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World Institute for Development Economics Research

Research Paper No. 2007/21

Pacific Islands' Bilateral Trade

The Role of Remoteness and of Transport Costs

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April 2007

Abstract

Bilateral trade of geographically distant countries is likely to be negatively affected by the distance separating them from their trading partners and positively affected by their remoteness, defined as the average weighted distance between two countries with weights reflecting the absorptive capacity of the partner country. In presence of competitive transport costs, the effect of remoteness and distance is diluted. An augmented gravity model applied to the Pacific islands' bilateral trade from 1980 to 2004 shows that a doubling of the elasticity of distance would decrease their average bilateral trade by 80 per cent. Remoteness positively affects the Pacific islands' bilateral trade, but does not compensate for the negative effect of distance. The opposite is found for the Caribbean islands, where the elasticity of trade with respect to remoteness is eight times bigger than that for the Pacific islands.

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Keywords: bilateral trade, remoteness, transport costs, infrastructure, gravity model, Pacific islands

JEL classification: C23, C24, F14, O56, O57, R49

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This study has been prepared within the UNU-WIDER project on Fragility and Development, directed by Mark McGillivray and Amelia Santos-Paulino.

UNU-WIDER gratefully acknowledges the financial contributions to the project by The Australian Agency for International Development (AusAID), the Finnish Ministry for Foreign Affairs, and the UK Department for International Development—DFID.

UNU-WIDER also acknowledges the financial contributions to the research programme by the governments of Denmark (Royal Ministry of Foreign Affairs), Norway (Royal Ministry of Foreign Affairs), and Sweden (Swedish International Development Cooperation Agency—Sida.

ISSN 1810-2611 ISBN 92-9190-960-2 ISBN 13 978-92-9190-960-5

By lowering transport costs, improved infrastructure fosters trade. A K-means cluster analysis for 30 small island developing states shows that the Pacific islands belong to the clusters with the weaker infrastructure stocks, leaving them with a large scope for improvement.

Acknowledgements

The views expressed here are those of the author and do not necessarily represent those of UNCTAD. The author gratefully acknowledges the suggestions made by Ms Pacheco-Lopez and by Mr Pizarro-Rios.

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Typescript prepared by Liisa Roponen at UNU-WIDER

Introduction

Distance in geographically remote countries acts like a natural barrier for their economies negatively affecting their bilateral trade. There is some confusion on the way remoteness is perceived and defined, as it is sometimes used *en lieu* of distance. This paper defines remoteness as the average weighted distance between two countries with weights reflecting the absorptive capacity of the partner country. The more remote a pair of countries is from the rest of the world, the higher their bilateral trade.

This paper applies a gravity model to the annual merchandise trade of the Pacific islands to analyse and quantify the role that distance and remoteness have played in affecting their bilateral trade. In the presence of competitive transport costs, the effect of distance and remoteness can be reduced. This possibility is being checked using an augmented model, which includes a transport equation. Transport costs are assumed to depend on (i) the in-country infrastructure stocks; (ii) the price of fuel and (iii) the differential freight costs between primary products and manufactures.

Although the analysis focuses mostly on the Pacific islands, two other country groups are used for comparative purposes, namely the Caribbean islands and the small island developing states (SIDS)[1] as a group, which represent the entire sample of 36 countries. Data coverage is for a period of 24 years: from 1980 to 2004.

This paper attempts to provide answers to the following questions. Is the Pacific islands' bilateral trade been affected by remoteness? What is the role of distance in affecting the Pacific islands' bilateral trade? Which of the two effects is bigger? Are the findings for the Pacific islands the same as for the Caribbean islands or the SIDS as a group? Do infrastructure stocks affect bilateral trade through transport costs? After having accounted for the geographic, transport-related, historical factors that can affect the Pacific countries' bilateral trade, is it possible to draw some implications on the artificial barriers that may have restricted trade during the period 1980-2004?

This paper is structured as follows: section 1 introduces and discusses the results of an application of a standard gravity model; section 2 introduces transport costs and presents the major findings of the 'augmented' gravity model. It also looks at the existing infrastructure gap between the Pacific and Caribbean islands. Section 3 summarizes the major points and presents some preliminary insights about the trade policies that have been followed by the sample countries over the period analysed.

1 The gravity model

The typical way to analyse the role that 'remoteness' has played in affecting the bilateral trade flows of small island developing states is by using gravity models. The

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1 The countries considered are: American Samoa (P), Antigua and Barbuda (C), Aruba (C), Bahamas (C), Barbados (C), Belize, Cape Verde, Comoros, Dominica (C), Dominican Republic (C), Fiji (P), French Polynesia (P), Grenada (C), Guam (P), Guinea-Bissau, Guyana, Haiti (C), Jamaica (C), Kiribati (P), Maldives, Mauritius, Netherlands Antilles (C), New Caledonia (P), Papua New Guinea (P), Samoa (P), Sao Tome and Principe, Seychelles, Solomon Islands (P), St Kitts and Nevis (C), St Lucia (C), St Vincent and Grenadines (C), Suriname, Tonga (P), Trinidad and Tobago (C), Tuvalu (P) and Vanuatu (P), where P stands for Pacific and C for Caribbean islands.

empirical use of gravity models to estimate international trade dates back to the 1960s, although its theoretical foundation is more recent.[2] In its basic formulation, a gravity model estimates bilateral trade flows (T_{ij}) between countries i and j as increasing function of their economic size, proxied by their GDPs (Y), and as decreasing function of the distance (d_{ij}) between them. Distance is taken as representing a natural trade barrier between two countries. Empirically, bilateral trade flows have included either exports or imports or the sum of the two, depending on the analysis to be carried out.

$$T_{ij} = \alpha \frac{Y_i Y_j}{d_{ij}} \varphi \qquad (1)$$

The 1 × k vector of gravity variables (φ) that are most often added to the basic formulation are: populations, country size, and several dummies representing landlockedness, common borders and/or language, membership in a trading agreement, institutional quality, and, more recently, dummies representing supply and market capacities.[3] Gravity equations are typically solved in a cross-sectional framework for a given year.

> The perceived empirical success of the gravity model has come without a great deal of analysis regarding its econometric properties, as its empirical power has usually been stated simply on the basis of goodness of fit (Cheng and Wall 2005: 50).

As of the late 1990s, authors have started to check the accuracy of the results.

The recent introduction of a time dimension has created what is normally referred to as the 'distance puzzle'. In a globalizing world where improved transport methods reduce the costs and time needed to move goods and persons from one place to another, standard gravity models find that the elasticity of bilateral trade with respect to distance is increasing (rather than falling) over time. While some authors have attempted to change the theoretical and empirical foundations of the standard gravity model (see for example, Coe et al. 2002; Frankel 1997; Matyas 1997; Cheng and Wall 2005), others have attempted to provide an explanation for it. Leamer and Levinsohn (1995: 1387), for example, argue that the 'dispersion of economic mass is the answer, not a shrinking globe' for this result.

Anderson and Van Wincoop (2003) and Brun et al. (2005) find that the common specification of gravity models biases the results for distance. They solve the puzzle by using a different specification of the model. According to them, the original model was mis-specified due to the omission of variables. This paper uses a slightly modified version of Brun et al.'s (2005) augmented model to assess the role of remoteness in affecting the Pacific islands' trade.

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2 See Deardorff (1998) for a review of the subject.

3 Redding and Venables (2004); Frankel, Romer and Cyrus (1996); Limao and Venables (2001), among others.

1.1 Does remoteness play a role?

To analyse the role that remoteness has played in affecting the bilateral trade flows, the following variables have been added to the standard specification presented in equation (1). Two measures of size have been included: population levels for countries *i* and *j* (*Pop*) and land area for countries *i* and *j* (*S*). As in Brun et al. (2005), the normalization of prices to unity, while using panel data, cannot be justified. It follows that a measure of the changes in the relative prices is necessary. The bilateral real exchange rates between country *i* and *j* have therefore been included (RER_{ijt}). A remoteness indicator has also been included (R_{ij}). Differently from Brun et al. (2005), this paper takes the total value of trade (measured as the sum of merchandise imports and exports) of country *i* versus country *j*, rather than imports alone, as dependent variable and includes land area as a complementary measure of size. A time trend variable (*time*) and two dummies have also been included to account for common language (*comlang*) and common colonizer (*comcol*).

$$T_{ijt} = f\left(Y_{it}, Y_{jt}, Pop_{it}, Pop_{jt}, S_i, S_j, RER_{ijt}, d_{ij}, R_{it}, dummies, time\right) \quad (2)$$

There are several ways of defining and measuring remoteness. ‘The principal difficulty in constructing such a measure is that remoteness depends not just on how far [one country] is from other countries, but also on the level of economic activity taking place in each other country’ (Ewing and Battersby 2004: 23). The methods differ in the way weights, applied to geographic distance, have been calculated. Many authors, including Brun et al., calculate remoteness by taking a weighted average of the distance to trading partners, where the weights are the proportions of world GDP held by trading partners. Other methods include: (i) an analysis of the percentage of world GDP within a given perimeter of a country;[4] (ii) the average distance of *i* from all trading partners, other than *j* (Anderson and Van Wincoop 2002); and (iii) an application of gravity-like models to calculate the ‘distance to the rest of the world GDP’ (Ewing and Battersby 2003).

Following Polak (1996), this paper defines remoteness as the average distance between countries *i* and *j*, with weights determined by the absorptive capacities of the partner country.

$$R_{it} = \sum_j \left(Y_{jt}^{0.8} Pop_{jt}^{-0.24} d_{ij}\right) \quad (3)$$

This paper uses a database composed of bilateral trade flows between the 36 SIDS and all of their trading partners over the period 1980-2004. Specific assumptions and adjustments have been applied to the data. First, the database used for the estimation does not differentiate between missing values and zero bilateral trade between two countries. Second, missing values are reported for 189,696 observations of bilateral trade. They are set to be equal to zero. Third, similar to Brun et al. (2005) and Frankel (1997), missing values have been assumed to be equal to T_{ij}=1 if a positive value is registered along the series line. This assumption led to 17,404 replacements. The database has a potentiality of 210,600 observations.

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4 This method is used, for example, by Ewing and Battersby (2004).

A log-linear specification of (2) is used, as it features the data well (Frankel and Romer 1999). The model to be estimated is the following[5]:

$$\begin{aligned}
\ln T_{ijt} &= \alpha_1 + \alpha_2 time + \beta_1 \ln(Y_i / Pop_{it}) + \beta_2 \ln(Y_j / Pop_{jt}) + \\
&\delta_1 \ln(Pop_{it}) + \delta_2 \ln(Pop_{jt}) + \nu_1 \ln(S_i) + \nu_2 \ln(S_j) + \\
&\phi \ln(RER_{ijt}) + \sigma_1 \ln(d_{ijt}) + \mu \ln(R_{it}) + \theta dummies + \varepsilon_{ij} = \\
&\alpha_1 + \alpha_2 \Psi + \sigma_1 \ln(d_{ijt}) + \mu \ln(R_{it}) + \varepsilon_{ij}
\end{aligned} \tag{4}$$

where we would expect $\alpha_2, \beta_1, \beta_2, \theta, \mu, \delta_1, \theta > 0$ and $\delta_2, \nu_1, \nu_2, \sigma_1 < 0$. An increase in *i*'s population leads to an increase in its trade, while an increase in *j*'s population leads to a trade fall. We would also expect $\phi < 0$, as the Pacific countries have substantially increased their current account deficit of merchandize trade over time. A depreciation of the real exchange rate of the importing country *i* versus the exporting country *j* leads to a fall in the bilateral merchandise trade between the two countries. The remoteness indicator is a measure of the average 'economic' distance of country *i* to its trading partner. We would expect σ_1 to be negative as the higher the distance between two countries, the fewer the goods being exchanged. We expect μ to be positive, as the more remote two countries are, the higher the trade between them, after controlling for distance. ε_{ij} is the log-normally distributed error term.

The model is solved using a Tobit specification with lower censoring at zero. Further details about the variables used and the source of data are given in Appendix 1. The results are summarized in Table 1.

Column (1) shows the results of a standard gravity equation with bilateral trade between Pacific islands and their bilateral trading partners as dependent variable. The variables have the correct signs and are statistically significant. Only the dummy representing whether the countries have had a common colonizer is not significant. As expected, the higher their GDPs, the higher their trade. Speaking the same language also largely and positively affects the Pacific islands' bilateral trade. Column (4) of Table 1 summarizes the results of equation (4). Trade is decreasing in *i*'s and *j*'s land areas, and it is decreasing in *j*'s size, measured by its population, with an elasticity of -0.14. Furthermore, a depreciation of the RER_{ij} decreases the Pacific islands' average trade with their partners by a fifth.

The size of the elasticity of trade with respect to distance differs from author to author. Estimates change depending on the time period analysed, the country groupings and the model specification used.[6] Elasticities of trade with respect to distance are typically found to be ranging between -0.6 and -1.3. Gravity models of bilateral trade flows that use distance as a proxy for transport costs find 'elasticities of trade volumes with respect to distance of between -1 and -1.3. This is a large effect, indicating that doubling distance cuts trade volumes by between 1/2 and 2/3' (Henderson, Shalizi and Venables 2000: 10). Some authors find that their estimated elasticities with respect to distance are

5 As in Soloaga and Winters (1999), only the remoteness of country *i* is considered.

6 See Frankel and Rose (2000); Soloaga and Winters (1999); Eichengreen and Irwin (1998); Coe et al. (2002), among others.

higher or smaller than the ones above. Using their estimated transport costs, Limao and Venables (2001) find an elasticity of trade with respect to distance as high as -2.5, while Grossmann (1998) suggests an elasticity as low as -0.03.[7]

Table 1
Estimation results

Dependent variable: Bilateral trade between country *i* and *j*

	Pacific islands[a]	Caribbean islands [b]	All SIDS	Pacific islands[a]	Caribbean islands[b]	All SIDS
	(1)	(2)	(3)	(4)	(5)	(6)
C	16.57***	13.57***	15.35***	16.40***	13.91***	17.59***
	(0.63)	(0.67)	(0.34)	(0.43)	(1.28)	(0.65)
Y_{it}/POP_{it}	0.28***	0.12**	0.06***	0.27***	0.12*	0.07**
	(0.03)	(0.04)	(0.02)	(0.04)	(0.07)	(0.02)
Y_{jt}/POP_{jt}	0.03*	0.12***	0.25***	0.15***	0.24***	0.18***
	(0.07)	(0.05)	(0.02)	(0.07)	(0.07)	(0.03)
R_{jt}	0.02**	0.15***	0.08***	0.03**	0.30***	0.16***
	(0.07)	(0.02)	(0.02)	(0.03)	(0.13)	(0.03)
D_{ij}	-0.71***	-0.18***	-0.14***	-0.66***	-0.32***	-0.19***
	(0.03)	(0.03)	(0.01)	(0.04)	(0.04)	(0.2)
Comcol	0.01	-0.17	0.06	-0.03	-0.73***	-0.17**
	(0.09)	(0.12)	(0.06)	(0.11)	(0.16)	(0.08)
Comlang	1.47***	1.27***	0.89***	1.41***	1.69***	0.99***
	(0.10)	(0.13)	(0.06)	(0.10)	(0.13)	(0.07)
S_i				-0.04	0.04	0.00
				(0.05)	(0.07)	(0.02)
S_j				-0.02	0.11***	0.24***
				(0.05)	(0.03)	(0.03)
Pop_{it}				0.09	0.01	0.04**
				(0.08)	(0.07)	(0.02)
Pop_{jt}				-0.14***	-0.45***	-0.57***
				(0.04)	(0.04)	(0.04)
RER_{ijt}				-0.21***	-0.26***	-0.30***
				(0.03)	(0.02)	(0.01)
Time				0.04***	0.04***	0.04***
				(0.01)	(0.01)	(0.00)
Uncensored obs	1,989	3,044	8,419	1,989	2,219	8,419
s.e.r.	1.69	1.95	2.01	1.63	1.70	1.810
Pseudo-R^2	0.39	0.42	0.37	0.54	0.57	0.51

Note: Tobit estimates with left-censoring at zero. Standard errors in brackets. Variables in logs. Estimates based on truncated sample. Berndt-Hall-Hall-Hausman optimization algorithm.

*** 1% significance level, ** 5% significance level and * 10% significance level.

(a Fiji, French Polynesia, Guam, New Caledonia, Papua New Guinea, Samoa, Solomon islands, Tonga, Tuvalu, Vanuatu.

(b Antigua and Barbuda, Aruba, Bahamas, Barbados, Dominica, Dominican Rep., Grenada, Haiti, Jamaica, Netherlands Antilles, St Kitts and Nevis, St Lucia, St Vincent and Grenadines, Trinidad and Tobago.

Source: Author's estimates.

7 Reported in Coe et al. (2002).

The estimated elasticity of the Pacific islands' bilateral trade with respect to distance is between -0.71 and -0.66, see columns (1) and (4) of Table 1. This implies that a doubling of d_{ij} would decrease the Pacific islands' average bilateral trade by two-thirds. The correspondent elasticity of trade with respect to remoteness is positive and significant, but its size is such that doubling it would increase bilateral trade by a modest 4 to 6 per cent. This finding was somewhat expected, as the Pacific islands' nearest trading partners are mostly other islands (which produce the same or very similar products)[8] while the large countries that could absorb more of their trade are farthest away. The remoteness effect seems to be bigger the richer and the more populated the countries are. In applying the standard gravity model to Australia's bilateral trade, Battersby and Ewing (2003), for example, note that in 2001 the elasticity with respect to distance was -0.46, while the elasticity for remoteness was 0.22.

The elasticity of trade with respect to distance is lower and the elasticity with respect to remoteness is higher in the case of the Caribbean islands and of SIDS as a group than it was for the Pacific islands. As shown in columns (2-3) and (5-6) of Table 1, $\sigma_{1,\,Caribbean}$ is between -0.18 and -0.32, while $\sigma_{1,SIDS}$ is between -0.14 and -0.19. This implies that a doubling of d_{ij} would decrease the Caribbean average bilateral trade by a third and the SIDS average bilateral trade only by a fourth. The average effect of distance on the bilateral trade of these two groups of countries is smaller, while remoteness effect is bigger than the ones for the Pacific islands. A doubling of $R_{Caribbean}$ would lead to an 82 per cent increase in the Caribbean average bilateral trade.

The next section uses an augmented version of equation (4) to account for transport costs. The aim is to check whether or not the distance and remoteness effects have the same impact as described above, and to assess the role that infrastructure (or the lack of it) plays in affecting bilateral trade.

2 The augmented model

The standard transport function includes distance and two dummy variables representing a common border and landlockedness. Bougheas, Demetriades and Morgenroth (1999: 170) have been the first to introduce infrastructure variables into a gravity model and to provide a theoretical explanation for it. They argue that 'differences in the volume and quality of infrastructure across countries may be responsible for differences in transport costs which in turn, may be able to account for differences in competitiveness'. They have used the stock of public capital and the length of motorway network as proxies for in-country infrastructure availability. Data unavailability seriously limits the extent of this analysis,[9] as 'there is no single source of data that provides a definite picture of the costs of transport' (Hummels 2001: 76).

8 The Pacific islands are importing primarily manufactures and machineries, and exporting mostly primary goods. It needs to be noted that the revenue from tourism and other service-related activities is not accounted for.

9 An attempt was made to estimate the transport costs that these island countries are facing, but the lack of data has made the exercise impossible.

Brun et al. (2005) identify the transport function (τ) between countries *i* and *j* at time *t* shown in equation (5), which accounts for the infrastructure stocks (*K*), the price of oil (P_{Ft}), the differential freight costs between primary products and manufactures (π) on the countries' bilateral trade.[10] To estimate *K* for *i* and *j*, an ad hoc indicator has been created. The indicator is composed of four main variables, namely telephone subscribers (both fixed and mobile) per 1,000 people, road density in km per 1,000 people, air transport freight (million tons per sq. meters) and a measure of port capacity in twenty-feet equivalent unit (TEU) per 1,000 people. Following Limao and Venables (2001), the variables are normalized to have means equal to 1. The linear average over the four variables is taken to obtain a single indicator per country and over time. Only those countries that have data for minimum three out of the four variables are retained and the remaining missing observations are ignored.[11]

$$\tau_{ijt} = f\left(K_{it,}K_{jt}, P_{Ft}, \pi_{jt}, d_{ij}\right) \qquad (5)$$

To account for the fact that transport costs increase with distance in a non-linear way, the elasticity of transport costs in distance is assumed to be approximated by the quadratic function in time described below.

$$\gamma_t \equiv \frac{\left(\partial\tau_{ijt} / \tau_{ijt}\right)}{\left(\partial d_{ij} / d_{ij}\right)} = \gamma_1 + \gamma_2 t + \gamma_3 t^2$$

The inclusion of equation (5) into (4) gives the following augmented model:

$$\begin{aligned} \ln(T_{ijt}) = \alpha_1 + \alpha_2\Psi + \lambda_1 \ln(k_{it}) + \lambda_2 \ln(k_{jt}) + \eta \ln(P_{Ft}) + \varsigma \ln(\pi_{jt}) + \mu \ln(R_{ijt}) + \\ + \sigma_1 \ln(R_{ijt}) + \sigma_2 t \ln(d_{ijt}) + \sigma_3 t^2 \ln(d_{ijt}) + \varepsilon_{ij} \end{aligned} \qquad (6)$$

where we would expect $\lambda_1, \lambda_2, \varsigma, \sigma_2, \sigma_3 > 0$ and $\eta < 0$. The results of equation (6) are summarized in Table 2.

All the variables for the Pacific islands have the expected sign. Interestingly, the elasticities of trade with respect to *i*'s and *j*'s infrastructure stocks are 0.01 and 0.03 respectively, and they are statistically insignificant.[12] We would have expected infrastructure to play a bigger role in affecting the Pacific islands' bilateral trade. Section 2.1 evaluates the existing infrastructure stocks in the Pacific islands and compares it with that of the Caribbean islands.

As expected, the price of fuel has negatively and significantly affected bilateral trade flows. The over time increase of the price of oil has reduced the Pacific islands' bilateral flows by a third. The differential freight costs between primary products and

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10 Because of data unavailability, the share of primary export products in total exports for country *j* is taken as proxy for π.

11 This assumption implies that missing observations take the same average value as the non-missing observations.

12 A likelihood ratio test rejects the null hypothesis that K_{it} and K_{jt} do not belong to the equation at 5 per cent significance level.

Table 2
Estimation results from the augmented model and residual analysis

Dependent variable: Bilateral trade between country *i* and *j*

	Pacific islands[a]	Caribbean islands[b]	All SIDS
	(7)	(8)	(9)
C	14.83*** (1.73)	17.75*** (2.29)	15.57*** (1.12)
Y_{it}/POP_{it}	0.27*** (0.06)	0.29** (0.12)	0.15*** (0.04)
Y_{jt}/POP_{jt}	-0.07 (0.12)	0.47*** (0.14)	0.16** (0.05)
R_{it}	0.10** (0.10))	0.82*** (0.07)	0.29*** (0.03)
d_{ij}	-0.85*** (0.07)	-0.12** (0.03)	-0.15*** (0.04)
Comcol	0.08 (0.10)	-0.57*** (0.16)	-0.09 (0.08)
Comlang	1.20*** (0.12)	1.50*** (0.13)	0.89*** (0.07)
S_i	-0.06 (0.05)	0.12 (0.08)	0.01 (0.02)
S_j	-0.19*** (0.04)	0.01 (0.04)	0.03 (0.03)
Pop_{it}	0.12 (0.09)	-0.05 (0.08)	0.04* (0.02)
Pop_{jt}	0.39*** (0.06)	-0.21*** (0.06)	-0.14*** (0.04)
RER_{ijt}	-0.26*** (0.03)	-0.30*** (0.02)	-0.37*** (0.01)
time	-0.06 (0.05)	-0.30*** (0.04)	-0.06*** (0.03)
K_{it}	0.01 (0.04)	0.17* (0.10)	0.01 (0.03)
K_{jt}	0.03 (0.06)	0.00 (0.00)	0.01 (0.02)
T^*d_{ij}	0.01* (0.01)	0.02*** (0.01)	0.02*** (0.00)
$t2^*d_{ij}$	-0.00 (0.00)	0.00*** (0.00)	0.00 (0.00)
P_{Ft}	-0.20* (0.20)	-0.87*** (0.205)	-0.31** (0.16)
π_{jt}	1.17*** (0.10)	0.59* (0.13)	1.18*** (0.06)
Uncensored obs	1,694	1,888	5,213
s.e.r	1.7	1.7	1.8
Pseudo-R^2	0.58	0.65	0.56
Average residual when at least one country is:			
Pacific island			-0.10
Caribbean island			0.07
Pacific LDC	-0.14		

Notes: See notes to Table 1.
Source: Author's estimates.

manufactures have played a positive and significant role in affecting their bilateral trade. As ‘geographically remote countries will find it harder to develop non-primary exports, especially manufacturing goods’ (Malik and Temple 2005: 6), a 10 per cent increase in the Pacific islands’ average bilateral trade would lead to a 12 per cent increase in the share of primary products in total exports (proxy used for the differential freight costs).

Furthermore, with a σ = -0.84, a doubling of distance would decrease their average bilateral trade by some 80 per cent. Again, the elasticity with respect to remoteness is far lower than the one with respect to distance. With respect to the coefficients of Table 1 in columns (4-6), the elasticity with respect to distance has increased and so has the one for remoteness.

Table 2 shows that remoteness plays a far bigger role in affecting bilateral trade for the Caribbean islands than for the Pacific islands. The net effect of the two variables has decreased for the Pacific islands from -0.63 to -0.74, while it has increased for the Caribbean islands (from -0.02 to 0.72). The elasticity of trade with respect to R_{ij} for the Caribbean islands is eight times bigger than that for the Pacific islands. This can be due to (i) closeness of the Caribbean islands to larger markets and/or (ii) higher intra-inlands trade than for the Pacific islands.

An improvement of the Caribbean’s infrastructure affects their bilateral trade with an elasticity of λ_1=0.17, significant at 10 per cent. It follows that a doubling of the Caribbean’s own infrastructure stocks increases their bilateral trade by some 40 per cent. The bilateral trade of the Caribbean islands has been more affected by the rise in the price of oil than the Pacific islands were. It was found that a doubling of the price of oil would decrease the Caribbean average bilateral trade by 80 per cent.

As it was for the Pacific islands, the elasticities of trade with respect to infrastructure stocks for the SIDS are statistically insignificant. Furthermore, a doubling of the share of primary products in total exports leads to a doubling of the SIDS’s bilateral trade. Furthermore, a doubling of distance decreases SIDS’ average bilateral trade by 25 per cent, while a doubling of remoteness would increase it by 80 per cent.

The main result from this analysis is that remoteness (measured as average distance, with weights determined by the absorptive capacity of the partner countries) has a small positive effect, compared to the large negative effect of distance, in affecting the Pacific islands’ average bilateral trade,[13] while it has a far bigger effect in the case of the Caribbean countries and of the SIDS as a group. The elasticities of the infrastructure stocks available in countries *i* and *j* are positive but statistically insignificant, except for the Caribbean islands. This finding was unexpected as better infrastructure can increase bilateral trade by reducing transport costs.

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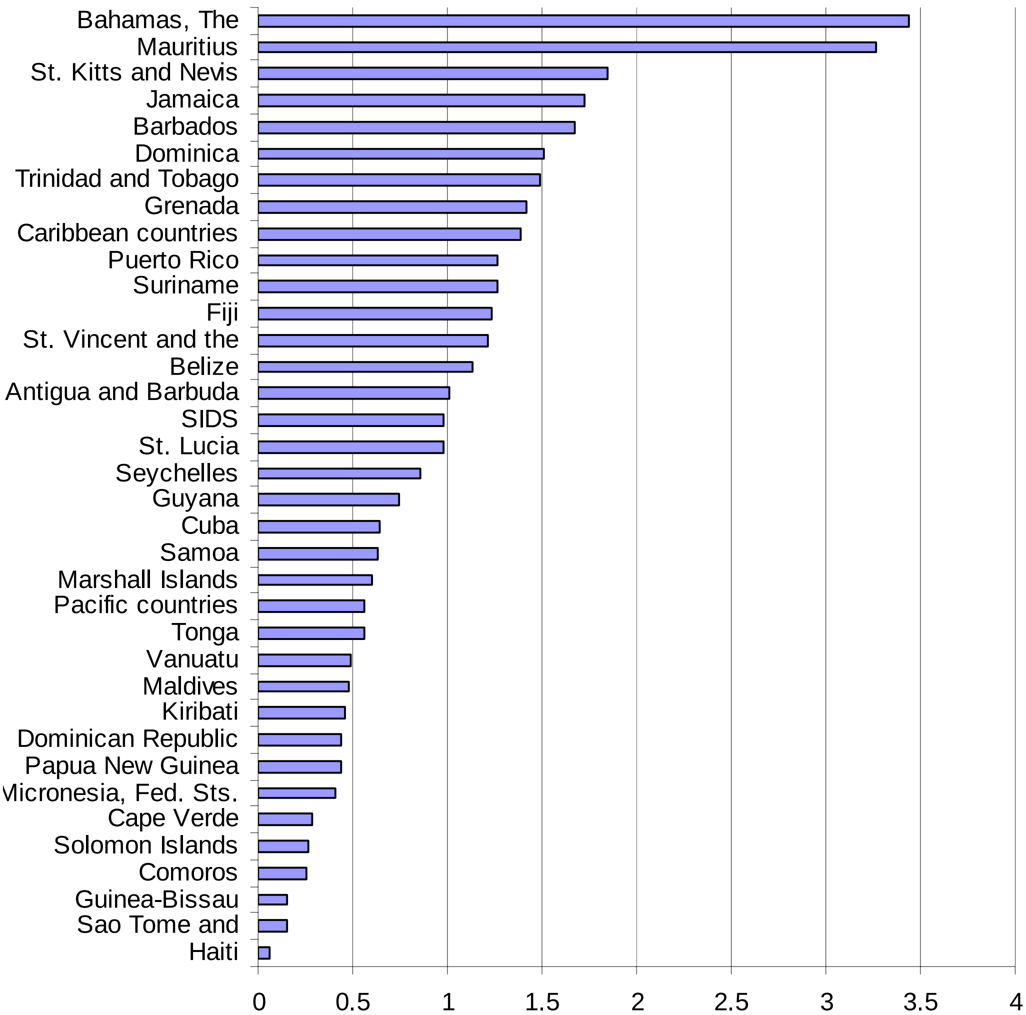
13 The correlation coefficient between R_{ij} and d_{ij} is 0.20 for the SIDS, 0.18 for the Pacific islands, 0.16 for the Caribbean islands.

2.1. The infrastructure gap

The distance effect on bilateral trade could be reduced in the presence of low and competitive transport costs. Transport costs depend largely on the extent and quality of infrastructure present in the country. The finding of a positive, although insignificant, elasticity of trade with respect to infrastructure stocks available in *i*'s and *j*'s, shows the potentiality that better infrastructure can have in fostering trade. This section highlights the existing infrastructure gap within the group of SIDS analysed and, in particular, between the Pacific and Caribbean islands. To do so, the infrastructure indicator described in Section 2 is taken as reference and a cluster analysis is carried out.

Figure 1 ranks the countries according to their infrastructure indicator, from the highest to the lowest, and highlights a large disparity existing in the infrastructure stock available within the SIDS. This should not be surprising given the income gap existing within the same group of countries. For example, the first five countries ranked in

Figure 1
Infrastructure indicators



Note: All SIDS for which data are available have been included in this analysis.

Source: Author's calculations.

Figure 1 have a real GDP that is five times bigger than that of the bottom five countries (2004 data). The countries ranked at the bottom are mostly LDCs, while the countries at the top are high- or middle-income countries. Furthermore, the Bahamas and Mauritius have infrastructure indicators that are far above those of the remaining countries. The variance in terms of the infrastructure stocks available within the SIDS is very high.

A non-hierarchical k-mean cluster analysis (see Annex 2 for details) is used to group the countries according to the similarity in their infrastructure stocks. As this analysis requires complete data for all countries, it relies only on three main variables: telephone subscribers of both mobile and fixed lines, road density and TEU (all per 1,000 people). Data are available for only 30 countries.[14] The number of clusters that best minimizes

Table 3
K-means cluster analysis: results

Clusters	Countries	Telephone subscribers[a]	Road density[a]	TEU[a]	Infrastructure indicator[b]
1	Bahamas	1022.5	9.1	534.1	4.6
2	Dominica				
	Jamaica				
	Puerto Rico	957.9	8.2	54	1.5
3	Antigua and Barbuda				
	Barbados	1199	4.7	56.6	1.5
4	Grenada				
	Mauritius				
	St Kitts				
	St Vincent				
	Suriname				
	Trinidad and Tobago	701.4	7.3	73.7	1.4
5	Belize				
	Cape Verde				
	Dominican Republic				
	Guyana				
	St Lucia	374.2	6.9	16.6	0.8
6	Fiji				
	Micronesia				
	Samoa				
	Tonga	187.5	4.4	44.1	0.7
7	Comoros				
	Cuba				
	Guinea-Bissau				
	Haiti				
	Kiribati				
	Papua New Guinea				
	Sao Tome				
	Solomon Islands				
	Vanuatu	46	3.7	14	0.3

Notes: [a] per 1000 people;
[b] based on the above three variables.

Source: Author's calculations.

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14 The inclusion of air freight would have reduced the number of countries to 21.

the distance between each observation and the cluster means, and maximizes the distance between each cluster is seven.[15] Table 3 summarizes the country groupings and ranks the clusters according to their average infrastructure indicator in decreasing order. It can clearly be seen that the majority of the Pacific islands belong to the clusters with lower infrastructure stocks, while the Caribbean islands have better infrastructure, in comparative terms.

The Pacific islands are lagging behind the Caribbean: the number of telephone subscribers per 1000 people in the Pacific islands is one-seventh, road density is two-thirds and port capacity is half that of the Caribbean islands. On the other hand, air-related transport infrastructures are more developed in the Pacific islands than in the Caribbean.[16] This could be explained by the fact that the Pacific islands have wider territories with fewer people living than the Caribbean islands.

Knowing that the Pacific islands are lagging far behind the Caribbean islands in terms of infrastructure stocks available, and given the positive and significant $\lambda_{1,Caribbean}$ that was estimated in Table 2, it could be inferred that an improvement in the Pacific islands' infrastructure stocks should increase their average bilateral trade and change its composition.[17]

3 Summary and further implications

The analysis contained in this paper based on traditional and augmented gravity models can be summarized into the following four main points. First, the Pacific islands' bilateral trade between 1980 and 2004 has been negatively and largely affected by distance. The positive effect of remoteness—defined as the average weighted distance with weights determined by the absorptive capacities of the partner country—was not big enough to compensate for distance. The estimated elasticity with respect to distance falls between the range of elasticities found in the literature.

Second, it was found that the remoteness effect was bigger than the distance effect for the Caribbean islands and for the SIDS as a group. The elasticity of trade with respect to remoteness for the Caribbean islands is eight times bigger than that of the Pacific islands. This could be due to the closeness of the Caribbean islands to larger markets and higher intra-islands trade than for the Pacific islands.

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15 A sensitivity analysis carried out using the Calinski and Harabasz index shows that the index is highest when the countries are grouped in seven clusters (226.74), followed by ten clusters (205.59) and by six clusters (167.83).

16 The inclusion of the air-related variable to the cluster analysis does not change the results by much. The number of countries lowers to 21. With the air variable, the number of clusters that best maximizes the Calinski and Harabasz index is 6. The country groupings stay nonetheless roughly the same.

17 Borgatti (2005) finds that an increase in electricity production (not included as a component of the infrastructure indicator for lack of data) in the LDCs would lead to a net increase in the exports of manufactures.

Third, through their impact on transport costs, the rising price of oil has negatively affected the bilateral trade of the three country groupings, while an increase in the differential freight costs between primary products and manufactures positively affects the islands' bilateral trade. Unexpectedly, the estimated elasticity with respect to infrastructure is positive for all country groups, but insignificant for the Pacific islands.

Fourth, there are large disparities in terms of in-country infrastructure stocks between the Pacific and Caribbean countries: the first are lagging far behind the second. A k-mean cluster analysis showed that the countries ranked at the bottom as having the worst infrastructure stocks are mostly Pacific islands, while those ranked at the top are high- or middle-income Caribbean islands. The Pacific islands, therefore, have large scope for improvement.

After having accounted for the geographic, transport and historical factors, it could be argued that the remaining factors that affect bilateral trade are due to trade barriers. An analysis of the average residuals from equation (6) for the Pacific and Caribbean islands can give some insights on the trade policy that the countries have followed throughout the time period considered. As in Rose (2002), it is assumed that the residuals from the gravity equation (or the unexplained components of the bilateral trade between two countries) are associated with their trade policy during 1980-2004. As Rose (2002: 1) puts it, 'a finding that a country's trade is consistently lower than predicted by the model is consistent with the idea that the country's barriers to trade are responsible for the underperformance'. The sign of the average residual indicates whether a country (or group of countries) trade more or less than the 36 SIDS analysed and its size gives an insight about the importance of the effect.

Furthermore, the average residual analysis, summarized at the end of Table 2, suggests that the Pacific countries trade almost one-tenth less than the other SIDS. On the other hand, trade from the Caribbean countries is one-seventh higher than it would be for non-Caribbean SIDS. Although other factors could be in play, trade policy seems to have been more restrictive for the Pacific than for the Caribbean islands.

The average residual when at least one country is a Pacific least developed country (LDC) is -0.14. This finding implies that (the log of) Pacific LDCs' bilateral trade is about one-seventh less than less than what is predicted from the gravity model used in the paper. This provides some preliminary insights about the different trade policies followed over time, whereby the Pacific LDCs have been more protectionist than the non-LDCs Pacific islands.

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Annex 1—Variables: definitions and sources

Bilateral trade (τ_{ijt}) between countries *i* and *j* in millions USD, real exchange rate (ER_t) and price of oil (P_{Ft}) (UK - Brent): IMF Direction of Trade Statistics (DOTS). The real exchange rates between countries *i* and *j* have been calculated by (1) taking the ratio of the nominal exchange rates with respect to the US dollar, (2) multiplying for the ratio of the consumer price indices for countries *i* and *j* at time *t*.

Real GDP in constant US dollars (Y_i and Y_j), population (Pop_i and Pop_j), land (S_i and S_j): World Bank (2006), *World Development Indicators 2006.*

Data on telephone subscribers, road density in km, air transport freight and port capacity in TEU, used to create the infrastructure indicator as described in the text: World Bank (2006), *World Development Indicators 2006*, and Estache and Goicoechea (2005).

Distance (d_{ij}), the dummy on whether two countries share a common official language (*Comlang*), the dummy on whether two countries have had a common colonizer after 1945 (*Comcol*): CEPII, available at www.cepii.fr.

Distances from one country to another have been calculated using the great circle formula, which uses the geographic coordinates of the most important cities in terms of population, rather than the capital cities. The most important cities, however, most often coincide with the capital cities. One important exception for this study is that the distance with Australia is calculated with respect to Sydney, rather than Canberra.

The share of primary products in total exports of country *j* ($Prim_j$): UN Comtrade

It has been calculated as the ratio between the exports recorded under SITC Rev. 2, chapters 0, 1, 2, 4 over the total exports.

Annex 2—Cluster analysis

A cluster analysis is a statistical technique that allows for the creation of homogenous groups of variables without prior information on the classification of the data. 'The objective is to sort observations into groups called clusters so that the degree of statistical association is high among members of the same group and low between members of different groups' (Berlage and Terweduwe 1988: 1,529). Each cluster is composed of elements that have a small distance from each other and a relatively large distance from the elements of another cluster. In other words, all available variables for *n* countries are classified in a given number of clusters *c* characterized by (i) a small variability within the cluster and (ii) a large variability across different clusters.

Although there are various ways to calculate the distance or proximity between two observations, this paper uses the most commonly used distance function, i.e., the Euclidean distance function, $d_{i,j}$, which is calculated as follows.

$$d_{i,j} = \left[\sum_{K=1}^{p} \left(X_{ik} - X_{jk} \right)^2 \right]^{1/2}$$

where $d_{i,j}$ represents the distance between observations *i* and *j*, X_{ik} is the value of the *ith* observation of the variable *k*, and *i= 1,…,n.*

This paper uses the K-means clustering method, which is one of the most used non-hierarchical methods. A hierarchical procedure (i.e., average linkage method, not shown here) has however been used to calculate the initial number of clusters used as starting point for the K-means clustering analysis.[18]

The K-means clustering method allocates the observations to a specified number of clusters in an iterative way in order to minimize the distance between each observation and the cluster means. The error component of the K-means can be defined as

$E[P(n,c)] = \sum_{i=1}^{c} \sum_{j=1}^{n} \delta_{ji} d_{j,i}^2$ where $P(n,c)$ stands for the partition of *n* observations into *c* clusters and δ_{ji} is an indicator function that takes the value 1 if the *j*th observation is in cluster *i* and 0 otherwise. The error component is calculated for each observation until no improvement in the within-cluster variance can be reached resulting in an optimal allocation of the *n* observations into the *c* clusters.

Furthermore, the Calinski and Harabasz pseudo-F index was used to identify the number of clusters that best maximize the distance function. This index measures the separation between clusters and is calculated as follows:

18 There are two different approaches to clustering: hierarchical and non-hierarchical. The difference between the two is that with a hierarchical method, once an observation is assigned to one cluster, it remains in that cluster, while with the non-hierarchical method the observations are moved around clusters in an iterative way until the distance function is maximized.

$\frac{S_b/(k-1)}{S_w/(n-k)}$ where S_b is the sum of squares between the clusters, S_w is the sum of squares within the clusters, k is the number of clusters and n is the number of observations. The higher the Calinski and Harabasz pseudo F-index, the greater the separation between the clusters and the best the country groupings that result from the analysis.