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The Pacific's connectivity and its trade implications

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**The Pacific's Connectivity and Its
Trade Implications**

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Abstract

Pacific economies are confronted with several structural constraints that limit their economic growth, most importantly their small size and remoteness from major world markets. In this paper we study the importance of transport connectivity for Pacific economies when participating in the world economy. The paper first describes the evolution of trade flows of the Pacific economies over the last decade, in terms of both trade in goods and services. It then introduces two new datasets. One contains all shipping connections within the Pacific and with the rest of the world; the second all flight connections within the Pacific and with the rest of the world. Combining both datasets with the corresponding trade flows allows us to assess the importance of connectivity for the Pacific's trade performance. Using a gravity model approach, we find that a direct shipping connection more than doubles trade in goods. Similarly, countries with direct flight connections to the sending country welcome twice as many tourists. The frequency of transport connections is similarly important. Using an instrumental variables approach we are able to confirm the robustness of our results.

JEL Classification: F14, F15, R40

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1. INTRODUCTION

The Pacific economies are faced with a number of structural constraints that render their participation in the world economy difficult. Most importantly, they are faced with several geographical disadvantages. First, most of the countries are small in terms of geographical area and spread across many islands. One stark example is Kiribati, which counts 33 islands that spread over 3.5 million square kilometers of water; an area larger than India. Second, several Pacific economies are located far from major economic centers. For example, the shipping distance between Fiji (Suva) and the People's Republic of China (PRC) (Shanghai) is 8,907 kilometers (km) and takes on average 14 days and 7 hours. The shipping distance between Fiji (Suva) and the United States (US) (San Francisco) is barely shorter at 9,225 km and requires almost the same shipping time (14 days and 19 hours).¹ Finally, many Pacific economies are located in a zone with a high risk of different natural disasters, such as cyclones, tsunamis, and earthquakes.

The implications of these structural constraints for the integration of the Pacific economies into the global economy are multiple. First and most obvious is that remoteness equals high transportations costs. Transport costs are high in absolute terms, but also in terms of delays. Both are considerable disadvantages when competing in global markets where profit margins are low and fast delivery is critical (e.g., Evans and Harrigan [2005]).² Second, remoteness combined with a small economic size translates into lower connectivity in terms of frequency as well as direct connections. Given the considerable economies of scale in the transportation sector, small economies are typically served less frequently and from fewer destinations (e.g., Hummels and Skiba [2004], or Winters and Martins [2002]).³ This lower connectivity means higher costs, not only for the shipping of physical goods, but also for the delivery of services across borders. Finally, being located in an area of high risk of natural disasters, shipping can become subject to considerable variance. Again, in a world economy where just-in-time production is critical, the Pacific economies are facing a heavy burden, which is difficult to remove.

Given this difficult trading environment, the objective of this paper is to study the determinants of trade performance in terms of connectivity of the Pacific economies. The subjects of this study are the 14 Pacific developing member countries (Pacific DMCs) of the Asian Development Bank: the Cook Islands, Fiji, Kiribati, the Marshall Islands, the Federated States of Micronesia, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Tuvalu, and Vanuatu.

In a first step, we analyze how trade in goods and services has developed in the Pacific over the past decade. We therefore first provide an overview of the trade in goods of Pacific DMCs from 2000 to 2012 and then study the evolution of tourism over the same time period—the main source of trade in services for Pacific DMCs. The paper then introduces two new databases. The first database contains the shipping connections and frequencies between Pacific DMCs and with other countries in the world. The second database includes all flight connections as well as their frequencies between Pacific DMCs and with all other countries in the world. Using these two databases we

¹ The two shipping distances and times were downloaded from the SeaRates website, available at: <http://www.searates.com/reference/portdistance/>

² Evans and Harrigan (2005) find evidence for the importance of delivery times for the production of clothing.

³ Using US trade data, Hummels and Skiba (2004) show that a 10% increase in product weight/value results in a 4%–6% increase in shipping costs. Winters and Martins (2004) find that the transportation cost by ship falls by 0.31% when the shipping volume increases by 1%.

are able to comprehensively describe the connectedness of Pacific DMCs for international trade in goods and services.

In a next step, the two databases are then combined with the corresponding data for trade in goods and tourism flows. Using simple node diagrams, we illustrate how the connectedness of Pacific DMCs contrasts with the exchange of goods and services. In other words, trade in goods and services is taking place between many economies, whereas the connectedness is limited, making it necessary to pass through trading hubs. We then apply a gravity model to estimate the importance of direct connections and the frequency of shipping and flights for trade. We find that for trade in goods and services a direct connection (either by shipping or flight) implies a statistically significant higher trade volume compared to country pairs with no direct connection. The frequency of shipping increases trade in goods by up to 300% and the inflow of tourists is boosted by 20%. In order to control for endogeneity, we apply an instrumental variable approach which confirms the results.

The paper makes the following two contributions to the trade literature. For the first time, we construct a database that approximates all physical transportation links of a specific set of economies. In the empirical trade literature the mode of transportation for trade is often ignored as countries exchange their goods and services using various forms of transportation. As a consequence, it is almost impossible to fully trace the different modes of transportation. The advantage of the Pacific economies is that shipping and flight connections cover all trade in goods and most trade in services. Second, given the detailed data on physical connectedness, we are able to construct a measurement of effective distance. In the trade literature, distance is commonly approximated by the geographical distance between the capital cities of two countries or a weighted geographical distance that takes into account the economic geography of countries. Our measurement is more refined as it takes into account the fact that most of the transportation links are only through hubs, which thus implies higher trade costs in terms of shipping time and actual costs.

The paper is constructed as follows. We first provide a short description of the evolution of trade in goods and tourism services for the Pacific DMCs from 2000 to 2012. We then provide an overview of the two new datasets on shipping and flight connectivity used in this paper. Using a gravity equation approach, we then show the importance of connectedness for Pacific DMC trade.

2. THE PACIFIC'S TRADE IN GOODS AND SERVICES

2.1 The Pacific's Trade in Goods

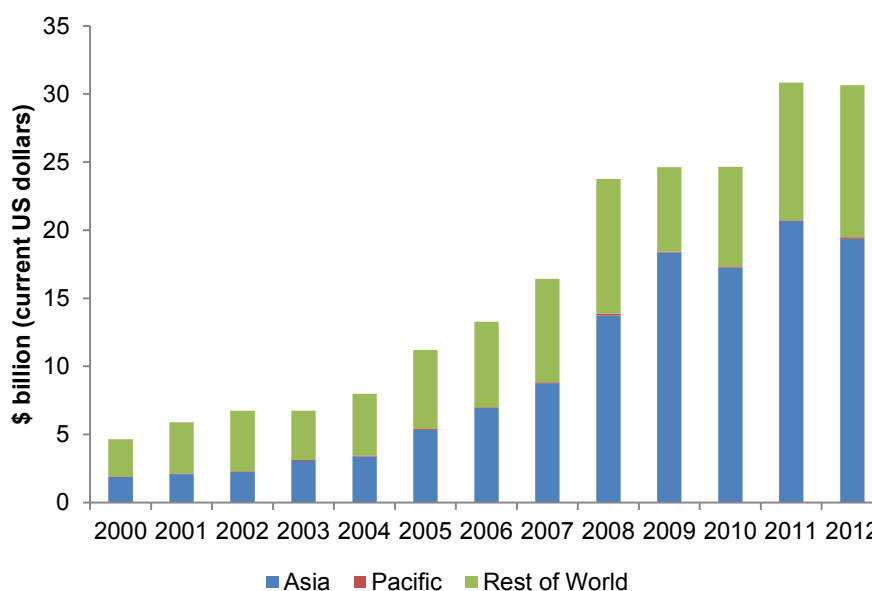
Trade in the Pacific has developed in a very dynamic way since 2000. Exports and imports of Pacific DMCs increased from less than \$5 billion in 2000 to around \$30 billion in 2012 (see Figure 1). Trade volumes grew particularly quickly from 2004 to 2008, whereas the years 2010 and 2012 were marked by no growth or even negative growth. It is interesting to observe that trade with Asia is accounting for an increasing share of Pacific trade. It increased from 40.7% in 2000 to 63.2% in 2012, whereas trade with the rest of the world fell from 58.7% to 36.6% in the same period.

It has to be noted that Papua New Guinea (PNG) and Fiji account for more than 80% of all trade of the 14 Pacific DMCs during the time period of our study. This can be mainly explained by the fact that these two economies are the largest of the Pacific DMCs. In 2012, Fiji had a gross domestic product (GDP) of \$3,908 million and PNG had a GDP of \$15,654 million, compared to \$5,542 million of all the other Pacific DMCs combined.

Another important particularity of Pacific DMCs' trade is their persistent and increasing trade deficit. In 2006, the total trade deficit of all Pacific DMCs amounted to less than \$2 billion, but surged to around \$15 billion in 2012. The deficit was mainly financed by remittances and official development aid. Another positive contribution comes from a trade surplus in services trade as we will discuss in the following section.

Trade in goods of the Pacific DMCs mainly consists of primary commodities. Pacific DMCs with rich fishing grounds typically export mainly fish and fish products, while Pacific DMCs with natural resources concentrate on the exports of those resources. The export of manufactured goods has declined over the past decade (ADB and ADBI, forthcoming). In the same time period, Asia has emerged as one of the world centers for manufacturing. One of the key success factors was that Asia was able to build up or join global and regional value chains and production networks. As a consequence, Asia's share of global trade in parts and components increased from 28% in 1990 to 51% in 2012.⁴ Many factors helped to establish Asia as "Factory Asia" (Baldwin 2008), among them a reduction in transportation costs and technological progress (OECD 2012). Being physically remote and having a small manufacturing base are two main reasons why the Pacific DMCs found it very difficult to join regional production networks or even had to scale down manufacturing.

Figure 1: Trade (Export and Imports) of Pacific Developing Member Countries, 2000–2012



Source: UNCOMTRADE; author's calculations.

2.2 Tourism in the Pacific

Tourism constitutes the largest portion of services exports for Pacific DMCs. In several economies, tourism even generates the largest revenue of all exports. For example, in Fiji tourism contributes to 40.5% of all exports, in Samoa 61.1%, and in Vanuatu 76.5% according to World Development Indicators.⁵ Tourism is also one of the most promising

⁴ Compiled from UN Comtrade database using methodology from Athukorala (2011).

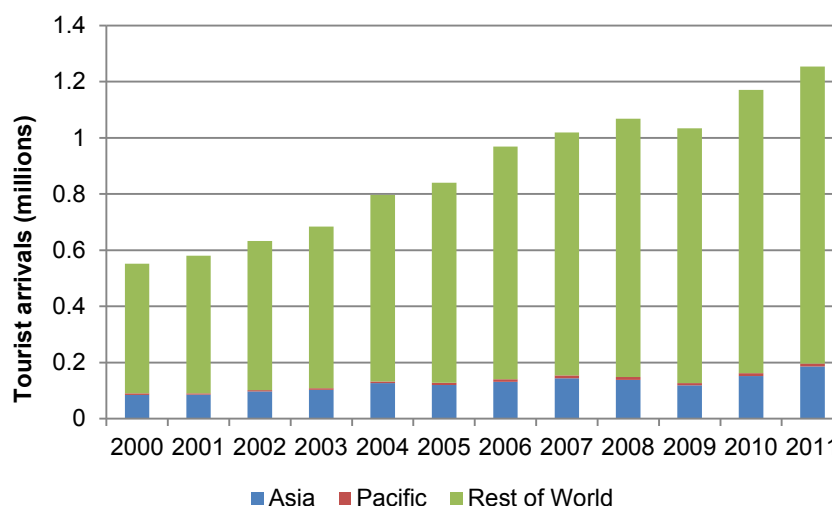
⁵ Downloaded from the World Development Indicators website: <http://data.worldbank.org/data-catalog/world-development-indicators> (10 August 2014).

growth sectors in the Pacific region. The number of tourist arrivals has more than doubled in the past decade, from around 600,000 in 2002 to 1.3 million 10 years later. And the potential for future growth looks substantial given that many Pacific DMCs offer unspoiled nature and scenic landscapes.

Under the General Agreement of Trade in Services (GATS) of the World Trade Organization, tourism falls under Mode 2 trade under which the customer consumes services abroad.⁶ According to statistics published by the United Nations World Tourism Organization (UNWTO), there were about 1.5 million tourist arrivals in the Pacific region in 2013. Similarly to trade, tourism is concentrated in a handful of countries. Almost half of all foreign tourists visiting the Pacific DMCs were welcomed by Fiji in 2012. The next largest receiving countries were Papua New Guinea (12%), Samoa (10%), the Cook Islands (9%), and Palau (9%).

The main source economies of tourists were Australia (44%), New Zealand (22%), the United States (7%), Japan (4%), and Taipei,China (3%). Despite Asia's proximity, Asian tourists play a minor role in Pacific tourism (Figure 2), with their share dipping from 15% in 2000 to 14% in 2011. Nonetheless, the number of tourists from the PRC has surged from 2,540 in 2000 to 35,426 in 2011.

Figure 2: Evolution of International Tourist Arrivals in Pacific DCMs, 2000–2011



Source: UNWTO database on number of inbound tourists.

Many observers expect that the number of tourists from Asia will further rise in the near future (ADB and ADBI, forthcoming). The main reason is that in many Asian countries, the middle class has been growing rapidly over the past decade accompanied by an increasing demand for leisure travel. Helble and Mutuc (2014) estimate that several Asian countries are far below potential and thus might constitute the major sources of tourists to the Pacific DMCs. In the near future, Asia is expected to become a major source of tourist arrivals in the Pacific.

Growing tourism inflows from Asia can become an important opportunity for Pacific DMCs to generate sustained growth. In the past, many Pacific DMCs have struggled to generate economic growth, mainly due to multiple structural constraints, such as their remoteness and small economic size. Tourism offers the possibility to overcome some

⁶ For some Pacific DMCs, so-called Mode 4 services trade constitutes another important source of services exports. Under Mode 4 the service provider temporarily moves abroad to deliver the service. Mode 4 exports are especially important for Pacific DMCs with agreements for seasonal workers, for example with Australia.

of these constraints and transform some constraints, such as their remoteness, into positive assets. Many Pacific DMCs have thus high hopes of achieving sustained economic growth by tapping into Asia's dynamic tourism sector.

We have seen above that trade in goods as well as services has increased in Pacific DMCs over the past decade. In the following section we would like to study the extent to which physical connectivity of Pacific DMCs determines their trade performance. We introduce the data used for the econometric modeling and present the methodology.

3. DATA AND METHODOLOGY

3.1 Data

3.1.1 Trade in Goods Data

The trade in goods data comes from the United Nations Comtrade database. Since we take as a proxy for trade in services the number of tourist arrivals and hence services exports, we decided to work with goods exports. For our gravity equation approach (see next section), several of our explanatory variables are only available for the years 2012 and 2013. We have therefore decided to create the 3-year simple average of trade spanning from 2011 to 2013. Taking a 3-year average has the advantage of leveling out certain infrequent trade flows. As our sample consists of several small economies, such infrequent events are not uncommon.

Following common practice, we first downloaded all bilateral trade flows in terms of imports from Pacific DMCs for the period 2011–2013. The reason for using imports instead of exports is that import flows are typically recorded with greater scrutiny compared to exports, because imports are often subject to import tariffs or other measures and therefore statistics on imports are typically more complete compared to exports. For the time period 2011–2013, imports from at least one of the 14 Pacific DMCs were reported by 180 economies (including the 14 Pacific DMCs). These importing economies have reported 2,304 positive trade flows (out of 7,560 possible observations).

The trade statistics based on imports can be complemented by trade statistics based on exports. For this method, so-called mirror statistics, the bilateral flows reported by the importer are compared with the trade statistics of the exporting economy. In theory, the value and volume of trade reported by both the exporter and importer should be identical. However, it has been observed that considerable discrepancies exist between the two records. The reasons are manifold and not yet fully understood. Furthermore, we find cases in which a bilateral trade flow is recorded by the exporter, but not by the importer. Mirror statistics can therefore be a useful tool to complement and complete trade statistics.

Applying the mirror-statistics approach, we have downloaded all exports by the Pacific economies to all economies in the world. These economies have reported 771 export flows to the rest of the world in the period 2011–2013.

In a next step, we combined the database on the bilateral import flows reported by the rest of the world and the bilateral export flow reported by Pacific DMCs and obtained a total number of 3,075 observations (over the 3 years). Out of these 3,075 observations, 2,583 were unique observations reported by either importers or exporters. 492 were observations for which we had an entry by both the exporting Pacific DMCs as well as the importing economies. In order to remove these duplicates, a simple average of the two entries was calculated and then only one entry kept. Calculating a simple average

allowed us to avoid deciding which entry (by the importing or exporting economy) is correct. After eliminating all flows that went to categories of economies that are either obsolete or classified as “unspecified,” and after taking the average over 3 years, we ended up with a sample of 1126 positive observations. In the gravity equation below, we will make also use of all zero observations between 14 Pacific DMCs towards the 180 economies (including Pacific DMCs), which equals to a total of 2,520 observations.

3.1.2 Outbound Tourist Statistics

Worldwide tourism flows are collected by the United Nations World Tourism Organization (UNWTO). Every year, UNWTO publishes the total number of tourist arrivals for over 200 economies. In addition, UNWTO estimates bilateral tourist flows (outbound) on a yearly basis since 1995. This database is not publicly available. For all Pacific DMCs, UNWTO has produced estimates for both the total number of tourist arrivals as well as the outbound tourists. As our research interest lies in the number of inbound tourists, we have downloaded all estimates of economies that have reported outbound tourists with a destination in the Pacific DMCs, including the Pacific DMCs.⁷

For our gravity equation approach (see next section), the flight connection data is only available for 1 year, namely 2012. We have therefore decided to create the 3-year simple average of tourist flows for the time period 2011–2013. The tourist data used for the gravity analysis contains the average tourist flows over the 3 years from 46 economies to the Pacific DMCs, which equals 171 positive tourist flows. Including zero observations, we count 645 observations.⁸

3.1.3 Shipping Connectivity Data

All Pacific DMCs are island economies and share no land border with other countries, except for PNG and Timor-Leste, which have a land border with Indonesia. The only two ways to reach most Pacific DMCs are thus either by ship or by air. For both means of transportation we have tried to find detailed data that describe the connectivity of the Pacific DMCs.

The first dataset describes the connectivity of Pacific DMCs in terms of the maritime network. We have used a database called Sea-web. Since 2001, major ships and ports worldwide have started to use the so-called automatic identification system (AIS) equipment. The AIS equipment automatically reports arrival and departure times to the port authority, mainly in order to avoid collisions. Today, all major ports (around 11,000 ports and terminals) and bigger ships (above 100 gross tonnage [GT]) have AIS devices installed. The resulting arrival and departure records are collected by the Lloyd’s Registry Fairplay and made available online on the Sea-web website.⁹ The database is generated by AIS signals and covers the vast majority of the international traffic of ships. The information on the movement of the ships is refreshed and updated every three minutes.

Using the Sea-web database, we first looked at all connections between ports in the Pacific DMCs and also the rest of the world between the period 1 January 2013–31

⁷ The total number of tourist arrivals and the outbound bilateral tourist flows are produced by different estimation techniques and do not necessarily sum up. For more information, please see <http://statistics.unwto.org>

⁸ We have only included those economies as partners from which at least one tourist visited one of the Pacific DMCs. Otherwise, the Poisson regression would not converge.

⁹ The information is accessible at www.sea-web.com for a fee. In addition, Lloyd’s Registry Fairplay manages the IMO Ship and Company Numbering Schemes, on behalf of the International Maritime Organization (IMO), providing unique identifiers for ships and ship owners.

December 2013. We were thus able to establish a matrix covering all maritime connections between ports in the 14 Pacific DMCs and with 34 other economies in the world (see Table 1). Overall, we counted 1,148 direct links.

Table 1: Overview of Maritime Network Connections of Pacific Developing Member Countries in 2013 (number of active connections between ports in origin and destination)

		Origin			
		Pacific DMC	Other Pacific	Asia	ROW
Destination	Pacific DMC	196 (821)	126 (428)	210 (428)	140 (21)
	Other Pacific	126 (474)			
	Asia	210 (426)			
	ROW	140 (45)			

Pacific DMC = Pacific developing member country, ROW = rest of world.

Note: Frequency of voyages is in parentheses.

Source: Sea-web, and author's calculations.

In addition to the direct links between economies, we have tried to obtain a measurement of frequency of connections between ports. Recent literature shows that the frequency of shipping connections reveals information about the freight rates. For the case of the Caribbean islands higher frequency means lower freight rates due to increased competition (Wilmsmeier and Hoffmann 2011). In order to obtain a frequency estimate, we have downloaded the last 50 observations of each ship (as of 1 July 2014) that travelled through a port in a Pacific DMC in 2013. Using this information we were able to produce an estimate of the frequency for each link. The total number of voyages was 2,643. It is possible that the total number for the frequency of connections for the year 2013 is higher. The reason is that the last 50 observations that are reported by each ship do not necessarily cover the entire year. However, we believe that our sample is representative of the shipping links over the full period.

The Sea-web website also holds information on the type of ship. We have excluded all those ship types that seem to be unrelated to international trade, such as research ships or cable layer ships. Our final sample holds eight types of ships: bulk cargo, chemical tanker, container, fishing and trawlers, general and refrigerated cargo, oil and gas tanker, product tanker, and passenger ships. For all ships we collected the ship name, the gross weight, the port of call, the country of call, the arrival date, and the sailing date. In addition, we calculated the voyage time in terms of number of days between two ports in two different countries.¹⁰ The descriptive statistics are presented in Table 2.

¹⁰ We excluded all movements of ships between ports within one economy.

Table 2: Descriptive Statistics of Shipping Data

No.	Type of Ship	Number of Observations		Gross Weight (tons)			
				Percent	Mean	Std. Dev.	Min
1	Bulk	158	6.10	17,835.80	17,777.95	2,551.00	106,367.00
2	Cargo	970	37.47	6,424.50	5,072.66	1,211.00	25,483.00
3	Chemical	199	7.69	14,119.18	16,568.96	1,997.00	50,672.00
4	Container	684	26.42	12,460.59	6,043.74	5,234.00	35,887.00
5	Fishing	299	11.55	1,616.17	608.01	349.00	3,415.00
6	Oil and gas	78	3.01	19,439.54	36,839.65	3,409.00	162,863.00
7	Passenger	153	5.91	60,295.03	33,035.25	235.00	90,090.00
8	Product tanker	48	1.85	25,009.58	23,879.61	1,584.00	65,162.00
Total		2,589	100.00				

Source: Sea-web, and author's calculations.

3.1.4 Flight Connectivity Data

Recently, more and more databases have emerged on international flight connections. Economic research has now started to use these databases, such as Arvis and Shepard (2011) or Yilmazkuday and Yilmazkuday (2014). We have made use of the freely available database called Openflights, which contains all flight routes worldwide as of January 2012 as well as the airline companies that operate on the routes.¹¹ Obviously, one route can be operated by several airline companies. We downloaded all routes that had one of the Pacific DMCs as the origin or destination. Overall, we have 57 direct flight connections: 22 direct connections between Pacific DMCs and 35 between Pacific DMCs and other economies in the world. The geographical spread is as follows: 19 direct connections to other economies in the Pacific/Oceania, 11 direct connections to Asia, and 4 direct connections to the US.

In contrast to the shipping data, the routes data is symmetric in the sense that flights are between two points back and forth. In the case of shipping, it is common to observe that one ship travels not only between two ports, but continues its travel to various additional destinations, before returning back to the port of origin.

Several of the 57 direct routes to the Pacific DMCs were maintained by more than one company. Openflights listed 117 connections to the Pacific DMCs as reported by the airlines. Several of the flights were, however, co-shared. In order to obtain an estimate of the frequency of the connection, we counted the number of flights by all airlines (excluding co-shared flights) per week for each of the direct routes. Information on frequency is not available on the Openflights website, but was researched on the corresponding airline websites. We found that on the 57 connections 294 flights operated weekly.

¹¹ <http://openflights.org/data.html>

3.1.5 All Other Economy-specific and Bilateral Data

For our gravity model analysis below, additional information is needed on economies as well as bilateral relationships (see Appendix). The corresponding data was downloaded from the website of the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), a leading French international economics research institute.

The following variables are used in our analysis: first, geographical distance between two economies; second, the use of a common official language or ethnic language spoken between trading partners; third, whether trading partners have been in a colonial relationship; and finally, whether trading partners share a common colonizer. We have not included other dummy variables (such as contingency) as for the Pacific DMCs it only applies to very few cases. A detailed description of the variables used can be found in the Appendix.

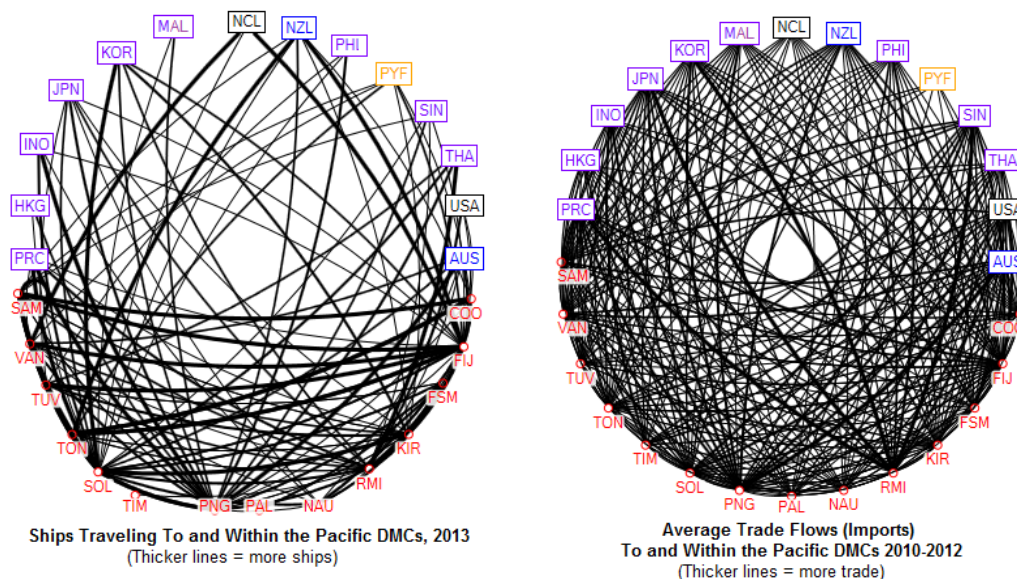
3.2 Nodes Diagrams

3.2.1 Shipping versus Trade Flows

One possibility to illustrate our datasets is by using node diagrams. A node diagram depicts all possible connections between nodes as well as the intensity of the connection. Figure 3 shows on the left the direct shipping connections between Pacific DMCS and major partners. In order to increase readability we have ignored the direct shipping links with weaker intensities (less than 20 entries in our sample). The thickness of the lines illustrates the intensity of the shipping connection. The busiest connections within the Pacific DMCs were between PNG and Solomon Islands. Between Pacific DMCs and other Pacific countries, the shipping connections between PNG and Australia as well as Fiji and New Zealand counted the most traffic. Outside the Pacific/Oceania, the route between the PRC and PNG appears to be by far the busiest.

On the right-hand side of Figure 3 we have depicted the trade connections among Pacific DMCs as well as between Pacific DMCs and the economies that had major direct shipping links (identical list of countries as the left-hand side). We observe that the trade web is very dense. The Pacific DMCs export to many of the economies included in the graph. Compared to the trade graph, the left shipping graph appears very sparsely populated. In other words, the trade linkages are much more frequent than the shipping connections. This implies that a substantive amount of trade is not directly shipped but routed through one or more economies. It is well known that world trade is organized in a hub and spoke system (for example, see Wilmsmeier and Notteboom [2009]). This architecture has been established partly following economic rationale; however, it often implies substantially higher trade costs for spoke economies compared to hub economies.

Figure 3: Node Diagrams of Direct Shipping Connections and Trade Flows between Asia and the Pacific and within the Pacific



Pacific DMC = Pacific developing member country.

Note: Only those 14 economies with the most shipping connections to the Pacific DMCs are included.

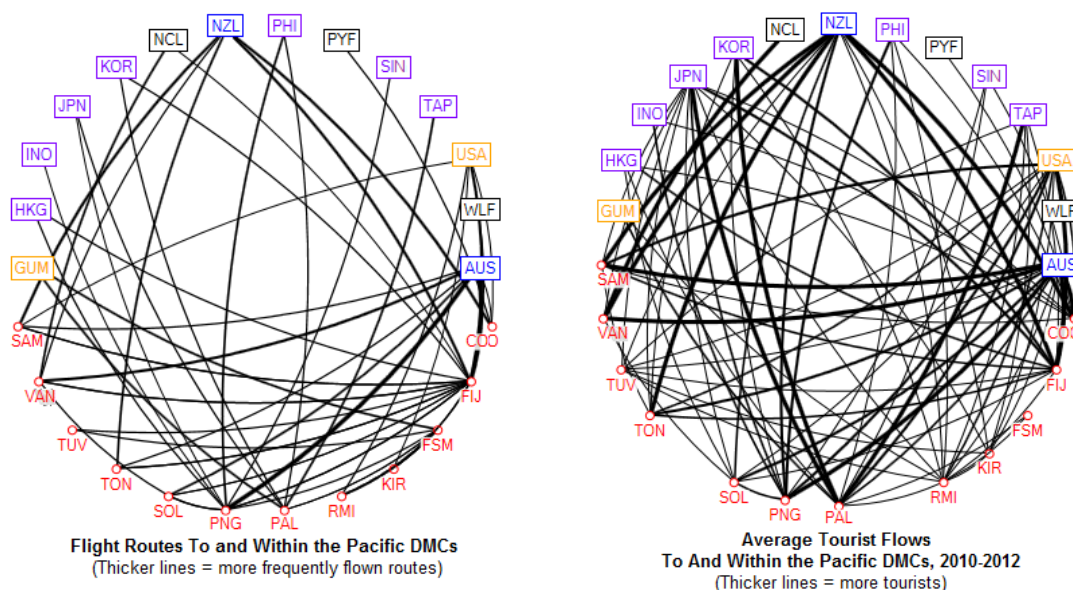
Source: Author.

3.2.2 Flight Connections versus Tourism Flows

Similar to the node diagrams above, the node diagram on the left of Figure 4 depicts all the flight connections available within the Pacific and with economies outside the region. Interestingly, out of the possible 168 flight connections between economies outside the Pacific region toward Pacific DMCs, only 35 are in place (between the Pacific DMCs, 28 out of 116 possible connections exist). The thickness of each link indicates the frequency of the flight connection. The routes between Australia and Fiji, as well as Australia and PNG are among the busiest ones.

The node diagram on the right of Figure 2 illustrates the bilateral tourism flows. A comparison of both nodes shows that many bilateral tourism flows remain unmatched with bilateral flight connections. Tourists need to take indirect flights to reach their destination. Similar to the trade flows, travelling through a hub implies additional costs, in terms of time, but also additional financial costs.

Figure 4: Node Diagrams of Direct Flight Connections and Tourism Flows between Asia and the Pacific and within the Pacific



Pacific DMC = Pacific developing member country.

Note: Only economies with at least one flight connection to one of the Pacific DMCs are included in the diagram.

Source: Author.

3.3 Methodology: The Gravity Equation

Over 50 years ago, the late Nobel Laureate Jan Tinbergen (1962) came up with the idea to use a gravity model to predict bilateral trade flows. Like the gravitational forces in physics, Tinbergen stipulated that the volume of trade between two countries would be a function of their distance as well as their masses. He found that compared to other trade models, such as Ricardo or Heckscher–Ohlin, the gravity model performed much better in predicting actual trade flows. However, for many years the gravity model was lacking a theoretical backing from economic theory.

It was only in 1979 that Anderson provided a first theoretical underpinning (Anderson 1979). Over time, more and more trade models were developed from which a gravity equation could be derived. This literature was revived at the beginning of the 2000s by the seminal contributions of Eaton and Kortum (2002) as well as Anderson and van Wincoop (2003). The two papers showed that neither the assumption of increasing return nor imperfect competition was needed to formulate a micro-founded gravity equation. After the introduction of the so-called new, new trade theory with heterogeneous firms by Melitz (2003), it took little time to develop a corresponding gravity approach, such as Chaney (2008). Given the success of the gravity model in predicting international trade flows and its strong theoretical backing, the gravity model has maintained its high popularity as a workhorse among trade economists.

The modeling of the gravity equation used in this paper follows closely the presentation of Head and Mayer (2014). The general gravity model can be formulated as follows:

$$X_{ni} = GS_i M_n \phi_{ni} \tag{1}$$

X_{ni} stands for the trade flows to the destination market n from i . S_i measures the ability of country i to export to all destination. M_n captures all characteristics of the destination

market n . Bilateral trade costs and their impact on trade flows between n and i are captured by ϕ_{ni} where $0 \leq \phi_{ni} \leq 1$. G is the constant and ε_{ni} the error term.

When taking logs of equation (1), we obtain the following equation:

$$\ln X_{ni} = \ln G + \ln S_i + \ln M_n + \ln \phi_{ni} + \varepsilon_{ni} \quad (2)$$

The log of GDP of the exporting and importing country were traditionally used as proxies for S_i and M_n . In order to observe the impact of capital and labor endowments on trade flows, the logs of GDP per capita and population have also been used in place of GDP. However, since the influential contribution by Anderson and van Wincoop (2003), it has become common practice to use fixed effects for importer and exporter instead. We follow this practice and use both importer and exporter fixed effects.

Our two datasets on trade in goods and in services contain a substantive number of zero entries. In the trade literature we find an extensive discussion on how to best handle zero entries in empirical estimations (see for example Helpman et al. [2008]). Over recent years, the approach suggested by Santos Silva and Tenreyro (2006) has gained most popularity. Santos Silva and Tenreyro (2006) show that the most appropriate approach is to use a (pseudo) Poisson maximum likelihood (ML) estimator. In this method the gravity equation is estimated in levels and it takes care of the possible presence of heteroskedasticity. Following Santos and Tenreyro's (2006) work, we use a Poisson ML estimator in our econometric approach, in addition to a traditional OLS approach.

4. RESEARCH RESULTS

4.1 Gravity Estimation Results for Goods Trade

The gravity estimation results for goods trade are listed in Table 3. The first three columns were estimated with a traditional OLS estimation technique neglecting possible zero trade flows. The first column shows the results when we run a standard gravity equation without including any variable for connectivity.

The first observation is that the distance coefficient is substantially higher than usually observed. Many empirical studies find for goods trade a distance coefficient of around -1.0 (e.g., Kimura and Lee [2006]). For the Pacific economies, we observe a higher distance coefficient (-1.36). The distance variable in our estimation controls for the geographical remoteness of Pacific countries. The bigger magnitude compared to other empirical trade studies seems to indicate that Pacific economies are confronted with additional trade costs that makes their integration into the global market particularly difficult. The other bilateral control variables hold several interesting results. First, speaking a common official language has a positive effect on trade, whereas sharing any other language appears to have a negative effect on Pacific trade. Both effects almost neutralize each other. Furthermore, Pacific economies seem to export more to economies that had the same colonizer. Finally, the value of R-squared indicates that our model predicts about 60% of all export flows.

In column (2) we add the dummy variable measuring whether we observe a direct connection in a bilateral pair. The dummy variable is highly statistically significant and of magnitude 1.52. As expected, a direct shipping connection is highly important for the export performance of economies. Interestingly, the distance coefficient in column two falls to -0.85 (compared to -1.36 in column [1]). Having direct connectivity thus seems to explain partly the high trade costs for some Pacific DMCs. In column (3) the variable

measuring the frequency of the connection is introduced. (Given the collinearity between the dummy variable for direct connections and frequency we are unable to introduce the two variables simultaneously.) The coefficient is again highly statistically significant. A higher shipping frequency increases trade, however, to a smaller extent compared to having a direct connection. Once again, we observe that the distance coefficient falls and turns statistically insignificant. The frequency of shipping seems thus to constitute another important element of trade costs.

In columns (4) and (5) we take into account zero trade flows. The distance coefficient is now even larger. The economic intuition is that the remoteness of the Pacific economies cuts them off from otherwise positive trade links. Using the Poisson estimation technique, trade costs become an even heavier impediment for international trade. The coefficient of the dummy variable measuring direct connectivity decreases to 0.37. The coefficient measuring the frequency falls to 0.33. The reason for the smaller coefficients might be that both connectivity variables are correlated with distance, especially when we include zero trade flows. Finally, the Poisson regression results show the important role of colonial links.

Table 3: Gravity Estimation Results of Pacific Developing Member Country Exports (2011–2013 average)

	(1)	(2)	(3)	(4)	(5)
Variables	Log(Trade)	Log(Trade)	Log(Trade)	Trade	Trade
Log (Distance)	-1.36*** (0.343)	-0.85** (0.350)	-0.39 (0.339)	-1.94*** (0.616)	-1.46** (0.741)
Common official language	0.73* (0.422)	0.75* (0.426)	0.61 (0.424)	-0.08 (1.234)	-0.05 (1.274)
Common other language	-0.78** (0.355)	-0.81** (0.360)	-0.69* (0.355)	-0.35 (1.054)	-0.39 (1.079)
Ever in colonial relationship	0.68 (0.535)	0.56 (0.545)	0.43 (0.522)	1.57*** (0.347)	1.44*** (0.340)
Common colonizer	0.56* (0.302)	0.42 (0.300)	0.38 (0.294)	0.18 (0.475)	0.06 (0.468)
Direct shipping connection		1.52*** (0.341)		0.37 (0.353)	
Log (Frequency)			1.11*** (0.137)		0.33** (0.153)
Observations	1,126	1,126	1,126	2,520	2,520
R-squared	0.60	0.61	0.62	-	-
Origin and Destination FE	Yes	Yes	Yes	Yes	Yes
Estimation Technique	OLS	OLS	OLS	Poisson	Poisson

Notes: Robust standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's estimation.

Overall, we find that trade costs play a key role in shaping the trade of Pacific economies. However, several Pacific economies are very small, and establishing new shipping links or increasing the frequency of existing connections might not be economically feasible or desirable. The Pacific economies lend themselves to a hub and spoke arrangement for shipping, which should be coordinated at the regional level.

4.2 Gravity Estimation Results for Tourism Flows

Next, we present the results of the gravity equation approach for tourism flows to the Pacific. On the left hand side of our equation we have the average number of tourist arrivals to one of the 14 Pacific DMCs for the years 2010, 2011, and 2012. The average number of tourists is explained by a number of variables, including distance, flight connectivity, and the ones also used in the gravity equation for trade flows.

Table 4: Gravity Estimation Results of Tourism Flows

	(1)	(2)	(3)	(4)	(5)
Variables	Log(Tourist)	Log(Tourist)	Log(Tourist)	Tourist	Tourist
Log (Distance)	-2.48***	-1.88***	-1.74***	-2.87***	-2.75***
	(0.487)	(0.556)	(0.586)	(0.597)	(0.720)
Common official language	0.40	0.26	0.25	1.74**	1.78**
	(0.572)	(0.580)	(0.575)	(0.769)	(0.755)
Common other language	0.41	0.26	0.22	-0.39	-0.68**
	(0.330)	(0.324)	(0.325)	(0.341)	(0.333)
Ever in colonial relationship	0.99***	0.86***	0.76**	0.15	0.09
	(0.351)	(0.329)	(0.341)	(0.345)	(0.363)
Common colonizer	0.61	0.25	0.25	0.47	0.49
	(0.566)	(0.584)	(0.566)	(0.538)	(0.532)
Direct flight connection		0.82**		1.08**	
		(0.322)		(0.460)	
Log (Frequency)			0.17***		0.17*
			(0.063)		(0.093)
Observations	171	171	171	645	645
R-squared	0.91	0.91	0.91	-	-
Origin and destination FE	Yes	Yes	Yes	Yes	Yes
Estimation technique	OLS	OLS	OLS	Poisson	Poisson

Notes: Robust standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's estimation.

In column (1) we present the results of the baseline gravity equation estimated by OLS and using origin and destination fixed effects. The first observation is that the distance coefficient is of higher magnitude (-2.48) compared to the gravity equation results for trade in goods flows (-1.36) and captures the high costs of reaching destinations in the Pacific for tourists. For worldwide tourist flows, the distance coefficient is of higher magnitude (around -1.4) compared to goods trade.¹² The Pacific countries thus again suffer from a substantial locational disadvantage when attracting international tourists. Similar to goods trade, sharing a colonial past is still an important determinant of tourist arrivals in the Pacific. Interestingly, speaking a common language does not play a role for Pacific tourist flows in the simple OLS specification. Overall, our baseline gravity regressions seem to model the tourist flows to the Pacific very well with an R-squared of over 90%.

In column (2) we add the dummy variable that controls for the existence of a direct flight connection. The coefficient is highly statistically significant and has a magnitude of 0.82. It is thus again smaller than the earlier results for goods trade. Again, it can be interpreted as follows: Pacific countries that have a direct flight connection to one of the

¹² For other services trade, the distance coefficient is substantially lower, around 0.7 (see Kimura [2006]).

source countries of tourists receive on average about 2.27 ($\exp[0.82]$) times as many tourists as Pacific countries without a direct flight connection. When including the dummy for a direct flight connection, the distance coefficient drops to -1.88 . Similar to the goods trade, the connectivity explains a significant proportion of the costs related to distance.

The coefficient for the frequency of flight connections is included in the regression results listed in column (3). The result implies that increasing the frequency by 1% will increase (on average with everything held equal) tourists by about 0.2%. The distance coefficient is again substantially lower in this regression compared to equation (1), indicating that distance partially captures the costs related to the frequency of flights.

In column (4) and (5) we have re-run the equation applying a Poisson ML estimator. The Poisson ML estimator does not converge when all countries in the world are included as possible source countries for tourists in the Pacific. We have therefore included as possible source countries only those countries from which at least one visitor arrived in the years 2010–2012. Overall, we counted 46 countries.

The regression results in column (4) show that distance now becomes an even bigger impediment for tourism. This result is intuitive as now zero tourism flows are included as dependent variables and explained by distance. The dummy variable capturing a direct flight connection is again highly statistically significant and close to one. The coefficient measuring the frequency of the connection has a very similar magnitude compared to the regression listed in column (3).

In our gravity equation, we have controlled for origin and destination characteristics by introducing the corresponding fixed effects (not reported). The sign and magnitude of the country fixed effects suggest that the biggest potential for new tourists to the Pacific lies in the PRC and Indonesia. Given their geographical proximity, populations, and economic size, the model implies that tourist arrivals in the Pacific from these two countries are far below potential.

In summary, our results indicate that both direct flight connections and the frequency of flights are important determinants of tourist flows to the Pacific. In the following section we provide several robustness checks before discussing the implications of our results.

4.3 Robustness Checks

The existence of shipping links and flight connections cannot always be assumed to be fully exogenously determined, but rather the opposite. The connectivity of an economy is in most cases a function of the demand for the transportation of goods and services. In order to control for endogeneity we apply an instrumental variable (IV) approach. The IV method is based on the idea of having an additional variable that is uncorrelated to the error term in equation (2), but is partially correlated with the variable that suffers from endogeneity. In our case, the connectivity variables (direct connection as well as frequency) are the ones that suffer from endogeneity. In order to control for the latter, we propose the following instruments:

Table 5: Overview of Instruments Used in the Instrumental Variable Regressions

	Possible Endogenous Variable	Instrument
Shipping	Direct connection	Flight connection
	Frequency of connection	Flight frequency
Flight	Direct connection	Shipping connection
	Frequency of connection	Shipping frequency

Source: Author.

The instruments for shipping connectivity in the trade in goods equations are flight connections and frequency, which come from the dataset on tourism flows. The instruments for the flight connectivity in the tourism equation are the shipping connection as well as the shipping frequency. Using these instruments, we obtain the results listed in Table 6.

Table 6: Gravity Estimation Results Using an Instrumental Variable Approach

	(1)	(2)	(3)	(4)
Variables	Log(Trade)	Log(Trade)	Log(Tourist)	Log(Tourist)
Log (Distance)	1.22**	0.39	-1.53	-2.31***
	(0.582)	(0.388)	(1.125)	(0.644)
Common official language	0.77	0.59	0.28	0.46
	(0.477)	(0.394)	(0.565)	(0.527)
Common other language	-0.86**	-0.69**	0.17	0.36
	(0.418)	(0.346)	(0.412)	(0.352)
Ever in colonial relationship	0.08	0.23	0.84**	1.00***
	(0.609)	(0.495)	(0.352)	(0.322)
Common colonizer	-0.16	0.19	-0.06	0.40
	(0.329)	(0.256)	(0.702)	(0.404)
Direct connection	7.75***		1.17	
	(1.456)		(1.490)	
Log (Frequency)		1.96***		0.02
		(0.310)		(0.137)
Endogeneity test	0.000	0.002	0.799	0.256
Observations	1,126	1,095	168	168
R-squared	0.42	0.61	0.91	0.91
Origin and destination FE	Yes	Yes	Yes	Yes
Estimation technique	IV	IV	IV	IV

Notes: Robust standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's estimation.

The robustness checks for the trade in goods equations confirm our previous results. In column (1) the dummy variable for direct connection remains highly statistically significant and even increases in magnitude. The distance coefficient turns positive, which is probably related to the fact that the direct flight connection is also a function of distance, which is not optimal for the IV method. The results of the IV estimation for the frequency yield very similar results. The coefficient measuring the frequency of the shipping connection is again highly statistically significant and large in magnitude. The endogeneity tests in columns (1) and (2) show that endogeneity is indeed a concern.

When we use the IV method on the tourism data, the connectivity results are similar to the ones in Table 4. Having a direct flight connection seems to be more important than the frequency. The standard errors in columns (3) and (4) are large. However, as explained in the literature (see for example Woolridge [2002]) the IV method typically yields large standard errors. Furthermore, the endogeneity tests for tourism indicate that endogeneity seems less of a concern for the tourism equations.

Another test of the stability of our results is by changing the distance measure. In our model, the distance between trading partners is measured by the geographical distance. However, the geographical distance seems only a rough approximation, especially for smaller economies that do not have many direct shipping or flight connections and rely on their connections to a hub. In order to take this into account, we have calculated the minimum distance between trading partners given the

underlying connectivity architecture. For example, if A is connected to B only through C, we have calculated the sum of geographical distances from A to C, and B to C. The estimation results are listed in Table 7.

Table 7: Gravity Estimation Results of Tourism Flows and Trade Flows Using Full Distance

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	Log(Trade)	Log(Trade)	Log(Trade)	Log(Tourist)	Log(Tourist)	Log(Tourist)
Log (Full distance)	-1.79*** (0.382)	-1.13** (0.487)	-0.25 (0.497)	-2.96*** (0.649)	-1.34* (0.796)	-0.88 (0.863)
Common official language	2.06** (0.864)	2.28** (0.881)	2.16** (0.878)	1.37 (1.032)	0.56 (0.958)	0.46 (0.886)
Common other language	-1.76*** (0.557)	-1.86*** (0.567)	-1.71*** (0.535)	0.96 (0.774)	0.86 (0.727)	0.73 (0.728)
Ever in colonial relationship	1.32* (0.680)	1.23* (0.686)	0.97* (0.582)	1.36 (0.966)	1.07 (0.928)	0.60 (1.030)
Common colonizer	0.76* (0.432)	0.63 (0.421)	0.51 (0.399)	0.82 (0.749)	0.22 (0.705)	0.23 (0.627)
Direct connection		0.92** (0.424)			1.71** (0.654)	
Log (Frequency)			0.97*** (0.182)			0.39** (0.148)
Observations	338	338	338	81	81	81
R-squared	0.68	0.69	0.71	0.85	0.87	0.87
Origin and destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Estimation technique	OLS	OLS	OLS	OLS	OLS	OLS

Notes: Robust standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Source: Author's estimation.

The sample size for goods trade and tourism flows is now smaller, as we only included those countries that have either a shipping or flight connection to the Pacific. However, the results found earlier are very stable. As expected, the distance coefficient increases significantly for both trade in goods and tourism (columns [1] and [4]). In the other columns all connectivity variables are highly statistically significant and of similar magnitude compared to the previous results. In summary, using a different distance measure confirms the results found earlier.

5. DISCUSSION AND CONCLUSION

5.1 Discussion

This paper highlights the potential of increased connectivity of the Pacific DMCs. However, several words of caution are in order.

First, we are faced with certain data limitations of our dependent variables. For goods exports, it would be ideal to have an estimate of the total volume of trade (in tons) instead of the value (in current US dollars) as our main research interest is assessing the effect of physical shipping connectivity. However, in international trade statistics,

apart from the good's value, products have different units (weight in kilograms, liters, etc.), which makes it very difficult to estimate the total volume of bilateral trade flows. The value of a bilateral trade flow is often a good proxy of the volume. However, in some cases it might overestimate or underestimate the trade volume. For example, certain Pacific DMCs export large amounts of precious raw materials, such as gold, which have relatively low weight compared to their value in the trade statistics. Another data concern is that for tourism flows, we have anecdotal evidence that the number of tourists might in some cases be overstated. For example, in the case of PNG, tourists are not required to request a visa prior to traveling to the country. As a consequence, PNG visitors with a different purpose regularly claim to be tourists. However, this bias might be limited as some travelers that visit a country for another reason than tourism might extend their stay and consume tourism services.

Second, certain caveats need to be mentioned about our econometric estimations. We have made an attempt to control for the problem of endogeneity. However, the instruments used so far might not be perfect. Future research might want to try to better control endogeneity. It also has to be noted that our econometric model estimates average marginal effects. Not every new connection or increase in the frequency of connections will have the same effect.

Finally, in our estimates we have not taken explicitly into account the supply constraints of Pacific DMCs in welcoming more tourists. Realizing the promising economic opportunities that come with more tourists will certainly depend not only on better connectivity, but on creating economic conditions that facilitate more tourism. Most importantly, it is the capacity of Pacific DMCs to accommodate the increased demand for hotels, amenities, and other facilities that come with additional tourists that will determine how much they would benefit from the presence of more visitors from new flights to and within the region. While increasing flights to the Pacific DMCs would attract more tourists, substantial investments in infrastructure would be needed to ensure that any growth in tourism—and the economic benefits associated with it—would be sustained.

5.2 Conclusion

In this paper we have found strong evidence that connectivity of the Pacific is an important determinant of their integration into the world economy. Applying a gravity model to flows of goods and services (tourism) yields several new sights. First, the remoteness of Pacific DMCs measured by their geographical distance from their trading partners acts as major barrier to trade. On average, Pacific DMCs face substantially higher trade costs compared to world average for good's trade. In case of tourism, Pacific countries also face a locational disadvantage when attracting international tourists. Second, the gravity equation shows that a direct transportation link with trading partners more than doubles trade flows. This result applies almost equally to the flows of goods and tourism. Finally, a higher frequency in transportation is another important determinant of trade performance, especially for goods trade.

The contributions of this paper are twofold. First, we exploit for the first time a database on shipping connections and combine it with international trade flows. The first results of this exercise are highly promising. We have now a better understanding of how the shipping network in the Pacific compares to the trade network. In the future, it would be important to have access to comprehensive historical shipping data. Access to this data would allow assessment of various policy interventions. For example, several Pacific economies are currently upgrading the physical infrastructure of ports. Exploiting the database could allow to measure the impact of these major port

infrastructure investments. Furthermore, it would be highly interesting to study which port infrastructure would be economically optimal for the region. Given the small size of many Pacific economies not every port can efficiently operate as a hub. Combining trade and shipping data one could calculate the hub-and-spoke arrangement that is optimal for the region. Another application would be to measure in real time the economic integration within and between regions. Finally, compared to international trade data, the shipping data is recorded in real time and could therefore also be used as a proxy for swings in international trade.

Second, this paper constitutes the first attempt to combine bilateral tourism data with international flight connectivity data. Our results show that better flight connectivity can boost tourist arrivals. Similar to the shipping database, extending the analysis by including historical flight and tourism data could solidify the econometric estimates and provide new insights.

Finally, it has to be recalled that in order to increase the connectivity of the Pacific more can be done than upgrading of the physical infrastructure. For example, introducing and ensuring competition in the transportation sector is one option. Another option is to lower bureaucratic or other burdens related to connectivity. For example, Asian Development Bank research (Arita et al., forthcoming) shows that simplified visa procedures can boost the inflow of tourists. Another possible step to improve flight connectivity could be to lower the landing fees of airports. As a last thought, whether improved connectivity will help stimulate economic growth in the medium to long run will crucially depend on the capacity of Pacific DMCs to respond to the growing demand. In the best case, both growing connectivity will go hand in hand with an increase in supply and demand.

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APPENDIX

Summary of Variables

Variable	Unit	Description
Imports	Current US dollars	Imports of economy i to economy j in year t
Exports	Current US dollars	Exports of economy i to economy j in year t
Distance	Kilometers	Geographical distance between the two economies' most populated cities
Contingency	0;1	Unity if two economies share a land border, zero otherwise.
Common official language	0;1	Unity if two economies share an official or primary language, zero otherwise.
Common ethnic language	0;1	Unity if a common language is spoken by at least 9% of the population in both economies, zero otherwise.
Colony	0;1	Unity if the economy pair has ever been in a colonial relationship, zero otherwise.
Common colonizer	0;1	Unity if the two economies share a common colonizer, zero otherwise.
Flight connection	0;1	Unity if a flight route exists between two economies, zero otherwise.
Flight frequency	0–7	Number of flight connections between two economies per week.
Shipping connection	0;1	Unity if at least one ship travelled from the economy of origin to the economy of destination in 2013, zero otherwise.
Shipping frequency	Number of ships	Total number of ships that travelled from origin to destination in 2013.

Source: Author.