control variables in order to account for technology and other fundamental determinants of income levels (primary resources, tropical area, institutions, *etc*.), Redding and Venables reach a reduced slope of around 0.30. The middle trend line is obtained, using the same data, for the cross-section limited to OECD countries. The slope is reduced from 0.51 to 0.09. When the cross-section is further restricted to the high-income OECD countries — excluding Eastern Europe members, Korea, Mexico and Turkey — in order to focus on a more homogenous group of countries, the slope falls to 0.05, but remains significantly different from zero.

3. The authors wish to thank Stephen Redding for having made their data available.

**Figure 1. GDP per capita and market access, 1994**[1]




1. Data are from Figure 3 in Redding and Venables (2004). Only fitted trend lines are added.

15. Clearly, an estimated slope of 0.30 would imply an unrealistic impact of remoteness for countries such as Australia and New Zealand, as well as for Belgium and the Netherlands. It is argued in section 3, where the impact is quantified, that the flattest curve provides more realistic estimates, which has two implications. On the one hand, there is strong qualitative support for the relationships identified by Redding and Venables, even though the importance of paying a closer attention to heterogeneity is underscored. On the other hand, there is collateral damage: the flatter and more reliable line cannot be easily reconciled with the structural parameters of the model, suggesting the need to amend it somehow such that it matches the data better. This is beyond the scope of this paper.

### *2.3. Construction of the access indicators*

16. Market and supplier access measures are derived from the estimation of a gravity-like relationship. As is common in the literature, trade costs, $\tau$, are assumed to depend on three variables: bilateral distance, common border and common language. Noting $X_{i \to j, t}$ as the export from country $i$ to country $j$ in year $t$ and $d_{ij}$ the bilateral distance between the two countries, the model leads to the following trade equation, which is estimated for each year between 1970 and 2005 using the OECD International Trade by Commodity Statistics database covering 98.5% of world goods trade flows:

$$Log\ X_{i \to j,t} = a_t\ Log\ d_{ij} + b_t\ Border_{ij} + c_t\ Language_{ij} + \alpha_t + Log\ m_{jt} + Log\ s_{it} + u_{ijt} \qquad (2a)$$

where trade costs enter into the gravity equation via the freeness of trade, the so-called phi-ness, $\phi_{ijt} = \tau_{ijt}^{1-\sigma}$, which is inversely related to trade costs:[4]

$$Log\ \phi_{ijt} = a_t\ Log\ d_{ij} + b_t\ Border_{ij} + c_t\ Language_{ij} + \alpha_t \qquad (2b)$$

17. The market capacity, $m_{jt}$, and the supplier capacity, $s_{it}$, are unobservable characteristics, even though they can be given a theoretical interpretation, as explained in Annex 1. In practice, they are proxied, for each year, by importer and exporter country fixed effects. The estimates of "intra-country" phi-ness, $\phi_{iit}$, is computed based on the same formula applied to internal distance, common border and common language.

18. The main distance measure in this study, *distcap*, commonly combines geodesic capital-to-capital distances between countries and internal distances based on surface areas, *i.e.* $d_{ii} = 2/3\sqrt{area_i / \pi}$.[5] Robustness of the results was checked using the four distance indicators in the economic geography database of CEPII (*Centre d'études prospectives et d'informations internationales*). In particular, results are shown for the alternative measure based on city-level data, *distcities*. More precisely with *distcities*, both internal distances and distances between countries are based on bilateral distance between the largest cities of each country, weighted by their share in the overall country's population.[6]

19. The world was grouped into 32 areas: Africa, Australia, Austria, Belgium, Brazil, Canada, China, CIS countries, Denmark, Eastern Europe, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Latin America (other than Brazil and Mexico), Mexico, the Middle East, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States and Asia (other than the countries already included). For each year, the sample is therefore composed of a maximum of 32*31 = 992 observations.

20. There are two reasons to geographically group countries that bear a low weight in trade flows. First, the focus in this study is placed on developed countries, and having many low-weight countries in the sample might distort the relevant estimates. Second, such groupings drastically reduce heteroskedasticity in trade level equations that leads to inconsistent estimates in the log specification, as convincingly shown by Santos Silva and Tenreyro (2006). However, in case heteroscedasticity remains problematic, the non-linear version of equation (2a) in levels (and not logs) is also estimated as a robustness check.

21. Market and supplier access are then constructed from the estimated parameters of the bilateral equation according to:

$$MA_{it} = \sum_k \phi_{ikt} m_{kt} \quad , \qquad SA_{it} = \sum_k \phi_{ikt} s_{kt} \qquad (3)$$

4. When trade costs are prohibitive $\tau = +\infty$ and $\phi = 0$; when they are negligible $\tau = 1$ and $\phi = 1$.

5. This measure makes the assumption that the surface of each country can be represented as a disk where all suppliers are located in the centre and customers are located uniformly over the area.

6. For more details, see the notes of the database at http://www.cepii.fr/distance/noticedist_en.pdf.

For all the countries, market access (supplier access, respectively) is computed as a weighted sum of unobserved importer characteristics $m_{kt}$ (exporter characteristics $s_{kt}$, respectively) of all countries. Only the weights put on each partner change across countries, with these weights being a function of the estimated trade costs. If a given country $k$ has a large market capacity $m_k$, countries having low trade costs with country $k$, *i.e*. a high freeness of trade, are associated with a high weight on $m_k$ and tend to have a high market access. A similar argument applies to supplier access with respect to supplier capacity. Note that the same principle applies to market potential, which weights all countries' GDP by the inverse of the bilateral distances.

22. In addition, it should be emphasised that market and supplier access, like market potential, are measures of market density as much as market size. The weighting of the domestic market is related to internal trade costs which are greater for a large and sparsely populated country than for a small and densely populated one. In the case of market potential, for example, the domestic market (GDP) is divided by the internal distance, itself an indicator of surface area. Furthermore, if a large autarkic country is split into two (or more) symmetric regions opened to each other, then each region would have a smaller domestic market access, but the same total market access as the whole country, provided that the overall phi-ness is measured correctly. Indeed, in the case of two regions, *1* and *2*:

$$MA_1 = \phi_{11} m_1 + \phi_{12} m_2, \quad MA_2 = \phi_{21} m_1 + \phi_{22} m_2, \quad \phi_{11} = \phi_{22}, \quad \phi_{12} = \phi_{21}, \quad m_1 = m_2 \qquad (4a)$$

$$\phi = \frac{\phi_{11} + \phi_{12}}{2} \quad \Rightarrow \quad MA_1 = MA_2 = \phi\,(m_1 + m_2) = MA_{country} \qquad (4b)$$

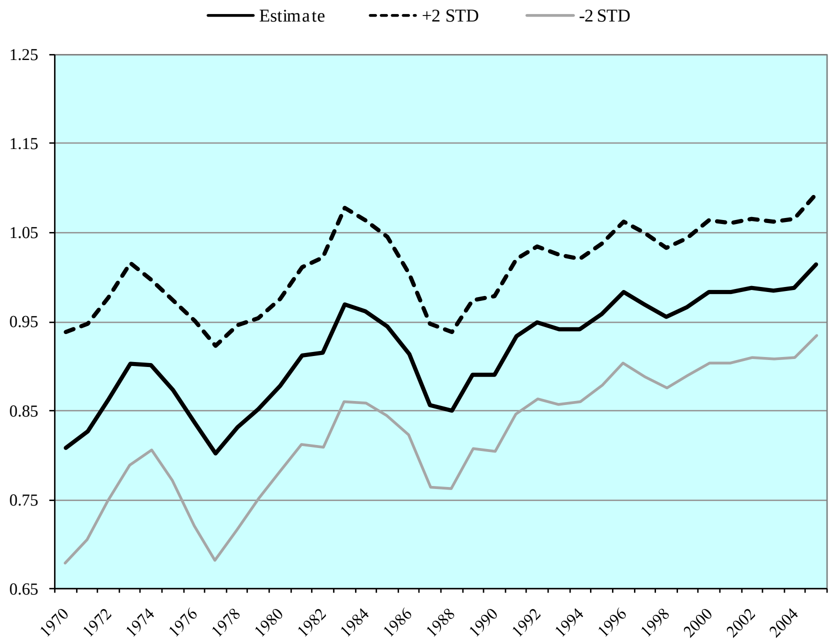
### *2.4. Results*

23. The most important and significant parameter in estimating (2) is that related to distance, which is shown in Figure 2a. It varies from -0.81 in 1970 to -0.99 in 2005 (Table A1 shows the estimates of the gravity equations), implying that an increase of 10% in the distance triggers a decrease of 9% in trade flows on average, consistent with the order of magnitude found in the literature.[7] Indeed, the meta-analysis of 103 papers carried out by Disdier and Head (2007) indicates that the elasticity of trade to distance is around -0.9 and that trade decreases with distance by roughly the same amount today than thirty years ago, with an increase in the impact of distance since the late eighties that is consistent with the findings reported in Figure 2a.

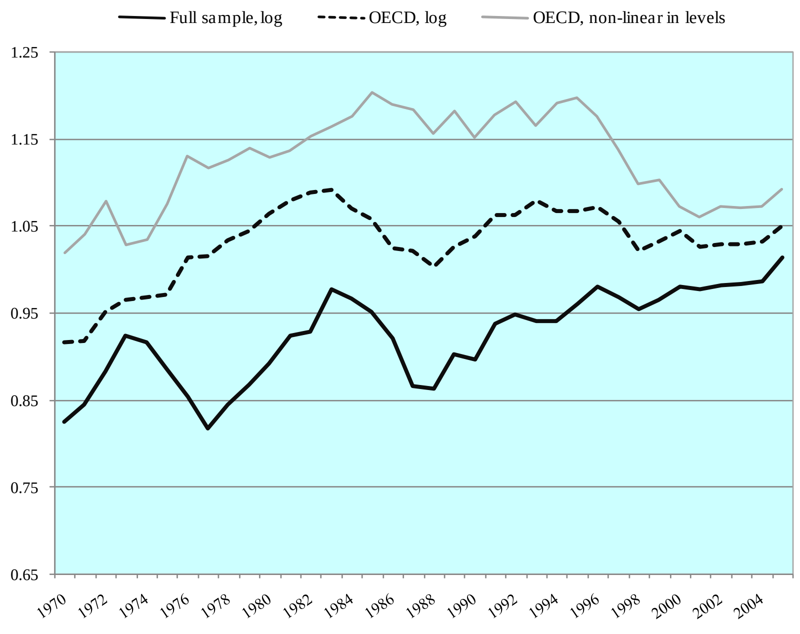
7. As an example based on this order of magnitude, the sole effect of distance implies that the value of France's imports from Australia or New Zealand should be only around 3% of that from the United Kingdom. In reality, this percentage was 15% and 5% in the 1970s for Australia and New Zealand, respectively; 8% and 2% in the 1980s; 4% and 1% in the period between 1990 and 2005.

**Figure 2. Absolute elasticity of trade flows to distance**

A. Estimated absolute elasticity and standard error using full sample[1]




B. Estimated absolute elasticity across samples / specifications[2]




1. Elasticity of trade flows to distance is estimated through the specification in equation (2).
2. The *full sample, log* line reproduces the estimated elasticity in Figure 2.A based on the log specification applied to the full sample. OECD, *log* uses the same specification restricted to OECD countries. OECD, *non-log* is derived from non-linear estimates of trade flows in levels on the OECD sample.

24. In order to check whether the non-decrease in the elasticity of trade to distance in absolute value is sensitive to the sample or the specification, two tests are conducted. First, the sample is restricted to the 24 OECD countries already included, excluding thereby all grouping. As shown, in Figure 2b (dashed line), the broad picture is similar: an increase in absolute terms into the early 1980s and a trough in the late 1980s. The main difference is that the elasticity has evolved in a tighter range since the 1980s and is not at the highest level at the end of the period. Second, following Coe *et al*. (2007), the trade equation was estimated on the same narrow OECD sample but with a specification in levels instead of in logs. As explained by Santos Silva and Tenreyro (2006), although this non-linear least-squares estimator is less efficient than pseudo-maximum-likelihood estimator in dealing with heteroskedasticity, it is asymptotically valid. Here the picture (grey line) is a bit different: the elasticity is even higher in absolute terms at each point in time; the increase over the whole period is more limited and there is even a decrease since the mid-1990s. In any case, the inference that the elasticity has not decreased in absolute value since the 1970s seems robust.[8] The apparent paradox between this result and the pace of globalisation characterised by rising trade flows is discussed in Section 4.

25. Table 1 reports the computed values for the 2005 access variables, as well as market potential for comparison. For presentational purposes, all indicators are scaled such that the average across countries is 100 in each year.[9] The range extends from around 25 for Australia, New Zealand and Brazil to above 200 for the very open core European economies of Belgium and the Netherlands. Unsurprisingly, the share of the domestic market in the total measures is the highest for Japan, which is both very densely populated and a large market, and for the United States, at around three-quarters and two-thirds respectively. That share is about one-half for Germany, and one-tenth for Northern European countries.

26. An alternative measure consists in using the alternative distance indicator, *distcities*. This measure entails some differences depending on the size of the countries (Table 2). In particular, the fact that Canada appears to have larger access than the United States is entirely due to the capital-to-capital measure, as the capital-to-capital distance is relatively low between the two countries, giving Canada a somehow too favourable access to the US market.[10]

8. This result is inconsistent with those found by Coe *et al.* (2007) from a sample of 70 countries. In the non-linear specification, the use of a smaller sample lowers efficiency, but still leads to consistent estimates. Therefore, the use of a smaller sample does not explain these significant differences. This suggests that these differences come from the heterogeneity of elasticities across pairs of trading partners, and, therefore, that it might be inadequate to assume the same elasticity across very different countries.

9. For each date $t$, the constant $\alpha_t$ in equation (2) cannot be identified due to country fixed effects, and both $Log\ s_{it}$ and $Log\ m_{jt}$ are known up to a constant. This means that, for each date, the level of phi-ness, the market and supplier capacity are known up to a multiple constant. It follows that the log of market and supplier access variables are known up to a time dummy and, therefore, that only the relative evolution through time can be depicted. In the econometric estimation of an equation such as (1), this is unproblematic insofar as the specification includes year fixed effects.

10. The other main difference between the two measures relates to the internal distance for Japan. Using the distance-to-cities measure, Japan is roughly at the average level, while the area-based measure places Japan in a better position.

**Table 1. Domestic and foreign components of market access, supplier access and market potential, 2005[1]**

Average across countries = 100 for each indicator

| | Market access | | | Supplier access | | | Market potential | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Domestic | Foreign | Total | Domestic | Foreign | Total | Domestic | Foreign |
| Australia | 25 | 9 | 17 | 23 | 5 | 18 | 21 | 4 | 17 |
| Austria | 116 | 13 | 103 | 123 | 15 | 108 | 124 | 14 | 110 |
| Belgium | 236 | 69 | 167 | 222 | 64 | 157 | 194 | 27 | 166 |
| Brazil | 25 | 4 | 21 | 26 | 6 | 20 | 28 | 4 | 25 |
| Canada | 126 | 7 | 120 | 86 | 3 | 83 | 111 | 5 | 106 |
| China | 48 | 15 | 33 | 71 | 34 | 37 | 46 | 10 | 36 |
| Denmark | 119 | 16 | 103 | 130 | 19 | 111 | 136 | 17 | 120 |
| Finland | 66 | 6 | 60 | 74 | 9 | 65 | 79 | 4 | 75 |
| France | 145 | 32 | 113 | 137 | 31 | 106 | 153 | 39 | 114 |
| Germany | 154 | 73 | 81 | 172 | 95 | 77 | 152 | 63 | 89 |
| Greece | 61 | 9 | 52 | 55 | 3 | 52 | 70 | 8 | 62 |
| Ireland | 100 | 12 | 88 | 101 | 24 | 77 | 107 | 10 | 97 |
| Italy | 115 | 54 | 61 | 110 | 50 | 60 | 116 | 43 | 73 |
| Japan | 111 | 83 | 28 | 163 | 129 | 35 | 127 | 99 | 28 |
| Korea | 104 | 61 | 43 | 154 | 91 | 63 | 85 | 34 | 52 |
| Mexico | 44 | 10 | 34 | 33 | 5 | 28 | 44 | 7 | 37 |
| Netherlands | 221 | 96 | 126 | 199 | 76 | 124 | 183 | 41 | 142 |
| New Zealand | 26 | 9 | 18 | 25 | 8 | 17 | 20 | 3 | 17 |
| Norway | 76 | 6 | 70 | 80 | 7 | 73 | 93 | 7 | 86 |
| Portugal | 73 | 12 | 62 | 59 | 7 | 52 | 76 | 8 | 68 |
| Spain | 96 | 40 | 55 | 73 | 19 | 54 | 89 | 21 | 68 |
| Sweden | 75 | 8 | 68 | 84 | 13 | 71 | 91 | 7 | 84 |
| Switzerland | 136 | 19 | 117 | 147 | 33 | 115 | 144 | 24 | 120 |
| Turkey | 52 | 6 | 46 | 52 | 5 | 47 | 60 | 6 | 54 |
| United Kingdom | 158 | 65 | 93 | 136 | 44 | 93 | 169 | 60 | 109 |
| United States | 92 | 64 | 28 | 64 | 39 | 25 | 82 | 54 | 28 |

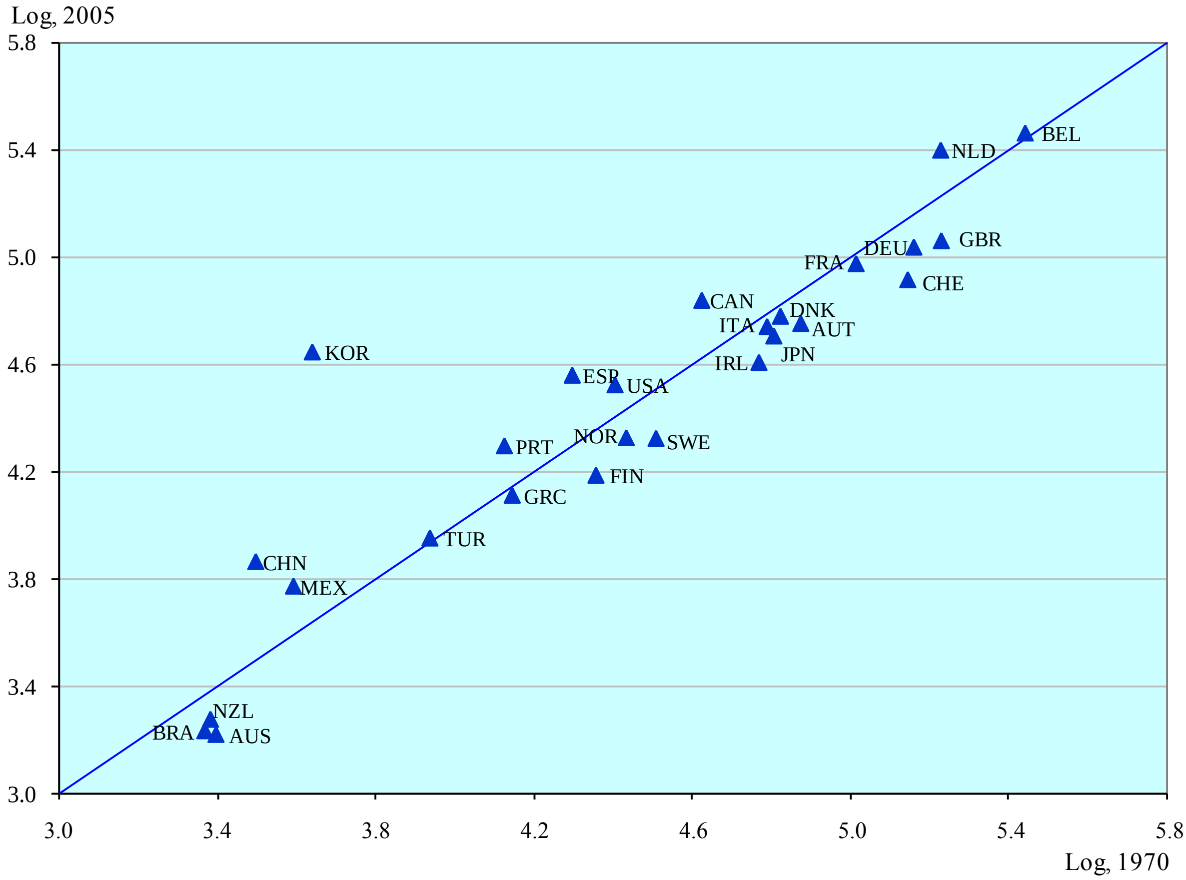
1. The distance measure used in this table is *distcap*. It is based on geodesic capital-to-capital distance between countries. The underlying assumption behind the internal distance $d_{ii} = 2/3\sqrt{area_i / \pi}$ is that a country is a disk where all suppliers are located in the centre and customers are located uniformly over the area.

27. Differences in access to markets across countries are very persistent as shown in Figure 3, which presents market access estimates in 1970 and 2005. The main changes relate to the market access gain of China and Korea. In addition, Spain and Portugal record significant improvements in market access due to their better integration in the European Union, while Canada and Mexico have benefited from both NAFTA and the dynamic US market. By contrast, Switzerland, Australia and most of Northern European countries have seen their relative position deteriorate by 15 to 20%, which can be measured as the vertical distance to the diagonal.[11]

11. Despite the rising economic importance of Asia, the impact for other OECD countries' access to markets is muted for two reasons. First, the share of Asia minus Japan in world GDP has gained less than 4 points since 1970. Second, even Australia and New Zealand, often seen as significant beneficiaries of strong growth in Asia, are far from the centres of growth in this area. For example, the geodesic capital-to-capital distance between Australia, on the one hand, and China and Korea, on the other hand, is 9 000 and 8 400 km respectively. For Germany, these distances are 7 400 and 8 100 km respectively. Moreover, Australia and New Zealand have not benefited from the large regional integration, such as driven by NAFTA or the European Single Market Programme.

**Figure 3. Market access, 2005 *vs* 1970[1]**

Average across countries = 100 for each year




1. Market access is computed as described in equation (3). The relative change between 1970 and 2005 compared to the average country is directly read from the graph as the vertical distance to the diagonal (as a first-order approximation). For example, for Australia, the log of market access was 3.40 in 1970 and 3.22 in 2005. The vertical distance is therefore -18%. The exact change is exp (-0.18) – 1 = -16.5%.

**Table 2. Market and supplier access, alternative distance measure, 2005[1]**

Average across countries = 100 for each indicator

| | Market access | | | Supplier access | | |
|---|---|---|---|---|---|---|
| | Total | Domestic | Foreign | Total | Domestic | Foreign |
| Australia | 27 | 9 | 19 | 25 | 5 | 20 |
| Austria | 122 | 11 | 111 | 126 | 12 | 114 |
| Belgium | 270 | 86 | 184 | 256 | 80 | 176 |
| Brazil | 26 | 5 | 22 | 27 | 7 | 20 |
| Canada | 69 | 6 | 62 | 50 | 3 | 47 |
| China | 55 | 20 | 35 | 84 | 45 | 39 |
| Denmark | 113 | 13 | 99 | 118 | 16 | 103 |
| Finland | 67 | 8 | 59 | 73 | 12 | 61 |
| France | 126 | 26 | 100 | 121 | 25 | 96 |
| Germany | 164 | 62 | 102 | 173 | 79 | 94 |
| Greece | 68 | 11 | 56 | 59 | 3 | 56 |
| Ireland | 113 | 14 | 99 | 113 | 28 | 86 |
| Italy | 102 | 30 | 72 | 98 | 27 | 71 |
| Japan | 88 | 55 | 32 | 126 | 85 | 41 |
| Korea | 104 | 56 | 48 | 152 | 83 | 69 |
| Mexico | 53 | 8 | 45 | 39 | 4 | 35 |
| Netherlands | 259 | 111 | 148 | 236 | 86 | 150 |
| New Zealand | 25 | 5 | 20 | 23 | 5 | 19 |
| Norway | 76 | 5 | 71 | 78 | 6 | 72 |
| Portugal | 70 | 7 | 63 | 59 | 4 | 55 |
| Spain | 87 | 27 | 60 | 71 | 12 | 59 |
| Sweden | 81 | 8 | 73 | 87 | 13 | 74 |
| Switzerland | 156 | 15 | 140 | 165 | 26 | 139 |
| Turkey | 55 | 5 | 49 | 54 | 4 | 49 |
| United Kingdom | 155 | 67 | 88 | 134 | 45 | 89 |
| United States | 71 | 49 | 22 | 51 | 30 | 21 |

1. The alternative distance measure is *distcities* in the CEPII database. Both internal distances and distances between countries are based on bilateral distance between the biggest cities of each country, weighted by their share in the overall country population.

## 3. Impact on GDP per capita

28. The impact of access variables on GDP per capita has been estimated using a sample of 21 OECD countries over 1970-2004.[12] The empirical specification takes advantage of the panel dimension and include *e.g.* country and year fixed effects and country specific time trends in order to control for the level of technical efficiency ( $Log\ a_{it}$ in eq. 1). In addition, estimates based on instrumental variables are reported in order to address the potential endogeneity of the access variables. As in Redding and Venables (2004), GDP per capita is taken as a proxy for the price of the immobile factor, $w$ :

$$Log\ (GDP / capita)_{it} = \theta_M\ Log\ MA_{it} + \theta_S\ Log\ SA_{it} + e_i + e_t + \varepsilon_{it} \qquad (5)$$

29. Table 3 reports a first series of results when equation (5) is estimated in levels (first three columns, left panel) or in first-differences which wipe out the country fixed-effects (last three columns, right panel). Comparing the estimates between these two panels suggest that auto-correlation in residuals might be a serious issue, while comparing them within panels reveals some potential collinearity issues between the two access measures. Faced with the latter problem, Redding and Venables (2004) use the structural parameters of the model to constrain the two variables. In the expression in brackets in (1), the weight of supplier access is $\alpha\,\sigma/(\sigma-1)$. Assuming a value for the share of intermediates, $\alpha$ , of between 0.5 and 0.6, and a value for the elasticity of substitution, $\sigma$ , of between 6 to 10, as is generally estimated, that weight varies between 0.55 and 0.72. The results hereafter were robust to any specific choice within that range and the reported results use the set that is preferred by Redding and Venables, *i.e.* $\alpha = 0.5$ and $\sigma = 10$.

**Table 3. GDP per capita and economic geography: market and supplier access separately**

| Dependant variable GDP per capita | levels | levels | levels | first differences | first differences | first differences |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Market access | 0.163*** | | 0.193 | 0.110*** | | 0.115*** |
| | *(0.058)* | | *(0.056)* | *(0.023)* | | *(0.025)* |
| Supplier access | | 0.413*** | 0.406*** | | 0.045* | -0.015 |
| | | *(0.057)* | *(0.061)* | | *(0.026)* | *(0.030)* |
| ***Fixed effects*** | | | | | | |
| Country | yes | yes | yes | no | no | no |
| Year | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.935 | 0.942 | 0.942 | 0.351 | 0.321 | 0.351 |
| ***Sample size*** | | | | | | |
| Total number of observations | 720 | 720 | 720 | 699 | 699 | 699 |
| Number of countries | 21 | 21 | 21 | 21 | 21 | 21 |

Note: Standard errors in brackets are robust to heteroscedasticity and auto-correlation within panels.
*: significant at 10% level; ** at 5% level; *** at 1% level.

30. The model gives some order of magnitude of the expected impacts. According to (1), the parameter for the weighted sum of the market and supplier access is $1/(\beta\,\sigma)$. Taking the share of labour in

12. Relative to the sample of 24 OECD countries, Korea, Mexico and Turkey are excluded, mainly due to data availability over the 1970s, but also to restrict the dataset to the high-income OECD countries.

output $\beta$ between a third and a half, the 6 to 10 range for the elasticity of substitution implies an expected parameter between 0.2 and 0.5. An estimate of 0.2, for example, means that if, for a given country, distances to markets were reduced by half, market and supplier access would increase each by roughly $0.9 * \ln(2) = 62\%$ and GDP per capita would increase by $0.2 * (1 + 0.6) * 0.62 \approx 20\%$. Redding and Venables (2004) find an estimate between 0.30 and 0.50, while Breinlich (2007) reports an estimate for market access of 0.25. After controlling for human capital stock across regions, Head and Mayer (2006) find a parameter of 0.10 (0.11 without controlling), and from a different theoretical model, Hanson (2005) finds 0.25 (0.35 without controlling).

31. The estimates for the constrained model are presented in Table 4. The fixed effect estimator produces an estimate of 0.23 for the access variable.[13] Since the explanatory variables are meant to capture market sizes, there is a well acknowledged endogeneity issue, which is most obvious with Harris' market potential. To take this into account, Redding and Venables lag the right-hand side term. When the access variable is lagged three times, the parameter, reported in the second column, is still very significant, albeit roughly halved. A better treatment of this issue is presented below.

13. Because the right-hand side variables are generated regressors, the standard errors might be underestimated (Pagan, 1984). To check the extent of the standard error bias, bootstrap techniques are used to obtain appropriate standard errors for the specification in levels without first-order correlation. Each bootstrap re-samples the 36 000 bilateral trade observations to re-calculate market and supplier access. The standard errors are based on 200 replications of equation (4) estimation. This exercise suggests that the reported standard errors are underestimated by around 10%-20%, which is not problematic given the high-level of significance of the results.

**Table 4. GDP per capita and economic geography: weighted sum of market and supplier access[1]**

| Dependant variable GDP per capita | level | level | level AR (1) | level AR (1) | level AR (1) | first differences | first differences AR (1) | first differences AR (1) IV |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Weighted sum of market and supplier access | 0.230*** | | 0.094*** | 0.097*** | 0.075*** | 0.080*** | 0.068*** | 0.100*** |
| | *(0.043)* | | *(0.018)* | *(0.017)* | *(0.012)* | *(0.018)* | *(0.016)* | *(0.036)* |
| Weighted sum of market and supplier access (t-3) | | 0.127*** | | | | | | |
| | | *(0.040)* | | | | | | |
| $Rho^2$ | | | 0.859 | 0.794 | 0.969 | | 0.298 | 0.296 |
| Country specific time trend | | | | yes | | | | |
| ***Fixed effects*** | | | | | | | | |
| Country | yes | yes | yes | yes | no | no | no | no |
| Year | yes | yes | yes | yes | yes | yes | yes | yes |
| $R^2$ | 0.938 | 0.937 | | | | 0.345 | | |
| ***Sample size*** | | | | | | | | |
| Total number of observations | 720 | 657 | 720 | 720 | 720 | 699 | 699 | 699 |
| Number of countries | 21 | 21 | 21 | 21 | 21 | 21 | 21 | 21 |
| **First stage regressions[3]** | | | | | | | | |
| Hausman test | | | | | | | | $c^2(1)=11.8$ |
| | | | | | | | | *(P=0.001)* |
| Hansen J-stat | | | | | | | | $c^2(33)=30.2$ |
| | | | | | | | | *(P value=0.60)* |
| Weighted sum of market and supplier access | | | | | | | | Shea $R^2=0.222$ |
| | | | | | | | | *(P value=0.000)* |

*Note*: Standard errors are in brackets. *: significant at 10% level; ** at 5% level; *** at 1% level.

1. In columns (1), (2) and (6), standard errors are robust to heteroscedasticity and auto-correlation. In columns (3), (4), (5), (7) and (8) which include an AR(1) process for the residuals, standard errors are robust to heteroscedasticity and contemporaneous correlation across panels.
2. Rho is the the first-order auto-correlation parameter.
3. The instruments used in column (8) are $Z_{it} = Distsum_i . h_t$ where the $h_t$ are time dummies. The Hausman test is a joint test of exogeneity of the access variables. The following tests are reported for the Instrumental Variables estimator. The overidentification test is the Hansen test. For first-stage regressions, Shea partial $R^2$ (i.e. based on the excluded instruments only) is reported, along with the P-value of the F-test.

32. Another serious concern is related to serial correlation. Indeed, taking into account the first-order auto-correlation, the estimate (columns 3-4) falls to around 0.09. The fact that excluding country fixed effects (column 5) gives very close results reveals that the access variables capture variations through time as well as across countries. Given the estimated level of the auto-correlation parameter, a reasonable alternative is indeed the first-difference specification. As indicated in columns (6-7), it produces an estimate of around 0.07.

33. In order to try to overcome the potential endogeneity bias, the sum of the distances of each country to Tokyo, Brussels and New York has been commonly used as an instrument in previous studies. However, the choice of these three locations is in itself very endogenous. One could expect that a researcher doing the same exercise in thirty years would include Beijing, Sao Paolo and Moscow. An appealing instrument is to sum the distances to all the other countries (Head and Mayer, 2006). In order to take advantage of the panel dimension of the data, the effect of this time-invariant instrument is allowed to vary through time. In other words, the proposed instruments are $Z_{it} = h_t \sum_j d_{ij}$ where the $h_t$ are time dummies. The IV-estimates of 0.10 is still very significant.

34. A few countries might well drive these results. As a robustness check, because Australia and New Zealand on the one hand, Belgium and the Netherlands on the other hand, hold a specific geographical position, the first-difference specification was re-estimated excluding either of these two pairs and both of them. Instead of the 0.080 parameter obtained for the full sample, that exercise leads to significant estimates between 0.062 and 0.087.

35. Also, the effects on GDP per capita are robust to the choice of the distance definition, *i.e.* *distcities* instead of *distcap*, essentially because differences between distance measures reflect mostly a level effect that are controlled for by country fixed effects.

36. One might be concerned that the above estimations might not be robust to the inclusion of the usual determinants of GDP per capita or to a better accounting of the dynamic adjustment towards the steady state. Therefore, an important robustness check consists in investigating whether the market and supplier access variables are still significant in an augmented-Solow framework. Boulhol *et al.* (2008) show that the access variables remain very significant and of the same order of magnitude when physical, human capital and population growth are included in the regression, as well as when accounting for the heterogeneity across countries of short term coefficients. This result suggests that the impact of centrality to markets acts on top of these usual determinants.

37. To sum up, market and supplier access seem to have a very significant impact on GDP per capita; the estimates herein are below most of those obtained in previous studies, but in line with those of Head and Mayer (2006). Of course, the samples are not the same. However, the failure to take into account country's idiosyncrasies in cross-section analysis might be the primary source of the differences in key estimated parameters. Nevertheless, this lower order of magnitude implies a sizeable impact over the wide spectrum of developed countries. Based on the level of the access variables reported in Table 1 and a parameter of 0.06, distance to markets is estimated to penalise Australia and New Zealand by around 10% of GDP compared to the average country in the sample, whereas, at the other extreme, Belgium and the Netherlands would benefit by around 6% (see Boulhol *et al*. for details).

## 4. Death of distance, elasticity of trade to distance and transport costs

38. *Relative* to the average of countries, the most remote OECD countries seem to be as penalised by their geographical location as thirty years ago despite increasing globalisation. This persistence in relative access to markets stems from the stability of the elasticity of trade to distance through time, which might question the validity of the "death-of-distance" hypothesis.

39. By itself, the "death of distance" or "earth is getting flatter" hypothesis can be interpreted in a number of ways which are not necessarily consistent. It can refer to the world getting smaller in the sense that the exchange of both goods and information is being carried over longer distances. It can also be associated with the presumed decline in transportation and telecommunication costs. Finally, it might imply that distance is nowadays playing a lesser role in shaping international trade across trading partners. All these interpretations imply a diminished importance of distance in trade relations.

40. However, Leamer (2007) points out that trade remains mostly a neighbourhood phenomenon. The conjunction of increasing globalisation and of a rather stable elasticity of trade to distance has been framed as the missing globalisation puzzle (Coe, Subramanian and Tamirisa, 2007). However, is it really paradoxical?

41. To answer this question, assume that trade costs, $\tau_{ijt}$, between countries $i$ and $j$ in year $t$ take the following form as a function of the bilateral distance $d_{ij}$:

$$\tau_{ijt} = a_t \, (d_{ij})^{\eta_t} \tag{6}$$

where $\eta_t > 0$ is the elasticity of trade costs to distance and $a_t$ an overall cost shift parameter. The elasticity of trade to distance is:

$$\varepsilon_t = \alpha \, \eta_t < 0 \tag{7}$$

where $\alpha < 0$ represents the elasticity of trade to trade costs. Under monopolistic competition and Dixit-Stiglitz preferences, as in the Redding and Venables model, $\alpha$ is typically a constant equal to 1 minus the elasticity of substitution between goods varieties. The idea that distance is playing a lesser role in trade is commonly thought to imply a decrease in the absolute value of $\varepsilon$ and, consequently, a decrease in the elasticity of trade costs to distance $\eta$:

$$\text{Presumption: } \Delta|\varepsilon_t| < 0 \quad \Rightarrow \qquad \text{Presumption: } \Delta\eta_t < 0 \tag{8}$$

However, differentiating equation (6) shows that changes in trade costs are not only related to changes in the elasticity of trade costs to distance but also, and probably more importantly, to changes in the overall shift parameter $a_t$:

$$\frac{\Delta \tau_{ijt}}{\tau_{ijt}} = \frac{\Delta a_t}{a_t} + Log(d_{ij})\Delta\eta_t \tag{9}$$

42. Four implications follow from this simple equation. First, if trade costs change uniformly whatever the trade then this uniform change is captured by the change in $a_t$, and $\Delta\eta_t = 0$:

$$\frac{\Delta \tau_{ijt}}{\tau_{ijt}} = \gamma_t \quad \forall\, i,\, j \quad \Rightarrow \quad \left( \frac{\Delta a_t}{a_t} = \gamma_t \,, \quad \Delta\eta_t = 0 \right) \tag{10}$$

More generally, this makes it clear that $\Delta a_t / a_t$ captures an average change in trade costs for a constant elasticity $\eta$.[14]

43. Second, the change in the elasticity is irrelevant as an indicator of the change in overall trade costs. Indeed, whether distance is measured in centimeters ($Log(d) > 0$) or in million of kilometers ($Log(d) < 0$) is purely conventional, but, based on equation (9), this would give a positive and negative sign, respectively, for the "contribution" of $\Delta\eta_t$ to the evolution of trade costs. Such a "contribution" obtained from a specific choice of distance unit will in fact be entirely offset by the estimation of $\Delta a_t / a_t$ according to $\Delta a_t / a_t = \Delta\tau_{ijt} / \tau_{ijt} - Log(d_{ij})\Delta\eta_t$ .

14. Coe *et al*. recognise in their introduction that the evolution in the overall level of trade costs has no implication for the estimated elasticity of trade to distance. However, they consider that the elasticity of trade to distance should have decreased (in absolute terms) because, given that the complete elimination of trade costs would make distance irrelevant, the elasticity "would go to zero as the cost of trade goes to zero" (p. 39). In fact, the case where distance becomes irrelevant means that $a_t$ in (6) goes to zero whatever the elasticity.

44. Third, the correct interpretation of $\Delta\eta_t$ is in terms of a marginal effect, as $\Delta\eta_t$ is the sensitivity of the changes in trade costs through time with respect to distance:

$$\Delta\eta_t = \frac{\partial(\Delta\tau_{ijt} / \tau_{ijt})}{\partial Log(d_{ij})} \tag{11}$$

45. Fourth, $\Delta\eta_t$ can also be interpreted as a relative effect:

$$\frac{\Delta\tau_{ijt}}{\tau_{ijt}} - \frac{\Delta\tau_{ikt}}{\tau_{ikt}} = Log\left(\frac{d_{ij}}{d_{ik}}\right)\Delta\eta_t \tag{12}$$

This last expression clearly indicates that a decrease in $\eta$ — one interpretation of the "death of distance" hypothesis — means that trade costs decrease relatively more, or increase relatively less, for longer distances, and reciprocally for an increase in $\eta$.

46. Hence, the "missing globalisation puzzle" might simply reflect that trade costs have fallen across all distances rather than being concentrated on longer distances. The elasticity of trade to distance measures a relative or marginal effect and could remain flat even if the world was getting "smaller" with the fall of distance-related transport costs (level effect), a point noted by Buch, Kleinert and Toubal (2004).

47. There are various possible explanations for the non-decrease in the importance of distance. One reason is that geographical distance might be a proxy for a more general and persistent concept of distance that includes differences in culture, religion and legal systems (Brakman and van Marrewijk, 2007).[15] Another simpler explanation might be the likely increase in substitutability between varieties associated with increasing foreign competition. Indeed, the more substitutable the goods, the more intense the competitive pressure and, therefore, the more trade flows become sensitive to costs. Moreover, it is generally believed that globalisation is associated with a decrease in mark-ups and therefore with an increase in the elasticity of substitution. The causality captured by (8) is based on the assumption that $\alpha$, which is negatively related to the elasticity of substitution, is time-invariant. In fact, an increase in the substitutability leads, *ceteris paribus*, to an *increase* in the (absolute) elasticity of trade to distance. Consequently, a decrease in the elasticity of trade costs to distance ($\eta$) could be consistent with a stable elasticity of trade flows ($\varepsilon$), if it has been offset by a rise in the absolute value of the elasticity of trade to trade costs ($|\alpha|$): $\Delta|\varepsilon| = 0 \quad \Leftrightarrow \quad \Delta|\alpha| / |\alpha| = -\Delta\eta / \eta$.

48. In any case, the upshot of this discussion is that a decline in transport costs would be reflected in a lower elasticity of trade to distance only insofar as those costs have fallen proportionally more on longer

15. Clark, Dollar and Micco (2004) have proposed another explanation. They suggest that, with the reduction in trade protection over the last decades, tariffs have become less relevant for trade and, conversely, the relative importance of transport costs as a remaining barrier to trade has increased. Although, this argument is appealing, it might be misleading. Assume that another term, $b$, representing tariff barriers is included in trade costs, $\tau_{ijt} = a_t\,(d_{ij})^{\eta_t}\, b_{ijt}$. If the tariffs are uniform across trading partners then including them or not in the estimation of the elasticity $\eta$ is irrelevant. In fact the bias in the estimates resulting from the omission of tariffs will depend on the correlation between tariffs and bilateral distance. If one considers that trade liberalisation has primarily consisted in regional integration, this means that tariffs are more positively correlated with distance today than before and, consequently, the elasticity $\eta$ would be more underestimated today. Therefore, this would be contrary to Clark *et al.*'s intuition.

than shorter distances and provided that this has not been offset by an increase in the absolute value of the elasticity of trade to trade costs. Moreover, even the presumption that transport costs have declined relative to the price of the goods being transported, *i.e.* mostly manufacturing goods, is far from obvious according to recent studies that provide direct measures of costs over different routes and modes of transportation (Hummels, 2007; Golub and Tomasik, 2008).

## 5. Conclusion

49. Distance continues to shape trade across countries to the same extent it did thirty years ago, notwithstanding the overall evolution of transport costs. As a result, remote countries are still penalised relative to more centrally located ones. The impression derived from Redding and Venables (2004) that distant developed countries, such as Australia and New Zealand, had largely escaped the “curse of distance” is due to the inability to adequately control for heterogeneity in technology levels in cross-section samples that mix both developing and developed countries. In contrast, by focusing on a more homogenous panel sample, this paper shows that the negative impact of distance to markets contributes significantly to GDP per capita even for the most developed countries. It is also argued that this focus provides a more precise estimate of the effect of distance, which is found to be some order of magnitude lower than previously estimated.

## ANNEX 1: THE REDDING AND VENABLES MODEL

50. The theoretical foundations are standard in the New Economic Geography literature. The world consists of $i=1,.,.,R$ countries and the focus is on the manufacturing industry which produces differentiated varieties under increasing returns to scale. On the demand side, each firm's product is used both in consumption and as an intermediate good, based on a constant elasticity of substitution, $\sigma>1$, in both cases. Demand for goods in location $j$ results from the maximisation of the representative consumer's CES utility function:

$$\max_{x_{ij}} U_j = \left[\sum_{i=1}^{R}\int_{n_i} x_{ij}(z)^{(\sigma-1)/\sigma}dz\right]^{\sigma/(\sigma-1)} = \left[\sum_{i=1}^{R} n_i x_{ij}{}^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \quad , \quad \sigma>1 \qquad (A.1)$$

where $z$ denotes manufacturing varieties, $n_i$ the number of firm / varieties in country $i$, and $x_{ij}(z)$ the country $j$ demand for variety $z$ produced in $i$, or simply $x_{ij}$ under the standard symmetry assumption. The resulting demand facing a firm in $i$ from country $j$ is:

$$x_{ij} = p_{ij}^{-\sigma}E_j G_j^{\sigma-1} \equiv p_{ij}^{-\sigma}m_j \qquad (A.2)$$

where $p_{ij}$ is the price of varieties produced in $i$ and sold in $j$, $E_j$ is country $j$'s total expenditure on manufactures and $G_j = \left[\sum_{i=1}^{R} n_i p_{ij}{}^{1-\sigma}\right]^{-1/(\sigma-1)}$ is the price index for manufactures in country $j$. As seen in (A.2), the own price elasticity of demand is $\sigma$ and Redding and Venables highlight that the position of the demand curve facing each firm $i$ in market $j$ is given by the term $E_j G_j^{\sigma-1} \equiv m_j$, which they refer to as the "market capacity" of country $j$.

51. On the supply side, technology is Cobb-Douglas in three types of inputs. One is an internationally immobile factor that is interpreted as labour, with price $w_i$ and input share $\beta$. The second is an internationally mobile factor with price $v$ and input share $\gamma$. The third is a composite intermediate good with price $G_i$ and input share $\alpha$ such that $\alpha+\beta+\gamma=1$. $\tau_{ij}$ being iceberg trade costs (*i.e.* $\tau_{ij}-1$ measures the proportion of output that is lost in shipping from $i$ to $j$ and $\tau_{ij}=1$ corresponds to costless trade), profits of the representative firm in country $i$ is:

$$\pi_i = \sum_{j=1}^{R} p_{ij}x_{ij} - G_i^{\alpha}w_i^{\beta}v^{\gamma}(F+x_i)/a_i \quad \text{with} \quad x_i \equiv \sum_j x_{ij}\tau_{ij} \qquad (A.3)$$

where $a_i$ and $F$ denote marginal input requirement (*i.e.* technical level efficiency) and fixed costs, respectively. Given (A.2), whatever the destination country, profit-maximising firms set a single f.o.b. price $p_i$, which is a mark-up over marginal costs:

$$p_{ij} = \tau_{ij}\, p_i \quad , \qquad p_i = \frac{\sigma}{\sigma - 1} G_i^{\alpha} w_i^{\beta} v^{\gamma} / a_i \tag{A.4}$$

Free-entry condition leads to $x_i = (\sigma - 1)F$ and equation (A.2) entails:

$$(\sigma - 1)F\ p_i^{\sigma} = \sum_j m_j / \tau_{ij}^{\sigma - 1} \tag{A.5}$$

52. The price $p_i$ in a country $i$ is a sum of the market capacity of all countries weighted by a function of trade costs. Bearing fixed costs of production under monopolistic competition, a firm which is located close to markets faces a large demand for its products and is able to charge a higher price, because products are differentiated. Consequently, in equilibrium, these firms pay higher wages. This is the market (domestic and foreign) access effect, which is formally obtained by combining (A.5) with (A.4):

$$F\,\sigma^{\sigma} (\sigma - 1)^{1-\sigma} \left( G_i^{\alpha} w_i^{\beta} v^{\gamma} / a_i \right)^{\sigma} = \sum_j m_j / \tau_{ij}^{\sigma - 1} \tag{A.6}$$

The price of intermediates is the price index for manufactures, which is now given by:

$$G_j = \left[ \sum_{i=1}^{R} n_i\, p_i^{\,1-\sigma} / \tau_{ij}^{\sigma - 1} \right]^{-1/(\sigma - 1)} \tag{A.7}$$

53. Being close to a large supplier (high $n_i$, low $p_i$) generates lower prices of intermediates. The term $n_i\, p_i^{\,1-\sigma} \equiv s_i$ measures the “supply capacity” of country $i$, and the price of intermediates is a function of the sum of supply capacities weighted by a function of trade costs. As seen in (A.6), lower input costs of intermediate goods enable firms to pay higher wages in equilibrium *ceteris paribus*. This is the supplier (domestic and foreign) access effect. Therefore, better access to markets raises the prices of the internationally immobile factors through both the market and supplier access effects.

54. Finally, bilateral trade flows are directly derived from (A.2), as the exports from $i$ to $j$, $X_{i \to j}$ are equal to:

$$X_{i \to j} = n_i\, p_{ij}\, x_{ij} = n_i\, p_i^{\,1-\sigma} \tau_{ij}^{1-\sigma} E_j\, G_j^{\sigma - 1} = s_i\, \tau_{ij}^{1-\sigma}\, m_j \tag{A.8}$$

Exports from $i$ to $j$ depend on three terms: the supply capacity of the exporter country, the market capacity of the importer country and the trade costs between the two countries. Market and supplier access, $MA$ and $SA$ respectively, are defined as the trade-costs-weighted sum of market and supply capacity, respectively, of all partner countries:

$$MA_i = \sum_k m_k / \tau_{ik}^{\sigma - 1} \quad ; \quad SA_i = \sum_k s_k / \tau_{ik}^{\sigma - 1} \tag{A.9}$$

Equation (A.7) directly relates the price of intermediates to supplier access according to:

$$G_j = \left[SA_j\right]^{-1/(\sigma-1)} \qquad (A.10)$$

Finally, $A$ being a constant, equation (A.6) becomes:

$$\left(w_i^{\beta} / a_i\right)^{\sigma} = A\, G_i^{-\alpha\sigma} \sum_j E_j G_j^{\sigma-1} / \tau_{ij}^{\sigma-1} = A\, MA_i \left(SA_i\right)^{\alpha\sigma/(\sigma-1)} \qquad (A.11)$$

Incorporating the time dimension leads to the wage equation:

$$Log\ w_{it} = cte_t + \frac{1}{\beta\,\sigma}\left[Log\ MA_{it} + \alpha\,\frac{\sigma}{\sigma-1}\,Log\ SA_{it}\right] + \frac{1}{\beta}\,Log\ a_{it} + \varepsilon_{it} \qquad (A.12)$$

**Table A.1. Bilateral trade equation, 1970-2004**[1]

Dependant variable: Bilateral trade flows (log), equation (9)

| Distance measure | Panel A Capital to capital | | | Panel B Largest cities | | |
|---|---|---|---|---|---|---|
| | 1970 | 2004 | Average[2] | 1970 | 2004 | Average[2] |
| Bilateral distance | -0.808*** | -0.987*** | -0.914*** | -0.850*** | -1.021*** | -0.954*** |
| | *(0.065)* | *(0.039)* | *(0.047)* | *(0.067)* | *(0.040)* | *(0.048)* |
| Common border | 0.195 | 0.284*** | 0.188 | 0.160 | 0.256*** | 0.156 |
| | *(0.185)* | *(0.102)* | *(0.129)* | *(0.184)* | *(0.102)* | *(0.129)* |
| Common language | 0.598*** | 0.192* | 0.280** | 0.604*** | 0.201* | 0.287** |
| | *(0.159)* | *(0.099)* | *(0.117)* | *(0.158)* | *(0.099)* | *(0.117)* |
| Adjusted $R^2$ | 0.799 | 0.863 | 0.845 | 0.801 | 0.863 | 0.847 |
| Total number of observations | 892 | 962 | 33469 | 892 | 962 | 33469 |

*Note*: Standard errors are in brackets. *: significant at 10% level; ** at 5% level; *** at 1% level.
1. The bilateral trade equation is estimated for each year separately. Standard-errors are robust to heteroscedasticity.
2. Average over the total period

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