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A Gravity Model of Barriers to Trade in New Zealand

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A Gravity Model of Barriers to Trade in New Zealand

Murat Genç and David Law

New Zealand Treasury Working Paper 14/05



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A Gravity Model of Barriers to Trade in New Zealand

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Abstract

There are many costs associated with international trade. These costs act as barriers to trade and affect the level of trade. This paper first provides a brief discussion of the state-of-the-art methods used to measure trade costs and to quantify their impact on trade. It then empirically investigates the role of a range of barriers to New Zealand's trade within the framework of a gravity model of trade. The analysis covers New Zealand's trade with around 200 trade partners over the years 2001 to 2006, and includes tariffs and a number of non-trade policy factors such as property rights, financial market sophistication, corruption, and a range of measures related to infrastructure quality. The empirical evidence both in the literature and in this study highlights the growing importance of non-policy induced barriers to trade.

JEL CLASSIFICATION F00 – International Economic - General
F10 – Trade - General
F14 – Country and Industry Studies of Trade

KEYWORDS Trade Barriers; International Trade; Panel Data; New Zealand

Executive Summary

There are many costs associated with international trade. These include transportation costs, local distribution costs, costs associated with the use of different currencies, legal and regulatory costs, information costs, contract enforcement costs, tariffs and para-tariffs, costs that arise because of the non-tariff measures imposed by trade policies, and transactions costs. These costs act as barriers to trade and affect the level of trade. It is therefore important to identify and measure the different components of trade costs, and determine their impact on the level of trade.

This paper provides a discussion of the state-of-the-art methods used to measure trade costs and to quantify their impact on trade. It also reviews the recent empirical studies that have investigated the effects of various trade barriers on trade flows. The studies reviewed highlight the importance of transactions costs and present empirical evidence on the trade-facilitating effects of improvements in infrastructure quality and institutional quality of the environment. Overall, the findings are consistent with Anderson and van Wincoop's observation in 2004 that most of the costs attributed to trade barriers are not due to policy-induced barriers. The impact of non-policy induced tangible barriers on the volume of trade is often found to be higher than the impact of tariffs and policy-related non-tariff measures.

Although Winchester (2009) estimates tariff equivalents of policy-related non-tariff measures, and Bryant *et al.* (2004) and Law *et al.* (2009) consider the effect of migration, there exists no other study that investigates the role of non-policy induced barriers in New Zealand's trade. An empirical application that does examine the role of such factors is therefore an important focus of this paper.

The analysis covers New Zealand's trade with around 220 trade partners over the years 2001 to 2006. A gravity model of trade that takes particular care to avoid any selection bias that may result from zero trade between countries is used. Of particular interest, the model includes tariffs and a number of non-trade policy factors such as property rights, financial market sophistication, corruption, and a range of measures related to infrastructure quality.

Tariffs are found to have a negative effect on New Zealand's exports with an elasticity of -0.2. As found in the studies reviewed, stronger property rights, financial market sophistication and better infrastructure in our trade partners are all found to be associated with higher exports from New Zealand to those countries. Consistent with the findings in the literature, the estimated elasticities of exports with respect to these factors are much larger than the elasticity with respect to tariffs.

When infrastructure is divided into its various components, it is found that port and air transport efficiency is much more important, also consistent with the findings in the literature. Similarly higher levels of corruption and more burdensome customs procedures in our trade partners are associated with lower exports from New Zealand to those countries.

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A Gravity Model of Barriers to Trade in New Zealand

1 Introduction

The costs of trade, using the very broad definition in Anderson and van Wincoop (2004), i.e., all costs of getting a good to a final user other than the marginal cost of producing the good itself, can be very high.¹ This broad definition of trade costs includes transportation costs (both freight and time costs), policy barriers (tariffs and nontariff barriers), information costs, contract enforcement costs, costs associated with the use of different currencies, legal and regulatory costs, and local distribution costs (wholesale and retail). Anderson and van Wincoop (2004) also highlight that trade costs are highly variable across both goods and countries.

The purpose of this paper is to examine the impact of a variety of trade costs on New Zealand's trade levels. Similar studies are reviewed in detail in Appendix 2. These studies highlight the importance of transactions costs and present empirical evidence on the trade-facilitating effects of improvements in infrastructure quality and institutional quality of the environment. Overall, the findings are consistent with Anderson and van Wincoop's observation in 2004 that most of the costs attributed to trade barriers are not due to policy-induced barriers. The impact of non-policy induced tangible barriers on the volume of trade is often found to be higher than the impact of tariffs and policy-related non-tariff measures.

A large majority of the empirical studies reviewed use various specifications of gravity models to determine the impacts on volume of trade of tariffs, non-tariff measures, and non-trade-policy related factors, often using only a subset of these factors in the study. Fifteen, which is about one third, of the studies include tariffs in their specification. The elasticity of volume of trade with respect to tariffs is found to range between 0.01 and 1.7 (in absolute value) with the coefficient on the tariff variable at times statistically insignificant. This is consistent with the observation that tariffs have drastically reduced over the last decades, and justifies the importance given to other trade barriers in the recent literature.

¹ Anderson and van Wincoop (2004) estimate that trade costs for industrialized countries, on average, are equal to an ad-valorem equivalent of 170%. This 170-percent is broken down into 55-percent local distribution costs and 74-percent international trade costs. The 74-percent international trade costs is further broken down as 21-percent transportation costs and 44-percent border-related trade barriers. The authors also provide a rough breakdown of the 44-percent border-related barriers: an 8-percent policy barrier (including nontariff barriers), a 7-percent language barrier, a 14-percent currency barrier (from the use of different currencies), a 6-percent information cost barrier, and a 3-percent security barrier.

Slightly more than half of these studies also include non-tariff measures, in addition to tariffs, in their specification. Half of these specifically deal with sanitary and phytosanitary (SPS) and technical barriers to trade (TBT). Disdier *et al.* (2008) find that SPS and TBTs do not significantly affect bilateral trade between OECD countries, but significantly reduce exports of developing and least developed countries to OECD countries. The other studies detect no strong tendency regarding the effects of SPS and TBTs. The results from studies that include non-tariff measures as a whole group are mixed. Helble *et al.* (2009) find that the effect of non-tariff measures (NTM) is not statistically significant. However, Hoekman and Nicita (2011) find that the elasticity of trade with respect to non-tariff measures is -0.15, slightly less than the elasticity with respect to tariffs. Olper and Raimondi (2008) find that an average NTM reduces trade by about twice as much as do tariffs in their analysis of food trade. A common result in these studies is that the effects of behind-the-border factors (information-related costs and cultural distance in Olper and Raimondi (2008), importer transparency in Helble *et al.* (2009), and logistics and trade facilitation performance in Hoekman and Nicita (2011)) are much larger.

The majority of the studies focus on the impact of the behind-the-border factors that are not related to trade policies. These factors include quality of transport logistics, quality of the regularity environment, quality of customs environment, corruption, infrastructure of information technology, cultural distance, quality of institutions, and informational barriers. Although the measurement of these factors varies across studies, the conclusions do not. They all find that these factors are important determinants of trade flows and their impact is often more substantial than the impact of tariffs and other trade policy related measures. Port efficiency in particular is found to have a substantial impact on trade flows.

The analysis in this paper covers New Zealand's trade with around 220 trade partners over the years 2001 to 2006. A gravity model of trade that takes particular care to avoid any selection bias that may result from zero trade between countries is used. Of particular interest, the model includes tariffs and a number of non-trade policy factors such as property rights, financial market sophistication, corruption, and a range of measures related to infrastructure quality.

Tariffs are found to have a negative effect on New Zealand's exports with an elasticity of -0.2. As found in the studies reviewed, stronger property rights, financial market sophistication and better infrastructure in our trade partners are all found to be associated with higher exports from New Zealand to those countries. Consistent with the findings in the literature, the estimated elasticities of exports with respect to these factors are much larger than the elasticity with respect to tariffs.

The remainder of this paper is organized as follows. Sections 2 to 4 provide a discussion of the methods available for use in the measurement of various trade costs, including transport costs, those related to trade control measures and costs incurred behind the border. Section 5 describes the standard approach employed in the literature to examine the impact of trade costs on a countries level of trade, the gravity model of trade. This approach is applied to the case of New Zealand's merchandise trade as well as a specific example of services trade (tourism) in Section 6. The final section concludes.

2 Transport Costs

Conceptually, transport costs are the simplest to measure as they only include freight charges when defined narrowly. Such direct transport costs also include insurance, which is typically added to the freight charge. There are also indirect transport costs which include holding cost for goods in transit, inventory cost due to variability of delivery dates, preparation costs associated with shipment size, time spent in transit, and the like. Such indirect costs need to be inferred.²

The most direct source for transport costs is industry or shipping firm information. However, this sort of data is extremely difficult to find since only a few countries report detailed information on shipping costs as part of their trade statistics.³ An alternative (indirect) measure is based on the gap between free-on-board (fob) values in the exporting country and values in the importing country that include cost, insurance and freight (cif). Comparing the valuation of the same flow reported by both the exporter and importer provides an economically meaningful measure of transport costs. Dividing the cif value by the fob value yields an ad-valorem estimate of bilateral transport costs. IMF Direction of Trade Statistics (DOTS) is a comprehensive source of matched partner cif/fob ratios, and several studies have used them to assess the effect of transportation costs on trade. However, Hummels and Lugovskyy (2006) show that matched partner cif/fob ratios from IMF and UN data are badly overridden in levels, and argue that they contain no useful information for time-series or cross-commodity variation. This has considerably limited the use of cif/fob ratios. However, as argued by Pomfret and Sourdin (2010), some national agencies now collect consistent data on fob and cif values at disaggregated levels, making the cif/fob ratios operationally useful.

² Djankov *et al.* (2010), for example, infer the costs associated with time delays in completing the shipment by estimating a difference gravity equation and find that each additional day that a product is delayed prior to being shipped reduces trade by more than 1%. Using U.S. import data, Hummels (2001) imputes a willingness-to-pay for time savings equal to 0.8% ad-valorem per day spent in transport for manufactured goods, implying that an average length ocean voyage of 20 is equivalent to a 16% tariff. Korinek and Sourdin (2009) find that an extra day spent at sea on an average sea voyage of 20 days implies a 4.5% drop in trade in agricultural products between a pair of trading countries. (Though their new results in the published version, Korinek and Sourdin (2010), suggest a slightly lower impact.) Nordås (2006) finds that time for exports is an important determinant of whether or not an exporter will enter a particular market and time is also important for trade volumes, particularly in the electronics sector.

³ Hummels and Lugovskyy (2006) state that they have only been able to identify lengthy time series on shipping for the imports of the US and New Zealand.

3 Costs Related to Trade Control Measures

There are many trade control measures that are dictated by trade policies of the countries. These measures are typically classified as tariffs (and quotas), para-tariffs (these include customs surcharges such as import license fees, foreign exchange taxes, stamps, etc.), and non-tariff measures. Although costs related to tariffs and para-tariffs can be measured directly, non-tariff measure related costs must be measured indirectly, by inference based on either quantities or prices.

3.1 Tariffs and Para-Tariffs

Tariffs and para-tariffs are usually reported in ad valorem terms, as a simple percentage of the value of the imported product. However, many countries have schedules that contain tariffs specified in non-ad valorem terms.⁴ The main types of non-ad valorem tariffs are specific tariffs (fixed monetary value per unit), compound tariffs (a combination of ad valorem and specific tariffs), mixed tariffs (a choice between ad valorem and/or specific tariffs), and technical tariffs (rate dependent on the input content such as sugar or alcohol). The existence of such tariffs may make it difficult to arrive at a meaningful picture of the level of tariffs.⁵

Even when ad valorem tariffs (or ad-valorem equivalents (AVEs) of non-ad valorem tariffs) are known for individual goods one faces the important problem of how to aggregate the large number of tariffs. There are often thousands of tariff lines in a typical tariff schedule of a country. It is common to use atheoretic indices such as arithmetic or trade-weighted average tariffs, as is done in the UNCTAD Handbook of Statistics for example. Anderson and Neary (2003) highlight the problems with such averages and develop a theoretically grounded index which they call the Mercantilist Trade Restrictiveness Index (MTRI). The MTRI is defined as the uniform tariff that yields the same volume of imports as a given tariff structure for comparisons of an arbitrary tariff structure with free trade. In a more general context when two different tariff structures are compared, the MTRI is defined as the uniform deflator which, applied to the new set of distorted prices, yields the same trade volume as the initial tariffs (Anderson and Neary (2003), p. 646.)⁶

Kee *et al.* (2009) make Anderson and Neary's conceptual contribution operational by providing an empirical implementation of their MTRI. They rename the MTRI as the Overall Trade Restrictiveness Index (OTRI), and introduce the Market Access OTRI (MA-OTRI) as the mirror image (from the exporter's perspective) of OTRI. The OTRI summarises the impact of each country's trade policies on its aggregate imports. (As will be discussed later, these indices also incorporate the non-tariff measures.) They state that OTRI answers the question: what is the uniform tariff that if imposed on home imports instead of the existing structure of protection would leave aggregate imports on their current level? The MA-OTRI, on the other hand, summarises the impact of other countries' trade policies on each country's exports, and answers the question: what is the

⁴ For example, 0.1% of 7,288 tariff lines for New Zealand had non-ad valorem tariffs in 2009, which came down from 2.7% in 2002 (Table III.1 in WTO (2009)).

⁵ See Stawowy (2001) and WTO (2003) for a discussion of possible methods to calculate ad valorem equivalents of non-ad valorem tariffs.

⁶ Although Anderson and Neary's contribution is conceptual, they provide a sample application using Computable General Equilibrium (CGE) models. One of their findings is that the trade-weighted average tariff for New Zealand in 1988 is 7.9% whereas the MTRI uniform tariff is 9.1%, based on the comparison of the actual tariff structure with free trade. The corresponding figures for Australia for the same year are 10.8% and 11.6%.

uniform tariff that if imposed by all trading partners on exports of country c instead of their current structure of protection would leave exports of country c at their current level.

The operational definitions of these indices in a partial equilibrium setting are given in Kee *et al.* as follows:

$$OTRI_c = \frac{\sum_n m_{n,c} \varepsilon_{n,c} T_{n,c}}{\sum_n m_{n,c} T_{n,c}} \quad (1)$$

where $m_{n,c}$ is the import value of good n in country c evaluated at world prices, which are all normalized to unity so that imported quantities equal $m_{n,c}$, $\varepsilon_{n,c}$ is the import demand elasticity, and $T_{n,c}$ is the overall level of protection that country c imposes on imports of good n , which at this stage is just the tariff applied but can also include ad-valorem equivalents of non-tariff measures when non-tariff measures are also being considered. As pointed out by Coughlin (2010), the index is the weighted sum of the protection levels, where the weights are the elasticity of import demand and imports.

The MA-OTRI is defined as

$$MA - OTRI_c = \frac{\sum_p \sum_n m_{n,c,p} \varepsilon_{n,p} T_{n,c,p}}{\sum_p \sum_n m_{n,c,p} \varepsilon_{n,p}} \quad (2)$$

where the subscript p refers to the trading partners of country c . The index is the weighted sum of protection levels in other countries, where the weights are the elasticities of demand in other countries and their imports from country c .

Kee, Nicita, and Olarreaga produce estimates for 78 countries of these indices by using tariff data between 2000 and 2004. They find that OTRI is 0.028 and MA-OTRI 0.063 for New Zealand based on tariffs (in 2001) only. Using their numbers Coughlin (2010) ranks the 78 countries from least restrictive countries to most restrictive. New Zealand comes as the 29th (equal) least restrictive country based on OTRI, and 73rd based on MA-OTRI when non-tariff measures are also included in calculating the indices. World Bank has been publishing these indices in their World Trade Indicators since 2006. The OTRI for New Zealand is 12.3% and MA-OTRI is 26.7 (as period averages for 2005-2008, including non-tariff measures) in the latest edition, WTI 2009/10.

3.2 Non-Tariff Measures

Non-tariff measures (NTMs) include many instruments such as antidumping and countervailing duties, standards, licensing requirements, and embargoes and prohibitions.⁷ There have been various definitions of NTMs in the literature, and there is no agreed definition as to what constitutes an NTM (Bora (2005)). Consequently, there is no agreed taxonomy of them either. Anderson and van Wincoop (2004) refer to John Haveman's grouping of hard barriers (price and quantity measures), threat measures (antidumping and countervailing duty investigations and measures), quality measures (standards, licensing requirements, etc.), and embargoes and prohibitions as customary. Deardorff and Stern (1997) classify NTMs into five groups: quantitative restrictions

⁷ The term "barrier" has traditionally been used in the academic literature. UNCTAD uses the term "measure" now, based on the rationale that "measures" encompasses all trade policy instruments, even though their restrictiveness or effects, if any, may vary between countries applying them (Bora *et al.* (2002)). The tendency in the literature these days is to use "measure" to underline that a measure may not be welfare-or-trade-reducing. This change in terminology is consistent with the fact that most measures are not quantitative restrictions anymore. This is also emphasized by Carrère and Melo (2011a).

(quotas, prohibitions, licensing, foreign exchange controls, etc.), non-tariff charges and related policies affecting imports (variable levies, antidumping and countervailing duties, border tax adjustments, etc.), government participation (subsidies, government procurement procedures, government monopolies, macroeconomic policies, etc.), customs procedures and administrative practices, and technical barriers to trade (health and sanitary regulations, safety and industrial standards and regulations, etc.). UNCTAD currently uses a classification with six categories: price control measures, finance measures, automatic licensing measures, quantity control measures, monopolistic measures, and technical measures.⁸ UNCTAD is about to adopt the following definition of NTMs: *Non-tariff measures (NTMs) are policy measures, other than ordinary customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both.* (p. xvi, UNCTAD 2010.) This effectively defines NTMs by what they are not, that is, all measures except tariffs.

Measurement of non-tariff measures is both much more problematic and more important than the measurement of tariff measures. It is more important because of the steady decline of tariff rates following the eight GATT rounds of multilateral trade negotiations. Non-tariff measures are rapidly gaining importance and have almost replaced tariff barriers in manufacturing sectors (UNCTAD 2010). It is more difficult because they are not published in tariff schedules and are not expressed as percentages or monetary values. The data typically record just the presence or absence of them. Furthermore, there are so many measures and instruments that can be applied. For example, UNCTAD Trade Control Measures Coding System identifies 112 instruments under its current six categories. In 2004, UNCTAD's TRAINS database censused on average 5620 tariff lines being subject to one type of NTM in each country (Fugazza and Maur (2008)). Even when all the effective NTMs and their characteristics are identified it is very difficult to compare and aggregate them to obtain an overall measure of trade interference (Das (2003)).

Deardorff and Stern (1997) classify various general methods that have been used for measuring NTMs as follows: frequency-type measures based on inventory listings of observed NTMs; price-comparison measures calculated in terms of tariff equivalents or price relatives; quantity-impact measures based on econometric estimates of models of trade flows; and measures of equivalent nominal rates of assistance. Ferrantino (2006) also includes simulation methods in his classification, and makes a distinction between the price gap method and price-based econometric methods. Cipollina and Salvatica (2008) introduce a more general classification as follows: incidence measures, outcome measures, and equivalence measures. Incidence measures are based on the intensities of policies themselves, and they measure the level of protection without considering the rate at which it is translated into market (economy) specific trade distortion. Outcome measures are based on both policy variables and weights (such as trade share), allowing some economic effects of existing NTMs to be taken into account. Equivalence measures evaluate how far actual observations are from other hypothetical equilibria, and they require explicit structures and/or estimated parameters for computation.

The most common methods are price-comparison and quantity-impact measures. Both of these methods are based on counterfactuals – representations of how economic outcomes would differ if the NTMs were not in place. If the good is homogeneous, the counterfactual can be obtained by observing the price of that good in some other market

⁸ However, these categories and sub-categories are about to change. The number of categories will increase to 13 with a substantial number of new categories on sanitary and phytosanitary (SPS) and technical barriers to trade (TBT). See Annex 2 in UNCTAD (2010) for details.

where the NTMs do not apply. This typically involves price comparisons between domestic and foreign markets, and sometimes price comparisons of similar goods within a domestic market. If no similar good can be found, then the counterfactual cannot be observed and it needs to be constructed. Econometric methods can be used to estimate the counterfactuals. This is typically done by estimating counterfactual quantities with a gravity model, though there are cases where prices are estimated as well.⁹

3.2.1 Frequency-type Measures

These measures are based on compiled inventories (such as UN Conference on Trade and Development's (UNCTAD) Trade Analysis and Information System (TRAINS)) or surveys to construct indices based on the frequency of occurrence of non-tariff measures.¹⁰ There are a number of measures that can be used.

Frequency Ratio

This is the simplest frequency measure. It is defined as just the number of product categories subject to NTMs as a proportion of the total number of product categories. It can be calculated for a specific or a group of NTMs or instruments. It can also be constructed for specific sectors, commodities, or for all tariff lines listed in the inventory. If calculated for sector/commodity i , it is obtained as follows:

$$F_i = \frac{T_i}{T} \cdot 100 \quad (3)$$

where T is total number of tariff lines belonging to sector/commodity i and T_i is the total number of tariff lines subject to the NTMS for which the index is calculated.¹¹

Frequency Index

The frequency ratio considers NTMs that are intended to be applied regardless of whether they have actually been applied. Thus, it can be replaced with a measure that looks at the percentage of categories that have actually been subjected to NTMs. This is called the frequency index. It is defined as

$$FI = \frac{\sum_k D_k \cdot I_k}{\sum_k I_k} \cdot 100 \quad (4)$$

⁹ This summary is presented in Dee *et al.* (2008).

¹⁰ Although TRAINS is the most comprehensive available data set, all the information in it is obtained through government agencies. Independent business surveys and reports issued by countries (based on complaints received) are alternative sources of information on non-tariff measures. Fliess (2005) reports and compares the results from a set of 23 surveys one of which is a New Zealand survey with the title "Assessing the Presence and Impact of Non-Tariff Trade Barriers on Exporters," produced by AcNielsen on behalf of Standards New Zealand (SNZ) in partnership with various Ministries of New Zealand. Carrère and Melo (2011b) describe all the main data bases that currently exist.

¹¹ The latest published frequency ratio for New Zealand is 36.5%, using all tariff lines and all NTMs. (International Trade Statistics (ITS) 2010, WTO.) Anderson and van Wincoop (2004) have calculated it as 39.1% using 1999 data. They find it to be 0% if they only include price and quantity control measures and quality control measures. Ando (2005) reports detailed unweighted frequency ratios for APEC countries by using 13 different groups of NTMs based on UNCTAD 2001 data, with a break-down into 6 sectors. Without the break-down into sectors, they report that of the 7246 tariff lines New Zealand had in 1999 1.09% contained price control measures, 19.35% contained quantity control measures, and 23.46% contained technical measures.

Where D_k is a dummy variable that takes the value of one if NTMs are applied to the tariff line item k and zero otherwise; I_k is a dummy variable that indicates whether good k has been imported (Bora *et al.* (2002) and Cipollina and Salvatica (2008)).

Both the frequency ratio and the import coverage ratio are incidence measures; they do not provide any information about the size of distortion the NTMs might have caused in trade. They do not take into account the different importance of the NTMs across sectors and commodities. One sector may have many products that are subject to minor NTMs. Another sector may have just a few products with very restrictive NTMs. If F or FI is calculated on a sector basis, then the first sector would have a much higher NTM incidence ratio even though the second sector would be expected to have much more restrictive NTMs. This ‘aggregation’ problem is handled by using weights to obtain what is known as the import coverage ratio, which is an outcome measure.

Import Coverage Ratio

If the dummy variable I_k in equation (4) is replaced with the value of imports of item k , the resulting index is a trade-weighted coverage ratio called the import coverage ratio:

$$C = \frac{\sum_k D_k \cdot V_k}{\sum_k V_k} \cdot 100 \quad (5)$$

where V_k is the value of imports of item k .¹²

Although less crude, the import coverage ratio suffers from the endogeneity of the weights. If, for example, a non-tariff measure is so restrictive that it precludes all imports of an item, the weight will be zero and the import coverage ratio will be downward biased.¹³

IMF’s NTB Index

The IMF uses an index as part of their Trade Restrictiveness Index (TRI) that consists of a three-point scale depending on the extent of a country’s usage of NTMs such as import/export quotas, restrictive licensing requirements, import/export bans, state trading, or exchange restrictions (Krishna (2009)). The index is assigned a value of 1 if the coverage of NTMs in trade or production is less than 1 percent, 2 if the coverage of NTMs is 1-25 percent, and 3 if the coverage of NTMs is greater than 25 percent.

An obvious limitation of this index is the insufficient differentiation of intensity between the ratings. The use of only three broad categories allows for a ‘lumping effect’ due to the fact that countries with significantly different non-tariff policies are grouped together. Both a country with only three minor barriers covering 5% of trade and a country with up to 25% of trade affected will have the same rating (Cipollina and Salvatici (2008)).

The main drawback of frequency-type measures is that they do not indicate anything about the economic significance of the existing NTMs. Despite their weaknesses, they provide some indication of the pervasiveness of NTMs, and can be used in econometric studies of trade flows.¹⁴

¹² Anderson and van Wincoop (2004) have calculated this as 47.9% for New Zealand, using 1999 data as in the previous footnote. They find it to be 0.4% if they only include price and quantity control measures and quality control measures.

¹³ See Bora (2005) and Bora *et al.* (2002) for more about this and related issues.

¹⁴ See Disdier *et al.* (2008) for a relatively recent study that uses the frequency ratio in a gravity model. Ando (2005) uses frequency-type measures to estimate price differentials as a function of them.

3.2.2 Price-comparison Measures

It is often desirable to convert NTMs to equivalent tariff measures. The tariff equivalent of a non-tariff measure is the amount of tariff that would be equivalent to the effect on trade of the presence of that measure. Because a measure can affect trade in two ways, affecting the quantity traded or the price, or both, tariff equivalents are estimated by considering either price differentials or quantity differentials that arise due to NTMs. Assuming the measure acts as a barrier (so that it raises the price of the imported good or reduces the quantity imported), the price-based method, also known as the price-wedge method, only requires to determine the price gap caused by the measure and express it as a percentage difference.¹⁵ The tariff equivalent, TE , for an imported commodity i that is subject to a non-tariff measure can therefore be expressed as

$$TE_i = 100 \cdot \frac{P_i^{NTM} - P_i}{P_i}, \quad (6)$$

where P_i^{NTM} is the price of commodity i in the presence of the non-tariff measure, and P_i is the price that would prevail in the absence of it, assuming the price paid to the suppliers remains unchanged. Simple as this seems there are difficulties with calculations. The main challenge is that P_i is not observable, it is a counterfactual price. It is most common to use either the cif import price at the port of entry or the “world” price. The world price is usually either the retail price of the same good in foreign exporting country or the lowest retail price among all exporting countries of the good.¹⁶ Another challenge is that prices of imported goods may increase everywhere along the supply chain, and some of these price increases would take place even in the absence of NTMs (Ferrantino (2006)). The factors that increase the price include shipping and handling costs, tariffs and other taxes. All such factors need to be removed from the price gap in order for the gap to be attributed to the non-tariff measure.¹⁷

The price-wedge method has several drawbacks, both conceptual and data-related. There are often many NTMs that coexist. This presents problems when the interest is in a particular non-tariff measure, since it is very difficult, if not impossible, to separate out the effect of different measures by simply comparing prices. Also, the domestic price can exist only if a commodity is imported. There is no price observed if there are NTMs so prohibitive that some commodities are not actually imported as a result of them. When trade flows do not exist, estimation of the tariff equivalents is a challenging task because no reference imports exist and because part of the tariff equivalent will be redundant when the policy is strictly prohibitive (Yue and Beghin (2009)). Another major limitation of the method is that any measurement error in margins or transport costs translates directly into error in calculated tariff equivalents. It is also very hard to distinguish the impact of known NTMs from other forces that contribute to the price gap. In addition, without standard errors, there is no way to judge the significance of NTMs in explaining the price gap (Dean *et al.* (2009)).

Anderson and van Wincoop (2004) point out that a large important component of trade costs is often borne by the exporter and then shifted to the importer. Thus, the price gap does not capture this portion of the full cost. The price-wedge method may falsely attribute these trading costs to NTMs. Another issue arises when the tariff equivalent is

¹⁵ Ferrantino (2006) calls this the ‘handicraft’ price gap method to differentiate it from price-based econometric models which are discussed in the next section.

¹⁶ Deardorff and Stern (1997) provide various formulae for specific non-tariff measures.

¹⁷ Ferrantino (2006) provides some formulae that can be used for breaking down various markups in the supply chain.

calculated for a group of commodities or for sectors. Typically it is assumed that domestic and foreign goods are perfect substitutes so that a world price can be constructed.¹⁸ The validity of this assumption is questionable, particularly when there are quality differences. Using the correct exchange rate can also be an issue when the import or world price is denominated in another currency depending upon the timing of the calculations.

Finding adequate price measures is often a challenge due to the lack of availability of price data. It is common to use unit values (ratio of the value and the quantity recorded in databases) as price measures, since unit values can easily be obtained for many products and countries.¹⁹ However, unit values can be notoriously inexact measures of prices at high levels of aggregation because of large quality differences in products (Bradford (2003)). Bradford (2003, 2005) demonstrates the considerable amount of effort required to obtain the price measures. Bradford (2003) uses the 1993 survey of highly disaggregate price data for over 100 traded goods compiled by the OECD to compute purchasing power parity adjusted exchange rates.²⁰ Because the prices in the data set are consumer prices rather than producer prices, he first converts them to producer prices by using data on distribution margins (wholesale trade, retail trade, and transportation costs) after matching the margins data with OECD retail price data. (The margin data were available for eight countries, and came from national input-output tables.) He then uses data on export margins and international transport costs (based on cif/fob ratios reported by Australia and the United States) to compute world prices (export price) for each product. He is then able to calculate the ratio of each country's producer price to the world price for each commodity as a measure of NTMs.

The price-wedge method is usually used in a single importing country because of its data requirements (data on prices, transport and handling costs, tariffs, tax and subsidies, etc.). Tariff equivalent estimates for multiple products across many countries can be obtained by price-based econometric models.

Price-based Econometric Methods

The price-wedge method is based on comparing the levels of prices. The difference between domestic prices and world prices is attributed to non-tariff barriers once transport, tariffs and other taxes are accounted for. In other words, the presence of NTMs is inferred from unexplained price gaps. A different methodological approach is to directly estimate the effects of NTMs on price gaps econometrically, conditional on information about their incidence (Dean *et al.* (2009)). These price-based regression methods exploit the so-called Balassa-Samuelson effect which explains higher real exchange rate (absolute price level) in rich countries with the higher levels of productivity in tradables relative to non-tradables. If it is possible to account for these systematic price differences between countries, then in principle some of the remaining price differences which are not otherwise accounted for may be due to NTMs (Ferrantino (2006)). The main advantage of this approach is that tariff equivalents can be estimated for multiple products across countries with a common methodology.

¹⁸ Yue *et al.* (2006) relax the homogeneous good assumption and account explicitly for perceived quality of substitutes. Their method is, however, a combination of the price-wedge approach and the gravity-equation approach.

¹⁹ For example, CEPII's Trade Unit Values Database contains Unit Value information (in US dollars per ton) over the period 2000-2008, with 173 reporters, 255 partners, and more than 5,000 product categories per year. The coverage changes over time. Unit values are provided in Harmonized System 1996 and 2002 revisions with 6 digits, Free on Board (FOB) and Cost of Insurance and Freight (CIF). The CIF unit values rely on importers' declarations, and include all trade costs (except tariffs and domestic taxes after the border). The FOB unit value is a proxy for the trade price at the factory gate, relying on exporters' declarations, and does not include trade costs. More information about this database can be found in Berthou and Emlinger (2011).

²⁰ His two studies are almost identical, one using 1993 data and the other 1999 data.

The approach is quite simple in principle. A model that explains the price gaps is developed and estimated. Ando (2005), for example, estimates the equation

$$P_i = \alpha + \sum_j F_{ji} + \varepsilon_i, \quad (7)$$

where P_i is the tariff equivalent of commodity i calculated according to equation (6) by using the cif import price and the domestic producer price of the domestic substitutes of commodity i , net of tariffs, and F_{ji} is the frequency ratio of j type of non-tariff measures for commodity i . (They also estimate versions of this base-case regression equation to control for income levels by adding GDP per capita or a developing economy dummy.) Estimating the equation for different types of NTMs allows her to obtain individual estimates of tariff equivalents for different types of measures. She estimates the regression equation for 21 commodities in 13 APEC countries.

Yue *et al.* (2006) extend the basic price-wedge method by using a CES utility function for consumers' preferences to relax the homogeneous good assumption. The model yields the following expression for the tariff equivalent (TE) of a NTM

$$TE = p_d \frac{1-\alpha}{\alpha} \left(\frac{Q_d}{Q_I} \right)^{1/\sigma} - p_w - IT - tariff - T, \quad (8)$$

where p_d is the price of the good produced domestically, Q_d is the quantity consumed of the domestically produced good, Q_I is the quantity consumed of the imported good, p_w is the world price (price of the exported good charged for the good exported to other importing countries) of the good, IT is the insurance and freight and other international costs, $tariff$ is the specific import tariff, T is the per-unit transportation and transaction costs from the border to the internal wholesale market in the importing country, σ is the elasticity of substitution between the domestically produced and imported good, and α is a taste parameter of the consumers' preferences.²¹ All this requires is estimates of the taste parameters α and σ , as all the other variables are either observed or can be constructed. If these taste parameters are not already available (there may be available estimates), then they can be estimated based on the assumed utility function for the consumers in the importing country. The CES utility function they use gives the following equation to estimate the taste parameters:

$$\ln \left(\frac{M}{p_d Q_d} - 1 \right) = \left(1 - \frac{1}{\sigma} \right) \ln \frac{1}{Q_I} + \ln \frac{1-\alpha}{\alpha}, \quad (9)$$

where M is the total expenditure on the commodity (including domestically produced and imported) evaluated at wholesale price. Note that the left-hand term is just the ratio of expenditure shares.

Dean *et al.* (2009) examine the price gaps using city-level retail price data and directly estimate the average impact of core NTMs (such as import quotas, prohibitions, import licenses, and VERs) on prices of 47 consumer products (grouped into four separate sectors) for more than 60 countries in 2001. They estimate the equation

$$P_{ij} = \beta_0 + \beta_1 gdp_{pc} + \beta_2 wage_j + \beta_3 rent_j + \beta_4 dist_j + \beta_5 tariff_{ij} + \beta_6 NTM_j + \beta_7 (tariff_{ij} \cdot NTM_j) + \beta_8 (NTM_j \cdot gdp_{pc}) + \varepsilon_{ij}, \quad (10)$$

²¹ It is easy to see that this collapses to the standard price-wedge expression when goods are homogenous. (For example, let $\alpha = \sigma$ and choose $\sigma = \frac{1}{\alpha}$.) Different preferences will lead to slightly different specifications of equation (8). They provide the expression that will be obtained for the linear-expenditure system in their paper.

where P_{ij} is the price of commodity i in city j , $gdppc$ is the GDP per capita of the country city j is in, $wage_j$ is maid's hourly wage in city j (as a proxy for city-level nontraded service wages), $rent_j$ is the rental on a one-bedroom furnished apartment in city j , $dist_j$ is the export-share weighted sum of the great circle distance from city j to all other cities in the sample (as a proxy of transport costs), $tariff_{ij}$ is the specific tariff on good i in city j , NTM_j is a dummy if the database indicates the presence of an NTM in city j . All variables except NTM dummy are measured in logs. GDP per capita is included to capture the Balassa-Samuelson effect. Maid's hourly wage and rent of apartments are included to capture mark-ups for local distribution costs. The interaction variables allow the effect of NTMs to vary with tariffs and incomes. Once the model is estimated, the coefficients of the NTM variables give the impact of non-tariff measures on prices, having controlled for other factors that may affect prices.²²

Kee *et al.* (2009) obtain the ad valorem equivalents of NTMs by first estimating the quantity-impact of NTMs on imports and then transforming the quantity-impacts into price effects, using the import demand elasticities in Kee *et al.* (2008). So, their method is a combination of price-based and quantity-based econometric methods. They estimate the equation (which is based on a general equilibrium model with log-linear utilities and log-linear constant returns to scale technologies)

$$\ln m_{nc} - \varepsilon_{nc} \ln(1 + t_{nc}) = \alpha_0 + \sum_k \alpha_{nk} C_c^k + \left(-e^{\beta_n^{NTM} + \sum_k \beta_{nk}^{NTM} C_c^k} \right) NTM_{nc} + \left(-e^{\beta_n^{DS} + \sum_k \beta_{nk}^{DS} C_c^k} \right) \ln DS_{nc} + \kappa_{nc}, \quad (11)$$

where m_{nc} is the import value of good n in country c evaluated at exogenous world prices (which are all normalised to unity so that imported quantities equal m_{nc}), α_n are tariff line dummies that capture any good-specific effect; C_c^k are k variables that provide country characteristics (relative factor endowments in the form of labour force/GDP, capital/GDP, agricultural land/GDP, and GDP to capture economic size, a dummy for islands, and the import-weighted distance to each trading partner); NTM_{nc} is a dummy variable indicating the presence of a core NTM (price control measures, quantity restrictions, monopolistic measures, and technical regulations); $\ln DS_{nc}$ is the log of agricultural domestic support, which is continuous and measured in dollars; t_{nc} is the ad valorem tariff on good n in country c ; ε_{nc} is the import demand elasticity.

The model allows for both tariffs and NTMs to affect trade with effects that vary by importing country and good. β_{nk}^{NTM} is the parameter that captures the impact that a core NTM imposed on good n in country c has on imports of good n in country c . Likewise, β_{nk}^{DS} is the parameter that captures the impact that agricultural domestic support granted to good good n in country c has on imports of good n in country c . They use the import demand elasticities that have been estimated in Kee *et al.* (2008).

²² They treat the NTM variable as endogenous and use an instrumental variable approach in the estimation. Drawing on the estimated parameters, they derive country-specific estimates of the average effect of NTMs on prices by sector. According to their results, core NTMs have a 59.9%, 62%, and 37.6% premia for fruit and vegetables, bovine meat, and processed foods, respectively, in New Zealand in 2001.

They estimate the model using non-linear least squares and use the following equations to obtain the ad valorem equivalents of core NTMs and agricultural domestic support imposed on goods^{23, 24}:

$$ave_{nc}^{NTM} = \frac{e^{\beta_{nc}^{NTM}} - 1}{\varepsilon_{nc}} \quad \text{and} \quad ave_{nc}^{DS} = \frac{\beta_{nc}^{DS}}{\varepsilon_{nc}}.$$

Although Kee *et al.* econometrically estimate the AVEs of NTMs, they don't actually use price data, but the end result is the percentage price differentials caused by the presence of NTMs. They recover the AVEs of NTMs indirectly by using price elasticities of import demand that are generated separately. Naturally, these indirect estimates are dependent upon the ability of their specification in (9) to explain trade flows, as well as the reliability of the separate elasticity estimates (Dean *et al.* (2009)).

3.2.3 Quantity-impact Measures

Quantity-impact measures are based on econometric estimates of the models of trade flows, which are almost exclusively gravity models. These measures focus on changes in the volume of trade caused by various NTMs.

Most gravity models are variants of the following basic form

$$\ln x_{ij} = \alpha_1 \ln y_i + \alpha_2 \ln y_j + \alpha_3 \ln D_{ij} + \sum_{m=1}^M \beta_m Z_{ij}^m + \varepsilon_{ij} \quad (12)$$

where x_{ij} is the volume of exports (or imports, or total trade) from i to j , y_i and y_j are the GDP (or GNP) of the exporter and importer, D_{ij} is a measure of the distance between i and j (as a proxy for transport costs), and z_{ij}^m ($m=1, \dots, M$) is a set of variables that enhance or impede trade.

If non-tariff measures are identifiable in terms of summary measures (such as frequency ratio) or their presence is known, it is possible to capture them in the equation above. Their impact on trade can then be determined in the usual fashion depending upon how the variable signifying the NTM has entered the specification. If, for example, the non-tariff measure has been captured by just a dummy variable that shows its presence, then its impact on the volume of trade can be obtained as the percentage change in x_{ij} :

$\% \Delta x_{ij} = 100 \cdot (e^{\beta_n} - 1)$, where β_n is the coefficient of the dummy variable. If on the other hand a summary measure such as frequency index or import coverage ratio has been used, then the impact can be obtained as an elasticity or semi-elasticity depending

²³ They run a regression for each HS six-digit category where at least one country in UNCTAD's TRAINS database imposes either a core NTM or domestic support. That's 4,575 regressions in total! Their findings are as follows. The simple average ad valorem equivalent in the entire sample for core NTMs is 12%; it is 10% when import-weighted. If averages are calculated only over tariff lines affected by core NTMs, the numbers are much higher: 45% and 32%, respectively. The simple and import-weighted averages of AVEs of agricultural domestic support are much smaller (generally below 1%) but that just reflects that a very small number of products are affected by domestic support in most countries. If the average is calculated only over those products affected by domestic support, the sample average is 48% and the import-weighted average is 21%. Not all NTMs are found to be binding, some AVEs have point estimates equal to zero or they are not statistically significant. When core NTMs are binding, the average in the sample is 95% with an average t-statistic of 3.16. Their results for New Zealand (based on 1999 NTMs and 2001 tariffs) are as follows. The average level of AVEs of core NTMs across all tariff lines is 14.3%. The average level of AVEs of core NTMs is 38.3% when they are calculated only over tariff lines affected by an NTM. The share of tariff lines where core NTMs are binding is 18.5%. There is, of course, no agricultural domestic support in New Zealand.

²⁴ One of their other findings is that tariffs and core NTMs are substitutes to each other once country and product fixed effects are controlled for. This supports the argument that constraints imposed by international or bilateral trade agreements on governments' ability to set tariffs may induce some countries to replace them by more restrictive NTMs (and vice-versa).

on whether the variable is logged or not. In all cases, the obtained impact can be converted to a price effect in the form of tariff equivalent if the price elasticity is known.²⁵

It is often the case that it is not possible to capture explicitly the non-tariff measures in the specification of the gravity model. There are two ways to determine the tariff equivalents of NTMs in these cases. Both methods are based on the implicit assumption that the specified gravity equation captures all trade costs other than the costs borne due to non-tariff measures. The first method treats the predicted trade flows that the gravity equation yields as the potential level of trade, and compares them with the actual trade flows. The difference between the two levels is then attributed to the existence of non-tariff barriers.²⁶ The second method is also based on a comparison. The comparison is between the international trade flows and domestic trade flows. The difference between them is attributed to the existence of national borders (hence the so-called 'border effect') which reflects the effects of non-tariff barriers that apply at the border that cannot be measured directly. Domestic trade flows are typically estimated by subtracting a country's exports from its domestic production, and the border effects are obtained from the coefficients of border dummy variables. This is a very widely used approach and further details are available in many studies, including Anderson and van Wincoop (2004).²⁷

In a relatively recent study, Yue and Beghin (2009) introduce a new way to estimate the tariff equivalent and trade effects when there is no trade flow of a commodity due to the presence of a strictly prohibitive non-tariff measure. They make explicit use of the Kuhn-Tucker conditions for corner solutions in consumption decisions in a random utility set-up, and derive a system of equations to be empirically estimated to recover preference parameters and the tariff equivalent of technical measures on prices. In the model a commodity is exported by country e to many countries, but country i imposes a ban on imports from country e . The solution to consumers' utility maximisation problem yields demand functions as functions of prices (which include transportation costs, tariffs and the tariff equivalent of the technical barrier) and a random component. This yields likelihood functions of consumption levels of the commodity in countries i , e , and other countries that depend on prices in those countries and taste parameters of the utility function. Estimation of the likelihood function gives the estimate of the tariff equivalent of the prohibitive measure. The method overcomes the lack of observed data on prices and trade flows.²⁸

3.2.4 Simulation Methods

Simulation methods provide another way of constructing counterfactuals by using a model of the economy that consists of mathematical equations consistent with economic theory and observed economic data. The model can be a partial equilibrium model, which focuses on narrowly-defined products or sectors, or a general equilibrium model that encompasses all economic activity in a country, and may or may not include linkages

²⁵ Bao and Qiu (2010) is a recent example where the frequency index and the import coverage are used in investigating the effects of technical barriers on China's trade. Cao and Johnson (2006) use dummy variables in investigating the impacts of mandatory meat hygiene regulations on the New Zealand meat trade. Disdier *et al.* (2008) use a combination of both.

²⁶ Further details can be found in a recent application of this method in Philippidis and Sanjuán (2007).

²⁷ In a recent application of this method Winchester (2009) calculates the tariff equivalents of non-tariff barriers for New Zealand, both for exports and imports. He finds that there are significant TEs on New Zealand fish, animal and dairy products exports. (For example, 579%, 177%, and 71%, respectively, for items exported to China.)

²⁸ Their application is about Australia's ban of imports of apples from New Zealand. They find that the ad valorem tariff equivalent of the ban is, on average, about 99% of the fob price inclusive of transportation costs. They also calculate the dollar value equivalent (in specific tariff form), and find that the average across the three years from 2003 to 2005 is \$0.97/kg. The trade injury caused by Australia to New Zealand is estimated to range between US\$35.11 million and US\$39.45 million over these years.

between other countries. The general equilibrium models are referred to as computable/calibrated general equilibrium (CGE) models, and they can be based on static or dynamic models. The effects of trade policies are typically studied by using multi-country CGE models. Because they capture all aspects of the economy, CGE analysis is able to determine the economic impacts of policy reforms on a much wider set of economic variables (not just exports and imports but also prices, wages, production, GDP, and so on) and also on welfare. There are many CGE models available, but the most widely used model in trade studies is the Global Trade Analysis Project (GTAP). A recently developed model, “Modeling International Relationships in Applied General Equilibrium (MIRAGE)”, is also gaining popularity.²⁹ The World Bank maintains a global CGE called the LINKAGE.

The main difference between simulation methods and the other methods is that CGE models provide a framework to examine the impact of changes in trade policy prior to implementation of the policy. The other methods rely on historical data and can only provide an ex-post analysis as opposed to an ex-ante analysis. However, certain parameters need to be fed into the model in order to calibrate the model, and when it comes to determining the effects of non-tariff measures this typically requires already calculated tariff equivalents (or similar measures), which can be obtained by any of the methods previously discussed. Once these parameters are entered the model simulates the outcomes based on which the impacts can be determined. Both price gaps and quantity gaps can be used as policy shocks. It is also possible to simulate the effects of a complete removal of NTMs. The results obtained are of course sensitive to the model, assumptions made, and the data set used.³⁰

Fugazza and Maur (2008) discuss the methodological hurdles to the modelling of the NTMs in CGE models, and also provide a review of previous general equilibrium applications of the effect of non-tariff measures. They conduct several experiments in GTAP by using the ad valorem equivalents of NTMs estimated by Kee *et al.* (2006). They find substantial differences in the results obtained, depending on whether AVEs are introduced using shocks on import tariffs or on technological change. They conclude that efforts of inventory and quantifications of NTMs should be intensified and modelling efforts improved to allow inclusion of beyond-the-border features.

²⁹ See Hertel (1997) for details about GTAP, and Decreux and Valin (2007) for details about MIRAGE.

³⁰ Bouët (2008) provides an assessment of 9 studies between 1999 and 2008 that looked at the impact of full trade liberalization on the world. The differences in the results obtained are quite striking.

4 Behind-the-Border Costs

Many factors other than transport costs and formal trade policy barriers have been identified in the literature as important determinants of international trade flows. These factors mainly represent the transaction costs associated with moving goods across borders. They include administrative barriers such as customs procedures, trade related documentary requirements, time delays, the quality of physical infrastructure (including transport infrastructure and telecommunications services), the ease of access to finance, and the transparency of the regulatory environment.

Anderson and van Wincoop (2004) review the empirical evidence on the effect of trade barriers on trade prices, and find that although formal policy barriers amount to no more than about 8 percent of trade costs for OECD countries, the combined share of costs related to different languages, different currencies, and imperfect information is 28 percent. They conclude that costs associated with such factors are more important for trade than direct trade policy instruments. The empirical evidence reviewed by them comes from gravity models, but Fugazza and Maur (2008) also come to a similar conclusion after conducting several experiments with CGE models as noted above.

There have been many studies since then that continued to demonstrate the importance of infrastructural inefficiencies, information barriers, cultural barriers, and institutional barriers. These barriers cannot be observed in terms of monetary or quantitative restrictions. Their impact on trade has therefore been almost exclusively determined by estimating gravity models after incorporating measures of these factors in the specification of the gravity equations. As discussed further in Appendix 2, all of these studies find the impact of these factors on trade flows to be very significant, often more important than trade-policy-related non-tariff measures.

5 The Impact on Trade: The Gravity Model

Our concern so far has been to identify the sources of trade costs and to discuss how they can be measured. We now turn to the issue of how to determine the impact of these various trade costs on trade flows.

It is not surprising to find that it is the gravity model that provides the link between trade costs and trade flows. The gravity model has been the workhorse in international trade studies for decades, but it has stayed an intellectual orphan until relatively recently because of its unconnectedness to economic theory.³¹ The traditional gravity equation is expressed as

$$X_{ij} = G \frac{M_i^\alpha M_j^\beta}{D_{ij}^\theta}, \quad (13)$$

where X_{ij} is the bilateral trade between country i and j , G is a proportionality constant, M_i and M_j indicate the relevant sizes of the two countries, and D_{ij} is the distance between the countries. It is called the gravity equation because of its resemblance to Newton's Law of Universal Gravity. It simply explains the bilateral trade using economic size and distance. The larger the two trading partners, the larger the trade flows; the larger the distance between the two countries, the smaller the trade flows. The model can easily be augmented to include other variables as proxies for trade frictions, such as whether the countries share a common border, speak the same language, common legal traditions, and the like.

Although there was no economic theory behind equation (13) up until 1979, various theories have been supplied since then. It is ironic that a model that was criticized for a long time for not having a theory behind it has so many theories behind it now. As Anderson and van Wincoop (2004) argue, any trade model will give a gravity-like structure provided that the allocation of trade across countries is assumed to be separable from the allocation of production and consumption within countries. Thus, the gravity model can be derived from Heckscher-Ohlin, as well as increasing returns to scale, Ricardian models, and so on (Bergeijk and Brakman (2010)).³² Gravity models that are based on any one of these theories are referred to as the structural gravity models. The dominant structural model used in the literature is based on the economic model in Anderson and van Wincoop (2003).

Taking logarithms of both sides of the equation, the multiplicative form in (13) can be converted to

$$\ln X_{ij} = \ln G + \alpha \ln M_i + \beta \ln M_j - \theta \ln D_{ij}, \quad (14)$$

which can be estimated after adding a stochastic error term. This specification is referred to as the traditional log-normal gravity model, as it is not based on an economic theory.

³¹ The phrase 'intellectual orphan' is from Anderson (2010). He points out that the gravity model didn't even appear in a textbook until 2004. There is now a book with the title 'The Gravity Model in International Trade', edited by P.A.G. van Bergeijk and S. Brakman and published in 2010.

³² Although they use different trade models, all these models use constant elasticity of substitution (CES) preferences to describe the demand side of the economy. Novy (2010) has recently developed a new model using the translog demand system, which does yield a different specification. The main feature of this new model is that trade is more sensitive to trade costs if the exporting country only provides a small share of the destination country's imports. As a result, trade costs have a heterogeneous impact across country pairs, with some trade flows predicted to be zero.

Compared to the structural gravity model developed by Anderson and van Wincoop, the formulation in (14) is missing the two price indices called ‘multilateral resistance indices,’ so it suffers from omitted variable bias.³³ A common way to deal with this problem is to apply fixed-effects estimation by including country-specific exporter and importer dummies in the specification.

Another issue in the estimation of (14) is how to deal with zero trade flows (which presents a problem since the logarithm of zero is undefined). It is often the case that there is no trade between some countries even when the model is estimated for aggregate trade flows between countries. Early applications of gravity models simply omitted the observations with values of zero and estimated the model by ordinary least squares. However, this causes sample selection bias if the zero values are not distributed randomly. Another way to circumvent the problem is to add a small positive number (usually 1) to all trade values. This is not adequate either, as it is possible to generate any value for the parameter estimate by adjusting the size of the constant as demonstrated by King (1988).³⁴ A more advanced approach has been to use Tobit models.

Silva and Tenreyro (2006) suggest estimating the gravity equation multiplicatively, without taking the log of trade values, using the Poisson pseudo-maximum likelihood estimator (PPML).³⁵ As with the log-linearized model, this also yields elasticities if the independent variables are in logs. Furthermore, it also represents a natural way to deal with zero trade values, and gives consistent estimators even in the presence of heteroscedasticity (which is often the case). The current trend is to use this method.

If it is believed that there is an underlying process that affects the choice of not to trade with a particular country, then both the volume of trade and the absence of it can be explained simultaneously by using a Heckman type selection model. A Poisson Hurdle model can also be used. Both approaches allow modelling the two different processes involving the decisions about whether or not to trade and about the level of trade flow conditional on the first decision. The first approach is the one adopted in this paper.

³³ The multilateral resistance terms in the structural gravity model imply that trade between two countries depends, after controlling for size, not only on the bilateral trade barriers between them but also on the average trade barriers both countries face with all their trading partners.

³⁴ The reference is from Linders *et al.* (2008).

³⁵ This is basically just Poisson regression, except the dependent variable is continuous rather than a count variable.

6 Application to New Zealand

Empirical evidence obtained in the last two decades based on gravity models suggests that costs related to non-trade-policy factors are at least as much, if not more, important as costs imposed by trade policies. There is no study that particularly looks at New Zealand's trade to investigate the impacts of such factors on New Zealand's trade. This section utilises the model and much of the data from Law, Genç, and Bryant (2009) to test the importance of not only tariff levels and our size and distance from foreign markets, but also more subtle factors such as the quality of infrastructure and property rights of our trade partners.

6.1 Method

The approach adopted here, like the majority of empirical studies reviewed in Appendix 2, is based on a gravity model of trade. The standard gravity equation in (14) is augmented by adding tariffs and variables that reflect the behind-the-border transaction costs, which are summarised in Table 1 below.

Our analysis is undertaken on annual country level data for the period 2001 to 2006. This means that for each country that New Zealand exports to, or imports from, we have up to six observations. Applying ordinary cross-sectional techniques in this case may be inappropriate and lead to incorrect standard errors and biased coefficient estimates. Rather, panel data techniques that account for unobserved differences across our sample should be used.

The two most common panel data techniques, fixed effects and random effects, both have limitations in the current context. Fixed effects does not allow for the estimation of coefficients on time-invariant variables such as distance. Random effects estimation requires that the explanatory variables in the model are not correlated with country specific effects which capture the permanent unexplained heterogeneity across our trade partners.

We therefore employ correlated random effects to overcome both of these limitations. This is operationalised by including time averages for each country of all time varying variables as further explanatory variables and then estimating using random effects.

Finally, given exports to or imports from many of our trade partners are zero for a number of years there is difficulty in including these observations within the current framework as the log of zero is undefined. If we were simply to exclude these observations then we run the risk of introducing selection bias. We therefore utilise a panel selection model whereby countries first decide whether or not to trade with New Zealand and then if so how much. This results in two equations to estimate simultaneously, a probit equation that estimates the probability of trading with a country and a trade equation that estimates the volume of trade with a country. Two sets of equations are estimated, one for imports and another for exports. A more detailed explanation of our methodology can be found in Appendix 1.

6.2 Data

Data are assembled for a panel of around 220 countries on average for the years 2001 to 2006.

Data on imports and exports come from the United Nations Statistics Division's Comtrade Database. The UN obtains estimates of New Zealand imports and exports from Statistics New Zealand. We treat the data as complete. If no trade is reported between New Zealand and a given country in a given year, we assume that the true value for that year was zero.

The World Economic Forum produces a Global Competitiveness Report each year. From the 2009/10 report we have sourced data on a variety of factors that might be thought to affect trade.³⁶ These include: average tariff levels; property rights; financial market sophistication; corruption; customs procedures and; a range of measures related to infrastructure quality (road, rail, port, air, electricity and telecommunications). These variables are mostly in the form of indices where higher levels indicate that a given country has more (or better) of the particular item. For example, if one country had a higher value of the index for customs procedures than another country, that would indicate its customs procedures were more burdensome for business and thus might retard trade.

The Global Competitiveness Report in turn sources much of its information from surveys. This series of reports has been running for some time, however, it is difficult to access older issues and information across time is not readily comparable. Hence we rely on one snapshot of information on these variables. For this reason we restrict the time period of our study to the six years between 2001 and 2006 even though for most other variables we have data for a further 20 years or more.

Estimates of the foreign-born population in New Zealand come from Statistics New Zealand and are based on data from the 2001 and 2006 Censuses. To calculate exact values for the inter-censal years it would be necessary to have data on deaths and international movements by place of birth, which are not available. Therefore, we have interpolated migrant numbers in inter-censal years. Data on short term visitor flows by country (our proxy for tourism exports) are also available from Statistics New Zealand, and can be disaggregated by reason for visit. These data are annual.

Data on the New Zealand diaspora come from the Global Migrant Origin Database.³⁷ Because of the imputation method used, the original estimates in the database overstate the number of New Zealanders in countries with missing data. We have adjusted these estimates downwards, as described in Law, Genç and Bryant (2009). Data are only available for (approximately) the year 2000, the time of the most recent global census round. Our Diaspora variable is thus only a proxy for the true number of expatriate New Zealanders in a country in any given year. This means that coefficients on the Diaspora variable are not directly comparable with coefficients on the migration variable. (The New Zealand census is also more accurate than most countries' censuses, so the Migrant Stock variable contains less measurement error than the Diaspora even in 2000.)

³⁶ <http://www.weforum.org/s?s=Global+Competitiveness+Report+2009>

³⁷ http://www.migrationdrc.org/research/typesofmigration/global_migrant

Table 1 – Variables used in the model

Variable name	Definition
Migrants	Log of the number of migrants in New Zealand from a given country
Diaspora	Log of the number of New Zealand-born living in a given country
Mass	A variable capturing economic mass. It is equal to the log of (NZ GDP x foreign country's GDP) / world GDP). All values are in 2006 \$NZ
Population	Log of a foreign country's population
Distance	Log of the distance between the foreign country's capital and Wellington
Non-English	A dummy variable taking a value of one if English is not widely spoken in the country.
WTO Member	A dummy variable taking a value of one if the country is a member of the World Trade Organisation
Real Exchange Rate	Log of the real exchange rate. Expressed so that an increase in this variable is associated with an appreciation of the New Zealand dollar.
Tariffs	Log of the average tariff level that applies in a given country.
Property Rights	Log of an index measuring the strength of property rights in a given country.
Corruption	Log of an index measuring the level of corruption in a given country.
FM Sophistication	Log of an index measuring financial market sophistication in a given country.
Customs Procedures	Log of an index measuring how burdensome customs procedures are in a given country.
Infrastructure	Log of an index measuring the quality of infrastructure in general in a given country.
Road	Log of an index measuring the quality of roads in a given country.
Rail	Log of an index measuring the quality of rail in a given country.
Port	Log of an index measuring the quality of ports in a given country.
Air	Log of an index measuring the quality of airports in a given country.
Electricity	Log of an index measuring the quality of Electricity in a given country.
Phone	Log of an index measuring the quality of Telecommunications in a given country.
Zero Migrants	Dummy variable taking a value of one if there are no migrants from the country
Zero Diaspora	Dummy variable taking a value of one if there are no New Zealand-born in the country
Average Migrants	The average value over time of the Migrants variable
Average Mass	The average value over time of the Mass variable
Average Population	The average value over time of the Population variable
Average Real Exchange Rate	The average value over time of the Real Exchange Rate Variable

Data on language and distance from New Zealand come from the Research Center in International Economics.³⁸ World Trade Organisation membership information is available directly from the WTO.³⁹ Most of our other important variables, such as each country's GDP and population, come from either the IMF or the UN.

The variables are summarised in Table 1.

6.3 Empirical Results

The result of the trade equation for both merchandise exports and imports are presented in Table 2. There are two models estimated. The first model uses an aggregate index to measure the quality of infrastructure whereas the second model breaks infrastructure into different components such as the quality of roads, rail, ports, air, electricity, and telecommunications. In both cases the dependant variable is the log of the value of either exports or imports between New Zealand and a particular trade partner for a particular year.

As this is a log-log model, coefficients can be interpreted as elasticities. That is, a one percent increase in the variable of interest will be associated with a $\beta\%$ increase in the dependant variable.⁴⁰ The coefficients of the standard gravity variables mass, population, and distance have the expected signs, and with the exception of the mass variable in the imports equations they all are statistically significant. The coefficient of the language variable is positive, suggesting that both exports and imports are, on average, higher if English is not spoken widely in a trading-partner country.

The variables migrants and diaspora reflect the network effects. The results indicate that the migrant stock in New Zealand from trading-partner countries do not affect New Zealand's imports. However, there is a positive effect on New Zealand's exports to these countries. A one percent increase is found to cause a 0.5% (model 1) or 0.27% (model 2) increase in New Zealand's exports. New Zealand's diaspora is found to have an adverse effect on New Zealand's trade, except in model 2 for exports where its coefficient is not statistically significant. Interestingly, the real exchange rate appears not to have a statistically significant effect on either our exports or imports.

Unsurprisingly, higher average tariff levels in trade partner countries are associated with lower levels of exports to those countries in both models. Higher tariffs in the trade partner country have the opposite effect on imports to New Zealand, but of course these ought to have little effect on the relative prices of those goods in New Zealand.

As well as tariffs a range of other factors appear important for New Zealand's trade. As one would expect, stronger property rights, financial market sophistication and better infrastructure in our trade partners are all associated with higher exports from New Zealand to those countries. Similarly higher levels of corruption and more burdensome customs procedures in our trade partners are associated with lower exports from New Zealand to those countries. In general, our results for imports are a little harder to interpret, probably being due to our increasing relatively cheap imports from developing countries less similar to ourselves than many of our historically more important trading partners.

³⁸ <http://www.cepii.fr/anglaisgraph/bdd/distances.htm>

³⁹ http://www.wto.org/english/thewto_e/whatis_e/tif_e/org6_e.htm

⁴⁰ For dummy variables, a coefficient value of β implies that, all else equal, the dependant variable will be $\beta\%$ higher when the dummy variable equals one.

Table 2 – Merchandise Exports and Imports (2001-2006)

Variable	Exports		Imports	
	Model 1	Model 2	Model 1	Model 2
Migrants	0.5032 ^{***} (0.0643)	0.2648 ^{***} (0.0760)	0.0194 (0.0575)	0.0097 (0.0407)
Zero Migrants	4.6806 ^{***} (0.3710)	3.6719 ^{***} (0.3761)	-1.0304 (0.9352)	-1.0454 ^{***} (0.2975)
Diaspora	-0.0967 ^{***} (0.0178)	-0.0026 (0.0193)	-0.0275 ^{**} (0.0131)	-0.1376 ^{***} (0.0093)
Zero Diaspora	-0.9242 ^{***} (0.1147)	-0.5865 ^{***} (0.1296)	-0.5236 ^{***} (0.0734)	-1.6802 ^{***} (0.0680)
Mass	0.8183 ^{***} (0.2548)	1.3764 ^{***} (0.3675)	-0.1094 (0.3381)	-0.1353 (0.1249)
Population	2.1322 ^{***} (0.3167)	4.7931 ^{***} (0.4794)	2.2893 ^{***} (0.2389)	1.4677 ^{***} (0.2323)
Distance	-1.8639 ^{***} (0.1215)	-1.4623 ^{***} (0.1260)	-1.9345 ^{***} (0.1168)	-1.750 ^{***} (0.0396)
Non-English	0.1575 [*] (0.0855)	0.5554 ^{***} (0.1042)	0.3183 ^{***} (0.0768)	0.1975 ^{***} (0.0313)
WTO Member	-0.5473 ^{***} (0.1125)	-0.4625 ^{***} (0.1225)	-0.4081 ^{***} (0.0992)	-0.1490 ^{***} (0.0498)
Real Exchange Rate	-0.0607 (0.2907)	0.0967 (0.4001)	-0.1857 (0.1619)	-0.2161 (0.1398)
Average Migrants	-0.3026 ^{***} (0.0647)	-0.0879 (0.0758)	0.3505 ^{***} (0.0557)	0.3316 ^{***} (0.0396)
Average Mass	-0.2231 (0.2557)	-0.8067 ^{**} (0.3708)	1.4487 ^{***} (0.3499)	1.1808 ^{***} (0.1364)
Average Population	-1.9674 ^{***} (0.3162)	-4.4655 ^{***} (0.4712)	-2.7762 ^{***} (0.2368)	-1.3795 ^{***} (0.2347)
Average Real Exchange Rate	-0.0145 (0.2913)	-0.0760 (0.4002)	0.1749 (0.1654)	0.1661 (0.1412)
Tariffs	-0.1729 ^{***} (0.0541)	-0.2511 ^{***} (0.0596)	0.0984 ^{**} (0.0502)	0.1900 ^{***} (0.0172)
Property Rights	1.0413 ^{***} (0.2636)	1.5300 ^{***} (0.2792)	-0.2531 (0.2111)	-1.2963 ^{***} (0.1021)
Corruption	-0.9796 ^{***} (0.1994)	-0.9114 ^{***} (0.2266)	-0.7478 ^{***} (0.1607)	0.3381 ^{**} (0.1539)
Infrastructure	2.5405 ^{***} (0.2000)		-1.3552 ^{***} (0.1662)	
FM Sophistication	2.2166 ^{***} (0.2291)	0.2515 (0.2438)	2.6856 ^{***} (0.1837)	3.0294 ^{***} (0.1070)
Customs Procedures	-2.1474 ^{***} (0.2848)	-2.6225 ^{***} (0.3340)	2.0846 ^{***} (0.2327)	2.7683 ^{***} (0.1458)
Road		0.3238 [*] (0.1945)		-2.2918 ^{***} (0.0962)
Rail		-0.1893 [*] (0.1046)		-0.1271 ^{***} (0.0480)
Port		0.9206 ^{***} (0.2175)		1.9141 ^{***} (0.1300)
Air		3.5916 ^{***} (0.2559)		1.0791 ^{***} (0.1156)
Electricity		-0.8452 ^{***} (0.1481)		-1.1231 ^{***} (0.0513)
Phone		0.4993 ^{***} (0.0546)		0.1060 ^{***} (0.0175)
Log Likelihood	-1542.310	-1292.233	-1368.122	-1167.008
Observations	1312	1312	1312	1312
Countries	228	228	228	228

Notes – Year and country specific effects are included in all regressions. Dependant variables are in 2006 New Zealand dollars. Standard errors are in parenthesis. Three stars (***) indicates that the coefficient is significantly different from zero at the 1% significance level, two stars (**) indicates that it is significant at the 5% level, and one star (*) indicates that it is significant at the 10% level.

When infrastructure is divided into its various components the effects tend to vary, perhaps a result of high correlation between the various sub indices. However, arguably increases in the two types of infrastructure most likely to be important for international trade (air and port infrastructure) are found to be associated with higher levels of both exports from and imports to New Zealand.

Table 3 illustrates a similar set of results where short term visitor flows to and from New Zealand (by country of origin and destination) are used as a proxy for a component of services trade: tourism. There are differences between these results and those for merchandise trade particularly with respect to measures of behind the border trade costs. In this case it is likely that at least in part the measures of behind the border trade costs included in the model reflect differences between countries making for interesting experiences for tourists. Another difference is that the effect of diaspora on trade flows is consistently positive and statistically significant.

Table 3 – Tourism Exports and Imports (2001-2006)

Variable	Exports		Imports	
	Model 1	Model 2	Model 1	Model 2
Migrants	0.2186 ^{***} (0.0338)	0.3414 ^{***} (0.0460)	0.3129 ^{***} (0.0367)	0.2931 ^{***} (0.0334)
Diaspora	0.0992 ^{***} (0.0082)	0.1179 ^{***} (0.0095)	0.0867 ^{***} (0.0092)	0.1170 ^{***} (0.0081)
Zero Diaspora	0.0934 (0.0584)		0.3895 ^{***} (0.0626)	0.4505 ^{***} (0.0575)
Mass	0.3995 ^{***} (0.1032)	0.4328 ^{***} (0.1556)	-0.0219 (0.0965)	-0.1367 (0.1796)
Population	-0.1848 (0.1499)	-1.3583 ^{***} (0.2682)	1.8576 ^{***} (0.1382)	2.0366 ^{***} (0.2079)
Distance	-1.4765 ^{***} (0.0542)	-1.6601 ^{***} (0.0643)	-1.7554 ^{***} (0.0638)	-1.7171 ^{***} (0.0743)
Non-English	-0.2645 ^{***} (0.0389)	-0.1018 ^{**} (0.0519)	0.0999 ^{**} (0.0436)	0.1586 ^{***} (0.0377)
WTO Member	0.1634 ^{***} (0.0489)	0.0945 (0.0662)	-0.0955 (0.0617)	-0.0343 (0.0517)
Real Exchange Rate	-0.2436 ^{***} (0.0619)	-0.2324 ^{***} (0.0740)	0.1015 (0.0798)	0.0845 (0.2111)
Average Migrants	0.1352 ^{***} (0.0336)	0.0116 (0.0418)	0.2248 ^{***} (0.0380)	0.2118 ^{***} (0.0331)
Average Mass	0.3423 ^{***} (0.1064)	0.5198 ^{**} (0.1595)	0.2306 ^{**} (0.1037)	0.2459 (0.1871)
Average Population	0.0035 (0.1497)	0.9248 ^{***} (0.2649)	-1.7264 ^{***} (0.1331)	-1.8298 ^{***} (0.2077)
Average Real Exchange Rate	0.3128 ^{***} (0.0626)	0.3066 ^{***} (0.0745)	-0.1150 (0.0806)	0.0931 (0.2103)
Tariffs	0.0017 (0.0259)	0.0244 (0.0314)	-0.1810 ^{***} (0.0273)	-0.1810 ^{***} (0.0274)
Property Rights	-1.0997 ^{***} (0.1264)	-0.9254 ^{***} (0.1476)	-0.4200 ^{***} (0.1256)	0.2403 ^{**} (0.1113)
Corruption	1.0937 ^{***} (0.0938)	0.7884 ^{***} (0.1141)	0.3867 ^{***} (0.0905)	0.0863 (0.0997)
Infrastructure	0.4591 ^{***} (0.0940)		0.4725 ^{***} (0.1147)	
FM Sophistication	0.1286 (0.1140)	0.9686 ^{***} (0.1383)	0.3054 ^{**} (0.1370)	-0.0055 (0.0908)
Customs Procedures	1.2430 ^{***} (0.1374)	0.7119 ^{***} (0.1746)	0.3072 ^{***} (0.1158)	0.2313 (0.1426)
Road		0.2653 ^{**} (0.1007)		0.6253 ^{***} (0.0884)
Rail		0.3967 ^{***} (0.0557)		0.0411 (0.0489)
Port		0.3819 ^{***} (0.1236)		-0.3860 ^{***} (0.0713)
Air		-0.8365 ^{***} (0.1328)		0.2789 ^{***} (0.0915)
Electricity		-0.2732 ^{***} (0.0795)		-0.1188 [*] (0.0649)
Phone		-0.2114 ^{***} (0.0276)		0.1770 ^{***} (0.0236)
Log Likelihood	-852.1232	-729.8811	-822.449	-692.1606
Observations	1312	1312	1312	1312
Countries	228	228	228	228

Notes – Year and country specific effects are included in all regressions. Dependant variables are in 2006 New Zealand dollars. Standard errors are in parenthesis. Three stars (***) indicates that the coefficient is significantly different from zero at the 1% significance level, two stars (**) indicates that it is significant at the 5% level, and one star (*) indicates that it is significant at the 10% level.

7 Conclusion

This paper has sought to examine the impact of a variety of these barriers to trade on both New Zealand's exports and imports. The analysis covered New Zealand's trade with around 220 trade partners over the years 2001 to 2006. A gravity model of trade that takes particular care to avoid any selection bias that may result from zero trade between countries was used. Of particular interest, the model included tariffs and a number of non-trade policy factors such as property rights, financial market sophistication, corruption, and a range of measures related to infrastructure quality.

Tariffs were found to have a negative effect on New Zealand's merchandise exports with an elasticity of -0.2. As found in a number of other studies, stronger property rights, financial market sophistication and better infrastructure in our trade partners are all found to be associated with higher exports from New Zealand to those countries. Consistent with the findings in the literature, the estimated elasticities of exports with respect to these factors are much larger than the elasticity with respect to tariffs.

When infrastructure is divided into its various components, it appears that port and air transport efficiency are particularly important, also consistent with the findings in the literature. Similarly higher levels of corruption and more burdensome customs procedures in our trade partners are associated with lower exports from New Zealand to those countries.

The majority of recent empirical research in this area has similarly focused on the impact of trade barriers on the volume of trade. This is not surprising as policy makers are ultimately interested in knowing the impact of various trade barriers on trade flows. Empirical evidence presented in these studies, as well as this one, suggests that costs related to non-trade-policy factors may be more important than costs imposed by trade policies. This is important as while much effort is expended on multilateral negotiations of tariffs and other trade-policy measures, many behind-the border trade barriers may be amenable to direct manipulation and therefore offer greater benefits for New Zealand's trade.

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Appendix 1: Methodology

Our approach is based on a standard gravity model of trade. Let m_i be the value of New Zealand's imports from country i (or New Zealand's exports to country i). If we define the product of the economic mass of countries i and j as the GDP of country i multiplied by New Zealand GDP as a fraction of world GDP, and denote it Y_i , we can rewrite equation (14) as

$$\ln m_i = \beta_0 + \beta_Y \ln(Y_i) + \beta_3 \ln D_i, \quad (\text{A.1})$$

where D_i is the distance between New Zealand and country i . As explained previously, it is common to "augment" the gravity model by including factors such as oil prices, real exchange rates, common languages, common borders, membership of trade blocs, and colonial ties. If we let \mathbf{X}_i denote all such factors, together with $\ln D_i$ and $\ln Y_i$, equation (A.1) can be expressed as

$$\ln m_i = \beta_0 + \mathbf{X}_i \boldsymbol{\beta}. \quad (\text{A.2})$$

A1.1 Unobserved Heterogeneity

The variables available to us cannot capture all influences on New Zealand's trade. In other words, there is likely to be unobserved heterogeneity across our sample. Applying ordinary cross-sectional techniques in the presence of unobserved heterogeneity can lead to incorrect standard errors and biased coefficient estimates.

Use of panel data, however, permits models of the form

$$\ln m_{it} = \alpha_i + \gamma_t + \mathbf{X}_{it} \boldsymbol{\beta} + u_{it}, \quad (\text{A.3})$$

where the subscript refers to country i as before, t refers to year t , α_i is an unobserved country-specific effect that represents the permanent cross-country heterogeneity, γ_t captures year-specific effects, and u_{it} is a time-varying idiosyncratic error.

If the α_i are assumed to be uncorrelated with the explanatory variables, then Equation (A.3) can be estimated using a Random Effects approach. The assumption of zero correlation is, however, difficult to justify in our case. No such assumption is required under a Fixed Effects approach. Under Fixed Effects, however, it is not possible to obtain coefficients for variables that are constant over time, such as Language.

Previous econometric studies of trade have used either ordinary cross-sectional techniques or Fixed Effects. There is, however, an alternative approach, referred to as Correlated Random Effects, that avoids the zero-correlation assumption and allows the inclusion of variables that are fixed over time. Under Correlated Random Effects, the correlation between the country-specific fixed effect α_i and the explanatory variables is explicitly modeled using the expression

$$\alpha_i = \mathbf{X}_{i1}\lambda_1 + \mathbf{X}_{i2}\lambda_2 + \dots + \mathbf{X}_{iT}\lambda_T + \eta_i \quad (\text{A.4})$$

where the λ_i are vectors of “projection coefficients” and η_i is a true random effect that is uncorrelated with the explanatory variables. We assign the same weight to all time periods, so that

$$\lambda_1 = \lambda_2 = \dots = \lambda_T = \lambda, \quad (\text{A.5})$$

and

$$\alpha_i = T\bar{\mathbf{X}}_i\lambda + \eta_i, \quad (\text{A.6})$$

so that the country-specific effects are determined by *time averages* ($\bar{\mathbf{X}}_i$). Substituting this expression into Equation (6) (and absorbing T , a constant, into λ) gives

$$\log m_{it} = \gamma_i + \mathbf{X}_{it}\boldsymbol{\beta} + \bar{\mathbf{X}}_i\lambda + \eta_i + u_{it}, \quad (\text{A.7})$$

which can be estimated using Random Effects.

A1.2 Selection Bias

Equation (A.7) does not allow for zero trade. In practice, however, 14.3% of our observations for imports are zeros, as are 23.5% of our observations for exports. Following Helpman *et al.* (2008) and other previous studies, we interpret the zeros to mean that observed trade values emerge from a two-step process. Countries in effect decide whether to trade, and then decide how much to trade. We adopt a Heckman (1979) selection model:

$$z_{it}^* = \gamma_i^0 + \mathbf{X}_{it}\boldsymbol{\beta}^0 + \bar{\mathbf{X}}_i\lambda^0 + \eta_i^0 + u_{it}^0 \quad (\text{A.8a})$$

$$z_{it} = \begin{cases} 0, & z_{it}^* < 0 \\ 1, & z_{it}^* \geq 0 \end{cases} \quad (\text{A.8b})$$

$$\log m_{it} = \gamma_i^1 + \mathbf{X}_{it}\boldsymbol{\beta}^1 + \bar{\mathbf{X}}_i\lambda^1 + \eta_i^1 + u_{it}^1, \quad z_{it} = 1 \quad (\text{A.9})$$

We assume that $u_{it}^0 \sim N(0,1)$, $u_{it}^1 \sim N(0,\sigma^2)$ and $\text{cov}(u_{it}^k, u_{it}^k) = 0$ where $s \neq t$, $k=0,1$. However, we allow for the possibility that $\text{cov}(u_{it}^0, u_{it}^1) = \rho \neq 0$. Equations (A.8a) and (A.8b) together make up the “selection equation,” while Equation (A.9) is the “trade equation”. We do not have ‘exclusion restrictions’ in our specification of the model, that is, both the selection and the trade equations have exactly the same set of regressors. Although exclusion restrictions are necessary in cross-section studies, they are not necessary, in general, in panel estimation. (Lee 2002: 163.) If $\rho \neq 0$, then simply using Equation (A.7) on the sub-sample with non-zero trade will lead to biased estimates. This is in fact often what the international literature on trade has done. Where selection models have been

applied, it has been in a cross-sectional rather than panel context. (The studies that estimated gravity models in the wider international trade literature applied pooled cross-section techniques even when they were using panel data.)

We carried out the estimation of Equations (A.8) and (A.9) using the statistical package LIMDEP 9.0. We treated η_i^1 and η_i^0 as random coefficients and applied maximum simulated likelihood methods, fitting a random parameters probit model first, and then using the results to fit the trade equation.

Appendix 2: Findings in Recent Empirical Studies

This section reviews the empirical studies since Anderson and van Wincoop (2004) that have investigated the effects of various trade barriers on trade flows. Almost all these studies use a gravity model to analyse empirically the bilateral trade flows between countries. The significant reduction in tariffs and quotas in the past years has shifted the attention to non-tariff barriers and behind-the-border measures, particularly to the latter in a long series of studies in the area of trade facilitation. Consequently, our focus is on how behind-the-border barriers have been measured and how their impacts compare to the impacts of trade-policy-related barriers when such barriers are also included in the models.

A2.1 Studies Specifically about New Zealand

There are only a few studies that are specifically about New Zealand. Cao and Johnson (2006) investigate the impact of quotas and the adoption of mandatory meat hygiene regulations to New Zealand's meat exports during 1994-2003 using a gravity model. Their results show that a uniform adaptation of mandatory meat hygiene regulations had a positive influence on sheepmeat and general meat exports. Their estimate of the coefficient of the dummy variable that reflects the existence of quotas is found to be statistically significant for beef, sheepmeat, and total meat exports with a positive sign for beef but negative for sheepmeat and total meat exports. They do state that due to the several limitations of the study their results are not useful in any interpretation of the general impacts of quotas on trade.

Winchester (2009) estimates the tariff equivalents of non-tariff barriers for New Zealand by using a series of gravity equations, and simulates reductions in tariffs and NTBs in a CGE model. His gravity model includes bilateral tariffs and ad valorem export subsidy paid to exporters, and various border dummy variables to account for all other impediments caused by international borders (such as NTBs and behind-the-border costs). He obtains data for 47 countries and 23 sectors from the 2006 GTAP database. The results from the estimation of the gravity model are such that with the exception of manufacturing tariffs, tariffs and export subsidies either do not have a statistically significant effect on trade or influence trade in a counterintuitive way. NTB's, measured by the border dummies, on the other hand are found to be highly significant. In aggregate trade New Zealand's exports to Australia are 30% of New Zealand's exports to itself. Corresponding figures for New Zealand's exports to China, Japan, Korea, ASEAN and other regions are 14.3%, 24.1%, 17.4%, and 20.7%, indicating that New Zealand exports to Australia face lower NTBs than exports to these nations. NTBs that apply to New Zealand's imports from Australia are also found to be lower than the NTBs pertaining to New Zealand imports from other countries. An interesting finding is that trans-Tasman trade faces fewer impediments than trade elsewhere for services. Closer Economic Relations (CER) normalized tariff equivalents of NTB's facing New Zealand exports and imports are calculated by using the estimated coefficients of the border dummy variables. These are reported for China, Japan, Korea, and ASEAN, and range between 0% and 579%, the latter for fish exports to China and ASEAN. Exports of animal products, dairy products, other food products, and other agriculture items are found to face significant tariff equivalents, more than 150% for animal products for example. Imports of animal products, forestry, and other food products are also found to face more than 100% tariff equivalents. Imports of manufacturing products are also found to face significant tariff equivalents.

Yue and Beghin (2009) investigate the tariff equivalents and trade effects in the presence of a strictly prohibitive non-tariff measure by analyzing the effects of Australia's ban of imports from New Zealand. Their method and the estimates of the ad valorem tariff equivalent of the ban (99% of the fob price) are already summarized in Section 3.

Bryant *et al.* (2004) investigate the effect of migration, representing network effects as an example of a behind-the-border factor, on New Zealand's trade by estimating a gravity model using data for the period 1981-2001 for 179 trading partners of New Zealand. Their model does not include tariffs or NTMs. The estimated elasticity of trade with respect to migrants in their benchmark model is 0.09 for exports and 0.15 for imports. Law *et al.* (2009) extend this study by including New Zealand's diaspora in the model and increasing the period of coverage to 1981-2006. The estimated elasticity of trade with respect to migrants is 0.06 for exports and 0.19 for imports. The effect of diaspora is found not to be statistically significant for exports, but a 1% increase in New Zealand's diaspora in a given country is found to cause a 0.10% increase in imports from that country.

A2.2 Other Studies

Wilson *et al.* (2003) develop four measures of trade facilitation and investigate their relationship to trade among members of the Asia Pacific Economic Cooperation (APEC) between 1989 and 2000. They construct indicators to measure the level of port efficiency, quality of customs environment, regulatory environment, and e-business usage. They include these indicators in a gravity model of trade to assess their importance for trade flows. Their model also includes tariffs to determine which of these factors might have a greater effect on trade flows within APEC. They find that all four measures affect the trade flows. Their results indicate that intra-APEC trade is particularly sensitive to the quality of ports (with the largest elasticity of 4.2), and the level of regulatory barriers (with an elasticity of -1.56). The estimated elasticity of trade with respect to tariff is -0.75, half of the elasticity with respect to regulatory environment.

Clark *et al.* (2004) first investigate the determinants of shipping costs to U.S. markets, and then construct four indexes of country-specific maritime transport costs to use in a gravity model to check for their explanatory power. They find that an important determinant of maritime transport costs is seaport efficiency, where seaport efficiency is not just a matter of physical infrastructure but includes organized crime as well. Improving port efficiency from the 25th to the 75th percentile is found to reduce shipping costs by 12%. They calculate that this is translated to a reduction in bilateral trade of around 25%.

De Groot *et al.* (2004) analyse the effect of institutional quality and good governance on trade using 1998 data for a set of more than 100 countries. Their institutional variables come from the database constructed by Kaufmann *et al.* (2002). The database has six indicators of perceived institutional quality. They construct dummy variables for these indicators and include them in their specification of a gravity equation one at a time. They also construct a composite indicator of institutional quality by using the simple arithmetic average of the scores on each separate indicator. They find that both institutional quality and similar quality of governance have a significant, positive and substantial impact on bilateral trade flows. For example, they find that an increase in regularity quality of one standard deviation from the mean leads to an estimated increase of 16-20% in trade. Lower corruption is found to account for 19-34% extra trade. Increasing the overall quality of institutions one standard deviation above its mean level is found to raise bilateral exports by 44%, and bilateral imports by 30%. These are very substantial effects.

Wilson *et al.* (2005) use the same methodology in Wilson *et al.* (2003), but broaden the set of countries in the analysis and the data on which the measures of trade facilitation are based. They again create four aggregate indexes to measure port efficiency, customs environment, regulatory environment, and service sector environment, and investigate their relationships to trade flows by estimating a gravity model that also includes tariff rates. They find that all four measures affect the trade in manufacturing goods in both exports and imports. Port efficiency of both the importer and the importer is positively associated with trade flows with the effect being higher for exporters than for importers (an estimated 0.92 elasticity with respect to the port efficiency index for exporters and 0.32 for importers). The elasticity of trade flows with respect to the index of customs environment index is found to be 0.47. Improving the regulatory environment is found to have a positive effect with coefficients (which are elasticities) of 0.28 and 0.62 for the regulatory environment of the importer and the exporter. Service sector infrastructures are also found to have a more significant positive effect for export trade than for imports. The estimated elasticity of trade with respect to service sector infrastructure is 1.94 for export trade, the highest among all trade facilitation measures. The estimated elasticity of trade flows with respect to tariffs is -1.56.

De Frahan and Vancauteran (2006) quantify the effect of harmonisation of EU food regulations on intra-EU trade in 10 food sub-sectors during 1990-2001 using a gravity model. They measure the harmonisation of food regulations by an export-weighted coverage ratio. They find that with the exception of condiments, harmonization has a significant and positive effect on EU imports. The estimates for the aggregate food sectors imply that trade would grow by a multiple of 4.7 if there were complete harmonisation. They calculate tariff equivalents of trade costs due to unharmonised food regulations for each food sub-sector as well as the aggregate food sector. They range from 10.5% (for meat) to 224% (for fruits and vegetables), with 184% for the aggregate food sector.

Tang (2006) investigates the impact of the decline of communication costs on the pattern of trade in differentiated goods. She estimates a gravity equation by using US import data from 1975 to 2000. The model is estimated three times with different proxies for communication costs: the total number of fixed telephone lines, the combination of fixed and mobile telephones, and the number of internet hosts. The sample is restricted to observations after 1989 when the number of internet hosts is used as the proxy for communication costs. All IT indicators are obtained from the World Telecommunications Indicators database collected by the International Telecommunications Union. The development of IT in foreign countries, regardless of how the telecommunication costs are measured, is always found to have a positive and significant impact on US imports of differentiated goods. The regressions based on the fixed telephone lines and the combined fixed and mobile phones produce very similar results. On average, every 1% increase in the number of phones in a foreign country increases US imports from the country by almost 1%. Small countries are found to benefit most from the IT development. The results based on the number of internet hosts are in general consistent with the findings based on telephones, but the magnitude of the effect is much smaller. The impact of IT is found to be more for imports of differentiated goods than for imports of goods with reference prices and goods traded through organized exchanges.

Levchenko (2007) looks at the effect of institutional quality on trade. He examines industry-level trade shares using data on the 1998 U.S. imports that cover 389 industries in 177 countries. He uses a measure of product complexity, the Herfindahl index of intermediate input use, as a proxy for institutional dependence. He finds that in a country that moves from the 25th to the 75th percentile in institutional quality, the predicted

relative import share in the good occupying the 25th percentile in institutional intensity decreases by 0.07, and the predicted relative import share in the good corresponding to the 75th percentile in institutional intensity increases by 0.23.

Sadikov (2007) investigates the effect of required signatures for exporting and business registration procedures on the volume and composition of country's exports. He estimates a gravity equation by using import data from 2004 for 140 countries. The number of signatures required to complete an export transaction is obtained from the World Bank's Doing Business 2005 dataset. Data on the number of procedures required to start a business are obtained from the Trading Across Borders indicators. He finds that each extra signature exporters have to collect before a shipment can take place reduces aggregate exports by 4.2%. This is equivalent to raising importer's tariff by 5 percentage points. Each signature lowers exports of differentiated products by 4-5 percent more than exports of homogeneous goods. Business registration procedures are found to affect exports of differentiated products only. He also finds that increasing average tariff by one percentage point causes about 0.8 percent reduction in exports.

Francois and Manchin (2007) examine the influence of infrastructure and institutional quality on patterns of bilateral trade by estimating a selection-based gravity model using panel data of imports between 1988 and 2002. They use institution indexes from "Economic Freedom of the World" database to measure institutional quality, and data from the World Development Indicators database to measure infrastructure. They construct a set of summary indexes using a principal component analysis for both sets of indexes. They use the summary indexes for the size of government and for legal system property rights as their measures of institutional quality. To measure infrastructure, they use the summary indexes for air transport and fixed and mobile phone subscribers. They find that the combination of institutional and infrastructure variation are much more important to the pattern of bilateral trade volumes than is bilateral protection (though the evidence on institutions is somewhat mixed). In their full sample, infrastructure variation implies marginal variations in the volume of trade of roughly 9% around the mean for communications and 4% for transport, compared to 5% for tariffs. In the North-South sample split, infrastructure variation implies an 11% variation in trade for communications and 7% for transport, compared to 2% effect for tariffs.

Ranjan and Lee (2007) examine the impact of contract enforcement by estimating a gravity model using 1992 data. The measures of contract enforcement used in their paper come from three different sources: the property rights index from The Heritage Foundation, the governance indicators from the World Bank, and the indexes from the International Country Risk Guide (ICRG). They find that the effects of the three alternative measures of contract enforcement are qualitatively very similar, with the effect being larger in exporting countries compared with importing countries. They calculate as an example that if Paraguay's Heritage Foundation index, which ranges from 1 to 5, increased from 2 to that of Brazil, which is 3, then Paraguay's exports of differentiated goods to the United States would be 10 times higher. Using the World Bank index of corruption this number would be the same, but using the ICRG index of efficiency it would be 4.4.

Disdier *et al.* (2008) study the influence of Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) in agricultural trade by estimating a gravity model using data for 154 importing and 183 exporting countries for 690 products in 2004. They consider three different variables to account for SPS and TBT measures: a simple dummy variable equal to one if the importing country notifies at least one barrier, a frequency index, and an ad valorem equivalent. Their model also includes tariffs. The coefficient

estimate on SPS and TBTs is always negative and statistically significant with values - 0.15 when the dummy indicator is used, -0.21 when the frequency index is used, and - 0.06 when the ad valorem equivalent is used to measure SPS and TBTs. The coefficient estimate on tariffs is -0.08 in these specifications. They perform further analyses by using different subsamples (all OECD countries versus EU countries only) and interaction variables. Their results suggest that SPS and TBTs do not significantly affect bilateral trade between OECD members but significantly reduce exports of developing and least developed countries to OECD countries. They also find that EU's demand for imports are more negatively affected by SPS and TBTs than imports of other OECD countries.

De (2008) provides estimates of sector-wise trade costs for ten Asian countries using a gravity model. The sectors analysed are food, chemicals, textiles and clothing, machinery, electronics, auto components, steel and meat, and transport equipment. He includes tariffs, transport costs and infrastructure quality in the model, and uses 2004 data. Bilateral transport costs are measured in two ways: the difference of ad valorem trade-weighted freight rate, and the differences of inter-country costs of transportation using shipping rate, collected from shipping companies. He constructs an infrastructure index based on principal component analysis by considering nine variables: railway length density, road length density, air transport freight, passengers (percentage of population) carried by air transport, aircraft departures, country's percentage share in world fleet, container port traffic, fixed line and mobile phone subscribers, and electric power consumption. Two sets of results are presented for each sector; they differ based on how transport costs are measured. Significance of transport costs using measure based on the differences of inter-country transportation costs is always found to be higher than that estimated by using trade-weighted transport costs for most of the sectors. The results show that tariffs, transport costs and infrastructure facilities have a significant influence on regional trade flows in Asia. A reduction in tariffs by 10% is found to increase bilateral trade by about 3.2% in the food sector, 3.4% in the chemical sector, 3% in textiles and clothing, 1.7% in machinery, 3.1% in electronics, 4.1% in auto components, 0.6% in steel and metal, and 0.1% in the case of transport equipment. A 10% reduction in transport costs would increase bilateral trade by 1.2% in the food and chemicals sectors, 1.5% in the textile and clothing sector, 1% in the machinery sector, 0.3% in the electronics and auto components sectors, 1% in steel and metal, and 1.4% in transport equipment. An improvement of current state of infrastructure by 10% in exporting countries will lead to a rise in exports by 2.4% in the food sector, 0.8% in the chemicals sector, 4% in the textile and clothing sector, 0.5% in machinery, 3% in electronics, 0.3% in auto components, 1.7% in steel and metal, and 3.9% in transport equipment.

Olper and Raimondi (2008) analyse food trade among 13 countries (the United States, Canada, Japan, and 10 European Union countries) for the period 1996-2001, and assess the role played by policy barriers (tariffs, non-tariff barriers to trade and domestic support) with respect to barriers unrelated to trade policy, such as information-related costs and cultural proximity. They include the stock of migrants and bilateral exchange of printed books as proxy for information-related costs and cultural proximity. Their results show that in all the country-pair combinations, NTBs dominate the trade reduction effect induced by tariffs, which is not surprising as food industry shows high levels of trade protection in comparison with other manufacturing industries. However, their results highlight that elements linked to information-related costs and home bias in preference not only matter but also dominate the effect of policy barriers. These conclusions are based on three sets of regressions of gravity models where bilateral border effects are estimated. The first set of regressions do not include any explanatory variables that represent tariffs, non-tariff barriers, or non-policy-related barriers, so that the estimated magnitudes of the border effects reflect the effect of all existing barriers, policy related or

not. The second set of regressions starts with including tariffs in the estimated model. This causes a reduction in the estimated coefficients of the border dummies, with the reduction being interpreted as the contribution of tariffs to the border effects. Although it displays strong variability across country-pairs, the average border effect reduction is found to be 9.9%. When they include the ad valorem equivalent of non-tariff measures instead, the average border effect reduction is found to be 26.5%, significantly higher than the reduction induced by tariffs. Thus, NTBs represent an important determinant for borders. They calculate that an average ad valorem equivalent of NTB reduces trade by 19%, a value about twice the effect of tariffs. They then include both tariffs and ad valorem equivalents of NTBs in the model. This results in an average border effect reduction of 28%. The third set of regressions adds the non-policy-related barriers in the model. The estimated coefficient of migrant stock is positive and strongly significant, and, interestingly, induces very strong reduction in estimated border effects. The average impact of migrants on trade flow is equal to 94%, with a similar effect in terms of border effect reduction. This suggests that social networks through their effect on the reduction of information costs represent a very important determinant of the border costs. When the proxy for cultural similarity, bilateral exchange in printed books, is included in the specification, the estimated coefficient is once again positive and strongly significant, with an average effect on trade flow of 69%. The inclusion of this variable induces a significant reduction in the estimated bilateral border coefficients of about 80% on average. The estimated coefficients remain quite stable when both non-policy variables are added simultaneously. However, the estimated coefficient of migrants is halved when bilateral exchange of books is included. When all policy and non-policy variables included together their estimated coefficients remain substantially unchanged in significance and magnitude, reinforcing the previous conclusions. In this specification, the border effects explained by policy variables, information costs and cultural proximity are very high and equal about 95%.

Blonigen and Wilson (2008) take a novel approach and estimate the port efficiencies using detailed data on US imports and associated costs. They incorporate these estimates (instead of indexes that come from surveys) into a gravity model to examine the effects of port efficiency on trade. They find that port efficiency significantly increases trade volumes. They estimate the elasticity of trade with respect to port efficiency to be 1.27. This is reduced to 0.32 when country-pair fixed effects are included in the estimation to control for all time-invariant observed and unobserved factors connected with the country pair. This implies that a change in port efficiency from the 25th percentile to the 75th percentile leads to a 5% increase in trade when unobserved country-pair characteristics are controlled for, a much more modest increase than the 25% increase implied by the results in Clark *et al.* (2004).

Linders *et al.* (2008) investigate the effects of both formal and informal trade barriers on trade by estimating a gravity model using data for 138 countries for the period 1996-2000. Tariffs are measured as trade-weighted applied bilateral importer tariffs, and non-tariff measures are captured by a 'low tariff and non-tariff barriers' dummy variable based on the overall trade restrictiveness indices (OTRI's) in Kee *et al.* (2009). They measure institutional barriers by constructing an 'institutional distance' variable using the six governance quality indices in Kaufman *et al.* (2004). This is basically an index defined as the weighted sum of the squared differences of the values of the six individual indices between two countries, where the weights are the variances of the individual indices across all countries. They also construct a cultural distance variable in the same way using the four cultural dimension scores assigned to countries in Hofstede (2001). They find that bilateral trade decreases by 5% on average if cultural distance increases by one standard deviation. A 1% increase in tariffs is found to decrease the volume of trade by

0.25%. Institutional distance is found to affect the probability of trade with a country, but not the volume of trade if the two countries already trade.

Shepherd and Wilson (2009) use the same approach in Wilson *et al.* (2003) to examine the effects of trade facilitation in South-East Asia using data for the period 2000-2005 for the ASEAN member countries. They find that intra-ASEAN trade is particularly sensitive to the quality of air transport infrastructure (with an elasticity of almost 5 percent) and the level of competition in the internet services sector (with an elasticity of 1.19). The coefficient of the tariff variable in their model is found to be statistically insignificant.

Helble *et al.* (2009) analyse the impact of transparency in the trading environment on trade flows using a gravity model of intra-APEC trade flows for the year 2004. They develop two composite measures of transparency, the Importer Transparency Index (ITI) and the Exporter Transparency Index (ETI), using factor analysis to combine indicators of transparency from the World Economic Forum's Global Competitiveness Report and the World Bank's Logistics Performance Index (LPI). Their gravity model also includes the importer's applied tariff and the ad valorem equivalent of its non-tariff barriers. Their results for all exported goods find that the effect of tariffs and non-tariff barriers is not statistically significant. However, they find that a 1 per cent increase in ITI causes a nearly 2 per cent boost to trade. It is harder to interpret the results in the case of the ETI, as the coefficient of this variable is not statistically significant with an unexpected negative sign.⁴¹

Schlueter *et al.* (2009) analyse the trade effects of different regulatory measures that are imposed in the meat sector by estimating a gravity model using data for 10 importing and 10 exporting (including New Zealand) countries for the years 1996 to 2007. They capture the effects of SPS measures by a frequency index, and their model includes bilateral tariffs. They arrange the twenty-nine specific regulatory instruments into six classes that describe different agri-food safety purposes: disease protection measures, requirements for microbiological testing for zoonoses, tolerance limits for residues and contaminants, production process requirements, conformity assessment and information requirements, and requirements for handling of meat after slaughtering. The twenty-nine instruments are additionally divided into four different policy goal groups consistent with mandatory national WTO notifications: food safety, animal health, plant protection, and protection of humans from animal/plant pests or diseases. Four sets of results are presented, varying with the way SPS measures are captured (using an aggregate measure of all instruments, the six classes, the four goal groups, and all twenty-nine instruments). The estimated factor change in meat trade for changes in tariffs is 1.01 in all specifications, which suggests a minor influence of tariffs on meat trade. The estimated factor change in meat trade for a change in the aggregate measure of regulatory measures is about the same, 1.015. Thus, a strong tendency cannot be determined from the results based on the aggregate measure: regulations may be trade facilitating or trade restricting, or may have no impact. The results based on the disaggregated measures show that regulatory measures produce differing trade effects. Disease prevention measures, tolerance limits for residues and contaminants, and conformity assessment and information requirements are found to promote meat trade, whereas production process requirements and requirements for handling of meat after slaughtering are found to have a negative impact. In the estimation using all twenty-nine instruments, only twelve instruments are found to

⁴¹ These are based on the instrumental variables estimation to cater for the probable endogeneity of transparency. The results from the standard Poisson estimation are such that the coefficient of ETI has the right sign, and the coefficients of both transparency indexes are both statistically and economically highly significant with an estimated elasticity of 6.89 with respect to ITI and 4.84 with respect to ETI, while the coefficients of both tariffs and non-tariff barriers remaining statistically insignificant (and also much lower in magnitude, less than one for both).

have a statistically significant effect on meat trade. In particular, the impact of production process requirements on genetically modified organisms and biotechnology is not significant. Of the requirements for handling meat after slaughtering, regulations about transportation is found to have positive impact, with only the irradiation regulations of the rest of the instruments having a significant negative impact. Only animal health is found to be significant (with a positive effect) among the four policy goal groups.

Olper and Raimondi (2009) measure international trade costs in processed foods in a large sample of more than 70 developed and developing countries that are observed over the 1976-2000 period. Their approach is quite different. They first compute an overall index of bilateral trade costs. This index is recently developed by Novy (2007). Although the index is theoretically based on a gravity model, it only requires data on production and bilateral exports, and two parameters, the elasticity of substitution between home and foreign goods plus the fraction of firms that produce processed foods. They set the first parameter equal to 7, and the second parameter equal to 0.8. They make the case that the rank and the percentage change of trade costs are not sensitive to the choice of these values. They are able to compute the index for specific country pairs and for specific years, which they see as an advantage over more traditional approaches, such as the estimation of border effects through a gravity equation.⁴² The second stage of their analysis involves explaining the trade cost variation across country pairs by regressing them on their potential determinants. Their model relies on four main groups of potential determinants, largely derived from the gravity literature: geographical factors, historical and cultural linkage, physical infrastructure, and institutional factors. Their findings indicate that geographical and historical factors dominate infrastructure and institutional determinants. Two countries sharing a common language are found to have a reduction in the tariff equivalents of trade costs by about 46 percentage points, while in countries with a previous colonial relationship the tariff reduction is 43 percentage points. The infrastructure proxies, road quality and port efficiency also induce a significant reduction in trade costs, but the magnitude of the economic effects is lower. A 1% increase in road quality reduces trade costs by about 0.15%, and a 1% improvement in port efficiency reduces costs by 0.2%. The coefficient of the institutional quality variable is found to be positive, which is at odds with all the other studies, but is barely statistically significant. The model also includes the income Gini coefficient to capture demand-side considerations, allowing them to control for the preferences component embedded in their trade costs index. The results indicate that income inequality is an important determinant of trade costs. It strongly and negatively affects trade costs. The intuition provided is that an increase in income inequality induces more imports of luxury goods relative to the imports of necessities, which increases the average value of goods traded, inducing a reduction in average trade costs that are expressed as a tariff.

Bao and Qiu (2010) examine the influence of technical barriers to trade imposed by China on the country's imports during the period between 1998 and 2006. They use both frequency index and coverage ratios to measure non-tariff barriers, and include them in a gravity model to estimate the degree of their impacts. Their specification of the model also includes tariffs, but it does not have any other intangible factors that may act as barriers to trade. The regressions are first run for the whole sample period, and then on 1998-2001 and 2002-2006 sub-periods to capture the possible structural changes due to China's accession to the WTO. When using the frequency index, they find that TBTs are trade restrictive: a one unit increase in TBTs will decrease import value by about 0.8%. However, when the coverage ratio is used, they find that the negative effects of TBTs are

⁴² For New Zealand, the calculated simple average tariff equivalent for 1976-2000 is 67%. The trade-weighted average is calculated as 52%. The minimum is obtained as 41% when paired with Singapore, and the maximum as 88% when paired with Iceland.

not statistically significant in the entire period. For the period 1998-2001, they find that TBTs have trade promotion effects. A one unit increase in TBTs will increase import value by about 0.2%. They also find that China's TBTs (measured by both frequency index and coverage ratio) are trade restricting for agriculture goods but trade promoting for manufacturing goods. When the frequency index is used, tariffs are found to have a negative impact with an elasticity of -0.65 for the period 1998-2006, -0.31 for the period 1998-2001, and -0.82 for the period 2002-2006. The corresponding elasticities with respect to tariffs are -0.72, -0.44, and -0.91 when the coverage ratio is used to measure NTBs. Tariffs are found to have a positive effect for agricultural products for the period 2002-2006, suggesting that agricultural imports of China are more responsive to changes in non-tariff measures than tariffs.

Disdier and Fontagne (2010) quantify the trade impact of EU measures on Genetically Modified Organisms (GMOs) in the perspective of the WTO complaints by USA, Canada, and Argentina. They estimate a gravity model by using data on trade flows of maize, cotton and oilseed rape for the period 1994 to 2005. The sample includes 20 exporting countries and 30 importing countries (one of which is New Zealand). The presence of a measure potentially affecting exports of complainant countries to the EU is represented by two dummy variables, each associated with different types of EU restrictions. They do not control for bilateral tariffs as they do not vary significantly over time. For all products, estimated coefficients on the "EU moratorium and/or product-specific measures" dummy variable are negative and significant. The implied reduction caused by the presence of these measures in the exports of maize seeds from Argentina, Canada, and U.S. is, on average, 89.4%. The percentages of the reductions are, respectively, 71.1% for maize other than seeds, 99.4% for oilseed rape, 98.3% for cotton seeds, 70.5% for starch residues, and 47.3% for preparations used in animal feed. They also investigate the impact of non-approvals adopted by other countries. This includes the general moratorium New Zealand put in place in 1996 which expired in October 2003. They find that the percentage reductions of exports from Argentina, Canada and the US to New Zealand are, respectively, 66% for maize seed, 99.3% for oilseed rape, and 94.7% for soybean.

Oh and Reuveny (2010) analyse the effects of climatic natural disasters and political risk on bilateral trade by estimating a gravity model using data over the period 1985 to 2003 covering 116 countries. They measure the political safety level of a country by an index compiled by Political Risk Service. The index aggregates 12 scores spanning different ranges, representing their relative contribution to the index, with a range of 0 to 100. Their climatic natural disasters data come from the Emergency Events Database (EM-DAT) which collects data from a wide array of national resources that report natural disaster events. They find that an increase in political risk for either the importer or the exporter country reduces their bilateral trade. The estimated elasticity of trade with respect to importer's political safety is found to be 0.25, and 0.21 with respect to exporter's political safety. The corresponding elasticities with respect to their measure of climatic natural disasters are -0.03 for importer's climatic disasters, and -0.006 for exporter's climatic disasters.

Genç *et al.* (2010) perform a meta-analysis of 48 studies that used gravity models to examine the impact of immigrants on international trade. Their results confirm that immigration boosts trade, an increase in the number of immigrants by 10 percent increases the volume of trade by about 1-2 percent.

Hernandez and Taningco (2010) examine the effects of time delays, quality of port infrastructure, telecommunication services, and depth of information on bilateral trade

flows in East Asia. They estimate a gravity model, and find that time delays (measured as the average number of days to import) in importing is negatively associated with trade with an estimated elasticity of -0.56. Quality of port infrastructure, telecommunication services (measured as the average level of competition among internet providers), and depth of credit information are all found to be positively associated with trade with elasticities ranging from 1.21 to 1.55 percent.

Dutt and Traca (2010) analyse the impact of corruption by estimating a gravity model using both sectoral-level and aggregate data over the period 1980 to 2004 covering more than 120 countries. They use the *International Country Risk Guide* survey-based index of corruption to measure the level of corruption. They find that corruption impedes trade for the vast majority of countries, but when the level of tariffs is high, corruption can produce a trade-enhancing effect. Their results indicate that at the average level of tariffs of 15% a one standard deviation increase in the corruption index of importers will result in 8.3% reduction in trade flows. However, if the tariff rates are in excess of 26%, then an increase in corruption will increase trade flows. On the other hand, at the average value of the corruption index, a one percentage point increase in tariffs will cause a 1.7% reduction in trade flows.⁴³

Jayasinghe *et al.* (2010) focus on the effect of tariffs and sanitary and phytosanitary (SPS) regulations on exports of the U.S. corn seed. They use a frequency index to measure the SPS effect, and estimate the export demand equation (a gravity-based model) for U.S. corn seeds by using data that cover 48 countries in the period 1989-2004. They find that tariffs have the largest marginal effect on trade, followed by distance and SPS measures. According to their results, removing tariffs (that are observed in 2004) would increase existing seed trade by about 12%. They conjecture that five SPS measures would be sufficient to maintain the SPS integrity of the seeds, and compute that the total trade expansion effect of rationalising SPS regulations in this way is nearly 8.8%.

Vigani *et al.* (2010) deals with the quantification of GMO regulations on bilateral trade flows. They develop a composite index of the complexity of such regulations for sixty countries, as well as an objective score for six GMO regularity sub-dimensions.⁴⁴ They estimate a gravity model using trade data for maize, soybean, rapeseed, and cotton products for years 2005-2007 for 61 countries. Their model includes two GMO bilateral indices. One is a similarity index that measures the bilateral regulatory closeness between two countries, ranging between 0 (completely different) and 1 (identical regulation). The second is an index of harmonisation in GMO regulations, obtained by taking the absolute deviation of their composite GMO index across country pairs. The estimated model also includes tariffs in order to properly identify the effect of GMO regulations as the bilateral might be correlated with tariffs. When the GMO index is treated as exogenous, their results indicate that the closeness index has a positive and strongly significant effect on trade. The magnitude of the coefficient estimate implies that a one standard deviation increase in GMO regularity distance (which is 0.148) increases exports by about 30%. The estimated coefficient of the harmonisation index is found to be negative and statistically significant. When the GMO index is treated as endogenous, its coefficient estimate increases by about four times. When GMO sub-components are analysed separately, the regulatory dimension that matters the most is found to be the labeling system, followed by the approval process and traceability requirements. Their results highlight that countries with strong differences in GMO regulations trade

⁴³ Author's own calculations based on the results in column (2) of Table 3 in Dutt & Traca (2010).

⁴⁴ New Zealand's GMO regulatory index is calculated as 0.65. The EU average is 0.69, and the US score is 0.35.

significantly less, suggesting that what matters for trade flows are not only the stringency of the standards, but the level of harmonisation between the countries.

Huchet-Bourdon and Chepta (2011) examine the role of informal barriers on agricultural and food trade in the presence of monetary union by using a data set that covers the exports and imports of the 11 founder countries of the EMU with all trade partners over the period 1996-2004. They consider three types of informal barriers: the quality of exporter and importer institutions (the quality of governance, the respect of law, etc.), their similarity (the degree of heterogeneity of norms, procedures, business practices, etc.), and cross-border information (measured by the mutual trade in newspapers) flows. They use the Rule of Law estimate from the World Bank Governance Indicators database to measure the quality of institutions. For the similarity of institutions of the importing and exporting countries, they use La Porta *et al.* (1999)'s data on the origin of the company law or commercial code of each country. Estimating a gravity model, they find that member countries' trade in agricultural products is sensitive to the quality and similarity of institution, and the availability of information on foreign partners. On average, a one standard deviation increase in the quality of exporter's institutions is found to lead to a 23% increase in bilateral trade. The pro-trade effect of information flows is estimated to be about 25%, on average.

Korinek and Sourdin (2011) investigate the role that trade logistics play in the volume and value of international trade and the extent to which poor quality logistics constitute a barrier to trade. They use indicators of trade logistic quality obtained from four sources: World Bank's *Logistics Performance Index* 2010, the infrastructure component of the *Global Competitiveness Index* from the World Economic Forum's *Global Competitiveness Report* (GCR), the CGR's *Global Enabling Trade Index* (ETI), and the World bank's *Doing Business: Trading across borders*. They estimate several gravity models of aggregate trade, and find that higher-quality trade logistics and improvements in infrastructure enhance trade very significantly. For example, they find that a 10% increase in the importing country's ETI is associated with an increase in trade on average of 19%, while a 10% improvement in the index in the exporting country is associated with increased trade of 36%. They also look at goods imported by sea and by air separately, and find, for example, that a one-unit increase in the quality of exporter's air infrastructure at the lower-middle income and upper-middle income levels is associated with increases in exports of 258% and 213% respectively. A one-unit improvement in port infrastructure is associated with an increase in trade of 236% and 171% for the corresponding levels of income. Overall, their conclusion is that time and costs associated with completing procedures for importing and exporting containerized goods impact trade more than time and costs associated with their transport.

Behar *et al.* (2011) develop a new gravity model that combines Anderson and van Wincoop (2003)'s multilateral resistance and Helpman *et al.* (2008)'s firm heterogeneity features. They construct an International Logistics Index based on 2007 Logistics Performance Index (LPI) of the World Bank, and estimate their gravity model by also including a religious similarity variable in their specification. The data they use are exports data for 2005 obtained from IMF Direction of Trade Statistics. Based on their estimates and the simulations they perform, they conclude that the evidence that exporter's logistics increase exports is very strong. Their results indicate that the impact varies by country size. They calculate elasticities for all countries, and find that the mean elasticity is 0.185. Their preferred specification implies that the elasticity of total exports with respect to a change in logistics is 0.74 for a country of average size. They also claim that the traditional log-normal gravity model would exaggerate the results almost three-fold.

Hoekman and Nicita (2011) use a gravity model to compare the trade impact of trade-policy related border measures with the effects of behind-the-border internal trade and transactions costs. They use World Bank's Logistics Performance index (as a measure of the efficiency of infrastructure services and related regulation) and the Doing Business indicator (as a measure of internal costs associated with shipping goods from the factory gate to the port, and from ports to retail outlets). Their analysis covers 105 countries and uses data from 2006. They find that tariffs, NTMs, and behind-the-border transaction costs are all statistically significant determinants of bilateral trade. On average, the elasticity of trade with respect to tariffs and NTMs are found to be -0.2 and -0.15, respectively. The elasticities of trade with respect to behind-the-border transaction costs are estimated to be much larger; -0.32 for exports and -0.22 for imports with respect to the Doing Business indicator, and -0.324 for imports and -0.41 for exports with respect to the LPI score.

Grosso and Shepherd (2011) assess the link between a more liberal air cargo regime and bilateral merchandise trade in the Asia Pacific region by estimating a gravity model using the Air Liberalisation Index (ALI) developed by the WTO. The ALI is a bilateral measure applied to each bilateral service agreement, and its value ranges between zero for very restrictive agreements and 50 for very liberal ones. The gravity model used includes tariffs in addition to the ALI, but factors other than the standard gravity variables are not included in the specification. They find that a one point increase in the ALI is associated with an increase of 4% in bilateral parts and components trade, which is the sector found to be most sensitive to the degree of aviation liberalization. Although the coefficient of ALI is positive for total imports, it is only marginally statistically significant (with a p-value 0.103). Tariffs are found to have a negative and highly significant coefficient.

Kneller and Pisu (2011) provide novel evidence on the barriers faced by firms wishing to export and those already exporting by using firm-level survey data. Their results confirm that the types of barriers that are found to be significant in gravity equation studies reviewed in this section are also recognized by firms as important barriers to trade. Through a factor analysis, they identify three groups of barriers that are perceived as difficulties faced by the exporting firms. The first are factors relating to networks of the type discussed by Rauch (1999) and include barriers related to identifying the first contact, basic information and marketing. The second group is related to procedural matters and includes problems of regulation, tax, logistics, and exchange rates. The third group includes cultural barriers to entry such as differences in language and culture. They also find that the probability that an exporting firm will find these barriers important decreases by export experience, with varying levels of experience beyond which additional experience no longer matters.

Duval and Utoktham (2011) use the Novy index (as in Olper and Raimondo (2009)) to compute the trade costs for 92 countries using panel data for the period 1988-2008. They then decompose the calculated trade costs into natural (time-invariant cultural and physical distance) and non-tariff policy related trade cost estimates. The final stage of their work presents the estimates of the direct effects of various trade facilitation measures and policies on the isolated policy-related trade costs. This allows them to assess the significance of a number of policy-related factors in reducing trade costs. The policy-related factors they consider are logistics and information and communication technology infrastructure, business environment, and exchange rates. They use UNCTAD's Liner Shipping Connectivity Index (LSCI) to measure trade infrastructure and services. The quality of inland transport and logistics services is measured by the World Bank's Doing Business Indicators. They use the number of internet users per 100 inhabitants as a proxy of the quality of information and communication technology. The

impact of exchange rates is captured by a misalignment variable that measures the undervaluation or overvaluation of the currency against USD. Their results suggest that bilateral trade costs are most elastic to the change in exchange rate misalignment to the US dollar of the currencies of either trade partners, followed closely by a change in liner shipping connectivity. Specifically, they find that, on average, a 10% increase in the valuation of currency against the US dollar of a given country increases that country's overall bilateral trade cost index by 0.9 to 1.1%. Similarly, a 10% increase in a country's liner shipping connectivity index value is found to reduce its trade cost index by 0.89 to 0.97%. The impact on trade costs of a country increasing the number of its internet users by one percent is found to be half of what may be expected from a one percent increase in liner shipping connectivity. Similarly, the impact on trade costs of a country reducing its direct costs of moving goods from/to factory to/from ship deck is found to be half of what may be expected from a one percent increase in internet users. Duval and Utoktham also quantify the actual contribution of the variables to total variation of non-tariff policy-related trade costs. They find that about 25% of the changes in non-tariff policy related trade costs can be explained by the liner shipping index. The second most important factor is found to be the level of internet usage, accounting for 10% of changes in trade costs. Interestingly, the direct cost of moving goods internally is found to only account for 0.5% of the variation in non-tariff policy related trade costs. The contribution of currency misalignment to variations in trade costs across country and time is found to be negligible as it affects import and export costs in opposite ways.