Quantifying the Trade Impact of Non-Tariff Measures:

Econometric and CGE Analysis

A thesis

submitted in fulfilment

of the requirements for the degree

of

Doctor of Philosophy in Economics

at

The University of Waikato

by

MIKE WEBB

THE UNIVERSITY OF

WAIKATO

Te Whare Wānanga o Waikato

2018

ABSTRACT

This thesis focuses on the impact of non-tariff measures (NTMs) on merchandise trade. NTMs are broadly defined as policy measures, other than tariffs, which may have an impact on international trade in goods and services. This is an area of emerging importance, for both researchers and policy makers.

My research involves three main contributions. I propose new approaches to econometrically estimating the effect of NTMs. In addition, I take novel approaches to modelling these effects in a computable equilibrium (CGE) framework. In order to utilise these econometric and CGE techniques to contribute to an improved understanding on the impacts of NTMs it was necessary for me to gather new data on New Zealand NTMs, which were contributed to an international collaborative project coordinated by the United Nations Conference on Trade and Development (UNCTAD).

This thesis comprises four applications. The first (chapter two) focuses on an examination of the effect of animal diseases on beef trade; NTMs are frequently applied to protect importers from diseases. The remaining three applications (chapters three, four and five) draw on the new UNCTAD NTM database, to which I contributed New Zealand data; my data contribution was significant covering 3,096 measures from 530 regulations. Chapter three is an econometric application drawing on these new data, while chapters four and five combine econometric and CGE analysis.

The first application focuses on the impact of foot and mouth disease (FMD) and bovine spongiform encephalopathy (BSE) on beef trade. I find that during and after a FMD outbreak, exporting countries substitute away from markets recognised as FMD-free toward lower value markets not recognised as FMD-free. Similarly, a country that has experienced BSE will export less to markets that have not experienced BSE and more to markets that have. Regaining official recognition of FMD-free status may aid recovery but does not negate the effects of a recent FMD outbreak.

The second application uses data from the UNCTAD NTM database for four developed markets. I apply a novel parsimonious regression approach which shows that NTMs that impose a conformity requirement, i.e. testing, certification or inspection, will reduce the number of countries exporting to these markets.

The third application uses data that I collected on the geographical restrictions imposed by New Zealand. These restrictions mean that plant products presenting a biosecurity risk cannot be imported unless the exporting country is covered by an import health standard for that particular commodity. Using the Global Trade Analysis Project (GTAP) model, I find that if, in a counterfactual scenario, all countries were able to export all fruit and vegetable products to New Zealand, imports from Europe, Latin America, Middle East and Africa and East Asia would increase at the expense of imports from Australia, Oceania, South East Asia, South Asia and North America.

The fourth application models the impact of NTMs on supply chains, with a focus on exports to major ASEAN countries. I first use the detailed UNCTAD NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into major ASEAN countries, using a gravity model framework. I then use these econometric estimates in an extended version of the GTAP model to examine the impact of eliminating the types of NTMs that are found to have significant negative effects on trade. My research illustrates the benefits, both to the major ASEAN countries themselves and to their exporting partners, from the partial liberalisation by ASEAN countries of their most trade distorting types of NTMs.

ACKNOWLEDGEMENTS

I would like to extend my heartfelt appreciation to my family, particularly my wife, Niki, for her unwavering support over the last four and a half years. I was fortunate to be able to use my research leave from paid work to spend two years as primary caregiver for our eldest daughter, Catalina. I finalised my University of Waikato Doctoral Scholarship application while cuddling Catalina as a new-born and submitted this PhD in her first term of school. Our youngest daughter, Emmeline, has never known a time where I was not working on this PhD.

I would like to convey my gratitude to my two supervisors, Anna Strutt and John Gibson. Their advice, particularly on preparing papers for journal submission, and networks have made a significant difference to this PhD. I would also like to thank two co-authors of different papers, Allan Rae and Terrie Walmsley, for contributing their expertise in agricultural modelling and GTAP modelling, respectively.

I further acknowledge the assistance of Guillermo Abramowitz, Santiago Fernandez De Cordoba, Fabien Dumesnil, Maxim Gubarev, Samuel Munyaneza, Ralf Peters and Denise Penello Rial from UNCTAD, as well as Rizqy Anandhika and Lili Yan Ing from ERIA, as I collected New Zealand NTM data and for providing access to the wider UNCTAD NTM database. I feel privileged to have the opportunity to contribute to this important initiative.

I appreciated feedback from journal reviewers and participants in various conferences: NZARES, 2014; WEAI, 2015; NZAE, 2015, 2016 and 2017; AARES 2017; and the Annual Conference on Global Economic Analysis, 2015 and 2017.

Finally, I would like to acknowledge the Ministry of Foreign Affairs and Trade (MFAT) and the New Zealand Treasury. This PhD research was completed separately from both organisations and does not represent their views. MFAT, however, permitted me to take two years leave to focus on this research and both MFAT and Treasury allowed me to work part-time while completing this research. I would also like to acknowledge colleagues, and agencies that supported my NTM data collection, particularly Peter Bailey, who was the official New Zealand Government representative for the UNCTAD-ERIA project.

TABLE OF CONTENTS

CHAPTER I: INTRODUCTION: DATA AND METHODOLOGICAL ISSUES IN ESTIMATING THE EFFECT OF NON-TARIFF MEASURES

Background, Motivation and Objectives

This PhD focuses on the impact of non-tariff measures (NTMs) on merchandise trade. NTMs are broadly defined as policy measures, other than tariffs, which may have an impact on international trade in goods and services (UNCTAD, 2013). This is an emerging and important area of focus, not only for researchers, but also for policy makers. (See Beghin, Maertens and Swinnen, 2015 for a summary.) This topic provides significant scope for contributions through proposing new approaches to econometrically estimating the effect of NTMs, and taking novel approaches to modelling these effects in a computable general equilibrium (CGE). In order to utilise these econometric and CGE techniques to contribute to an improved understanding on the impacts of NTMs it was necessary for me to gather new data on New Zealand NTMs, which were contributed to an international collaborative project.

NTMs affect trade because they can raise either the fixed or variable costs of firms. Moreover, at a firm level, learning about foreign markets can be complex (Rauch and Watson, 2003) and NTMs exacerbate this cost. While NTMs are frequently applied for legitimate public policy reasons – such as food safety or environmental reasons - the setting of NTMs can reflect protectionist pressures (Marette and Beghin, 2010). It is therefore difficult to determine the extent to which NTMs can, or should, be removed or modified.

There has been a dramatic increase in the number of NTMs notified to the WTO since 2000, both Sanitary and Phytosanitary (SPS) measures and Technical Barriers to Trade (TBT) measures. This has coincided with growing concern for health, quality and environmental attributes and externalities (Beghin, Maertens and

Swinnen, 2015). At the same time, there has been a shift in emphasis in trade negotiations from tariff reductions to the removal of NTMs (Berden and Francois, 2015). For instance, New Zealand's Trade Agenda 2030 released in 2017 emphasises an increased focus on non-tariff barriers as one of four "shifts".[1] The focus of this PhD is therefore highly topical.

The overarching objective of this PhD is to provide more sophisticated and nuanced analysis of the impact of NTMs on merchandise trade. Such analysis requires detailed data. With NTMs being so broadly defined and pervasive, previous research has been constrained by the lack of detailed data on NTMs, an issue which is discussed subsequently. This PhD therefore contributes detailed data on New Zealand NTMs to a major international database coordinated by the United Nations Conference on Trade and Development (UNCTAD), making extensive use of the new data available in this database.

Previous literature has often treated NTMs as homogenous, whereas throughout this thesis I aim to focus on the different effect of various categories of NTMs. Given my objective of undertaking more nuanced analysis than has previously been possible, I avoid trying to estimate and model "headline" numbers for the overall impact of NTMs. Instead, I start "small" with econometric estimation of a single product (beef) and the most significant issue from a sanitary perspective – animal diseases.

I then move on to examine a broad range of NTMs – using the comprehensive UNCTAD NTM database to which I contributed – but starting with

[1] https://www.mfat.govt.nz/en/trade/nz-trade-policy/trade-agenda-2030

separate estimates of four developed markets, to understand the different interactions, for instance with market size.

I then move to a very narrow question – what is the effect of a particular type of NTM (geographical restrictions on fruit and vegetable imports) for a single country (New Zealand)? The CGE techniques applied, which involve the direct implementation of "quantity" shocks into CGE can then form the basis for approaching broader NTM modelling.

I take this forward in the final substantive chapter of this PhD, which is some ways the culmination of the PhD. This research first uses the detailed UNCTAD NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into major ASEAN countries, using a gravity model framework. I then use these econometric estimates in a CGE framework to examine the impact of eliminating the types of NTMs that are found to have significant negative effects on trade. While this work is broader, it still stays focused on detailed analysis of particular types of NTM.

THESIS OVERVIEW

This PhD comprises four main chapters, along with the contribution of New Zealand NTM data to a major international database, as described in appendix 1.[2] The four substantive chapters of this thesis are:

1. The Impact of Diseases on International Beef Trade: Market Switching and Persistent Effects (the "animal diseases" chapter).

[2] I was the lead author for each of these papers, working with co-authors as detailed in appendix 2. The first, second and third of these papers have been published in peer reviewed journals (Food Policy, The World Economy and the Journal of International Agricultural Trade and Development). The final paper has been submitted for publication.

2. Market Access Implications of Non-Tariff Measures: Estimates for Four Developed Country Markets (the “extensive margin” chapter).
3. Impacts of Geographical Restrictions: New Zealand Fruit and Vegetable Imports (the “geographical restrictions” chapter).
4. Modelling the Impact of Non-Tariff Measures on Supply Chains in the Asia Pacific Region (the “ASEAN supply chains” chapter).

THESIS CHAPTERS IN THE CONTEXT OF PREVIOUS RESEARCH

The chapters that constitute this thesis form part of the wider literature on non-tariff measures. In broad terms, the empirical literature on NTMs can be divided across two dimensions: the number of countries studied and the number of measures or products under investigation. With these two types of divisions, four categories emerge (See table 1). This thesis includes an example of each type of work.

Typically, analysis of the effect of NTMs on trade value is undertaken through econometric estimation of a gravity model, which is described later in this chapter. Chapters two (animal diseases), four (geographical restrictions) and five (ASEAN) utilise this framework. Many papers in the literature, including chapters four (geographical restrictions) and five (ASEAN supply chains), incorporate econometric estimates into a CGE framework to enable general equilibrium interactions and estimates of welfare effects. In this thesis, the Global Trade Analysis Project (GTAP) is the CGE model used, with chapter five using the ImpactECON Supply Chain model, which is an extension of the comparative static GTAP model. Papers that incorporate CGE modelling are shown in italics in table 1.

Table 1: Main Categories of NTM Research and Selected Examples

Single country (or bilateral relationship), multiple measures	**Multiple measures and countries**
Chapter 3 (extensive margin), *Francois, Berden, Tamminen, Thelle, & Wymenga (2013)*, Egger, Francois, Manchin, & Nelson (2015) Winchester (2009), Peterson, Grant, Roberts, & Karov (2013); Examples of gravity models with a single country include Alam, Uddin, and Taufique (2009)	*Chapter 5 (ASEAN supply chains)*, Kee, Nicita, & Olarreaga (2009) (as utilised in various CGE applications), Fontagné et al. (2005), Hoekman & Nicita (2011), Winchester et al. (2012) Crivelli & Gröschl (2016)
Single measure, single country (or bilateral relationship)	**Single measure or product, multiple countries**
Chapter 4 (geographical restrictions), *Boulanger, Dudu, Ferrari, & Philippidis (2015)*, *Kutlina-Dimitrova & Narayanan (2015),* *Philippidis (2010)* , *Henseler et al. (2013).*	Chapter 2 (animal diseases), Otsuki, Wilson, & Sewadeh (2001), Ferro, Otsuki, & Wilson (2015), Schlueter, Wieck, and Heckelei (2009), Yang, Reed, & Saghaian (2013)**,** Arita, Mitchell, & Beckman (2015) applied in *Grant & Arita (2017)*

There is a tension in empirical NTM research, with a trade-off between targeted research that reflects the particular characteristics of certain types of NTMs and work that has more general application. This is shown by contrasting cross-country studies which focus on a single measure of product with cross country work that includes multiple measures (the bottom right and top right quadrants of table 1).

Some of the earliest research on NTMs focuses on a single measure. The seminal paper in this area is Otsuki et al. (2001) which applies a gravity model framework to estimate the effect of differing aflatoxin standards on cereal, nut, fruit and vegetable imports of 15 European countries from nine African countries.[3] To provide a more recent example, Ferro, Otsuki and Wilson (2015) utilise a gravity model framework to estimate the effect of maximum residual limits for pesticides on trade for 66 fruit and vegetable products for 61 importing countries.

As an illustration of product specific research, Schlueter, Wieck and Heckelei (2009) utilise a gravity model to assess the effect of six classes of SPS regulatory measures on meat trade between the world's ten largest exporters and ten largest importers. Similarly, Arita et al. (2015) examine, separately, NTM measures on beef, pork, poultry, corn and soy, and fruit and vegetables. These results were then applied in a CGE framework in Grant and Arita (2017).

Chapter two (animal diseases) follows this approach by applying a gravity model framework to estimate the effects of outbreaks of foot and mouth disease (FMD) and bovine spongiform encephalopathy (BSE) on beef trade. While this chapter does not explicitly draw on data on NTMs, the approach in this paper recognises that the barriers and costs placed on exporters, NTMs in other words, vary depending on the disease status of both importing and exporting countries, which can manifest itself in restrictions or requirements placed on some countries by others (typically by disease free countries on those that present risks). In this way, my approach builds on previous literature - particularly Yang, Reed, and Saghaian (2013) which examines the impact of FMD on pork trade – with my paper accounting for official FMD status and for the impact of recent disease outbreaks, both for exporters and importers. This chapter is the only one in this thesis that does not make use of NTM data collected as part of the UNCTAD project; it was

[3] As described in the paper, aflatoxins are toxic compounds found in stored agricultural crops such as peanuts.

completed first, including as an opportunity to develop new gravity modelling and data management techniques.

While research focusing on a single product has the advantage of not combining effects that might be quite distinct for different sectors, large numbers of these studies would be necessary to understand the impact that NTMs have on trade generally. Moreover, through focusing on a single product, the number of observations is much lower than in studies which combine imports of multiple products, which reduces the statistical power of econometric estimation.[4]

Similarly, while research on – for instance – aflatoxin or maximum residue limit standards is useful for policy makers concerned with these issues, and focusing on specific measures enables a detailed consideration of the measures themselves including their stringency, a very large number of studies would be necessary to understand the effects of all the different types of NTM applied globally. Moreover, through focusing on a single NTM there is a risk of omitted variable bias, if other NTMs not included in the study are correlated with the measure under investigation.[5]

A further challenge for research looking at multiple types of NTM affecting diverse products is the detailed data requirements for this analysis. The paucity of data has constrained research in this area. A significant component of this PhD was the collection of data on all New Zealand NTMs affecting goods trade, as part of a major international project coordinated by UNCTAD, in partnership with other international organisations including the World Bank, and the Economic Research

[4] By "combining imports", I mean separately including variables for the level of imports of different products, rather than a single aggregate.
[5] This issue does not arise in my animal disease paper because I do not focus on specific measures.

Institute for ASEAN and East Asia (ERIA). **The data contribution is described in appendix 1**, and these data are used in three chapters. In addition to the chapters in this thesis, Cadot and Gourdon (2016), Cadot, Asprilla, Gourdon, Knebel, and Peters (2015) and Vanzetti, Peters, and Knebel (2014) provide pertinent applications of the new UNCTAD NTM database.

Chapter three (extensive margin) is the first of three papers using the UNCTAD NTM database. It provides a unique contribution by estimating the effects of NTMs on the number of countries exporting particular products to Canada, the European Union, New Zealand and the United States, with separate regressions for each market.[6] I start by looking at individual countries to understand the factors that may be at play here.

Papers which empirically estimate the effects on NTMs for a single country's imports are rare, particularly because gravity models are often intractable with insufficient variation.[7] Work in this area is often based on alternative approaches such as surveys (see, for instance, Francois, Berden, Tamminen, Thelle, and Wymenga, 2013), or through considering historical evidence of FTAs (see, for instance, Egger, Francois, Manchin, and Nelson, 2015, and Winchester, 2009).

By concentrating on the number of countries exporting a product, I am able to adopt a parsimonious regression that abstracts from the level of detail about the importer-exporter dyads that are required in gravity model estimation. I can therefore undertake separate regressions for each of the individual markets, which provides flexibility with regard to possible regulatory differences between

[6] These are the first developed markets for which detailed and comprehensive NTM data have been collected.
[7] A rare example of a single importing country gravity model is Alam, Uddin, & Taufique (2009) although this is not concerned with imports.

countries, and allows the potential for interactions with country-level attributes such as market size.

I find that NTMs that impose a conformity requirement - i.e. testing, certification, and inspection requirements - significantly reduce the number of countries exporting to a market. Conformity requirements imposed for sanitary or phytosanitary reasons have the largest effect in Canada, reducing the number of exporting countries by 47 percent compared to the situation where no compliance requirement is imposed. Conformity requirements imposed for other reasons covered by the WTO Agreement on Technical Barriers to Trade have the largest effect in Canada and New Zealand, reducing the number of exporting countries by 27 percent compared to the situation where no compliance requirement is imposed.

In contrast, I generally find a statistically significant positive effect for non-tariff measures that do not impose a compliance burden, suggesting that such measures may facilitate trade. Previous research by Crivelli and Gröschl (2016) finds that sanitary and phytosanitary (SPS) compliance measures that have been raised as a concern at the WTO reduce the number of countries exporting to a market. However, my research is much broader in showing that compliance measures have an effect more generally, and the effect is not just for those NTMs that are sufficiently problematic to be raised at the WTO.

Chapter four (geographical restrictions) takes an even narrower approach, focusing on a particular type of NTM (geographical restrictions on fruit and vegetable imports) for a single country (New Zealand). Such narrow papers are relatively uncommon, with examples including two recent analyses of Russia's import ban on specified agri-food products from certain countries (Boulanger, Dudu, Ferrari, and Philippidis, 2015 and Kutlina-Dimitrova and Narayanan, 2015), as well as studies of a hypothetical EU import ban on GM soybeans and maize/oil seeds from Argentina, Brazil and the USA (Philippidis, 2010, and Henseler et al., 2013). Outside the CGE field, a notable gravity modelling application is Peterson et al. (2013) which estimates the effects of different types of phytosanitary measures applied by the United States.

Chapter four examines the trade effects of New Zealand restricting, for biosecurity reasons, the countries from which particular fruit and vegetable products can be imported. I propose a new index to quantify the extent to which fruit and vegetable exports from each region are constrained by these restrictions. This index is validated econometrically and simulations are undertaken to determine expected imports if all fruit and vegetable products could be imported from all countries. In this counterfactual scenario, we expect increased fruit and vegetable imports from Europe, Middle East and Africa, the Americas (excluding the United States), and East Asia at the expense of imports from Oceania, Australia, the United States, South East Asia and South Asia.

Despite the narrow focus, my paper makes significant novel contributions to the more general NTM literature by presenting a new approach to modelling, within a CGE framework, NTMs that restrict imports. In particular, my approach begins by estimating the direct effect of a policy on imports, and then implements this estimate into a CGE framework to allow for general equilibrium effects. This methodology has potentially wide application to other types of NTMs. The approach is well-suited to analysing policies that affect countries to different extents, for instance, where there are geographical restrictions on eligibility preventing the import of specified products from particular countries. Moreover, the direct implementation of “quantity” shocks into CGE can form the basis for approaching broader NTM modelling– which I take forward in the final substantive chapter of this PhD.

At the other end of the spectrum from papers focused on a single type of NTM, are papers which seek to explore the overall impact of NTMs. In such papers, the NTM variable often combines various different types of NTMs. These include papers such as Fontagné et al. (2005), Hoekman and Nicita (2011) and Winchester et al. (2012). Li and Beghin (2012) and Beghin, Maertens and Swinnen (2015) provide useful surveys.

Perhaps the most well-known work in this area is Kee et al. (2009). This paper estimates the effect of non-tariff measures at the product line level using data for 78 countries. The paper has been widely cited in CGE work because the authors have used estimates of demand elasticity to obtain an estimate of the ad valorem equivalent (AVE) of these NTMs i.e. the level of tariff (in percentage terms) that would have the same effect as the NTM protection. Various CGE applications have incorporated these estimates, including Boughanmi, Al-Shammakhi, and Antimiani (2016), Kawasaki (2015), and Fontagné, Gourdon, Jean, et al (2013).

While the approach in Kee et al. (2009) is relatively sophisticated in its econometrics, a key limitation is it treats all NTMs under investigation – described as "core non tariff barriers" in the paper - as having the same effect and does not take into account the cumulative effect of multiple NTMs: in their paper the core non tariff barrier dummy variable is unity if a country imposes at least one core non tariff barrier on the product. The weakness of this approach is that not all NTMs have the same effect, and some can actually facilitate trade.[8] Indeed a recent paper,

[8] See Cadot and Gourdon (2014) for a discussion of the trade facilitating effect of NTMs.

Beghin, Disdier, and Marette (2015), re-estimates the database in Kee et al. (2009) but focuses only on measures classified as "technical regulations" which are described by the authors as "standard-like measures potentially addressing market imperfections". Beghin, Disdier, and Marette (2015) find that about 39 percent of the product lines affected by NTMs exhibit negative AVEs which they interpret as "indicating a net trade-facilitating effect of these measures".

The database in Kee et al. (2009) and used in Beghin, Disdier, and Marette (2015) draws on an earlier version of the current UNCTAD database and is missing the detailed classification system and robust collection methodology of the latest iteration. Two of the authors of the Kee et al. (2009) paper have presented at conferences recently with research that uses new UNCTAD data. As presented thus far, this work continues the approach of a single NTM dummy variable.

An alternative and significant econometric paper, which focuses solely on SPS measures is Crivelli and Gröschl (2016).[9] This paper applies a gravity model (the Heckman selection model) and data on specific concerns about SPS measures raised at the WTO at the 4 digit level of the Harmonized System classification.[10] The authors find that such SPS measures reduce the probability of exporting to these markets but, conditional on trade occurring, values exported are higher. In a key innovation which I mirror in chapter three, they further distinguish between on SPS concerns relating to conformity assessment (i.e. certificate requirements, testing,

[9] This is more detailed than similar earlier work by Disdier, Fontagné and Mimouni (2008).
[10] WTO data on NTMs includes those notified or raised either notified to the World Trade Organization (WTO) under obligations imposed by the Agreement on the Application of Sanitary and Phytosanitary Measures and the Agreement on Technical Barriers to Trade, or raised as specific concerns by WTO members. While a rich source of data, this database may give rise to measurement errors, because the agencies responsible for notifying the WTO, often trade ministries, may not be aware of all regulations that may constitute NTMs or they may not have the resources and incentives to report these fully in a systematic manner. Moreover, measures raised as specific concerns at the WTO constitute a subset of all NTMs, as only the most problematic are raised (see Grant & Arita, 2017, for a discussion focused on the sanitary and phytosanitary context).

inspection and approval procedures) and concerns related to product characteristics (i.e. requirements on quarantine treatment, pesticide residue levels, or labelling and packaging) finding that only conformity requirements have negative effects, both on the likelihood of market entry and the value of trade if it takes place.

Chapter five (ASEAN supply chains) fits alongside these papers which examine multiple measures and multiple countries. In contrast to papers such as Kee et al. (2009) it takes advantage of the detail of the UNCTAD NTM database with different dummy variables capturing the incidence of different types of non-tariff measures. I focus on six major ASEAN countries: Indonesia, Viet Nam, Singapore, the Philippines, Malaysia and Thailand.

I first use the detailed NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into the major ASEAN countries, using the ppml gravity model framework, proposed in Santos Silva and Tenreyro (2006). I then use these econometric estimates in a global computable general equilibrium model to examine the impact of liberalising the types of NTMs that are found to have significant negative effects on trade. I use a newly available Global Supply Chain Model, based on the well-known Global Trade Analysis Project (GTAP model), which is discussed in the next section. By utilising this model, I can capture separately the effects of removing the NTMs identified as particularly problematic, on products sold for intermediate production and those sold to final consumers. This enables quantification and in-depth analysis of the impact of NTMs on supply chains.

METHODOLOGICAL TECHNIQUES APPLIED

Gravity modelling

All four chapters have an econometric component. I make use of gravity model estimation which is widely considered to be the "workhorse" of applied trade work (Shepherd, 2013). In particular, I make use of the two types of gravity model estimation used in contemporary analysis: the poisson pseudo maximum likelihood (ppml) estimator proposed in Santos Silva and Tenreyro (2006) and the Heckman Selection estimator, including an extension proposed in Helpman, Melitz, and Rubinstein (2008). These estimators have proven themselves well suited to some of the issues encountered in trade data, including zero trade flows and – in the case of the ppml estimator – heteroskedasticity. Both have over 2500 citations on *Google Scholar*. They are each suited to different purposes, so I use the estimator most suited for each application: Chapters four (geographical restrictions) and five (ASEAN supply chains) apply the ppml estimator, whereas chapter two (animal diseases) applies the Heckman Selection estimator and the Helpman, Melitz and Rubinstein extension as I am particularly interested in exploring instances of zero trade.

A gravity model posits that the trade between two countries depends on their GDPs and bilateral transaction costs, for instance arising from distance; the latter costs are referred to as "multilateral resistance" (Anderson and Wincoop, 2003). In addition to distance, shared borders, common languages, past colonial relationships and regional trade agreements are commonly used as controls variables affecting the cost of trade. It is worth noting that unobserved variables, such as cultural affinity, therefore enter the residual term. This only poses issues where they are correlated with variables of interest. A useful summary of gravity modelling from a practical perspective is provided by Shepherd (2013).

The most widely used estimator to estimate gravity models is currently the Poisson pseudo-maximum likelihood (ppml) estimator presented in Santos Silva and Tenreyro (2006). As explained in Shepherd (2013), this estimator is consistent in the presence of fixed effects, accounts for observations of zero trade and can be estimated to allow for heteroskedasticity which is important because errors are likely to be clustered by country.

Negative binomal regressor and zero inflated negative binomial estimators have also been used in gravity modelling. There are, however, some practical challenges with negative binomal regressors, including that the estimates are not scale invariant (see Shepherd, 2013) so the general preference is now for ppml estimation.

One disadvantage of the ppml estimator is that it assumes that the probability of trade occurring is generated by the same function that explains the volume of trade if it takes place. As noted by Crivelli and Gröschl (2016): "In contrast to the Heckman model, the Poisson method assumes that there is nothing special about zero trade". Alternative estimators based on the Heckman selection model, are therefore preferred in some applications, including Crivelli and Gröschl (2016). As explained in Shepherd (2013), the Heckman method, including as proposed in Helpman, Melitz, and Rubinstein (2008) requires specifying two equations, a selection equation which describes the probability of trade taking place and an outcome equation which describes the expected volume of trade conditional on it taking place. Recent papers, have, however, emphasised the importance of the distributional assumptions, stressing, in particular, the sensitivity of results from the

Helpman, Melitz, and Rubinstein (HMR) estimator to the presence of heteroskedasticity. (See Santos Silva and Tenreyro, 2015 and Martin and Pham, 2015.) This suggests that the HMR estimator is best confined to circumstances where explaining effects on the probability of trade occurring is the central area of focus.

Computable General Equilibrium Modelling

My thesis also utilises computable general equilibrium modelling, particularly the Global Trade Project (GTAP) model (Hertel, 1997), along with the version 9 database (Aguiar, Narayanan, and McDougall, 2016). GTAP is a well-known and fully-documented CGE model that has been widely used for a variety of policy applications.[11] The GTAP model specifies trade bilaterally, with imperfect substitution between foreign and domestic goods and between imports from different sources. Chapter four (geographical restrictions) uses the GTAP framework to allow us to take account of the substitutions between potential exporters as well as other inter-sectoral and inter-regional linkages in my scenario that involves the removal of all New Zealand geographical restrictions enabling all countries to export all products. Chapter five (ASEAN) is at the frontier of CGE modelling, and I am among the first to utilise channels that enable NTM reductions to have different effects on the exporting country, and for imports of intermediates and final goods.

[11] See www.gtap.org for detailed and updated information on the model and database, along with wide-ranging applications.

Other Approaches

In addition to the gravity modelling approaches, and CGE analysis, detailed above, various other techniques have been applied to assess the impact of NTMs. These include price-based work, firm level study and analysis of regulatory heterogeneity.

Perhaps the most notable alternative to gravity modelling, is econometric work that uses unit price rather than the trade values used in gravity modelling. Key examples of this research include Dean, Signoret, Feinberg, Ludema, and Ferrantino (2009), Cadot and Gourdon (2014) and Cadot and Gourdon (2016). In broad terms, such papers aim to compare the domestic price of a good relative to the reference price of a comparable good. Two major challenges with this work are possible differences and changes in the quality of good, as well as possible distortions due to omitted trade costs. (Beghin, Disdier, and Marette, 2015). Some research aims to minimise these issues through utilising retail data, but product coverage is often limited and this data generally not reconciled with the Harmonized System; to illustrate Dean et al. (2009) focused on 47 consumer products, and the data in the World Bank International Comparisons Project used in Cadot and Gourdon (2014) only covers approximately 100 products - not the over 5,000 products classified at the 6 digit level in the Harmonized System (HS). I considered using New Zealand retail price data for fruit and vegetables in Chapter four, but the data available (from Statistics New Zealand) was limited to a small number of products. While good quality unit value data is available from CEPII (http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp) and was used to good effect in Cadot and Gourdon (2016), there is a lag in its production and it is still subject to distortion by differences in product quality.

There is also an emerging field of research using firm level data to assess the impacts of non-tariff measures, which includes papers such as El-Enbaby, Hendy, and Zaki (2016) and Fontagné, Orefice, Piermartini, and Rocha (2015) who examine the effect of examine sanitary and phytosanitary measures notified to, or raised as concerns at, on exports by Egyptian and French firms respectively. This seems a promising area for future research but is outside the scope of this PhD.

Finally, while my research goes further than many papers in examining different types of NTMs, particularly in Chapter five, it does not explicit consider harmonisation or other alignment of requirements in NTMs. The significance of this is well understood with pioneering work by Reyes (2011) showing the gains from harmonisation of electrical product standards in the EU. Cadot et al. (2015) make a significant contribution using the UNCTAD NTM data to calculate measures of "regulatory distance" between countries but they stop short of econometric analysis. Future work could apply these concepts into an econometric framework, perhaps using the UNCTAD NTM database to extend the work in Winchester et al. (2012) to a wider range of countries and products. This would, however, likely require a large project team, such as that assembled in Winchester et al. (2012).

DATA COLLECTION

My data collection involved collecting data on all New Zealand Acts, regulations and other delegated legislation which affected merchandise trade. This involved identifying all sources of these regulations and then collecting detailed information including implementation date, description and objectives. I classified each NTM according to a common classification framework (UNCTAD, 2013) and

(UNCTAD, 2014), and detailed the exact tariff lines affected by the product to enable researchers using this database to match NTMs with trade data.

The data was initially collected under a project supported by the World Bank and overseen by UNCTAD between September 2014 and June 2015: these were included in the UNCTAD NTM database publicly launched in July 2016. For a subsequent ERIA-UNCTAD project, I updated the data with changes made to measures between September 2014 and May 2016. In the 2016 version, there are 3,096 measures from 530 regulations. I collected all data, with my chief supervisor providing quality control. This data collection is set out in appendix 1, which draws on material published as a chapter in an UNCTAD ERIA report. The data is publicly available at http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures/NTMs-Data.aspx .

References

Aguiar, A., Narayanan, B., & McDougall, R. (2016). An Overview of the GTAP 9 Data Base. *Journal of Global Economic Analysis, 1*(1), 181–208. https://doi.org/10.21642/JGEA.010103AF

Alam, M. M., Uddin, M. G. S., & Taufique, K. M. R. (2009). Import Inflows of Bangladesh: the Gravity Model Approach. *International Journal of Economics and Finance, 1*(1), 131. https://doi.org/10.5539/ijef.v1n1p131

Anderson, J. E., & Wincoop, E. van. (2003). Gravity with Gravitas: A Solution to the Border Puzzle. *The American Economic Review, 93*(1), 170–192.

Arita, S., Mitchell, L., & Beckman, J. (2015). *Estimating the Effects of Selected Sanitary and Phytosanitary Measures and Technical Barriers to Trade on U.S.-EU Agricultural Trade* (United States Department of Agriculture Economic Research Report No. 212887). Retrieved from https://ideas.repec.org/p/ags/uersrr/212887.html

Beghin, J. C., Disdier, A.-C., & Marette, S. (2015). Trade restrictiveness indices in the presence of externalities: An application to non-tariff measures. *Canadian Journal of Economics/Revue Canadienne d'économique, 48*(4), 1513–1536. https://doi.org/10.1111/caje.12157

Beghin, J., Maertens, M., & Swinnen, J. F. (2015). Non-tariff measures and standards in trade and global value chains. *Annual Review of Resource Economics, 7*. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2572937

Berden, K., & Francois, J. (2015). *Quantifying Non-Tariff Measures for TTIP*. (Paper No. 12 in the CEPS-CTR project 'TTIP in the Balance' and CEPS Special Report No. 116). Retrieved from http://www.ceps.eu/publications/quantifying-non-tariff-measures-ttip

Boughanmi, H., Al-Shammakhi, A., & Antimiani, A. (2016). Deeper Integration or Wider Integration?: the case of Gulf Cooperation Council. *Journal of Economic Integration, 31*(2), 206–233.

Boulanger, P. H., Dudu, H., Ferrari, E., & Philippidis, G. (2015). *The cost of import prohibition for political reason: CGE analysis of the Russian ban on agri-food products*. Paper presented at the 18th Annual Conference on Global Economic Analysis, Melbourne. Retrieved from http://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4688

Cadot, O., Asprilla, A., Gourdon, J., Knebel, C., & Peters, R. (2015). *Deep Regional Integration and Non-Tariff Measures: A Methodology for Data Analysis*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series 69). Retrieved from http://www.researchgate.net/profile/Julien_Gourdon/publication/272086370_Deep_Regional_Integration_and_Non-Tariff_Measures_A_Methodology_for_Data_Analysis/links/54da01100cf25013d0439fd6.pdf

Cadot, O., & Gourdon, J. (2014). Assessing the Price-Raising Effect of Non-Tariff Measures in Africa. *Journal of African Economies, 23(4),* 425–463. https://doi.org/10.1093/jae/eju007

Cadot, O., & Gourdon, J. (2016a). Non-tariff measures, preferential trade agreements, and prices: new evidence. *Review of World Economics, 152*(2), 227–249. https://doi.org/10.1007/s10290-015-0242-9

Cadot, O., & Gourdon, J. (2016b). Non-tariff measures, preferential trade agreements, and prices: new evidence. *Review of World Economics, 152*(2), 227–249. https://doi.org/10.1007/s10290-015-0242-9

Crivelli, P., & Gröschl, J. (2016). The impact of sanitary and phytosanitary measures on market entry and trade flows. *The World Economy, 39*(3), 444–473.

Dean, J. M., Signoret, J. E., Feinberg, R. M., Ludema, R. D., & Ferrantino, M. J. (2009). Estimating the Price Effects of Non-Tariff Barriers. *The B.E. Journal of Economic Analysis & Policy, 9*(1). https://doi.org/10.2202/1935-1682.1972

Disdier, A.-C., Fontagné, L., & Mimouni, M. (2008). The Impact of Regulations on Agricultural Trade: Evidence from the SPS and TBT Agreements. *American Journal of Agricultural Economics, 90*(2), 336–350.

Egger, P., Francois, J., Manchin, M., & Nelson, D. (2015). Non-tariff barriers, integration and the transatlantic economy. *Economic Policy, 30*(83), 539–584.

El-Enbaby, H., Hendy, R., & Zaki, C. (2016). Do SPS measures matter for margins of trade? Evidence from firm-level data. *Applied Economics, 48*(21), 1949–1964. https://doi.org/10.1080/00036846.2015.1111987

Ferro, E., Otsuki, T., & Wilson, J. S. (2015). The effect of product standards on agricultural exports. *Food Policy, 50*, 68–79. https://doi.org/10.1016/j.foodpol.2014.10.016

Fontagné, L., Gourdon, J., Jean, S. (2013). *Transatlantic trade: whither partnership, which economic consequences?* (CEPII Policy Brief). Retrieved from http://www.ifoinstitut.net/dms/ifodoc/docs/Akad_Conf/CFP_CONF_VSI/VSI_2014/vsi14-rmd-Felbermayr/Papers/vsi14-rmd-Gourdon.pdf

Fontagné, L., Mimouni, M., & Pasteels, J.-M. (2005). Estimating the impact of environmental SPS and TBT on international trade. Integration and Trade Journal, 22(3), 7–37.

Fontagné, L., Orefice, G., Piermartini, R., & Rocha, N. (2015). Product standards and margins of trade: Firm-level evidence. *Journal of International Economics, 97*(1), 29–44. https://doi.org/10.1016/j.jinteco.2015.04.008

Francois, J., Berden, K., Tamminen, S., Thelle, M., & Wymenga, P. (2013). *Non-tariff measures in EU-US trade and investment: An economic analysis.* (Report of the Institute for International and Development Economics). Retrieved from https://ideas.repec.org/p/lnz/wpaper/20090806.html

Grant, Jason, & Arita, Shawn. (2017). *Sanitary and Phyto-Sanitary Measures: Assessment, Measurement, and Impact* (IATRC Commissioned Paper No. 21). Retrieved from https://ageconsearch.umn.edu/record/259417

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating Trade Flows: Trading Partners and Trading Volumes. *The Quarterly Journal of Economics, 123*(2), 441–487.

Henseler, M., Piot-Lepetit, I., Ferrari, E., Mellado, A. G., Banse, M., Grethe, H., … Hélaine, S. (2013). On the asynchronous approvals of GM crops: Potential market impacts of a trade disruption of EU soy imports. *Food Policy, 41*, 166–176. https://doi.org/10.1016/j.foodpol.2013.05.005

Hertel, T. W. (Ed.). (1997). *Global trade analysis: modeling and applications*. Cambridge ; New York: Cambridge University Press.

Hoekman, B., & Nicita, A. (2011). Trade Policy, Trade Costs, and Developing Country Trade. *World Development, 39*(12), 2069–2079. https://doi.org/10.1016/j.worlddev.2011.05.013

Kawasaki, K. (2015). The relative significance of EPAs in Asia-Pacific. *Journal of Asian Economics, 39*, 19–30. https://doi.org/10.1016/j.asieco.2015.05.001

Kee, H. L., Nicita, A., & Olarreaga, M. (2009). Estimating Trade Restrictiveness Indices. *The Economic Journal, 119*(534), 172–199. https://doi.org/10.1111/j.1468-0297.2008.02209.x

Kutlina-Dimitrova, Z., & Narayanan, B. (2015). *The economic impact of the Russian import ban*. Paper presented at the 18th Annual Conference on Global Economic Analysis, Melbourne.

Li, Y., & Beghin, J. C. (2012). A meta-analysis of estimates of the impact of technical barriers to trade. *Journal of Policy Modeling, 34*(3), 497–511. https://doi.org/10.1016/j.jpolmod.2011.11.001

Marette, S., & Beghin, J. (2010). Are Standards Always Protectionist? *Review of International Economics, 18*(1), 179–192. https://doi.org/10.1111/j.1467-9396.2009.00856.x

Martin, W. J., & Pham, C. S. (2015). *Estimating the gravity model when zero trade flows are frequent and economically determined.* (World Bank Policy Research Working Paper 7308). Retrieved from https://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-7308

Otsuki, T., Wilson, J. S., & Sewadeh, M. (2001). Saving two in a billion: quantifying the trade effect of European food safety standards on African exports. *Food Policy, 26*(5), 495–514. https://doi.org/10.1016/S0306-9192(01)00018-5

Peterson, E., Grant, J., Roberts, D., & Karov, V. (2013). Evaluating the Trade Restrictiveness of Phytosanitary Measures on U.S. Fresh Fruit and Vegetable Imports. *American Journal of Agricultural Economics, 95*(4), 842–858. https://doi.org/10.1093/ajae/aat015

Philippidis, G. (2010). EU import restrictions on genetically modified feeds: impacts on Spanish, EU [European Union] and global livestock sectors. *Spanish Journal of Agricultural Research, 8*(1), 3–17.

Rauch, J. E., & Watson, J. (2003). Starting small in an unfamiliar environment. International *Journal of Industrial Organization, 21*(7), 1021–1042. https://doi.org/10.1016/S0167-7187(03)00018-3

Reyes, D. (2011). *International Harmonization of Product Standards and Firm Heterogeneity in International Trade*. (World Bank Policy Research Working Paper 5677). Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1859200

Santos Silva, J. M. C., & Tenreyro, S. (2006). The Log of Gravity. *The Review of Economics and Statistics, 88*(4), 641–658.

Santos Silva, J. M. C., & Tenreyro, S. (2015). Trading Partners and Trading Volumes: Implementing the Helpman–Melitz–Rubinstein Model Empirically. *Oxford Bulletin of Economics and Statistics, 77*(1), 93–105. https://doi.org/10.1111/obes.12055

Schlueter, S. W., Wieck, C., & Heckelei, T. (2009). Regulatory Policies in Meat Trade: Is There Evidence for Least Trade-Distorting Sanitary Regulations? *American Journal of Agricultural Economics, 91*(5), 1484–1490.

Shepherd, B. (2013). *The gravity model of international trade: A user guide*. ARTNeT Books and Research Reports. Retrieved from http://www.unescap.org/sites/default/files/full-report-gravity-model-2013.pdf

UNCTAD. (2013). *Classification of Non-tariff Measures: February 2012 Version*. New York and Geneva.

UNCTAD. (2014). *Guidelines to Collect Data on Official Non-Tariff Measures: September 2013 Version*. New York and Geneva.

Vanzetti, D., Peters, R., & Knebel, C. (2014). *Sand in the Wheels: Non-Tariff Measures and Regional Integration in SADC*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series No 71.) Retrieved from http://unctad.org/en/PublicationsLibrary/itcdtab73_en.pdf

Winchester, N. (2009). Is there a dirty little secret? Non-tariff barriers and the gains from trade. *Journal of Policy Modeling, 31*(6), 819–834. https://doi.org/10.1016/j.jpolmod.2009.08.004

Winchester, N., Rau, M.-L., Goetz, C., Larue, B., Otsuki, T., Shutes, K., … Nunes de Faria, R. (2012). The Impact of Regulatory Heterogeneity on Agri-food Trade. *The World Economy, 35*(8), 973–993. https://doi.org/10.1111/j.1467-9701.2012.01457.x

Yang, S.-H., Reed, M., & Saghaian, S. (2013). International Pork Trade and Foot-and-Mouth Disease. *Journal of International Agricultural Trade and Development, 9*(1), 1–19.

CHAPTER II: THE IMPACT OF DISEASES ON INTERNATIONAL BEEF TRADE: MARKET SWITCHING AND PERSISTENT EFFECTS

This paper was published in *Food Policy* (2018) 93-108.

Food Policy 75 (2018) 93–108

Contents lists available at ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

The impact of diseases on international beef trade: Market switching and persistent effects

Mike Webb, John Gibson*, Anna Strutt

Department of Economics, University of Waikato, Hamilton, New Zealand

ARTICLE INFO

JEL classification:
F14
Q17

Keywords:
Beef
Biosecurity
BSE
FMD
Food safety, Gravity model
International trade

ABSTRACT

We quantify effects of disease outbreaks on agricultural trade with a gravity model of impacts of foot and mouth disease (FMD) and bovine spongiform encephalopathy (BSE) on beef trade. We account for official FMD status and for the impact of recent disease outbreaks. During and after a FMD outbreak, exporting countries substitute away from markets recognized as FMD-free toward lower value markets not recognized as FMD-free. Similarly, a country that has experienced BSE will export less to markets that have not experienced BSE and more to markets that have. Regaining official recognition of FMD-free status may aid recovery but does not negate the effects of a recent FMD outbreak. Models of FMD impacts should incorporate these market-switching effects, while analysis of FMD outbreaks should not focus solely on the loss of markets but rather should incorporate our finding that these loses are somewhat mitigated by market substitution. For countries not free of FMD, if the disease were to be eradicated an exporter should eventually be able to substitute towards higher value FMD-free markets. The value of this change in export market profile should be counted when considering the benefits of FMD eradication programs.

1. Introduction

Animal disease outbreaks, particularly foot and mouth disease (FMD) and bovine spongiform encephalopathy (BSE), may have severe economic consequences for international beef trade.[1] With global exports valued at US$40 billion in 2015, beef is a large contributor to world agriculture trade and so understanding the effects of diseases on beef trade is an important food policy concern. The salience of this issue for exporting countries is increased by the fact that the effects of a disease outbreak on market access may persist long after the outbreak has ended. For example, the full United States ban on Canadian beef imports after a 2003 BSE outbreak in Alberta lasted only four months, but the border opened only partially thereafter and it took four more years to end all restrictions on Canadian beef imports. Thus, as noted by Jones and Davidson (2014), the policy concern with animal disease outbreaks may quickly shift from issues of food safety to issues of market access.

These market access issues may not be well understood in the literature. Trade barriers that importers erect in response to a disease outbreak may force exporters to switch to lower value markets, such as those not FMD-free, so costs of the outbreak may exceed what is shown by studies that focus just on the immediate trade impact. If exports by other countries rise to fill the gaps left by a traditional exporter whose market access is affected by a disease outbreak, it may take several years for the disease-affected exporter to regain market share in higher value markets after the outbreak is over. It may take even longer for a country to be officially recognized as disease-free and this lack of recognition may further hinder market access.

These multiple and time-varying effects on market access may confound studies of how animal disease outbreaks affect international food trade. For example, Yang et al. (2013) use a gravity model to show that a FMD outbreak reduces exports during the period of the outbreak, with the impact possibly varying with whether a vaccination or slaughter policy is in place. This research does not, however, consider differences in response when the importer has FMD, whether there are persistent effects of the outbreak on trade, or whether official recognition of disease-free status reduces trade impacts. A similar possible understatement of long run effects on market access may be present in scenarios provided by Tozer and Marsh (2012) of a hypothetical FMD outbreak in Australia (the second largest beef exporter in the world). Some scenarios assumed that it would take just one year for beef prices to return to baseline levels after implementation of FMD mitigation

* Corresponding author at: Department of Economics, Private Bag 3105, University of Waikato, Hamilton 3240, New Zealand.
E-mail address: jkgibson@waikato.ac.nz (J. Gibson).

[1] See, for example, Lloyd et al. (2006) and Wieck and Holland (2010) on BSE and Knight-Jones and Rushton (2013) and Kompas et al. (2015) for useful surveys on FMD. Estimates of the value of trade are based on UN Comtrade data used throughout this article.

https://doi.org/10.1016/j.foodpol.2018.01.006
Received 30 June 2017; Received in revised form 15 January 2018; Accepted 19 January 2018
Available online 17 February 2018
0306-9192/

measures. This assumption of a relatively quick recovery differs from what we find in the current study, which is that disease outbreaks affect trade for several years after they are contained.

In this paper we use a gravity model of international beef trade, for 195 countries from 1996 to 2013, to study the trade impacts of FMD and BSE. Our approach is novel in taking into account both a country's official disease status and the impact of recent disease outbreaks. The distinction between disease outbreaks and being officially recognized as disease-free also matters for policy makers; there are often costly compliance activities required in order to gain disease-free recognition and some exporters may question the value of gaining this status. By accounting for these factors separately we can address important food policy issues such as whether a disease outbreak has persistent trade effects even after it is eradicated and whether official recognition of disease-free status can facilitate trade after disease eradication. The value of distinguishing between recent disease outbreaks and official disease status is shown by our finding that, in the case of FMD, the substitution by exporters away from markets that are recognized as FMD-free towards lower value markets that are not recognized as FMD-free occurs both during *and* after a disease outbreak. Similarly, a country that has experienced BSE tends to subsequently export less to markets that have not experienced BSE and more to markets that have. While exporting to a lower value market may be a better alternative than not exporting, it is still a negative shock from the exporter point of view. This substitution to lower value markets can create persistent impacts, so that the costs of a disease outbreak may be rather higher than what is shown by models that just consider the immediate impacts on trade. On the other hand, a narrative about the effect of disease outbreaks should not focus solely on markets that become closed, since these loses are somewhat mitigated by market substitution.

Our approach can be applied to any commodity affected by pests or diseases, although meaningful results are more likely for commodities with a small number of significant diseases subject to periodic outbreaks, such as FMD and BSE. It is also worth noting that FMD and BSE themselves have different characteristics: while FMD is highly contagious among animals it is not typically classified as a zoonotic disease since it rarely crosses the species barrier to affect humans; in contrast BSE is not highly contagious but is of concern as it is zoonotic so can affect humans. The growing literature using the gravity model to estimate the impact of food safety standards on trade flows, which we review in Section 2, might be informed by our approach. A disease outbreak typically means that a country no longer meets the requirements of importing markets, so exporters switch to markets that impose less stringent standards – this is analogous to the case of the food standards literature; however, we explicitly consider conditions in the exporting country in a way that the food standards literature does not.

The rest of the paper is structured as follows: Section 2 summarizes prior studies; Section 3 describes our data and the gravity model methodology; Section 4 covers the empirical results; and, Section 5 discusses the implications and concludes the paper.

2. Previous literature

Simulated impacts of animal disease outbreaks in several countries are reported in recently commissioned studies. For example, the Australian Bureau of Agricultural and Resource Economics and Sciences and the New Zealand Ministry of Primary Industries have combined Computable General Equilibrium (CGE) and epidemiology models to assess the economic impact of a foot and mouth disease outbreak (Buetre et al., 2013; Forbes and van Halderen, 2014). Similarly, in the United States, the Department of Homeland Security has modelled the costs of a FMD outbreak originating from a National Bio and Agro-Defense Facility (Pendell et al., 2015). Recent modelling studies focused on the United States are surveyed by Schroeder et al. (2015). These papers generally rely on assumptions about the likely time taken for market access to be restored after an outbreak.

While simulations inform studies of animal diseases, econometric work using cross country data to assess impacts on trade is less common. Important issues for modelling that may not have been thoroughly considered include: whether a disease outbreak has persistent effects even after it is eradicated; and, whether official recognition of disease-free status can facilitate trade after disease eradication. In the broader literature on the impact of product standards and food safety standards on trade flows, the gravity model is the most common approach (Ferro et al., 2015; Wilson et al., 2003). Drawing upon this approach, our modelling is further informed by the body of work applying gravity models to the impact of Sanitary and Phytosanitary (SPS) measures; many of which are aimed at preventing the introduction of diseases. Perhaps the most comprehensive research into SPS measures is Crivelli and Gröschl (2016), who estimate a gravity model examining different effects of SPS measures in the WTO database of specific trade concerns, considering trade at the relatively disaggregated (HS4) level.[2] The SPS measures include: conformity assessments and certification requirements; testing, inspection and approval procedures; and product characteristics, including requirements for quarantine treatment, pesticide residue levels, labeling or geographic application of measures.

Some studies focus more narrowly on meat. Yang et al. (2013) apply a gravity model to international pork trade, finding that a FMD outbreak does reduce exports during the period of the outbreak, with impacts that may depend on whether a vaccination or slaughter policy is in place. Schlueter et al. (2009) utilize a gravity model to assess the effect of six classes of SPS regulatory measures on meat trade between the world's ten largest exporters and ten largest importers. More detailed analysis is available in Schlueter (2009). A more limited analysis by Tapia et al. (2011) considers Germany and Argentina and the sanitary measures affecting their beef trade.

Other than Yang et al. (2013) none of these papers take into account the disease circumstances of an exporting country. This can matter because effects of an importing country's measures may depend on the exporting country's actual or perceived SPS status. Thus, an exporter may find a particular measure more or less stringent due to its disease status.

3. Data and methods

To analyze impacts of FMD outbreaks and of official international recognition of disease-free status we use International Animal Health Organization [OIE] data (http://www.oie.int). The changes in the incidence of FMD and BSE, according to the OIE data for the countries included in our panel, are shown in Fig. 1. On average, between 50 and 70 countries in our panel are recorded as having an FMD outbreak while the number of countries not recognized as FMD-free is about twice as high; although the latter has declined over time as more countries have become officially recognized as FMD free (without vaccination). The number of countries who have reported a BSE outbreak is much lower, but increased with the spate of outbreaks in Japan and various European countries in 2000 and 2001.

We derive two FMD outbreak variables (*FMD outbreak exporter* and *FMD outbreak both*) from OIE databases. Between 1996 and 2004, the OIE data contains the number of reported cases of FMD and the year in which an outbreak was last recorded. From 2005, the OIE uses categories for disease presence or absence; we consider there to be no outbreak if the country was classified as "Never reported" or "Disease not reported during this period".

The duration of trade impacts after an outbreak is of key interest for policy makers and modellers. The conditions and timing for regaining market access are generally not specified *ex ante* by importing countries, and in practice can depend on various features of the exporting and importing countries, including the risk tolerance of the importing

[2] This is more detailed than similar earlier work by Disdier et al. (2008).

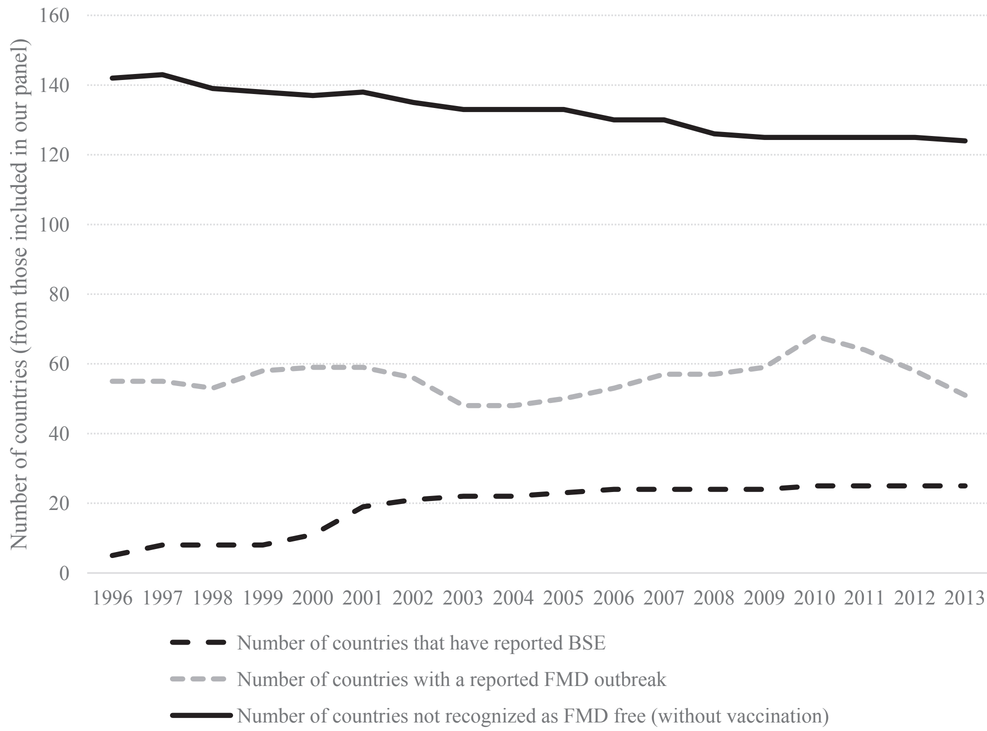


Fig. 1. FMD and BSE incidence.
Source: OIE data and authors' calculations. Based on a panel of 188 exporting countries.

country, protectionist pressures and even the political relationship between the countries. In many markets, exporting countries must first negotiate sanitary approval to export their animal products, which are often conditional on the absence of diseases such as FMD.[3] This means that trade can be discontinued quickly, but regaining access can be a lengthy and uncertain process. The experience of Argentina after FMD outbreaks beginning in 2001 shows different responses from different importers; access to many markets was regained after the OIE recognized part of Argentina as FMD free, but in 2012, after Argentina had failed to regain access to the United States market 6 years after its last reported case of FMD it brought a dispute to the WTO (Bown and Hillman, 2017). Uncertainty around how importers may respond is recognized by Agriculture Ministries. For example, for New Zealand it is noted that "despite [a] generally strong reputation and its importance as a supplier, current health certificates of many trading partners have a clause saying that FMD 'does not occur in New Zealand' and in a few cases that 'New Zealand has been free of FMD for the previous 12 months' and that in practice there could be further delays following an outbreak, including to reactivate supply chains (Forbes and van Halderen (2014).

Given this uncertainty, we consider a range of time windows for our variables capturing recent outbreaks (*Recent FMD exporter* and *Recent FMD both*). These vary from an outbreak in the previous year to an outbreak sometime in the last six years. As we explain in the results section, however, a window of the past five years appears most appropriate. This is within the range in the literature. For example, for New Zealand it is suggested trade would recover the year after, even for a large outbreak (Forbes and van Halderen, 2014) while for Australia a study assumes that after a large outbreak beef exports would recover only slowly, increasing to 80% of original levels the tenth year after the outbreak (Buetre et al., 2013). Earlier work by the Australian Productivity Commission (2002) assumed full recovery by the eighth year.

Separately from outbreaks, the OIE also officially recognize countries as being free from FMD (Fig. 1 shows the gap between these two concepts). Our data on official disease status comes from historical records of OIE resolutions. The variables *FMD risk status exporter* and *FMD risk status both* consider a country to be recognized as FMD-free without vaccination if the OIE recognizes the entire country as FMD-free, if FMD vaccination was not practiced, and if there was no recorded outbreak of FMD that year.

We distinguish between a country with FMD exporting to countries with, and without, FMD since biosecurity and consumer responses may be quite different if the importing country already has FMD. We also control for the official FMD status of the importing country through including the variable *No FMD importer*. We calculate, using unit price data for imports in the dataset described below, that FMD-free markets command higher prices; import prices are 132% higher, on average, than for markets that are not FMD-free.

The other main disease affecting international beef trade is BSE. Data on outbreaks of this disease are also available from the OIE.[4] The dummy variable *BSE occurrence exporter* equals one if the exporting country has experienced at least one case of BSE but their trading partner has not. The variable *BSE occurrence both* equals one if both the exporter and importer have reported at least one case of BSE as recorded in the OIE database which begins in 1989. As with FMD, we distinguish between a country that has reported BSE exporting to countries with, and without, BSE due to the likelihood of different biosecurity and consumer responses. However, unlike with FMD, we do not take into account the BSE risk status as recognized by the OIE because there does not appear to be sufficient variation over the period; for instance, after its three BSE cases between 2003 and 2006, the United States was not able to achieve a "negligible risk" status until 2013.[5] We also control for the BSE status of the importing country

[3] For example, in the case of the United States, such requirements are contained in title 9, chapter III, part 327 of the Code of Federal Regulations.

[4] http://www.oie.int/animal-health-in-the-world/bse-specific-data/annual-incidence-rate/4.

[5] Unlike for FMD, we do not distinguish between an outbreak period and the periods after an outbreak because of the limited number of cases – in our panel just 26 countries had an instance of BSE.

through including the variable *No BSE importer*.

Beef trade data are the aggregate of total annual imports of products in HS headings 0201 (fresh beef) and 0202 (frozen beef) from the UN COMTRADE database; we use import data as they are likely more accurate.[6] GDP data are from the *World Development Indicators*. Beef production data are from FAO for "cattle meat" production, which covers beef and veal.[7] As these values were expressed in tonnes of dressed carcass weight, we multiplied them by the average import price of carcasses (HS020110 and 020220) in that year to get data in monetary terms.[8] Typical gravity model controls affecting trading costs and thus trade flows – distance, contiguity, colonial history and a common legal system – are from the widely used CEPII database.[9] The existence of a regional trade agreement between two trading partners is based on data available in the CEPII database. As these data are only available until 2006, we update by adding new agreements that enter into force from 2006 and are notified to the WTO.[10]

Tariffs are from the World Trade Organization's Integrated Tariff Data Base (IDB).[11] This contains both the MFN tariff rate applied generally to all countries and the preferential rate applied to some countries, for instance when a RTA is in place. Data are missing for some years but since tariffs typically are relatively stable over time, where there was a gap between reported rates, the rate from the last available year was assumed to be in place until superseded by a new reported rate. Specific tariff rates were converted to *ad valorem* equivalents using data on the average price of imports in the same HS 6 digit subheading for that year, adjusted by national currency information within the WTO dataset.

Our data starts in 1996 – the first year the OIE data, detailed above, became available. Also, in 1996 a link was found between consuming BSE-infected meat and a variant of Creutzfeldt-Jackob disease, transforming BSE into a major concern in international trade. Our time-series ends in 2013. In terms of the cross-sectional element of our panel, we have data for 195 countries. As we exclude countries that did not export any beef between 1996 and 2013, we have 188 exporting countries, although some data are missing for some countries in some years.

Table 1 has some stylised facts to motivate our econometric analysis, by comparing the profile of import markets across different types of disease status. For beef exporters who do not have a currently reported FMD outbreak, just over three-quarters (77%) of the value of beef exports goes to markets that are recognized as FMD free (without vaccination). Conversely, for countries currently reporting a FMD outbreak only 31% of their exports, by value, go to markets that are recognized as FMD free (without vaccination) and these markets are just 28% of the countries they export to. The same patterns exist if we consider whether an exporter is officially recognized as FMD free (without vaccination), or whether exporters and importers have ever reported BSE. Thus, being free of an animal disease, and being recognized as such, allows an exporter to trade more with higher value import markets that are disease-free. However, it is important to note that for exporters who are not disease-free, there are still markets available given that many countries are not recognized as FMD-free (Fig. 1). Obviously, there are other reasons that might explain these patterns, if, say, countries not recognized as FMD are geographically closer. To untangle these possible effects, econometric analysis is necessary.

Table 2 has another way of considering possible effects of FMD and BSE, based on the unconditional mean probability of beef trade occurring between countries (and the average value of that trade where it occurs). For an exporter without a FMD outbreak and an importer that is recognized as FMD-free, there is a 9.4% chance of trade occurring (and it has an average value of $26.6 million if it occurs). However, the odds of trade occurring fall to only 2.9% if the exporter has an FMD outbreak and the conditional value of trade falls by almost two-thirds. In contrast, if the importer is not recognized as FMD-free then the adjustment by the exporter is rather less, and in fact if an exporting country loses its FMD free status the average value of exports (when they occur) to the importer who is not FMD-free increases. Table 2 suggests that markets may be adjusting to disease outbreaks, which provides a hypothesis for testing with the econometric estimation that can control for other variables that affect trade between country pairs. We see a stronger suggestion of market switching in the case of BSE, where both the probability of exporting to a market that has reported BSE and the value of trade when it occurs are higher if an exporting country has reported BSE.

3.1. Gravity modelling methodology

A gravity model posits that trade between two countries depends on their incomes and bilateral transaction costs, such as those arising from distance, which are often referred to as "multilateral resistance".[12] Disease or pest status can enter the model as another multilateral resistance term; as used by Yang et al. (2013). Methodological underpinnings of gravity modelling and estimation issues are addressed in Anderson and Wincoop (2003) and Helpman et al. (2008), among others. A useful summary is provided by Shepherd (2013), while Bergeijk and Brakman (2010) present a survey of gravity models.

Two principal estimation techniques are applied in contemporary work: the Poisson pseudo-maximum likelihood (ppml) approach, as applied in Yang et al. (2013) and Schlueter et al. (2009); and, the Heckman selection approach, as applied in Crivelli and Gröschl (2016) and Ferro et al. (2015). Both allow for the fact that zero trade flows are frequent, particularly in disaggregated data, and these zero trade flows are often explained by high trade costs. The Heckman selection approach has the advantage of estimating the impact of disease outbreaks on both the probability of trade occurring between countries – the "selection equation" may show if prohibitive restrictions are imposed – and impacts on the volume of trade, where the "outcome equation" could show how trade is reduced by compliance requirements.

There are two main ways to implement Heckman selection estimates. One has selection and outcome equations estimated simultaneously using a maximum likelihood estimator. (See Shepherd (2013) for more detail and Crivelli and Gröschl (2016) for an example.) Alternatively, Helpman, Melitz and Rubinstein (2008) propose an estimator to control for firm heterogeneity using two-step estimation. This estimator is widely referred to as the HMR estimator after the surnames of the three co-authors. (See WTO (2012) for a discussion and Ferro et al. (2015) for an example.) We use both but focus our discussion on the results of the HMR estimator. As a robustness check we also estimate the first step of the HMR estimator with a logit rather than probit specification. These results, set out in our sensitivity

[6] From http://comtrade.un.org/ which is reported in current US$. As these are official statistics they exclude product smuggled or otherwise informally traded. They also exclude beef offal, which is part of HS 0206 that also includes offal from sheep, pigs, goats, and horses.

[7] http://faostat3.fao.org/faostat-gateway/go/to/download/Q/*/E8.

[8] http://databank.worldbank.org/data/databases/commodity-price-data9.

[9] http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp. As an example, Crevelli and Groschl (2012) use GDP, population, distance, adjacency, common language, "ever colony", "common colonizer", "colonizer post 1945" and "common religion" as their gravity controls. A weighted average tariff is included for robustness.

[10] http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx. A RTA is considered to be in force for a given year if its date of entry into force was on or before 1 January of that year.

[11] http://tariffdata.wto.org.

[12] Recent examples applied to agricultural trade include Ferro et al. (2015), Yang et al. (2013), Crivelli and Gröschl (2016) and Schlueter et al. (2009).

Table 1
Descriptive profile of markets for exporters according to disease status.
Source: Authors calculations based on OIE and COMTRADE data.

	Percentage of Trade (by Value)		Percentage of Trade (by number of markets)	
	Importer recognized as FMD free	Importer not recognized as FMD free	Importer recognized as FMD free	Importer not recognized as FMD free
No FMD outbreak exporter	77.50%	22.50%	53.57%	46.43%
FMD outbreak exporter	31.20%	68.80%	27.61%	72.39%
Exporter recognized as FMD free	84.57%	15.43%	56.59%	43.41%
Exporter not recognized as FMD free	38.61%	61.39%	33.62%	66.38%
	Percentage of Trade (by Value)		Percentage of Trade (by number of markets)	
	Importer has never reported BSE	Importer has reported BSE	Importer has never reported BSE	Importer has reported BSE
Exporter has never reported BSE	76.84%	23.16%	76.84%	23.16%
Exporter has reported BSE	61.24%	38.76%	61.24%	38.76%

Table 2
Unconditional probability of trade occurring (and value of trade) for various exporter-importer pairs according to disease status.
Source: Authors calculations based on OIE and COMTRADE data. To more accurately show extensive margin changes only countries with a change in FMD outbreak, FMD recognition status or BSE outbreaks are included in each of these calculations.

	Probability of Trade Occurring		Average Value of Trade (Where it Occurs) (US$)	
	Importer recognized as FMD free	Importer not recognized as FMD free	Importer recognized as FMD free	Importer not recognized as FMD free
No FMD outbreak exporter	9.37%	4.52%	26,642,864	9,697,284
FMD outbreak exporter	2.87%	2.73%	9,821,184	4,857,565
Exporter recognized as FMD free	8.20%	2.87%	28,787,783	4,170,861
Exporter not recognized as FMD free	2.08%	1.36%	10,608,614	6,247,133
	Probability of Trade Occurring		Average Value of Trade (Where it Occurs) (US$)	
	Importer has never reported BSE	Importer has reported BSE	Importer has never reported BSE	Importer has reported BSE
Exporter has never reported BSE	14.50%	49.47%	17,474,373	24,143,802
Exporter has reported BSE	11.45%	54.76%	8,955,393	33,499,135

analyses, are consistent with the main results from the HMR specification but show a greater selection effect of FMD and BSE on the probability that a country exports to a market free of these diseases.

Given the economic theory underpinning modern gravity models, demand and supply must both be incorporated into the model (Anderson and Wincoop, 2003). In our model, the GDP of the importing country reflects demand and their own beef production captures any production shocks that might affect their import demand. Supply is incorporated principally through beef production in the exporting country but we also allow for any changes in the GDP of the exporting country which may lead to increased domestic demand and thus less beef being exported. We include typical gravity control variables, along with both exporter and importer fixed effects that control for country specific factors affecting beef imports or exports. We initially included time fixed effects, but these showed clear evidence of a time trend and were absorbing some of the information related to outbreaks in particular years, so we use a linear time trend instead. Our initial specification is summarized in Table 3, and the equations are as follows:

Probit selection equation:

$$\begin{aligned}\Pr(\text{comtradebeef}_{ijt} > 0) = \Phi[&\alpha_i + \alpha_j + \beta_1\text{GDP importer}_{it} + \beta_2\text{GDP exporter}_{jt}\\ &+ \beta_3\text{Beef production exporter}_{it} + \beta_4\text{Beef production importer}_{jt} + \beta_5\text{Tariff}_{ij} + \beta_7\text{Distance}_{ij}\\ &+ \beta_7\text{Contiguity}_{ij} + \beta_8\text{Colony}_{ij} + \beta_9\text{Common legal system}_{ij} + \beta_{10}\text{RTA}_{ijt}\\ &+ \beta_{11}\text{Common language}_{ij} + \beta_{12}\text{No FMD importer}_{jt} + \beta_{13}\text{FMD outbreak exporter}_{ijt}\\ &+ \beta_{14}\text{FMD outbreak both}_{ijt} + \beta_{15}\text{FMD risk status exporter}_{ijt} + \beta_{16}\text{FMD risk status both}_{ijt}\\ &+ \beta_{17}\text{Recent FMD exporter}_{ijt} + \beta_{18}\text{Recent FMD both}_{ijt} + \beta_{19}\text{No BSE importer}_{jt}\\ &+ \beta_{20}\text{BSE occurrence exporter}_{ijt} + \beta_{21}\text{BSE occurrence both}_{ijt} + \beta_{22}\text{year}_t + \varepsilon_{ijt}]\end{aligned}$$

Outcome equation:

$$\begin{aligned}\ln(\text{comtradebeef}_{ijt}|\text{comtrade}_{\text{beef}_{ijt}} > 0) = &\alpha_i + \alpha_j + \beta_1\text{GDP importer}_{it} + \beta_2\text{GDP exporter}_{jt}\\ &+ \beta_3\text{Beef production exporter}_{it}\\ &+ \beta_4\text{Beef production importer}_{jt} + \beta_5\text{Tariff}_{ij} + \beta_7\text{Distance}_{ij} + \beta_7\text{Contiguity}_{ij} + \beta_8\text{Colony}_{ij}\\ &+ \beta_9\text{Common legal system}_{ij} + \beta_{10}\text{RTA}_{ijt} + \beta_{11}\text{No FMD importer}_{jt}\\ &+ \beta_{12}\text{FMD outbreak exporter}_{ijt} + \beta_{13}\text{FMD outbreak both}_{ijt} + \beta_{14}\text{FMD risk status exporter}_{ijt}\\ &+ \beta_{15}\text{FMD risk status both}_{ijt} + \beta_{16}\text{Recent FMD exporter}_{ijt} + \beta_{17}\text{Recent FMD both}_{ijt}\\ &+ \beta_{18}\text{No BSE importer}_{jt} + \beta_{19}\text{BSE occurrence exporter}_{ijt}\\ &+ \beta_{20}\text{BSE occurrence both}_{ijt} + \beta_{21}\text{year}_t + \varepsilon_{ijt}\end{aligned}$$

The selection equation for the Heckman and HMR estimators requires that a variable affects the probability of trade occurring between two countries but not the volume of trade, if it occurs. We use common language between the importer and exporter. To determine if this variable was appropriate, we first estimated the equation with common language in both the selection and outcome equation, with a variable

Table 3
Summary of variables included in initial specification.

Variable	Description	Expected effect on the value of trade (if it occurs)	Expected effect on the probability of trade occurring
FMD outbreak exporter	Exporter has a FMD outbreak; importer recognized as FMD free	Negative	Negative
FMD outbreak both	Exporter has a FMD outbreak; importer not recognized as FMD free	Uncertain	Uncertain
No FMD importer	Importer recognized as FMD free	Uncertain	Uncertain
FMD risk status exporter	Exporter not recognized as FMD free; importer recognized as FMD free	Negative	Negative
FMD risk status both	Exporter not recognized as FMD free; importer not recognized as FMD free	Positive/Uncertain	Positive/Uncertain
Recent FMD exporter	Exporter has had a FMD outbreak in preceding (5) years; importer recognized as FMD free	Negative	Negative
Recent FMD both	Exporter has had a FMD outbreak in preceding (5) years; importer not recognized as FMD free	Positive/Uncertain	Positive/Uncertain
BSE occurrence exporter	Exporting country has had a case of BSE but importing country has not	Negative	Negative
BSE occurrence both	Both trading partners have had a case of BSE	Uncertain	Uncertain
No BSE importer	Importing country has had a case of BSE	Uncertain	Uncertain
Year	Time trend	Positive	Positive
GDP importer	Nominal GDP in importing country (expressed in logarithmic form)	Positive	Positive
GDP exporter	Nominal GDP in exporting country (expressed in logarithmic form)	Negative	Negative
Beef production exporter	Nominal beef production in exporting country (expressed in logarithmic form)	Positive	Positive
Beef production importer	Nominal beef production in importing country (expressed in logarithmic form)	Negative	Negative
Tariff	Applicable tariff rate for beef imports	Negative	Negative
Distance	Distance between trading partners	Negative	Negative
Contiguity	Trading partners are contiguous	Positive	Positive
Colony	A colonial relationship has ever existed between partners	Positive	Positive
Common legal system	Trading partners have a common legal system	Positive	Positive
RTA	A RTA is in force between trading partners	Positive	Positive
Common language	Official language is the same	NA[a]	Positive

[a] Common language is the exclusion restriction and so only appears in the selection equation.

for common religion in the selection equation.[13] This showed that common language had no statistically significant effect on the volume of trade, so it was an appropriate choice for the exclusion restriction.

4. Results

The results of the selection and outcome equations for our initial specification (as outlined in Table 3) are reported in Table 4. If a country that had no recent history of FMD – i.e. no outbreak within the preceding five years – has an outbreak, they can be expected to export to approximately 12–13% fewer FMD-free markets, but to 5–7% more markets not recognized as FMD-free.[14] These effects are shown by the coefficients on *FMD outbreak exporter* and *FMD outbreak both*. Independently of currently having an FMD outbreak, and of official disease status, a recent outbreak (defined as occurring any time in the preceding five years) reduces the probability of exporting to a FMD free market by between 11% and 13%, while raising the odds of exporting to a non FMD free market by up to 6%. In addition to these market participation effects, the value of exports is up to 17% lower for a same-year FMD outbreak and about 23% lower for a recent outbreak (using the results of the HMR model in column (1) of Table 4).[15] These trade effects are conditional on beef production in the exporting country, so to the extent that an FMD outbreak reduces production (e.g. due to slaughter and disposal) there is an additional pathway to reduced exports (given the elasticity of 0.7 for export values with respect to production in the exporting country).

Even after controlling for FMD outbreaks, whether current or in the past five years, there appear to be additional effects on beef trade from the official recognition of disease risk status. A country not recognized as FMD-free is 8% more likely to export to countries also not recognized as FMD-free, according to results for the variable *FMD risk status both*. However, we caution that the FMD status variables are highly correlated with current or past outbreaks, so it is difficult to separate the two sets of effects. In order to ensure that our findings are not contaminated by multicollinearity, we also report estimates that omit these risk status variables, in columns (3), (4), (7) and (8). The general pattern of results for the current and recent FMD outbreak variables are the same, with or without the risk status variables, although the selection towards import markets that also have FMD gets a bit stronger.

The models in Table 4 are also informative about trade effects of BSE. A country that has developed BSE is about 12% less likely to export to a market that has not had BSE. The value of trade that does take place is reduced by 20% according to the HMR model, and by 30% according to the Heckman model. Again there is evidence of market switching, with a country that has had BSE exporting significantly more to other countries that have also had BSE.

For the control variables, a 10% rise in importing country GDP increases beef demand from each supplying country by just over five percent, and appears slightly higher with the Heckman model than with the HMR estimator. Richer countries get beef from more countries.[16] Beef production in the exporting country affects the value of exports to

[13] This is from http://scholar.harvard.edu/helpman/pages/data-1. We only use this to check if common language is a plausible exclusion restriction because using the common religion variable limits our sample size.

[14] Outbreaks may occur partway through the year so annual imports will be non-zero even if they are prohibited for the rest of the year; hence, estimates of the reduction in the number of markets are likely to be conservative.

[15] Since the dependent variable is in logarithms, percentage changes are estimated as $([\exp(_j) - 1] \times 100)$.

[16] We use GDP of the exporting country to proxy for income changes that might affect domestic beef demand and thus beef exports, but did not find this to be significant.

Table 4
Results from estimation of initial specification (where a FMD outbreak affects exports for the following 5 years).

	Helpman, Melitz & Rubinstein Model				Heckman Selection Model			
	Including Status Variables		Excluding Status Variables		Including Status Variables		Excluding Status Variables	
	Outcome (1)	Selection (2)	Outcome (3)	Selection (4)	Outcome (5)	Selection (6)	Outcome (7)	Selection (8)
FMD outbreak exporter	−0.191*	−0.121***	−0.121	−0.130***	−0.167	−0.124***	−0.120	−0.134***
	(0.0984)	(0.0288)	(0.0922)	(0.0274)	(0.118)	(0.0353)	(0.106)	(0.0321)
FMD outbreak both	−0.0157	0.0505**	−0.00431	0.0693***	−0.0506	0.0519*	−0.0213	0.0703***
	(0.0814)	(0.0239)	(0.0780)	(0.0230)	(0.103)	(0.0283)	(0.0934)	(0.0258)
No FMD importer	−0.643***	−0.0841**	−0.594***	−0.117***	−0.638***	−0.0766	−0.629***	−0.110***
	(0.112)	(0.0380)	(0.107)	(0.0352)	(0.130)	(0.0482)	(0.118)	(0.0424)
FMD risk status exporter	0.240**	0.00190	…..	…..	0.200	−0.000864	…..	…..
	(0.110)	(0.0341)			(0.148)	(0.0469)		
FMD risk status both	0.120	0.0836**	…..	…..	0.183	0.0805*	…..	…..
	(0.109)	(0.0327)			(0.152)	(0.0429)		
Recent FMD exporter	−0.262***	−0.113***	−0.219***	−0.134***	−0.261***	−0.109***	−0.246***	−0.131***
	(0.0769)	(0.0262)	(0.0735)	(0.0240)	(0.0876)	(0.0333)	(0.0865)	(0.0318)
Recent FMD both	−0.366***	0.0397*	−0.377***	0.0611***	−0.417***	0.0407	−0.405***	0.0618**
	(0.0772)	(0.0232)	(0.0724)	(0.0217)	(0.0975)	(0.0276)	(0.0988)	(0.0271)
BSE occurrence exporter	−0.233***	−0.122***	−0.229***	−0.123***	−0.356***	−0.124***	−0.356***	−0.125***
	(0.0718)	(0.0233)	(0.0718)	(0.0233)	(0.0969)	(0.0325)	(0.0972)	(0.0325)
BSE occurrence both	0.142*	0.0516	0.134	0.0582*	0.441***	0.0623	0.440***	0.0689
	(0.0845)	(0.0315)	(0.0844)	(0.0314)	(0.135)	(0.0568)	(0.136)	(0.0568)
No BSE importer	0.00578	−0.0260	−0.00202	−0.0232	0.112	−0.0203	0.108	−0.0176
	(0.0868)	(0.0288)	(0.0867)	(0.0288)	(0.123)	(0.0399)	(0.124)	(0.0399)
Gravity Model Control Variables								
GDP importer	0.544***	0.0628***	0.542***	0.0634***	0.566***	0.0627**	0.564***	0.0633**
	(0.0738)	(0.0225)	(0.0738)	(0.0225)	(0.104)	(0.0311)	(0.104)	(0.0311)
GDP exporter	−0.0963	−0.0163	−0.104	−0.0191	−0.146	−0.0177	−0.157	−0.0202
	(0.0770)	(0.0232)	(0.0768)	(0.0231)	(0.104)	(0.0310)	(0.103)	(0.0311)
Beef production exporter	0.699***	0.00668	0.696***	0.00606	0.703***	0.0105	0.701***	0.00987
	(0.0812)	(0.0238)	(0.0811)	(0.0239)	(0.0990)	(0.0312)	(0.0989)	(0.0312)
Beef production importer	−0.108	0.00589	−0.113*	0.00444	−0.116	0.00357	−0.121	0.00215
	(0.0664)	(0.0187)	(0.0664)	(0.0187)	(0.0824)	(0.0262)	(0.0825)	(0.0263)
Tariff	0.00194*	−0.00153***	0.00182*	−0.00148***	0.00133	−0.00154***	0.00130	−0.00149***
	(0.00103)	(0.000304)	(0.00102)	(0.000302)	(0.00184)	(0.000558)	(0.00184)	(0.000558)
Distance	−1.53***	−0.680***	−1.52***	−0.681***	−1.607***	−0.683***	−1.608***	−0.684***
	(0.136)	(0.00999)	(0.136)	(0.00999)	(0.0784)	(0.0228)	(0.0781)	(0.0228)
Contiguity	0.556***	0.312***	0.557***	0.312***	0.938***	0.321***	0.940***	0.321***
	(0.0925)	(0.0267)	(0.0927)	(0.0267)	(0.180)	(0.0659)	(0.180)	(0.0659)
Common language	…..	0.309***	…..	0.308***	…..	0.306***	…..	0.305***
		(0.0188)		(0.0188)		(0.0424)		(0.0424)
Colony	0.580***	0.339***	0.578***	0.339***	0.677***	0.330***	0.677***	0.330***
	(0.110)	(0.0286)	(0.111)	(0.0286)	(0.208)	(0.0708)	(0.208)	(0.0708)
Common legal system	0.437***	0.130***	0.435***	0.130***	0.473***	0.134***	0.473***	0.134***
	(0.0510)	(0.0120)	(0.0511)	(0.0120)	(0.0942)	(0.0275)	(0.0942)	(0.0276)
RTA	0.454***	0.232***	0.438***	0.238***	0.370***	0.238***	0.363***	0.243***
	(0.0743)	(0.0177)	(0.0742)	(0.0175)	(0.132)	(0.0393)	(0.130)	(0.0391)
Year	0.00930	0.0203***	0.0102	0.0206***	0.0174*	0.0208***	0.0187*	0.0210***
	(0.00883)	(0.00268)	(0.00882)	(0.00267)	(0.0103)	(0.00348)	(0.0102)	(0.00347)
Importer/Exporter FE	YES	YES	YES	YES	YES	YES	YES	YES
Number of Observations	23,628	385,100	23,628	385,100	23,628	387,349	23,628	387,349
Number of Censored Obs		361,472		361,472		363,721		363,721
Lambda						0.740***		0.740***
						(0.0574)		(0.0573)

Note: Robust standard errors in parentheses.
*** $p < .01$.
** $p < .05$.
* $p < .1$

a given market but not the probability of trade occurring. A RTA between countries raises the likelihood of trade occurring by 23–24% and the volume of trade is increased by 57% in the HMR model and by 45% in the Heckman model. These large effects may be because RTAs promote transparency (Lejárraga et al., 2013) and potentially reduce non-tariff barriers (see, for instance, Winchester, 2009) and are in addition to the effects of a reduction in tariffs – which have a negative effect on the probability of trade occurring but a less precisely estimated effect on the value of trade, if it occurs. The distance and contiguity between countries, their common legal system, and a colonial history all have the expected effects.

The final notable result from Table 4 is that if the selection and outcome equation are estimated simultaneously, a statistically significant positive selection term (lambda, on the inverse Mills ratio) is apparent.[17] Thus, the unobserved factors that affect the probability of beef trade between two countries also affect the volume of that trade. This correlation in the unobservable terms highlights the importance of

[17] Also notable is that the fixed effects for exporters and importers are jointly statistically significant, as confirmed by likelihood ratio tests.

using selection models rather than restricting the sample to the (non-random) sub-set of country-pairs where trade actually occurred.

4.1. Robustness analyses: searching over alternative windows for "recent" outbreaks

To see if the results in Table 4 depend on how "recent" is defined, we estimated HMR and Heckman models for windows ranging from one year (i.e. an outbreak the previous year) to six years. The results are in Table A1 for our full specification and in Table A2 for a truncated specification without the risk status variables. The effect of a recent outbreak on both market participation and the value of trade becomes stronger as the time window lengthens, albeit with effects on market participation that begin to decrease from the five year window onwards. For the smallest possible window, that considers outbreaks occurring one year previously, the pattern of results are quite different than in all of the other variants. We also considered model selection tests based on Akaike and Bayesian Information Criterion (AIC and BIC), where the lower values that are preferred are seen when using the longer windows. On balance we consider a five-year window to be the best compromise between statistical fit for the model as a whole and the significance of key disease outbreak variables. The remainder of our analysis focuses on results from this framework.

4.2. Sensitivity analyses: an alternative, more structured, specification

The model outlined in Table 3, with estimates in Table 4, is relatively unstructured, in the sense that contemporaneous and previous disease outbreaks, and the official recognition of disease status, all entered the model in an unconstrained way. A more structured specification that captures a common progression where a country may eradicate a disease, and then obtain official recognition of disease-free status but still encounter market access challenges if FMD has only recently been eradicated is outlined in Table 5. This model uses four new variables: ***FMD risk without outbreak exporter***, ***FMD risk without outbreak both***, ***FMD recent without risk status exporter***, and ***FMD recent without risk status both***. These variables capture different combinations of either having FMD or not, and official recognition as FMD-free or not. The equations for this specification are as follows:

Probit selection equation:

$$\begin{aligned}
&\Pr(\text{comtradebeef}_{ijt} > 0) = \Phi[\alpha_i + \alpha_j + \beta_1\text{GDP importer}_{it} + \beta_2\text{GDP exporter}_{jt}\\
&+ \beta_3\text{Beef production exporter}_{it} + \beta_4\text{Beef production importer}_{jt} + \beta_5\text{Tariff}_{ij} + \beta_7\text{Distance}_{ij}\\
&+ \beta_7\text{Contiguity}_{ij} + \beta_8\text{Colony}_{ij} + \beta_9\text{Common legal system}_{ij} + \beta_{10}\text{RTA}_{ijt}\\
&+ \beta_{11}\text{Common language}_{ij} + \beta_{12}\text{No FMD importer}_{jt} + \beta_{13}\text{FMD outbreak exporter}_{ijt}\\
&+ \beta_{14}\text{FMD outbreak both}_{ijt}\\
&+ \beta_{15}\text{FMD risk without outbreak exporter}_{ijt} + \beta_{16}\text{FMD risk without outbreak both}_{ijt}\\
&+ \beta_{17}\text{FMD recent without risk status exporter}_{ijt} + \beta_{18}\text{FMD recent without risk status both}_{ijt}\\
&+ \beta_{19}\text{No BSE importer}_{jt} + \beta_{20}\text{BSE occurrence exporter}_{ijt}\\
&+ \beta_{21}\text{BSE occurrence both}_{ijt} + \beta_{22}\text{year}_t + \varepsilon_{ijt}]
\end{aligned}$$

Outcome equation:

$$\begin{aligned}
&\ln(\text{comtrade}_{\text{beef}_{ijt}}|\text{comtrade}_{\text{beef}_{ijt}} > 0)\\
&= \alpha_i + \alpha_j + \beta_1\text{GDP importer}_{it} + \beta_2\text{GDP exporter}_{jt} + \beta_3\text{Beef production exporter}_{it}\\
&+ \beta_4\text{Beef production importer}_{jt} + \beta_5\text{Tariff}_{ij} + \beta_7\text{Distance}_{ij} + \beta_7\text{Contiguity}_{ij} + \beta_8\text{Colony}_{ij}\\
&+ \beta_9\text{Common legal system}_{ij} + \beta_{10}\text{RTA}_{ijt} + \beta_{11}\text{No FMD importer}_{jt}\\
&+ \beta_{12}\text{FMD outbreak exporter}_{ijt} + \beta_{13}\text{FMD outbreak both}_{ijt}\\
&+ \beta_{14}\text{FMD risk without outbreak exporter}_{ijt} + \beta_{15}\text{FMD risk without outbreak both}_{ijt}\\
&+ \beta_{16}\text{FMD recent without risk status exporter}_{ijt} + \beta_{17}\text{FMD recent without risk status both}_{ijt}\\
&+ \beta_{18}\text{No BSE importer}_{jt} + \beta_{19}\text{BSE occurrence exporter}_{ijt}\\
&+ \beta_{20}\text{BSE occurrence both}_{ijt} + \beta_{21}\text{year}_t + \varepsilon_{ijt}
\end{aligned}$$

The HMR and Heckman selection estimates of this more structured model are reported in Table 6.[18] The interpretation of FMD estimates from this specification can be illustrated by considering an exporter that is making advances in the eradication of FMD. If a country eradicates FMD, the coefficient on the *FMD outbreak exporter* suggests it can expect to export to 22% more FMD-free markets. Almost as many markets (specifically, 19%) that are not FMD-free would be substituted away from.

If an exporter is then able to obtain official recognition of being FMD-free (without vaccination), they could expect to continue to substitute away from those markets that are not FMD-free towards higher value markets that are FMD-free. Specifically, the results in Table 6 suggest that an exporting country which does not have an FMD outbreak but is not recognized as FMD-free is 6% less likely to export to a FMD-free market, according to the coefficient on *FMD risk without outbreak exporter*. Conversely, this exporter is 12% more likely to export to a non FMD-free market, according to the coefficient on *FMD risk without outbreak both*. In other words, independently of actual outbreaks, there is a trade effect that follows from official recognition of disease-free status; these results are consistent with the estimates from our first, less structured, specification.

Obtaining FMD-free status is not sufficient to negate the trade effects of a recent FMD outbreak. An exporter that was recognized as FMD-free without vaccination but that had an FMD outbreak within the preceding five years is likely to export to 10% fewer countries that are without FMD, according to the coefficient on the *FMD without risk status exporter* variable. For this exporter, the export values to all markets are also reduced quite substantially.

4.3. Sensitivity analysis: alternative estimators

4.3.1. Use of a logit specification

As a robustness check, we estimated the HMR estimator with a logit specification for the market participation (selection) equation rather than with a probit equation as used previously. The results are set out in Tables A3 and A4, which can be compared with Tables 4 and 6 respectively.

The main difference is that both FMD and BSE appear to have a much larger effect on the probability of trade occurring in the logit specification; these effects are typically twice as large as the earlier estimates. For example, the estimates from the logit estimator imply that during a FMD outbreak the probability of exporting to a FMD free market is reduced by 29% whereas there was just a 13% reduction with the probit specification. Conversely, the probability of exporting to a market that is not FMD-free increases by 13% for a current outbreak, compared to a 7% rise shown by the probit specification (these effects are shown by *FMD outbreak exporter* and *FMD outbreak both*). Using a window of the five years following an outbreak, the logit model suggests that the probability of exporting to a FMD-free market is reduced by 24–26% while this persistent effect was estimated by probit as just a 13% fall in the odds of exporting to these markets (as seen from *Recent FMD exporter*). Meanwhile, an outbreak within the previous five years increases the odds of exporting to a market that is not FMD-free by between 9% and 11%, whereas this substitution into lower valued markets was just 6% with the probit specification. For outbreaks of BSE, the logit model suggests that a country that has developed BSE is 23% less likely to export to a market that has not had BSE (and conditional on trade occurring, the value of exports goes down 19%); in contrast, the probit specification had a fall in the odds of exporting to BSE-free markets of just 12%.

The increased effects of outbreaks, of risk, and of official recognition, on the likelihood of trade occurring under the logit model compared to the probit model also shows up in our more structured specification (the one based on Table 5). The estimates from the logit estimator imply that if a country eradicates FMD, it can expect to export to 49% more FMD free markets, whereas the expected increase was just 22% with the probit estimator. Conversely, eradicating FMD facilitates substitution away from non-FMD markets: the logit estimator implies

[18] With the alternative specification, there is minimal change in the estimated coefficients on variables other than those relating to FMD so these results are not discussed.

Table 5
Summary of alternative FMD variables.

Variable	Description	Expected sign in Outcome Equation	Expected sign in Selection Equation
FMD outbreak exporter	If exporter country has a FMD outbreak and importer is recognized as FMD free	Negative	Negative
FMD outbreak both	If exporter has a FMD outbreak and importer is not recognized as FMD free	Uncertain	Uncertain
No FMD importer	If importing country is recognized as FMD free	Uncertain	Uncertain
FMD risk without outbreak exporter	If exporter does not have a FMD outbreak, but is not recognized as FMD free while importer is recognized as FMD free	Negative	Negative
FMD risk without outbreak both	If exporter does not have a FMD outbreak and both importer and exporter are not recognized as FMD free	Positive/Uncertain	Positive/Uncertain
FMD recent without risk status exporter	If exporter has had a FMD outbreak in preceding 5 years but is recognized as FMD free; importer is recognized as FMD free	Negative	Negative
FMD recent without risk status both	If exporter has had a FMD outbreak in preceding 5 years but is recognized as FMD free; importer not recognized as FMD free	Positive/Uncertain	Positive/Uncertain

that a country exports to 31% fewer markets that are not FMD-free whereas the probit estimator suggests that this substitution effect was to just 19% fewer markets that are not FMD-free (these effects are shown by *FMD outbreak exporter* and *FMD outbreak both* in Tables 6 and A4). With the logit estimator, an exporter that is recognized as FMD-free without vaccination but which has experienced FMD within the preceding five years is likely to export to 23% fewer countries without FMD, whereas the estimated effect was 10% from probit estimation (see *FMD recent without risk status exporter* and *FMD recent without risk status both*).

4.3.2. Estimation with Poisson Pseudo-Maximum Likelihood estimation

The microfoundations of the HMR estimator are widely accepted, and this class of estimator remains the only gravity modelling approach generally accepted and able to disentangle outcome and selection effects. Recent papers, have, however, emphasized the importance of the distributional assumptions, stressing, in particular, the sensitivity of results from the HMR estimator to the presence of heteroskedasticity. (See Santos Silva and Tenreyro, 2015; Martin and Pham, 2015.) We therefore estimate our regressions using the other estimator commonly applied for gravity model estimation: the Poisson Pseudo-Maximum Likelihood (PPML) estimator proposed in Santos Silva and Tenreyro (2006).

These results are set out in Table A5. When FMD status is included, in column (1), this appears to be the decisive variable: a country not recognized as free of foot and mouth is expected to export 47% less to markets recognized as FMD free and 149% more to markets that are also not recognized as FMD free (these come from the coefficients of -0.64 and 0.91 on *FMD risk status exporter* and *FMD risk status both*). With PPML estimation, neither a current nor a recent outbreak have statistically significant effects on the value of exports. However, as noted earlier, the FMD status variables are highly correlated with current or past outbreaks, so it is difficult to separate these effects.

Column 2 in Table A5 therefore excludes these risk status variables. We see that a current outbreak leads to a 37% decrease in exports to markets recognized as FMD free, and no change to other markets. A recent outbreak – within the past 5 years – leads to a 21% decrease in exports to markets recognized as FMD free, but a 116% increase in exports to markets not recognized as FMD free. This evidence of market substitution is consistent with the results from the HMR specification, but the changes in market values are larger with ppml estimation. As with our HMR and Heckman estimation, we find that having reported BSE will lead to a decrease in exports to markets that have not reported BSE.

The estimates of our alternative, more structured, specification are broadly consistent, but it is notable that the ppml estimates suggest a large and statistically significant decrease in exports to markets recognized as FMD free during an outbreak. Overall, these robustness tests with the ppml estimator further support our conclusion of market switching although they do suggest that the estimates of the effect of disease outbreaks coming from the Heckman and HMR estimators may be understated.

5. Discussion and conclusions

The results reported here add to the literature that examines the impact of animal diseases on international trade. In particular, we have shown how the widely used gravity model of international trade can provide meaningful estimates of the implications for exporters of an outbreak of diseases such as FMD and BSE, both during and after an outbreak. A key insight from our analysis is that there is clear evidence that even after FMD is eradicated, an outbreak will continue to affect exports in the medium term. Regaining official recognition of FMD-free status may assist in recovering access to markets, which is important for exporters because there is clear evidence of there being a shift in the export profile towards lower value markets that are not recognized as FMD-free following an outbreak.

For countries that are free of FMD, our results suggest that the modelling of potential impacts of an FMD outbreak should incorporate these medium-run substitution effects. If medium-run effects are ignored, one may misunderstand the trade impacts of an outbreak. Our analysis suggests that incorporating trade effects that last for five years after an outbreak is consistent with the patterns in the international trade data, as revealed in our gravity models. On the other hand, an analysis solely focused on "lost" markets does not tell the full story, as we find evidence of substitution towards lower value markets that are not FMD-free. Given this possibility of market switching, policy makers and exporters in FMD free countries may wish to develop relationships and market access arrangements to facilitate exports to these markets if an outbreak does occur.

For countries that are not free of FMD, we show that if the disease were to be eradicated, after several years an exporter should be able to substitute towards higher value FMD-free markets. Moreover, there is an effect of official recognition of disease-free status, on top of the effects of actual (current or past) outbreaks. We see similar market-switching effects for outbreaks of BSE, although we are not able to separately estimate the effects of current and previous episodes or the effect of official recognition of disease-free status because there are far fewer episodes of BSE than of FMD in our data. An overall implication is that the value of these changes in export market profile should be taken into account when considering the benefits of disease eradication programs, biosecurity efforts, and also trade policy more generally.

Acknowledgements

We are grateful to two anonymous reviewers and audiences at the AARES, WEAI and NZAE conferences for helpful comments. The views expressed here are those of the authors alone.

Table 6
Results with alternative specification of FMD variables.

VARIABLES	Helpman Melitz & Rubinstein Outcome (1)	Helpman Melitz & Rubinstein Selection (2)	Heckman Selection Model Outcome (3)	Heckman Selection Model Selection (4)
FMD outbreak exporter	−0.0718	−0.222***	−0.0972	−0.226***
	(0.121)	(0.0356)	(0.148)	(0.0456)
FMD outbreak both	−0.065	0.191***	−0.0660	0.190***
	(0.116)	(0.0331)	(0.152)	(0.0404)
No FMD importer	−0.402***	0.0329	−0.396***	0.0363
	(0.0874)	(0.0288)	(0.102)	(0.0377)
FMD risk without outbreak exporter	0.127	−0.0643*	0.0857	−0.0649
	(0.108)	(0.0329)	(0.146)	(0.0454)
FMD risk without outbreak both	−0.0845	0.116***	−0.0523	0.113***
	(0.107)	(0.0318)	(0.155)	(0.0423)
FMD recent without risk status exporter	−0.226***	−0.104***	−0.238**	−0.0965*
	(0.100)	(0.0379)	(0.118)	(0.0520)
FMD recent without risk status both	−0.660***	0.0347	−0.733***	0.0338
	(0.113)	(0.0353)	(0.152)	(0.0459)
BSE occurrence exporter	−0.211***	−0.120***	−0.338***	−0.122***
	(0.0718)	(0.0232)	(0.0969)	(0.0323)
BSE occurrence both	0.156*	0.0583*	0.461***	0.0687
	(0.0846)	(0.0314)	(0.135)	(0.0567)
No BSE importer	0.0121	−0.0209	0.118	−0.0151
	(0.0868)	(0.0287)	(0.123)	(0.0398)
Gravity Model Control Variables				
GDP importer	0.526***	0.0598***	0.550***	0.0597*
	(0.0736)	(0.0224)	(0.104)	(0.0309)
GDP exporter	−0.0524	−0.0156	−0.100	−0.0169
	(0.0766)	(0.0229)	(0.104)	(0.0307)
Beef production exporter	0.705***	0.0127	0.709***	0.0164
	(0.0810)	(0.0236)	(0.0986)	(0.0308)
Beef production importer	−0.114**	0.00630	−0.119	0.00411
	(0.0662)	(0.0185)	(0.0823)	(0.0260)
Tariff	0.00188**	−0.00152***	0.00125	−0.00153***
	(0.00103)	(0.000303)	(0.00184)	(0.000556)
Distance	−1.47***	−0.677***	−1.580***	−0.680***
	(0.136)	(0.00989)	(0.0787)	(0.0228)
Contiguity	0.544***	0.313***	0.938***	0.323***
	(0.0927)	(0.0264)	(0.179)	(0.0655)
Common language	…..	0.305***	…..	0.301***
		(0.0185)		(0.0419)
Colony	0.579***	0.347***	0.701***	0.339***
	(0.112)	(0.0284)	(0.208)	(0.0705)
Common legal system	0.439***	0.125***	0.482***	0.130***
	(0.0504)	(0.0118)	(0.0934)	(0.0275)
RTA	0.448***	0.233***	0.374***	0.239***
	(0.0744)	(0.0175)	(0.132)	(0.0391)
Year	0.00685	0.0201***	0.0157	0.0205***
	(0.00881)	(0.00266)	(0.0103)	(0.00347)
Importer/Exporter FE	YES	YES	YES	YES
Number of Observations	23,842	373,763	23,822	397,818
Number of Censored Observations		349,921		373,976
Lambda				0.735***
				(0.0570)

Note: Robust standard errors in parentheses.
*** p < .01.
** p < .05.
* p < .1.

Appendix A

See Tables A1–A5.

Table A1
Effect of varying number of years for which a "recent" FMD outbreak can affect exports (including risk status variables).

	Helpman, Melitz & Rubinstein Model						Heckman Selection Model					
Years following an outbreak used in "Recent FMD" variable	1	2	3	4	5	6	1	2	3	4	5	6
Selection Equation												
FMD outbreak exporter	−0.158***	−0.100***	−0.107***	−0.115***	−0.121***	−0.138***	−0.161***	−0.103***	−0.110***	−0.118***	−0.124***	−0.142***
	(0.0282)	(0.0301)	(0.0293)	(0.0290)	(0.0288)	(0.0286)	(0.0346)	(0.0327)	(0.0341)	(0.0348)	(0.0353)	(0.0356)
FMD outbreak both	0.0650**	0.0408*	0.0441*	0.0461*	0.0505**	0.0528**	0.0657**	0.0418	0.0452*	0.0474*	0.0519*	0.0544*
	(0.0255)	(0.0243)	(0.0241)	(0.0239)	(0.0239)	(0.0239)	(0.0255)	(0.0261)	(0.0272)	(0.0278)	(0.0283)	(0.0287)
FMD risk status exporter	−0.0318	−0.00634	0.00105	0.0103	0.00190	−0.0135	−0.0401	−0.00843	−0.00100	0.00841	−0.000864	−0.0169
	(0.0941)	(0.0322)	(0.0327)	(0.0335)	(0.0341)	(0.0344)	(0.0863)	(0.0446)	(0.0448)	(0.0460)	(0.0469)	(0.0475)
FMD risk status both	0.123	0.0969***	0.0925***	0.0873***	0.0836**	0.0896***	0.113	0.0925**	0.0884**	0.0835**	0.0805*	0.0873**
	(0.0930)	(0.0312)	(0.0316)	(0.0323)	(0.0327)	(0.0329)	(0.0826)	(0.0418)	(0.0419)	(0.0425)	(0.0429)	(0.0430)
Recent FMD exporter	−0.00249	−0.116***	−0.119***	−0.134***	−0.113***	−0.0897***	0.00401	−0.115***	−0.118***	−0.133***	−0.109***	−0.0842**
	(0.0900)	(0.0279)	(0.0264)	(0.0260)	(0.0262)	(0.0265)	(0.0768)	(0.0293)	(0.0291)	(0.0310)	(0.0333)	(0.0353)
Recent FMD both	0.0241	0.0631***	0.0526**	0.0399*	0.0397*	0.0132	0.0257	0.0652**	0.0542**	0.0407	0.0407	0.0139
	(0.0256)	(0.0242)	(0.0235)	(0.0231)	(0.0232)	(0.0238)	(0.0253)	(0.0254)	(0.0255)	(0.0261)	(0.0276)	(0.0300)
Outcome Equation												
FMD outbreak exporter	−0.171*	−0.123	−0.137	−0.178*	−0.191*	−0.200**	−0.180	−0.118	−0.132	−0.154	−0.167	−0.178
	(0.0983)	(0.0987)	(0.0981)	(0.0984)	(0.0984)	(0.099)	(0.116)	(0.108)	(0.112)	(0.116)	(0.118)	(0.118)
FMD outbreak both	−0.0193	−0.0244	−0.0124	−0.0158	−0.0157	−0.0196	−0.0356	−0.0487	−0.0369	−0.0491	−0.0506	−0.0526
	(0.0849)	(0.0822)	(0.0814)	(0.0815)	(0.0814)	(0.0814)	(0.0926)	(0.0963)	(0.0996)	(0.102)	(0.103)	(0.105)
FMD risk status exporter	0.432	0.308***	0.282***	0.254**	0.240**	0.210*	0.389	0.264*	0.240*	0.218	0.200	0.160
	(0.2910)	(0.1060)	(0.107)	(0.109)	(0.110)	(0.111)	(0.264)	(0.143)	(0.143)	(0.146)	(0.148)	(0.149)
FMD risk status both	0.224	0.0451	0.0489	0.0667	0.120	0.174	0.283	0.107	0.11	0.127	0.183	0.236
	(0.2900)	(0.1070)	(0.107)	(0.108)	(0.109)	(0.110)	(0.267)	(0.154)	(0.153)	(0.153)	(0.152)	(0.153)
Recent FMD exporter	−0.175	−0.199***	−0.152*	−0.182**	−0.262***	−0.287***	−0.174	−0.208**	−0.173*	−0.186**	−0.261***	−0.280***
	(0.2760)	(0.0885)	(0.0824)	(0.0798)	(0.0769)	(0.0760)	(0.230)	(0.0992)	(0.090)	(0.0871)	(0.0876)	(0.0914)
Recent FMD both	0.0699	0.0111	−0.0628	−0.150*	−0.366***	−0.516***	0.0299	−0.0321	−0.106	−0.198**	−0.417***	−0.573***
	(0.0699)	(0.0809)	(0.0788)	(0.0772)	(0.0772)	(0.0779)	(0.0878)	(0.0893)	(0.0926)	(0.0939)	(0.0975)	(0.104)
AIC	86026.29	85648.66	85296.8	84817.07	84374.42	83983.83	193,107	192,414	191758.5	190939.6	190164.8	189490.4
BIC	89610.27	89228.48	88861.97	88354.65	87872.95	87467.94	200478.2	199,710	199056.8	198196.8	197386.5	196621.8
Obs	384,821	380,008	375,639	368,902	361,472	357,445	408,500	402,670	397,507	392,504	197347.9	382,514
DF	330	330	329	327	324	323	675	669	670	667	661	657
LL	−42683.15	−42494.33	−42319.4	−42081.53	−41863.21	−41668.91	−95878.52	−95537.98	−95209.24	−94802.8	−94421.4	−94088.18

Note: Models reported in this table include the other variables shown in Table 2.

Table A2
Effect of varying number of years for which a “recent” FMD outbreak can affect exports (excluding risk status variables).

	Helpman, Melitz & Rubinstein Model						Heckman Selection Model					
Number of years following an outbreak used in “Recent FMD” variable	1	2	3	4	5	6	1	2	3	4	5	6
Selection Equation												
FMD outbreak exporter	−0.213***	−0.114***	−0.117***	−0.122***	−0.130***	−0.153***	−0.215***	−0.117***	−0.120***	−0.125***	−0.134***	−0.157***
	(0.0263)	(0.0290)	(0.0281)	(0.0277)	(0.0274)	(0.0272)	(0.0326)	(0.0298)	(0.0310)	(0.0316)	(0.0321)	(0.0324)
FMD outbreak both	0.0967***	0.0622***	0.0639***	0.0646***	0.0693***	0.0742***	0.0967***	0.0624***	0.0643***	0.0653***	0.0703***	0.0756***
	(0.0251)	(0.0238)	(0.0235)	(0.0232)	(0.0230)	(0.0229)	(0.0242)	(0.0241)	(0.0248)	(0.0253)	(0.0258)	(0.0262)
Recent FMD exporter	0.0426	−0.139***	−0.141***	−0.153***	−0.134***	−0.119***	0.0403	−0.138***	−0.140***	−0.152***	−0.131***	−0.114***
	(0.0266)	(0.0265)	(0.0248)	(0.0241)	(0.0240)	(0.0242)	(0.0314)	(0.0286)	(0.0289)	(0.0303)	(0.0318)	(0.0334)
Recent FMD both	0.0517**	0.0881***	0.0757***	0.0606***	0.0611***	0.0389*	0.0531**	0.0894***	0.0765***	0.0607**	0.0618**	0.0396
	(0.0252)	(0.0232)	(0.0224)	(0.0218)	(0.0217)	(0.0224)	(0.0243)	(0.0244)	(0.0252)	(0.0258)	(0.0271)	(0.0294)
Outcome Equation												
FMD outbreak exporter	−0.0904	−0.0225	−0.0463	−0.0968	−0.121	−0.150	−0.136	−0.0425	−0.0654	−0.0949	−0.120	−0.152
	(0.0950)	(0.0939)	(0.0930)	(0.0927)	(0.0922)	(0.0931)	(0.113)	(0.0968)	(0.101)	(0.103)	(0.106)	(0.107)
FMD outbreak both	−0.0492	−0.0385	−0.0226	−0.0198	−0.00431	0.00927	−0.0468	−0.0454	−0.0299	−0.0359	−0.0213	−0.00615
	(0.0832)	(0.0796)	(0.0787)	(0.0783)	(0.078)	(0.078)	(0.0872)	(0.0868)	(0.0895)	(0.0919)	(0.0934)	(0.0953)
Recent FMD exporter	0.1208	−0.116	−0.0817	−0.126	−0.219***	−0.256***	0.136	−0.155	−0.133	−0.155*	−0.246***	−0.286***
	(0.0886)	(0.0856)	(0.0793)	(0.0768)	(0.0735)	(0.0723)	(0.104)	(0.0984)	(0.0909)	(0.0874)	(0.0865)	(0.0888)
Recent FMD both	0.0278	−0.0234	−0.0988	−0.178**	−0.377***	−0.505***	0.00393	−0.0454	−0.120	−0.204**	−0.405***	−0.538***
	(0.0817)	(0.0785)	(0.0755)	(0.0729)	(0.0724)	−0.0726	(0.0848)	(0.0869)	(0.0924)	(0.0943)	(0.0988)	(0.105)
AIC	86053.86	85659.8	85304.82	84822.22	84379.18	83991.29	193,107	193,107	191758.5	190939.6	190164.8	189490.4
BIC	89616.12	89217.92	88848.32	88338.17	87856.11	87453.83	200478.2	200478.2	199056.8	198196.8	197347.9	196621.8
Obs	384,821	380,008	375,639	368,902	361,472	357,445	408,500	402,670	397,507	392,504	387,349	382,514
DF	328	328	327	325	322	321	675	669	670	667	661	657
LL	−42698.93	−42501.9	−42325.41	−42086.11	−41867.59	−41674.64	−95878.52	−95537.98	−95209.24	−94802.8	−94421.4	−94088.18

Note: Models reported in this table include the other variables shown in Table 2.

Table A3
Results from estimation of initial specification (logit estimation).

VARIABLES	HMR with logit (including status variables) Outcome (1)	Selection (2)	HMR with logit (excluding status variables) Outcome (1)	Selection (2)
FMD outbreak exporter	-0.186^{*}	-0.284^{***}	-0.110	-0.289^{***}
	(0.0986)	(0.0561)	(0.0921)	(0.0534)
FMD outbreak both	-0.00916	0.112^{**}	-0.007	0.129^{***}
	(0.0811)	(0.0455)	(0.0774)	(0.0436)
No FMD importer	-0.644^{***}	-0.216^{***}	-0.586^{***}	-0.238^{***}
	(0.112)	(0.0712)	(0.106)	(0.0664)
FMD risk status exporter	0.239^{**}	0.0196	…..	…..
	(0.110)	(0.0653)		
FMD risk status both	0.0847	0.0797	…..	…..
	(0.108)	(0.0627)		
Recent FMD exporter	-0.252^{***}	-0.244^{***}	-0.205^{***}	-0.258^{***}
	(0.0767)	(0.0493)	(0.0724)	(0.0453)
Recent FMD both	-0.364^{***}	0.0893^{**}	-0.386^{***}	0.107^{***}
	(0.0770)	(0.0440)	(0.0719)	(0.0410)
BSE occurrence exporter	-0.215^{***}	-0.232^{***}	-0.210^{***}	-0.233^{***}
	(0.0709)	(0.0433)	(0.0708)	(0.0433)
BSE occurrence both	0.136	-0.0366	0.128	-0.0326
	(0.0833)	(0.0587)	(0.0832)	(0.0585)
No BSE importer	-0.00427	-0.114^{**}	-0.0128	-0.111^{**}
	(0.0869)	(0.0548)	(0.0868)	(0.0548)
Gravity Model Control Variables				
GDP importer	0.525^{***}	0.128^{***}	0.521^{***}	0.129^{***}
	(0.0734)	(0.0429)	(0.0734)	(0.0429)
GDP exporter	-0.0813	-0.0118	-0.0886	-0.0150
	(0.0766)	(0.0436)	(0.0764)	(0.0435)
Beef production exporter	0.691^{***}	-0.00117	0.689^{***}	-0.00235
	(0.0808)	(0.0469)	(0.0808)	(0.0469)
Beef production importer	-0.105	0.0127	-0.110^{*}	0.0112
	(0.0661)	(0.0360)	(0.0661)	(0.0360)
Tariff	0.0023^{**}	-0.00299^{***}	0.00218^{**}	-0.00295^{***}
	(0.00102)	(0.000596)	(0.00101)	(0.000595)
Distance	-1.465^{***}	-1.333^{***}	-1.46^{***}	-1.334^{***}
	(0.126)	(0.0190)	(0.126)	(0.0190)
Contiguity	0.592^{***}	0.592^{***}	0.594^{***}	0.592^{***}
	(0.0880)	(0.0510)	(0.0881)	(0.0510)
Common language	…..	0.654^{***}	…..	0.652^{***}
		(0.0363)		(0.0362)
Colony	0.522^{***}	0.620^{***}	0.521^{***}	0.621^{***}
	(0.104)	(0.0561)	(0.1038)	(0.0561)
Common legal system	0.415^{***}	0.248^{***}	0.413^{***}	0.248^{***}
	(0.0492)	(0.0228)	(0.0492)	(0.0228)
RTA	0.429^{***}	0.458^{***}	0.410^{***}	0.461^{***}
	(0.0723)	(0.0339)	(0.0717)	(0.0337)
Year	0.00739	0.0382^{***}	0.00821	0.0386^{***}
	(0.00862)	(0.00505)	(0.00860)	(0.00503)
Importer/ Exporter FE	YES			
Number of Observations	23,628	361,472	23,628	361,472
Number of Censored Observations		337,844		337,844

Note: Robust standard errors in parentheses.
*** $p < .01$.
** $p < .05$.
* $p < .1$

Table A4
Results from estimation of alternative specification (logit estimation).

Variables	Outcome	Selection
FMD outbreak exporter	−0.0622	−0.487***
	(0.121)	(0.0690)
FMD outbreak both	−0.0945	0.314***
	(0.113)	(0.0632)
No FMD importer	−0.412***	0.0327
	(0.0869)	(0.0546)
FMD risk without outbreak exporter	0.128	−0.131**
	(0.107)	(0.0631)
FMD risk without outbreak both	−0.118	0.155**
	(0.105)	(0.0607)
FMD recent without risk status exporter	−0.227**	−0.230***
	(0.100)	(0.0696)
FMD recent without risk status both	−0.659***	0.0810
	(0.112)	(0.0660)
BSE occurrence exporter	−0.195***	−0.228***
	(0.0708)	(0.0430)
BSE occurrence both	0.153*	−0.0226
	(0.0833)	(0.0586)
No BSE importer	0.00215	−0.103*
	(0.0868)	(0.0546)
Gravity Model Control Variables		
GDP importer	0.507***	0.122***
	(0.0732)	(0.0427)
GDP exporter	−0.038	−0.0107
	(0.0762)	(0.0432)
Beef production exporter	0.698***	0.0128
	(0.0806)	(0.0464)
Beef production importer	−0.113*	0.0124
	(0.0660)	(0.0357)
Tariff	0.00223**	−0.00300***
	(0.00102)	(0.000594)
Distance	−1.41***	−1.328***
	(0.126)	(0.0189)
Contiguity	0.583***	0.592***
	(0.0879)	(0.0507)
Common language	…..	0.647***
		(0.0359)
Colony	0.526***	0.635***
	(0.105)	(0.0558)
Common legal system	0.420***	0.239***
	(0.0486)	(0.0227)
RTA	0.425***	0.458***
	(0.0722)	(0.0337)
Year	0.00517	0.0379***
	(0.00861)	(0.00502)
Importer/Exporter FE	YES	
Number of Observations	23,842	373,763
Number of Censored Observations		349,921

Note: Robust standard errors in parentheses.
*** p < .01.
** p < .05.
* p < .1.

Table A5
Results from Poisson pseudo-maximum likelihood (ppml) estimation (where a FMD outbreak affects exports for the following 5 years).

Initial Specification			Alternative Specification	
Variable	Including Status Variables (1)	Excluding Status Variables (2)	Variable	Estimated Coefficients (3)
FMD outbreak exporter	−0.205 (0.159)	−0.468*** (0.154)	FMD outbreak exporter	−0.875*** (0.234)
FMD outbreak both	−0.159 (0.182)	0.0769 (0.180)	FMD outbreak both	0.857*** (0.226)
No FMD importer	0.390** (0.165)	−0.0199 (0.150)	No FMD importer	0.365** (0.153)
FMD risk status exporter	−0.641*** (0.236)	NA	FMD risk without outbreak exporter	−0.642*** (0.245)
FMD risk status both	0.914*** (0.248)	NA	FMD risk without outbreak both	0.995*** (0.232)
Recent FMD exporter	0.0129 (0.0634)	−0.246** (0.112)	FMD recent without risk status exporter	0.120** (0.0537)
Recent FMD both	0.153 (0.135)	0.772*** (0.160)	FMD recent without risk status both	−0.0955 (0.343)
BSE occurrence exporter	−0.196 (0.194)	−0.195 (0.202)	BSE occurrence exporter	−0.209 (0.193)
BSE occurrence both	−0.382*** (0.147)	−0.294* (0.158)	BSE occurrence both	−0.394*** (0.146)
No BSE importer	0.211 (0.167)	0.262 (0.178)	No BSE importer	0.217 (0.167)
GDP importer	1.189*** (0.214)	1.253*** (0.230)	GDP importer	1.169*** (0.207)
GDP exporter	−0.200 (0.143)	−0.159 (0.154)	GDP exporter	−0.230 (0.144)
Beef production exporter	0.967*** (0.199)	0.920*** (0.218)	Beef production exporter	0.985*** (0.195)
Beef production importer	−0.680*** (0.172)	−0.671*** (0.182)	Beef production importer	−0.670*** (0.171)
Tariff	−0.00749*** (0.00202)	−0.00467** (0.00217)	Tariff	−0.00772*** (0.00200)
Distance	−1.595*** (0.128)	−1.555*** (0.130)	Distance	−1.591*** (0.127)
Contiguity	−0.0125 (0.181)	0.0346 (0.183)	Contiguity	−0.00854 (0.180)
Common language	0.0413 (0.206)	0.0640 (0.223)	Common language	0.0513 (0.206)
Colony	−0.0316 (0.267)	−0.0607 (0.260)	Colony	−0.0305 (0.268)
Common legal system	0.629*** (0.136)	0.595*** (0.143)	Common legal system	0.620*** (0.136)
RTA	0.872*** (0.286)	1.064*** (0.300)	RTA	0.869*** (0.285)
Year	0.0130 (0.0104)	0.00947 (0.0108)	Year	0.0148 (0.0105)
Importer/Exporter FE	YES	YES	Importer/Exporter FE	YES
Number of Observations	361,472	361,472	Number of Observations	373,763
Number of Dropped Obs	25,877	25,877	Number of Dropped Obs	24,055

Note: Robust standard errors in parentheses.
*** $p < .01$.
** $p < .05$.
* $p < .1$.

References

Anderson, James E., van Wincoop, Eric, 2003. Gravity with gravitas: a solution to the border puzzle. Am. Econ. Rev. 93 (1), 170–192.
Australian Productivity Commission, 2002. Impact of a Foot and Mouth Disease Outbreak on Australia. Australian Productivity Commission.
The Gravity Model in International Trade: Advances and Applications. Cambridge University Press, Cambridge, New York.
Bown, Ch.ad.P., Hillman, Jennifer A., 2017. Foot-and-mouth disease and Argentina's beef exports: the WTO's US–animals dispute. World Trade Rev. 16 (2), 253–277.
Buetre, Benjamin, Wicks, Santhi, Kruger, Heleen, Millist, Niki, Yainshet, Alasebu, Garner, Graeme, Duncan, Alixaandrea, et al., 2013. Potential Socio-economic Impacts of an Outbreak of Foot-and-mouth disease in Australia. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, Australia.
Crivelli, Pramila, Gröschl, Jasmin, 2016. The impact of sanitary and phytosanitary measures on market entry and trade flows. World Econ. 39 (3), 444–473.
Disdier, Anne-Célia, Fontagné, Lionel, Mimouni, Mondher, 2008. The impact of regulations on agricultural trade: evidence from the SPS and TBT agreements. Am. J. Agric. Econ. 90 (2), 336–350.
Ferro, Esteban, Otsuki, Tsunehiro, Wilson, John S., 2015. The effect of product standards on agricultural exports. Food Policy 50 (1), 68–79.
Forbes, Rod, van Halderen, Andre, 2014. Foot-and-mouth Disease Economic Impact Assessment: What it means for New Zealand. 2014/18. Ministry of Primary Industries Technical Paper. Ministry of Primary Industries, Wellington, New Zealand.
Helpman, Elhanan, Melitz, Marc, Rubinstein, Yona, 2008. Estimating trade flows: trading partners and trading volumes. Quart. J. Econ. 123 (2), 441–487.
Jones, Kevin Edson, Davidson, Debra J., 2014. Adapting to food safety crises: interpreting success and failure in the Canadian response to BSE. Food Policy 49 (1), 250–258.
Knight-Jones, T.J.D., Rushton, J., 2013. The economic impacts of foot and mouth disease – what are they, how big are they and where do they occur? Prevent. Veterin. Med. 112 (3–4), 161–173.
Kompas, Tom, Nguyen, Hoa Thi Minh, Van Ha, Pham, 2015. Food and biosecurity: livestock production and towards a world free of foot-and-mouth disease. Food Secur. 7 (2), 291–302.
Lejárraga, I., Shepherd, B., van Tongeren, F., 2013. Transparency in nontariff measures: effects on agricultural trade. In: Beghin, C. (Ed.), Frontiers of Economics and Globalization: Non Tariff Measures with Market Imperfections. Trade and Welfare

Implications (Chapter 4).
Lloyd, T.A., McCorriston, S., Morgan, C.W., Rayner, A.J., 2006. Food scares, market power and price transmission: the UK BSE crisis. Eur. Rev. Agric. Econ. 33 (2), 119–147.
Martin, Will J., Pham, C.S., 2015. Estimating the Gravity Model when Zero Trade Flows are Frequent and Economically Determined. World Bank Working Paper.
Pendell, D.L., Marsh, T.L., Coble, K.H., Lusk, J.L., Szmania, S.C., 2015. Economic assessment of FMDv releases from the national bio and agro defense facility. PLoS ONE 10 (6), e0129134. http://dx.doi.org/10.1371/journal.pone.0129134.
Santos Silva, J.M.C., Tenreyro, S., 2006. The log of gravity. Rev. Econ. Stat. 88 (4), 641–658.
Santos Silva, J.M.C., Tenreyro, S., 2015. Trading partners and trading volumes: implementing the Helpman-Melitz-Rubinstein model empirically. Oxford Bull. Econ. Stat. 77 (1), 93–105.
Schlueter, Simon Wilhelm, 2009. Impact of Regulatory Measures on International Trade in Meat Products (Ph.D. Thesis). University of Bonn.
Schlueter, Simon W., Wieck, Christine, Heckelei, Thomas, 2009. Regulatory policies in meat trade: is there evidence for least trade-distorting sanitary regulations? Am. J. Agric. Econ. 91 (5), 1484–1490.
Schroeder, Ted C., Pendell, Dustin L., Sanderson, Michael W., Mcreynolds, Sara, 2015. Economic impact of alternative FMD emergency vaccination strategies in the midwestern United States. J. Agric. Appl. Econ. 47 (01), 47–76.
Shepherd, Ben, 2013. The gravity model of international trade: a user guide. ARTNeT Books Res. Rep.
Tapia, Ciro, Iglesias, Daniel, Lema, Daniel, Ghezan, Graciela, 2011. Assessment of Sanitary NTM upon Beef Trade Flows for the UE (Germany) and Argentine. 11/08. NTM-IMPACT Working Paper.
Tozer, Peter, Marsh, Thomas L., 2012. Domestic and trade impacts of foot-and-mouth disease on the Australian beef industry. Aust. J. Agric. Resour. Econ. 56 (3), 385–404.
U.S. Department of Homeland Security, 2012. National Bio and Agro-Defense Facility (NBAF): Updated Site-Specific Biosafety and Biosecurity Mitigation Risk Assessment. U.S. Department of Homeland Security, Science and Technology Directorate.
Wieck, Christine, Holland, David W., 2010. The economic effect of the Canadian BSE outbreak on the US economy. Appl. Econ. 42 (8), 935–946.
Wilson, J.S., Otsuki, T., Majumdsar, B., 2003. Balancing food safety and risk: do drug residue limits affect international trade in beef?. J. Int. Trade Econ. Dev. 12 (4), 377–402.
Winchester, Niven, 2009. Is there a dirty little secret? Non-tariff barriers and the gains from trade. J. Policy Model. 31 (6), 819–834. http://dx.doi.org/10.1016/j.jpolmod.2009.08.004.
WTO, 2012. A Practical Guide to Trade Policy Analysis. Available at < www.wto.org/english/res_e/publications_e/practical_guide12_e.htm > .
Yang, Shang-Ho, Reed, Michael, Saghaian, Sayed, 2013. International pork trade and foot-and-mouth disease. J. Int. Agric. Trade Dev. 9 (1), 1–19.

CHAPTER III: MARKET ACCESS IMPLICATIONS OF NON-TARIFF MEASURES: ESTIMATES FOR FOUR DEVELOPED COUNTRY MARKETS

This paper has been accepted for publication in *The World Economy*.

Market access implications of non-tariff measures: Estimates for four developed country markets

Mike Webb
John Gibson
Anna Strutt

University of Waikato

We quantify the effects of non-tariff measures on the extensive margin of trade, examining the number of countries exporting particular products to Canada, the European Union, New Zealand and the United States. We find that non-tariff measures that impose a conformity requirement, i.e. testing, certification or inspection, will reduce the number of countries exporting to these markets. Conformity requirements imposed for sanitary or phytosanitary reasons have the largest effect in Canada, reducing the number of exporting countries by 47 percent compared to the situation where no compliance requirement is imposed. Conformity requirements imposed for other reasons covered by the WTO Agreement on Technical Barriers to Trade have the largest effect in Canada and New Zealand, reducing the number of exporting countries by 27 percent compared to the situation where no compliance requirement is imposed. However, we generally find a statistically significant positive effect for non-tariff measures that do not impose a compliance burden, suggesting that such measures may facilitate trade.

JEL: F13, F14, L50

Keywords: Non-tariff measures; Extensive margin; International trade

Acknowledgements: We are grateful to assistance from Guillermo Abramowitz, Santiago Fernandez De Cordoba, Fabien Dumesnil, Maxim Gubarev, Samuel Munyaneza, Ralf Peters, Denise Penello Rial, and to helpful comments from audience members at the NZAE conference and from an anonymous reviewer.

Address for correspondence: Department of Economics, University of Waikato, Private Bag 3105, Hamilton, New Zealand 3240, fax: 64-7-838-4331, e-mail: jkgibson@waikato.ac.nz

INTRODUCTION

Non-tariff measures (NTMs)[1] have been receiving increased attention in recent years, both by policy makers and in the literature (see Beghin, Maertens, & Swinnen, 2015, for a summary). NTMs can be much more significant barriers to trade than tariffs, particularly as many tariffs have already been substantially lowered over time (see, for instance, Egger, Francois, Manchin, & Nelson, 2015; Kee, Nicita, & Olarreaga, 2009). However, obtaining reliable data on NTMs is a challenge due to their frequency, variety and the fact that they are enshrined in a wide range of domestic regulations.

Empirical papers have responded to NTM data challenges in various ways. Some use surveys (Berden & Francois, 2015). Others change the focus from measurement to instead studying additional benefits of Free Trade Agreements – beyond their tariff-reducing effects – which is that they can also assist in reducing the effects of NTMs on trade (Egger et al, 2015; Winchester, 2009). However, with the exception of papers related to seminal work by Kee et al (2009), which uses an early version of the UNCTAD TRAINS database, most previous research seeking to quantify effects of NTMs across wide panels of countries has relied on data on NTMs either notified to the World Trade Organization (WTO) under obligations imposed by the Agreement on the Application of Sanitary and Phytosanitary Measures and the Agreement on Technical Barriers to Trade, or raised as specific concerns by WTO members. These notifications and specific concerns may give rise to measurement errors, because the agencies responsible for notifying the WTO, often trade ministries,

[1] NTMs are typically defined as policy measures, other than tariffs, which may have an impact on international trade in goods and services.

may not be aware of all regulations that may constitute NTMs or they may not have the resources and incentives to report these fully in a systematic manner. Moreover, measures raised as specific concerns at the WTO constitute a subset of all NTMs, as only the most problematic are raised (see Grant & Arita, 2017, for a discussion focused on the sanitary and phytosanitary context).

In this paper we contribute to the literature on NTMs by applying a count data framework in a novel way to a comprehensive new database of NTMs. We examine the effect of NTMs on the “extensive margin” of trade, in terms of the probability that bilateral trade in particular products will occur between countries. The extensive margin of trade is an important area of focus in the theoretical and empirical trade literature (see Foellmi, Hepenstrick, & Zweimuller, 2017; Santos Silva, Tenreyro, & Wei, 2014; Debaere & Mostashari, 2010; Feenstra & Ma, 2014; Bernard, Jensen, Redding, & Schott, 2007; Felbermayr & Kohler, 2006). Changes to the extensive margin have been shown to have important implications for international trade. On the one hand, increasing the number of exporting countries increases the welfare of the importing country (see Broda & Weinstein, 2006, building on the seminal “love-of-variety” work by Krugman, 1979, and Feenstra & Weinstein, 2017, for an exploration of competition effects). However, perhaps even more important for global welfare are the productivity benefits to firms and countries from participating in exporting (see, for instance, Feenstra & Kee, 2008), especially when they export to developed countries.

It is difficult to untangle effects of firms self-selecting into export markets (Clerides et al, 1998) from learning-by-exporting effects (de Loecker, 2007). However, a randomized intervention that reduced trade costs shows that exporting raises the technical efficiency of participating firms (Atkin, Khandelwal, & Osman, 2017).[2] Moreover, if exports are from firms in developing countries to buyers in developed countries, there are stronger knowledge flows, and greater incentives for the firms to absorb and implement this knowledge. It is therefore no surprise that quality positively co-varies with income per capita in the export destination (Hallak, 2006; Hallak and Sivadasan, 2013). To the extent that NTMs imposed by developed countries may limit participation of developing country firms in exporting, they can be expected to reinforce the large cross-country gaps in productivity.

The new NTM database that we utilize in this paper is compiled under the leadership of UNCTAD and other international agencies.[3] For each country in this database, teams of researchers worked through the country's legislation, regulations, and other official rules to identify all NTMs that might affect merchandise trade. A common classification framework was used, with UNCTAD working closely with all research teams to ensure consistency of approach (UNCTAD, 2013, and UNCTAD, 2014).[4] We focus here on the effect of NTMs on the number of countries exporting specific products to Canada, the European Union, New Zealand and the United States. These are the first developed country markets for which these types of detailed and comprehensive NTM data have been collected.

[2] A survey of the literature on the effects of exporting on productivity is provided by Wagner (2007).
[3] Other early applications of this database include Cadot & Gourdon (2014 and 2016) and Vanzetti, Peters, & Knebel (2014) - though these focus primarily on developing economies.
[4] This database is a considerable extension of that used in Kee, Nicita, & Olarreaga (2009) as it has a more detailed NTM classification and was compiled in a more systematic and comprehensive manner. Two authors of the current paper were responsible for contributing the New Zealand data to this database.

We find that NTMs imposing a conformity requirement, i.e. testing, certification or inspection, significantly reduce the number of countries exporting to a market. This is consistent with previous research by Crivelli & Gröschl (2016) which finds that sanitary and phytosanitary (SPS) compliance measures that have been raised as a concern at the WTO reduce the number of countries exporting to a market. However, our current research is much broader, showing that compliance measures have an effect for both SPS and technical barriers to trade (TBT) related measures, and the effect is not just for those measures that are sufficiently problematic to be raised at the WTO.

The validity of our inferences is enhanced by the fact that we analyze separately four quite different markets with different approaches to trade policy. At one end of the spectrum, New Zealand is a small open economy with little influence on international standard adoption, given the size of its economy. At the other end of the spectrum, both the United States and European Union have significant scope for negotiating and bargaining within their trade policy and their standards are more likely to be adopted, given the importance of their markets to manufacturers.

By concentrating on the number of countries exporting a product, we are able to adopt a parsimonious regression modelling approach that abstracts from the level of detail about each of the importer-exporter dyads that is required in gravity model estimation. We can therefore undertake separate regressions for each of the individual markets, which provides flexibility with regard to possible regulatory differences between countries, and allows the potential for interactions with country-level attributes such as market size.

PREVIOUS STUDIES

Gravity analysis is the benchmark for analyzing the effects of policy measures on trade, including NTMs. Helpman, Melitz and Rubinstein (2008) detail a gravity model specification allowing for fixed costs and variable transport "melting iceberg" costs for exporting from one market to another. Compliance requirements from NTMs can readily be conceptualized within this framework: fixed costs from NTMs include transactions costs associated with learning import requirements or obtaining any necessary certification; variable costs could include testing of all, or a sample of, products shipped.

Gravity modelling is widely applied, but two applications are of particular relevance to our work.[5] Crivelli & Gröschl (2016) use a Heckman selection model and data on specific concerns about SPS measures raised at the WTO. They find that such SPS measures reduce the probability of exporting to these markets but, conditional on trade occurring, values exported are higher. When they separate effects of conformity and other requirements, they find that it is the conformity measures that have negative effects on market entry. Ferro, Otsuki and Wilson (2015) apply the Helpman, Melitz and Rubinstein (2008) framework to examine the effect that maximum residual limits for pesticides have on trade for 66 fruit and vegetable products for 61 importing countries. They find that the main effect of tighter standards in a market is to reduce the likelihood of an exporting country exporting to this market. The effect on the volume of trade – if trade takes place – is less robust but likely to be indistinguishable

[5] To illustrate how widespread gravity modeling is, *Google Scholar* records over 2,500 citations to each of the two seminal papers which set out the main approaches to estimating these models: Helpman, Melitz and Rubinstein (2008) and Santos Silva and Tenreyro (2006).

from zero. Other applications of gravity models to NTMs include an influential paper by Otsuki, Wilson and Sewadeh (2001), and Kee, Nicita and Olarreaga (2009), which is frequently cited in computable general equilibrium (CGE) modelling of the effects of NTMs.[6]

A separate strand of the literature examines an alternative definition of the extensive margin: the number of products that a country exports to a market. Export diversification by developing countries has received particular attention (Dennis & Shepherd, 2007; Santos Silva et al., 2014). Another set of papers extend the Poisson pseudo-maximum likelihood estimator proposed by Santos Silva and Tenreyro (2006). This approach is suited for variables that vary across country pairs, but not across products, with applications including: Bista & Tomasik (2017) on the effect of time zones; Flam & Nordström (2006) on effects of Euro membership; and Dutt, Mihov, & Van Zandt (2013) on effects of WTO membership.

Other papers use firm level data to examine the effects of NTMs on the probability of exports occurring, and the value of exports. El-Enbaby, Hendy, & Zaki (2016) examine the impact of SPS measures notified to the WTO on Egyptian firm exports. They find that SPS measures reduce the probability of a firm exporting to that market but find no statistically significant effect on the intensive margin. Fontagné, Orefice, Piermartini, & Rocha (2015) find that SPS measures that have been raised as concerns at the WTO reduce the probability of French firms exporting and the value of exports. These effects are reduced for larger firms.

[6] See Berden & Francois (2015) for a discussion of different measures drawn on in CGE research.

Also relevant is the work of Jaud, Cadot, and Suwa-Eisenmann (2013), which examines effects of SPS measures on the concentration of supply of agricultural products exported to the EU. Their measure of concentration is the Theil entropy index, which they calculate for EU-12 agri-food imports at the tariff line level between 1988 and 2005.[7] This concentration index is regressed on a measure of sanitary risk that is developed by using food alert notifications, with the authors finding that both the number of exporters and the market share of the top exporters are higher for higher risk products.

In the current paper, we concentrate on a framework centred on the number of exporters (extensive margin), based on the underlying theory of the gravity model. Consequently, our outcome measure is the number of exporters, rather than a concentration index such as the Theil index used in Jaud, Cadot, and Suwa-Eisenmann (2013). As explained later in this paper, we find our specification to be more tractable than a gravity model. Our framework is appropriate because the policy issue under investigation is whether NTMs reduce the number of suppliers, rather than any effect on the relative value of trade supplied by each exporting country. A change in the number of supplying countries is also more readily measured, and may be better understood by policy makers. Indeed, some of the same policy makers in rich countries may be providing donor funding for trade facilitation, such as the WTOs Aid-For-Trade initiative, to help poor countries overcome trade-related constraints in order to enter export markets.

[7] For earlier applications of the Theil, Herfindel and other concentration indices to patterns of export diversification, see Cadot, Carrère & Strauss-Kahn (2010).

DATA AND METHODOLOGY

Our data on non-tariff measures are from the NTM database coordinated by UNCTAD.[8] These data were collected in 2014 (for the European Union and the United States) and in 2015 (for Canada and New Zealand). There is not yet a time series dimension available that can be exploited in the analysis.

In constructing variables from the UNCTAD database, we distinguish between non-tariff measures imposed for sanitary and phytosanitary reasons (Chapter A of the UNCTAD classification), and non-tariff measures imposed for other reasons classified as technical barriers to trade (UNCTAD Chapter B). This distinction is important because SPS and TBT tend to be imposed for different reasons and are disciplined by separate WTO agreements. Moreover, we further distinguish between those NTMs that impose a performance or quality/safety requirement while minimizing the compliance costs in assessing compliance, for instance through recognition of suppliers' declarations, and those that additionally specify a way of assessing conformity which imposes additional burdens on firms, through either testing, certification, or inspection.[9]

In our econometric analysis, described later in this section, we use dummy variables to capture the presence of these different types of NTMs. We create five dummy variables, one for each type of non-tariff measure, where the dummy is set to

[8] Data are available at http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures/NTMs-Data.aspx

[9] Cadot, Malouche & Saez (2009) discuss the importance of streamlining conformity assessment procedures, including adopting a "risk based" approach. In the dataset, each conformity requirement is coupled with a SPS or TBT requirement, which is the requirement that is being tested for compliance. The existence of a matched SPS or TBT requirement was checked as part of the data quality assurance process, with a limited number of SPS or TBT measures added where a SPS or TBT compliance measure was recorded in the database without a matching measure.

equal one, if for each subheading of the Harmonized System (HS) (described below), at least one NTM applies to some products within this subheading. Table 1 describes each of these NTM dummy variables.

Table 1: NTM Variables

SPS Compliance Measure	At least one of the following requirements is applied for SPS reasons: testing (UNCTAD grouping A82); certification (UNCTAD grouping A83); or inspection (UNCTAD grouping A84).
Geographical Restriction	A geographical restriction on origin for SPS reasons is present (UNCTAD grouping A12). As this type of NTM restriction by definition reduces the number of countries exporting it is treated separately. See Webb, Strutt, & Rae (2017) for a discussion of this type of NTM.
SPS Measure	At least one SPS measure other than testing, certification, inspection and geographical restrictions applies i.e. UNCTAD grouping A1 (prohibitions/restrictions) (excluding A12), A2 (tolerance/substance limits), A3 (labelling, packaging etc.), A4 (hygienic requirements), A5 (treatment requirements), A6 (production requirements), A8 (excluding A82, A83 and A84 i.e. production registration, traceability and quarantine) and A9 (other SPS).
TBT Compliance Measure	At least one of the following requirements is applied for TBT reasons: testing (UNCTAD grouping B82); certification (UNCTAD grouping B83); or inspection (UNCTAD grouping B84).
TBT Measure	*At least one TBT measure* other than testing, certification, inspection and geographical restrictions applies i.e. UNCTAD grouping B1 (prohibitions/restrictions), B2 (tolerance/substance limits), B3 (labelling, packaging etc.), B4 (production requirements), B6 (identity requirements), B7 (performance requirements, B8 (excluding B82-B84) i.e. production registration, traceability and quarantine), B9 (other TBT).

The number of exporting countries is calculated based on data on imports into each of the four markets that we focus on, using data at the six-digit level of the

Harmonized System (HS) from the UN COMTRADE database.[10] We use the year corresponding to when the NTM data were collected i.e. 2014 for the EU and the United States and 2015 for Canada and New Zealand. The six-digit level is the most detailed level at which trade data are available in COMTRADE with classifications uniformly applied by customs agencies around the world. The NTM data were collected at the HS six-digit level for the United States, but are available at a more detailed eight-digit level for Canada, the European Union, and New Zealand. We use the six-digit data for our main results but report a sensitivity analysis with the eight-digit data.

As products in some sectors may naturally be supplied by fewer countries, it was important to control for the sector when estimating count data regressions of how many exporting countries there are. To do this, we constructed "sector" variables using a mapping of six-digit HS subheadings to 42 goods sectors in the widely used Global Trade Analysis Project (GTAP) database.[11] However, we do not control for tariffs when modelling the number of exporters because the bilateral variation that results from preferential trade agreements and other preferences means that there is not a single measure of tariffs that is applied on all imports. Beyond controlling for differences between the 42 sectors, we do not split the sample to separate agricultural and non-agricultural subsamples. While SPS measures are mainly thought of as applying to

---

[10] https://comtrade.un.org/

[11] The concordance is available from http://wits.worldbank.org/product_concordance.html. Further information on the GTAP database is available at www.gtap.agecon.purdue.edu/databases/v9/. While there are 44 goods sectors, raw milk is a domestic only sector in the GTAP database and electricity is not traded as a good.

agricultural trade, they can also apply to non-agricultural products (e.g. farm machinery) and TBTs are found in many sectors.[12]

Summary statistics for our data are reported in Table 2. As the HS six-digit subheadings are common across countries, we have 5204 observations for each country. New Zealand typically has the fewest countries exporting to it, with a mean of 15 and a maximum of 88 exporting countries supplying a product. In contrast, the European Union typically has the most countries exporting to it, with a mean of 38 and a maximum of 180 exporting countries supplying a product. The data appear over-dispersed, with a conditional variance much larger than the conditional mean. As we discuss later, this over-dispersion has implications for the choice of estimator.

Table 2: Summary Statistics

	Canada	EU	NZ	USA
Number of Observations	5204	5204	5204	5204
Mean: Number of Exporters	25.82	37.69	14.65	25.75
Variance: Number of Exporters	502.61	787.37	208.69	439.08
Standard Deviation: Number of Exporters	22.42	28.06	14.45	20.95
Conditional Mean: Number of Exporters (where > 0)	26.08	37.96	16.24	26.13
Conditional Variance: Number of Exporters (where > 0)	500.86	782.77	205.52	435.62
Maximum: Number of Exporters	173	180	88	157
Dummy Variables (Frequency):				
SPS Measure	1268	1555	1590	2019
SPS Compliance Measure	598	853	1065	1516
TBT Measure	4086	4837	3003	5053
TBT Compliance Measure	3766	3953	340	4005
Geographical Restriction	15	709	163	157

As data on the number of exporters is a count variable, we use econometric estimators that are designed for such data. A common starting point with count data is

[12] In our robustness analysis we do consider differences between agricultural and non-agricultural sectors for exports to the United States.

the Poisson regression model, in which the number of exporters is explained by the following model:

$$Exporters_i = \exp(\propto_1 Sector\ 1_i + \cdots + \propto_{42} Sector\ 42_i + \beta_1 SPS_i + \beta_2 SPS\ Compliance_i + \beta_3 A12\ Restriction_i + \beta_4 TBT\ etc_i + \beta_5 TBT\ Compliance_i + \varepsilon_i) \quad (1)$$

Where *Exporters* is the number of exporters exporting product *i* to the market that is the focus in each regression, ε_i is the error term, and the other variables are the sector and NTM variables described earlier.

The Poisson model is based on each event – in our case at least one firm in a country exporting to a market over the course of a year – occurring based on a Poisson framework.[13] The exploratory variables are those that affect the probability of the event occurring through affecting the profitability of exporting to the destination market.

Our approach can be compared with gravity modeling which is typically used to explain the value of trade between two countries. Gravity models based on Heckman selection models adopt the same approach as our Poisson framework in the first step of their estimation: the "selection equation" in which the exploratory variables are derived as those that affect the probability of it being profitable for the most productive firm in a country to export to a given market (see Helpman, Melitz and Rubinstein, 2008).[14] Under the Helpman, Melitz and Rubinstein (2008) approach the "selection equation",

[13] See Long and Freese (2014) for a detailed explanation of the Poisson framework.
[14] It should be noted that unlike a Poisson distribution which is based on counting occurrences over a fixed time period - in our case a year - the approach outlined in Helpman, Melitz and Rubinstein (2008) is based on a single occurrence i.e. firms selecting an export market for a year.

which is estimated through Probit estimation, explains incidences of zero trade between countries.

As an alternative to approaches based on the Heckman selection approach, many papers in the gravity model literature employ a Poisson estimator to explain the value of trade between two countries, building on the seminal work of Santos Silva and Tenreyro (2006).[15] In doing so, they treat the value of trade as count data. Despite employing the Poisson estimator, these papers are based on different underpinnings to our approach, and to the Helpman, Melitz and Rubinstein (2008) approach, because they do not explicitly account for the threshold issue of whether any firms in an exporting country find it profitable to export to a given market.

A practical advantage of our specification over gravity formulations is that we use observations on the number of exporting partners rather than on whether each potential exporter actually exports a given product to the market under investigation. This reduces the number of observations in the dataset by a factor of up to 194 – the number of potential exporter pairs when using the widely used CEPII gravity dataset. Moreover, we do not need to include exporter and exporter-importer pair specific variables such as the GDP of the exporting and importing country and the distance between these countries. Our specification is therefore tractable in situations where gravity estimation fails, which is more likely when data for only a single year are used. For example, we encountered computational issues when attempting to implement the

[15] Burger, Van Oort and Linders (2009) provide a useful survey of this gravity model literature.

Poisson Pseudo-Maximum Likelihood (PPML) estimator or Heckman selection equation to estimate the gravity model formulation associated with equation 1.[16]

We note that estimates from our approach may be conservative. The endogenous protection literature emphasizes that higher levels of import penetration may lead to greater protection through more non-tariff barriers, and therefore estimates of the effect of non-tariff barriers may be biased downwards, with estimated coefficients smaller in magnitude than would otherwise be the case (Trefler, 1993; Lee & Swagel, 1997). We expect, however, any bias to be relatively small for three reasons. First, papers such as Trefler (1993) and Lee & Swagel (1997) focus on non-tariff barriers which are the subset of non-tariff measures used for protectionist intent, such as quantitative restrictions; in contrast, we consider all regulations which may affect trade, even if protection is not their intent. Second, our dependent variable is not the level of imports but rather the number of countries who export to a market. Third, our sector dummy variable will capture the effect of any variation in the strength of protectionist pressure at the sectoral level. While it is quite common for papers in this area to not control for endogeneity (see the meta-analysis of Li & Beghin, 2012), those that do often make use of panel data features which are not available in our data set (see the discussion in Baier & Bergstrand, 2007, which focuses on the major issue of endogeneity with respect to free trade agreements) or utilize country-pair characteristics which are not captured in our approach (Vigani, Raimondi, & Olper, 2012).

[16] The Heckman selection equation requires that a variable included in the "selection" equation be omitted in the "outcome" equation. In the formulation that we tried, the omitted variable was the common language variable.

RESULTS

Our main results are shown in tables 3 and 4, where table 3 shows the coefficients and standard errors and table 4 sets out the average percentage impact of a change in each variable. Given that the data appear over-dispersed, with a conditional variance much larger than the conditional mean, we also estimate a Negative Binomial Regression (NBREG). This extends the Poission framework by enabling the variance to differ from the mean in the count data process. The NBREG results are also reported in tables 3 and 4.[17]

We find – almost consistently – a statistically significant negative effect of compliance measures, applied for either SPS or TBT reasons. For example, a compliance measure applied for SPS reasons is expected to lead to a 12 percent decrease in the number of countries exporting to the European Union. A compliance measure that is applied for TBT reasons is expected to lead to a 11 percent decrease in the number of countries exporting to the European Union (table 4, NBREG results). This result is statistically significant at the 1 percent level (table 3).

[17] Long and Freese (2014) provide a detailed explanation of the differences between the Poisson and Negative Binomial Regression.

Table 3: Estimation Results (Coefficients)

VARIABLES	Canada Poisson	Canada NBREG	EU Poisson	EU NBREG	NZ Poisson	NZ NBREG	USA Poisson	USA NBREG
SPS Measure	0.120***	0.191***	0.115***	0.101***	0.0836**	0.142***	-0.0278	0.001
	(0.035)	(0.042)	(0.034)	(0.037)	(0.0416)	(0.046)	(0.036)	(0.038)
SPS Compliance Measure	-0.655***	-0.628***	-0.142***	-0.122***	-0.0692	-0.0611	0.137***	0.170***
	(0.068)	(0.072)	(0.046)	(0.047)	(0.0673)	(0.082)	(0.049)	(0.047)
Geographical Restriction	0.207	0.307	-0.177***	-0.161**	-0.0787	0.132	-0.0273	-0.106
	(0.320)	(0.374)	(0.067)	(0.066)	(0.179)	(0.162)	(0.146)	(0.121)
TBT Measure	0.220***	0.170***	0.069	0.084	0.0668**	0.0986***	0.173***	0.151***
	(0.048)	(0.049)	(0.049)	(0.051)	(0.0332)	(0.034)	(0.051)	(0.055)
TBT Compliance Measure	-0.296***	-0.307***	-0.081**	-0.116***	-0.379***	-0.315***	-0.041	-0.064*
	(0.048)	(0.050)	(0.036)	(0.039)	(0.0589)	(0.064)	(0.034)	(0.035)
alpha		0.536***		0.405***		0.839***		0.481***
		(0.012)		(0.009)		(0.020)		(0.011)

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Sector fixed effects are not shown.

Table 4: Percentage Change in Expected Number of Exporting Countries

	Canada Poisson	Canada NBREG	EU Poisson	EU NBREG	NZ Poisson	NZ NBREG	USA Poisson	USA NBREG
SPS Measure	12.8	21.0	12.2	10.6	8.7	15.2	-2.7	0.1
SPS Compliance Measure	-48.1	-46.6	-13.2	-11.5	-6.7	-5.9	14.7	18.6
Geographical Restriction	23.0	36.0	-16.2	-14.9	-7.6	14.2	-2.7	-10.0
TBT Measure	24.5	18.6	7.1	8.7	6.9	10.4	18.9	16.3
TBT Compliance Measure	-25.6	-26.4	-7.8	-11.0	-31.6	-27.0	-4.0	-6.2

On the other hand, we typically find statistically significant positive effects for NTM measures lacking compliance components, for instance, performance requirements, hygienic or treatment requirements.[18] This is perhaps not surprising given that the literature shows that NTMs can be either trade facilitating or trade restricting. As shown in table 3, there is a statistically significant estimate of alpha in all cases, confirming that the Negative Binomial Regression should be preferred to Poisson estimation, as the Poisson model constrains alpha at zero.

[18] Full descriptions of the types of NTMs which do not include a compliance requirement can be found in UNCTAD (2013).

In interpreting our results, it is important to account for the fact that compliance measures are always associated with either a TBT or SPS measure, which is tested or inspected against. We therefore calculate marginal effects that allow for this conditional nature.[19] Table 5 shows the marginal effect of the imposition of a TBT compliance measure when a TBT measure is already in place. Focusing on the Negative Binomial Regression results, we see statistically significant effects at the 1 percent level for all countries, except the United States where the results are statistically significant at the 10 percent level.

The effects seem to diminish as market size increases. A compliance measure imposed by New Zealand or Canada is expected to reduce the number of exporting countries by 26-27 percent, compared to the situation where only a TBT measure is in place. The corresponding decreases for the European Union and United States are 11 and 6 percent, respectively. The differences in the size of the effect may be due to the fact that there is a smaller incentive to adjust production processes or incur transaction costs to meet the New Zealand and Canadian requirements, as compared to the European Union or the United States, because of either: (i) their relatively small market size; or (ii) that Canadian and New Zealand standards are not often adopted by many other countries. In contrast, exporters have greater incentive to adapt to EU or US standards, especially because those standards might be adopted by other importers.

[19] We use the Stata mchange command, detailed in Long and Freese, 2014.

*Table 5: Marginal Effect of the Imposition of a TBT Compliance Measure**

Data	Estimator	From	To	Change	Percentage Change	p-value
Canada	Poisson	24.504	18.219	-6.285	-25.65%	0.000
Canada	NBREG	24.230	17.830	-6.400	-26.41%	0.000
EU	Poisson	34.948	32.251	-2.727	-7.80%	0.018
EU	NBREG	35.017	31.170	-3.847	-10.99%	0.002
NZ	Poisson	13.000	8.896	-4.104	-31.57%	.
NZ	NBREG	13.166	9.608	-3.558	-27.02%	0.000
USA	Poisson	23.620	22.668	-0.952	-4.03%	0.213
USA	NBREG	23.586	22.121	-1.465	-6.21%	0.059

* *When a TBT measure is already in place.*

*Table 6: Marginal Effect of the Imposition of a SPS Compliance Measure**

Data	Estimator	From	To	Change	Percentage Change	p-value
Canada	Poisson	25.612	13.299	-12.313	-48.08%	0.000
Canada	NBREG	26.991	14.403	-12.588	-46.64%	0.000
EU	Poisson	37.725	32.727	-4.998	-13.25%	0.001
EU	NBREG	37.356	33.063	-4.293	-11.49%	0.007
NZ	Poisson	13.393	12.497	-0.896	-6.69%	.
NZ	NBREG	13.933	13.107	-0.826	-5.93%	0.445
USA	Poisson	23.105	26.510	3.406	14.74%	0.006
USA	NBREG	23.497	27.864	4.367	18.59%	0.000

* *When an SPS measure is already in place.*

Table 6 shows the change in the number of exporting countries due to the imposition of a SPS compliance measure when a SPS measure is already in place. We see large and negative effects for the European Union (an 11 percent reduction) and Canada (a 47 percent reduction) whereas the effects for New Zealand, while negative, are not statistically significant.

While our results are consistent, finding that both TBT and SPS compliance measures reduce the number of countries exporting to a market, the differences between the effects of SPS and TBT measures in Canada and New Zealand could be explained by differences in their frequency and focus. (See tables 1 and A1.1 in the appendix.) In contrast to the other countries in this study, New Zealand applies more

SPS compliance measures than TBT compliance measures. The relatively widespread nature of New Zealand SPS compliance measures may make it less likely to find a statistically significant negative effect, given there is less variation across product groups. In contrast, Canada applies relatively few SPS compliance measures but – as shown in table A1.1 - these are focused in food and agriculture, which has traditionally been protected and supported by Canadian Government policies, including producer support, tariffs and supply management schemes (see, for instance, Anderson and Martin, 2005). This could compound the earlier mentioned effects of Canada being a relatively small market.

Somewhat unexpectedly, a SPS compliance requirement has a positive effect on the number of countries exporting to the United States. While this could be explained by a different regulatory regime, and/or consumer preferences, whereby certification either reduces costs to firms e.g. through added certainty – or assists them in the market, it is a result that warrants further attention, which we explore as part of the robustness checks.

ROBUSTNESS CHECKS

US data: Different Effects for Different Sectors

A key feature of United States NTMs is the much higher incidence of SPS compliance measures outside of the food and agriculture sectors, where they are typically concentrated for most other countries, see table A1.1 in appendix 1. It is therefore useful to examine if SPS compliance measures have a different effect on non-agricultural sectors in the United States. To do this, we add an interaction term between the food and agriculture sectors and SPS compliance measures, where our dummy variables (*SPS Measure* and *SPS Compliance Measure*) are multiplied by a dummy variable equal to unity if the product is classified as part of the food and agriculture sector. This gives four new variables: *SPS Measure (on a Food or Agricultural Product)*; *SPS Measure (on a Non-Agricultural Product)*; *SPS Compliance Measure (on a Food or Agricultural Product)*; *SPS Compliance Measure (on a Non-Agricultural Product).*

The results of regressions using these four new variables, also including the food and agriculture dummy variable, are set out in table A1.2. We now find a statistically significant negative effect of SPS compliance measures in the food and agricultural sectors where these are expected to reduce the number of countries exporting to the United States from 44 to 29 compared to the case where a SPS measure without a compliance element is in place, a decrease of 35 percent. While this enables us to say that in the food and agriculture sectors, SPS compliance measures decrease the number of countries exporting to the United States, which is the pattern we observe in the other markets, it leaves unresolved how these measures affect the non-agricultural sector given that we still find statistically significant positive effects of measures in these sectors. As we discuss in the next section, the explanation may lie in taking into account "partial coverage" i.e. where a NTM does not affect all products within a HS subheading.

Partial Coverage

A challenge for NTM data collection is that the coverage of a NTM may not align with the tariff codes, with only some products in a tariff line affected. In this case, the data collector assigns a "partial coverage" indicator to the NTM data.[20] This is particularly an issue where the NTM only applies to a small subset of the goods; as an example, part 94 of title 9 of the US Code of Federal Regulations requires certification and inspection of the absence of dirt on used farm equipment imported from regions where rinderpest or foot-and-mouth disease exists.[21] As there is no separate HS code for used farm equipment, a wide variety of HS codes for equipment that may be used on a farm is classified as subject to a certification requirement, even though the majority of imports are expected to be new and not subject to this requirement.

The choice in econometric estimation is whether to include partial coverage NTMs and run the risk of classifying too many products as subject to an NTM, or omit them and run the risk of classifying too few products as subject to an NTM. On balance, we expect it to be preferable to include partial coverage NTMs on the basis that a NTM which applies to a related product is still expected to "chill" trade and for the most part, the effect would be to reduce the estimated coefficient. However, as a robustness check and to investigate further the results for the United States non-agricultural sector, we ran regressions excluding NTMs with partial coverage. In addition to excluding NTMs with partial coverage, we also excluded NTMs that do not cover all tariff lines in an HS subheading.[22]

Results from this econometric specification are set out in appendix 2. In general, we see a larger effect when NTMs with partial coverage are excluded from the analysis.

[20] No partial coverage indications are present in EU data.

[21] https://www.gpo.gov/fdsys/pkg/CFR-2014-title9-vol1/xml/CFR-2014-title9-vol1-part94.xml

[22] As US NTM data are at the HS 6 digit level, partial coverage already takes into account NTMs that do not cover all tariff lines in an HS subheading.

In this framework, a TBT compliance requirement reduces the number of countries exporting: to the European Union by 18 percent (compared to 11 percent when NTMs with partial coverage were included); to New Zealand by 32 percent (compared to 27 percent when NTMs with partial coverage were included); to the United States by 35 percent (compared to 6 percent when NTMs with partial coverage were included). A SPS compliance requirement reduces the number of countries exporting: to the EU by 17 percent (compared to 11 percent when NTMs with partial coverage were included); to Canada by 55 percent (compared to 47 percent when NTMs with partial coverage were included); to New Zealand by 27 percent (compared to 6 percent when NTMs with partial coverage were included) – a result that is now statistically significant. Moreover, we now see a negative effect of SPS measures in the United States, although this result is not statistically significant.

On the other hand, we do find one counter-intuitive result; when measures with partial coverage are excluded we find that a TBT compliance measure has a statistically significant positive effect on the number of countries exporting to Canada. Such a counter-intuitive result can be explained by the fact that some TBT compliance measures that have a significant negative effect on trade only have partial coverage so the results are distorted by their omission. This supports our initial approach of including NTMs with partial coverage, except where the data suggest that these NTMs might be distorting the results – as was the case with United States NTM data, particularly in the non-agricultural sector.

As a specific check of whether the statistically positive effect of SPS compliance measures in the non-agriculture sector can be explained by partial coverage, we estimate equation 2 excluding NTMs with "partial coverage". Results are shown in table A2.5 in appendix 2. We now find a negative effect of SPS compliance measures in this sector – although the result is not statistically significant.

Using Eight-Digit New Zealand Data

While we used data at the six-digit level in the harmonized system, for many countries - other than the United States – both tariff and NTM data are available at a more detailed level. Beyond the six-digit level, codes are not harmonized between countries. Therefore most cross-country work is done at the six-digit, or more aggregated level, for instance Crivelli & Gröschl (2016) undertook their analysis at the four-digit level. As a robustness check to determine the effect of using more detailed data, we compare our results using six-digit data for New Zealand to results obtained using eight-digit data. Our overall results on the effect of TBT or SPS compliance measures are consistent, although effects of a TBT restriction are slightly lower with the more disaggregated data, with the difference approximately one standard error.[23]

CONCLUSIONS

Our study finds relatively robust evidence that compliance measures affect the number of countries exporting to developed country markets, even with just the one year of NTM data that are available. We generally find a statistically significant negative effect of compliance measures, applied for either SPS or TBT reasons. Conversely, there is a positive effect for NTM measures that do not have a compliance

[23] Results are available on request from the authors.

component. This lends further support to the literature showing that NTMs can be trade facilitating in some circumstances and trade restricting in others. Our results are market specific, with findings differing by importer as well as for TBT and SPS compliance measures.

In the case of TBT measures, we find that Canadian and New Zealand TBT compliance measures reduce the number of exporting countries by 26-27 percent compared to the situation where no compliance requirement is imposed. This is a substantially larger effect on the number of exporting countries than for measures imposed by the European Union or the United States. Two possible explanations for this are: (i) the relatively small size of the Canadian and New Zealand markets reduces the incentive to meet these requirements; (ii) Canadian and New Zealand standards are not often adopted by many other countries, unlike the case for United States or European standards. Since the standards imposed by Canada and New Zealand do not have a global reach, meeting these requirements may require relatively costly changes to standard production processes.

SPS compliance measures have the largest effect in Canada and the European Union, reducing the number of countries exporting to these markets by 47 and 11 percent, compared to the situation where a SPS measure was in place with no testing, certification or inspection requirements. Given the relatively high incidence of SPS compliance measures outside the food and agriculture sector in the United States, we undertake a regression allowing for measures to have different effects in these sectors. We find that SPS compliance measures on food and agricultural products in the United States are expected to lead to a 35 percent decrease in the number of countries exporting, compared to the situation where a SPS measure was in place but there was no testing, certification or inspection associated with the measure

The differences in results for different markets may have implications for future researchers. Since this is a new database, this research examining individual country data may help to provide an important validity check for researchers who undertake analyses in the future, particularly for studies where the data are pooled across countries. While pooling of countries is likely to be necessary in many empirical applications, particularly where a gravity model is desired, for instance to analyze effects on the value of trade, the differences in results that we find for our selection of developed countries markets suggests that pooling should be done carefully, using groups of countries that are as similar as possible.

Our results have significant policy implications. Regulators in importing countries that are considering imposing compliance measures should be aware that these are likely to reduce the number of exporters to their country. This is likely to affect product variety and, potentially, competition and so may lower the welfare of their own consumers. On the other hand, policy makers in exporting countries should not only be concerned with NTMs in the markets that they export to, but also note the likelihood that NTMs – particularly compliance measures – may be preventing their firms from profitably exporting to other new markets. Finally, to the extent that rich countries are concerned with ensuring access of poor countries to their markets, compliance measures may hinder this access. Of particular note may be when importer blocs splinter, as will occur with Brexit; if breakaway countries impose different compliance measures, it is likely to reduce the number of exporters, who may be the same (developing) countries who are receiving aid assistance to overcome barriers to trade.

References

Anderson, K., & Martin, W. (2005). Agricultural trade reform and the Doha Development Agenda. T*he World Economy*, 28(9), 1301-1327.

Atkin, D., Khandelwal, A. K., & Osman, A. (2017). Exporting and Firm Performance: Evidence from a Randomized Experiment. *The Quarterly Journal of Economics*, *132*(2), 551–615. https://doi.org/10.1093/qje/qjx002

Baier, S. L., & Bergstrand, J. H. (2007). Do free trade agreements actually increase members' international trade? *Journal of International Economics*, 71(1), 72–95. https://doi.org/10.1016/j.jinteco.2006.02.005

Beghin, J., Maertens, M., & Swinnen, J. F. (2015). Non-tariff measures and standards in trade and global value chains. *Annual Review of Resource Economics*, *7*.

Berden, K., & Francois, J. (2015). *Quantifying Non-Tariff Measures for TTIP*. Paper No. 12 in the CEPS-CTR project "TTIP in the Balance" and CEPS Special Report No. 116/July 2015.

Bernard, A. B., Jensen, J. B., Redding, S. J., & Schott, P. K. (2007). Firms in International Trade. *Journal of Economic Perspectives*, *21*(3), 105–130.

Bista, R., & Tomasik, R. (2017). Time Zone Effect and the Margins of Exports. *The World Economy*, *40*(6), 1053–1067. https://doi.org/10.1111/twec.12415

Broda, C., & Weinstein, D. E. (2006). Globalization and the Gains From Variety. *The Quarterly Journal of Economics*, *121*(2), 541–585. https://doi.org/10.1162/qjec.2006.121.2.541

Burger, M., Van Oort, F., & Linders, G. J. (2009). On the specification of the gravity model of trade: zeros, excess zeros and zero-inflated estimation. *Spatial Economic Analysis*, *4*(2), 167–190.

Cadot, O., Carrère, C., & Strauss-Kahn, V. (2010). Export Diversification: What's behind the Hump? *Review of Economics and Statistics*, *93*(2), 590–605. https://doi.org/10.1162/REST_a_00078

Cadot, O., & Gourdon, J. (2014). Assessing the Price-Raising Effect of Non-Tariff Measures in Africa. *Journal of African Economies*, *23*(4), 425–463. https://doi.org/10.1093/jae/eju007

Cadot, O., & Gourdon, J. (2016). Non-tariff measures, preferential trade agreements, and prices: new evidence. *Review of World Economics*, *152*(2), 227–249. https://doi.org/10.1007/s10290-015-0242-9

Cadot, O., Malouche M., & Saez, S. (2009) *Streamlining Non-Tariff Measures A Toolkit for Policy Makers*. The World Bank.

Crivelli, P., & Gröschl, J. (2016). The impact of sanitary and phytosanitary measures on market entry and trade flows. *The World Economy*, *39*(3), 444–473.

Clerides, S. K., Lach, S., & Tybout, J. R. (1998). Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico, and Morocco. *Quarterly Journal of Economics*, *113*(4), 903–947.

de Loecker, J. (2007). Do Exports Generate Higher Productivity? Evidence from Slovenia. *Journal of International Economics*, *73*(1), 69–98.

Debaere, P., & Mostashari, S. (2010). Do tariffs matter for the extensive margin of international trade? An empirical analysis. *Journal of International Economics*, *81*(2), 163–169. https://doi.org/10.1016/j.jinteco.2010.03.005

Dennis, A., & Shepherd, B. (2007). *Trade costs, barriers to entry, and export diversification in developing countries*. World Bank Policy Research Working Paper.

Dutt, P., Mihov, I., & Van Zandt, T. (2013). The effect of WTO on the extensive and the intensive margins of trade. *Journal of International Economics*, *91*(2), 204–219. https://doi.org/10.1016/j.jinteco.2013.08.001

Egger, P., Francois, J., Manchin, M., & Nelson, D. (2015). Non-tariff barriers, integration and the transatlantic economy. *Economic Policy*, *30*(83), 539–584. https://doi.org/10.1093/epolic/eiv008

El-Enbaby, H., Hendy, R., & Zaki, C. (2016). Do SPS measures matter for margins of trade? Evidence from firm-level data. *Applied Economics*, *48*(21), 1949–1964. https://doi.org/10.1080/00036846.2015.1111987

Feenstra, R. C., & Weinstein, D. E. (2017). Globalization, Markups, and US Welfare. *Journal of Political Economy*, Forthcoming. https://doi.org/10.1086/692695

Feenstra, R., & Kee, H. L. (2008). Export variety and country productivity: Estimating the monopolistic competition model with endogenous productivity. *Journal of International Economics*, *74*(2), 500–518. https://doi.org/10.1016/j.jinteco.2006.11.006

Feenstra, R., & Ma, H. (2014). Trade Facilitation and the Extensive Margin of Exports. *Japanese Economic Review*, *65*(2), 158–177. https://doi.org/10.1111/jere.12031

Felbermayr, G. J., & Kohler, W. (2006). Exploring the Intensive and Extensive Margins of World Trade. *Review of World Economics*, *142*(4), 642–674. https://doi.org/10.1007/s10290-006-0087-3

Ferro, E., Otsuki, T., & Wilson, J. S. (2015). The effect of product standards on agricultural exports. *Food Policy*, *50*, 68–79. https://doi.org/10.1016/j.foodpol.2014.10.016

Flam, H., & Nordström, H. (2006). *Euro effects on the intensive and extensive margins of trad*e. Institute for International Economic Studies Seminar Series

Foellmi, R., Hepenstrick, C., & Zweimuller, J. (2017). International Arbitrage and the Extensive Margin of Trade between Rich and Poor Countries. *The Review of Economic Studies*, forthcoming.

Fontagné, L., Orefice, G., Piermartini, R., & Rocha, N. (2015). Product standards and margins of trade: Firm-level evidence. *Journal of International Economics*, *97*(1), 29–44. https://doi.org/10.1016/j.jinteco.2015.04.008

Grant, J., & Arita, S. (2017). *Sanitary and Phyto-Sanitary Measures: Assessment, Measurement, and Impact.* IATRC Commissioned Paper

Hallak, J. (2006). Product Quality and the Direction of Trade. *Journal of International Economics*, *68*(1), 238–265.

Hallak, J., & Sivadasan, J. (2013). Product and Process Productivity: Implications for Quality Choice and Conditional Exporter Premia. *Journal of International Economics*, *91*(1), 53–67.

Helpman, E., Melitz, M., & Rubinstein, Y. (2008). Estimating Trade Flows: Trading Partners and Trading Volumes. *The Quarterly Journal of Economics*, *123*(2), 441–487.

Jaud, M., Cadot, O., & Suwa-Eisenmann, A. (2013). Do food scares explain supplier concentration? An analysis of EU agri-food imports. *European Review of Agricultural Economics*, *40*(5), 873–890. https://doi.org/10.1093/erae/jbs038

Kee, H. L., Nicita, A., & Olarreaga, M. (2009). Estimating Trade Restrictiveness Indices. *The Economic Journal*, *119*(534), 172–199. https://doi.org/10.1111/j.1468-0297.2008.02209.x

Krugman, P. R. (1979). Increasing returns, monopolistic competition, and international trade. *Journal of International Economics*, *9*(4), 469–479.

Lee, J.W., & Swagel, P. (1997). Trade Barriers and Trade Flows Across Countries and Industries. *Review of Economics & Statistics*, 79(3), 372–382. https://doi.org/10.1162/00346530055696

Li, Y., & Beghin, J. C. (2012). A meta-analysis of estimates of the impact of technical barriers to trade. *Journal of Policy Modeling*, 34(3), 497–511. https://doi.org/10.1016/j.jpolmod.2011.11.001

Long, J. S., & Freese, J. (2014). *Regression Models for Categorical Dependent Variables Using Stata* (Third). Texas: StataCorp LP.

Otsuki, T., Wilson, J. S., & Sewadeh, M. (2001). Saving two in a billion: quantifying the trade effect of European food safety standards on African exports. *Food Policy*, *26*(5), 495–514. https://doi.org/10.1016/S0306-9192(01)00018-5

Santos Silva, J. M. C., & Tenreyro, S. (2006). The Log of Gravity. *The Review of Economics and Statistics*, *88*(4), 641–658.

Santos Silva, J. M. C., Tenreyro, S., & Wei, K. (2014). Estimating the extensive margin of trade. *Journal of International Economics*, *93*(1), 67–75. https://doi.org/10.1016/j.jinteco.2013.12.001

Trefler, D. (1993). Trade liberalization and the theory of endogenous protection: An econometric study of U.S. import policy. *Journal of Political Economy*, 101(1), 138.

UNCTAD. (2013). *Classification of Non-tariff Measures: February 2012 Version*. New York and Geneva.

UNCTAD. (2014). *Guidelines to Collect Data on Official Non-Tariff Measures: September 2013 Version*. New York and Geneva.

Vanzetti, D., Peters, R., & Knebel, C. (2014). *Sand in the Wheels: Non-Tariff Measures and Regional Integration in SADC*. Policy Issues in International Trade and Commodities Study Series

Vigani, M., Raimondi, V., & Olper, A. (2012). International trade and endogenous standards: the case of GMO regulations. *World Trade Review*, 11(3), 415–437. https://doi.org/10.1017/S1474745612000262

Wagner, J. (2007). Exports and Productivity: A Survey of the Evidence from Firm-level Data. *The World Economy*, 30(1), 60–82.

Webb, M., Strutt, A., & Rae, A. N. (2017). Impacts of Geographical Restrictions: New Zealand Fruit and Vegetable Imports. *Journal of International Agricultural Trade and Development*, *10*(2). 203-224.

Winchester, N. (2009). Is there a dirty little secret? Non-tariff barriers and the gains from trade. *Journal of Policy Modeling*, *31*(6), 819–834. https://doi.org/10.1016/j.jpolmod.2009.08.004

Appendix 1: Allowing for Different Effects on Different Sectors

Table A1.1: Breakdown of Dummy Variables by Food and Agriculture, and Non-Agricultural Sectors

	Canada	EU	NZ	USA
Dummy Variables (in Food and Agriculture Sectors)				
SPS Measure	873	876	873	897
SPS Compliance Measure	517	638	837	888
TBT Measure	839	896	820	892
TBT Compliance Measure	810	323	4	462
Dummy Variables (in Other Sectors)				
SPS Measure	395	679	717	1122
SPS Compliance Measure	81	215	228	628
TBT Measure	3246	3940	2182	4160
TBT Compliance Measure	3629	3629	336	3542

Table A1.2: Coefficients from Estimation of United States Results with Interaction between Food and Agriculture Dummy and SPS Compliance Measures

VARIABLES	Coefficient
Food and Agriculture Dummy	-0.944***
	(0.340)
SPS Measure (on a Food or Agricultural Product)	0.750*
	(0.387)
SPS Measure (on a Non-Agricultural Product)	-0.012
	(0.038)
SPS Compliance Measure (on a Food or Agricultural Product)	-0.429*
	(0.255)
SPS Compliance Measure (on a Non-Agricultural Product)	0.190***
	(0.048)
Geographical Restriction	-0.102
	(0.124)
TBT Measure	0.146***
	(0.055)
TBT Compliance Measure	-0.061*
	(0.035)

Notes: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Coefficients for sector dummy variables are not shown.

Appendix 2: Excluding Partial Coverage

Table A2.1: Comparison of Dummy Variables When Partial Coverage is Excluded

	Canada		EU		NZ		USA	
	Number	% of Total*	Number	% of Total*	Number	% of Total*	Number	% of Total*
Dummy Variables in Food and Agriculture Sectors								
SPS Measure	854	92.21%	869	99.20%	805	92.21%	844	94.09%
SPS Compliance Measure	491	81.84%	616	96.55%	685	81.84%	324	36.49%
TBT Measure	696	96.22%	896	100.00%	789	96.22%	782	87.67%
TBT Compliance Measure	105	25.00%	284	87.93%	1	25.00%	254	54.98%
Geographical Restriction	9	59.24%	646	97.58%	93	59.24%	105	68.18%
Dummy Variables in Non-Agriculture Sectors								
SPS Measure	81	61.23%	596	87.78%	439	61.23%	132	11.76%
SPS Compliance Measure	71	54.39%	202	93.95%	124	54.39%	63	10.03%
TBT Measure	963	51.47%	3927	99.67%	1123	51.47%	1927	46.32%
TBT Compliance Measure	613	22.02%	3596	99.09%	74	22.02%	507	14.31%
Geographical Restriction	0	16.67%	42	89.36%	1	16.67%	0	0.00%
All Dummy Variables								
SPS Measure	935	78.24%	1465	94.21%	1244	78.24%	976	48.34%
SPS Compliance Measure	562	75.96%	818	95.90%	809	75.96%	387	25.53%
TBT Measure	1659	63.67%	4824	99.73%	1912	63.67%	2709	53.61%
TBT Compliance Measure	718	22.06%	3881	98.18%	75	22.06%	761	19.00%
Geographical Restriction	9	57.67%	688	97.04%	94	57.67%	105	66.88%

** Total NTMs include those with partial coverage*

Table A2.2: Estimation Results (Coefficients): Partial Coverage is Excluded

VARIABLES	Canada Poisson	Canada NBREG	EU Poisson	EU NBREG	NZ Poisson	NZ NBREG	USA Poisson	USA NBREG
SPS Measure	0.262***	0.265**	0.103***	0.0891**	-0.0323	-0.0166	-0.175**	0.0229
	(0.095)	(0.109)	(0.035)	(0.0376)	(0.044)	(0.053)	(0.078)	(0.0842)
SPS Compliance Measure	-0.792***	-0.798***	-0.202***	-0.186***	-0.286***	-0.310***	-0.061	-0.0809
	(0.069)	(0.0741)	(0.046)	(0.0467)	(0.080)	(0.077)	(0.085)	(0.0778)
Geographical Restriction	-0.585***	-0.573***	-0.275***	-0.269***	-0.452***	-0.233	-0.725***	-0.802***
	(0.125)	(0.121)	(0.064)	(0.0620)	(0.165)	(0.177)	(0.110)	(0.128)
TBT Measure	-0.065	-0.0727	0.110**	0.145***	0.107***	0.150***	0.185***	0.163***
	(0.044)	(0.0454)	(0.048)	(0.0503)	(0.034)	(0.038)	(0.032)	(0.032)
TBT Compliance Measure	0.201***	0.255***	-0.146***	-0.204***	-0.524***	-0.389***	-0.424***	-0.425***
	(0.054)	(0.0561)	(0.036)	(0.0381)	(0.116)	(0.118)	(0.041)	(0.042)
Alpha		0.531***		0.400***		0.838***		0.466***
		(0.012)		(0.009)		(0.020)		(0.011)

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Coefficients for sector dummy variables are not shown.

Table A2.3: Marginal Effect of a TBT Compliance Measure (When a TBT Measure is Already Applied): Partial Coverage is Excluded

Data	Estimator	From	To	Change	Percentage Change	p-value
Canada	Poisson	22.318	27.286	4.968	22.26%	0.000
Canada	NBREG	22.172	28.613	6.441	29.05%	0.000
EU	Poisson	35.019	30.250	-4.768	-13.62%	0.000
EU	NBREG	35.088	28.619	-6.469	-18.44%	0.000
NZ	Poisson	13.508	7.998	-5.510	-40.79%	0.515
NZ	NBREG	13.875	9.405	-4.470	-32.22%	0.000
USA	Poisson	25.452	16.659	-8.793	-34.55%	0.000
USA	NBREG	25.182	16.460	-8.722	-34.64%	0.000

Table A2.4: Marginal Effect of a SPS Compliance Measure (When a SPS Measure is Already Applied): Partial Coverage is Excluded

Data	Estimator	From	To	Change	Percentage Change	p-value
Canada	Poisson	28.920	13.092	-15.827	-54.73%	0.000
Canada	NBREG	28.962	13.041	-15.921	-54.97%	0.000
EU	Poisson	37.397	30.565	-6.831	-18.27%	0.000
EU	NBREG	37.016	30.720	-6.296	-17.01%	0.000
NZ	Poisson	12.315	9.252	-3.063	-24.87%	0.518
NZ	NBREG	12.460	9.135	-3.325	-26.69%	0.000
USA	Poisson	20.199	19.009	-1.190	-5.89%	0.469
USA	NBREG	23.726	21.883	-1.844	-7.77%	0.292

Table A2.5: Comparison Coefficients from Estimation of United States Results with Interaction between Food and Agriculture Dummy and SPS Compliance Measures

VARIABLES	Coefficient (including partial coverage)	Coefficient (excluding partial coverage)
Food and Agriculture Dummy	-0.944***	-0.940***
	(0.340)	(0.133)
SPS Measure (on a Food or Agricultural Product)	0.750*	0.261**
	(0.387)	(0.129)
SPS Measure (on a Non-Agricultural Product)	-0.012	-0.0195
	(0.038)	(0.131)
SPS Compliance Measure (on a Food or Agricultural Product)	-0.429*	-0.022
	(0.255)	(0.086)
SPS Compliance Measure (on a Non-Agricultural Product)	0.190***	-0.222
	(0.048)	(0.188)
Geographical Restriction	-0.102	-0.824***
	(0.124)	(0.130)
TBT Measure	0.146***	0.159***
	(0.055)	(0.032)
TBT Compliance Measure	-0.061*	-0.419***
	(0.035)	(0.042)

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

CHAPTER IV: IMPACTS OF GEOGRAPHICAL RESTRICTIONS: NEW ZEALAND FRUIT AND VEGETABLE IMPORTS

This paper has been published in the *Journal of International Agricultural Trade and Development* 10(2) 203-224.

Journal of International Trade and Development ISSN: 1556-8520
Volume 10, Number 2

IMPACTS OF GEOGRAPHICAL RESTRICTIONS: NEW ZEALAND FRUIT AND VEGETABLE IMPORTS

Mike Webb[1]***, Anna Strutt***[1,*] ***and Allan N. Rae***[2]
[1]Department of Economics, University of Waikato, Hamilton, New Zealand
[2]School of Economics and Finance, Massey University, Palmerston North, New Zealand

ABSTRACT

This paper explores the trade effects of New Zealand restricting, for biosecurity reasons, the countries from which particular fruit and vegetable products can be imported. We propose a new index to quantify the extent to which fruit and vegetable exports from each region are constrained by these restrictions. This index is validated econometrically and simulations are undertaken to determine expected imports if all fruit and vegetable products could be imported from all countries. In this counterfactual scenario, we expect increased fruit and vegetable imports from Europe, Middle East and Africa, the Americas (excluding the United States), and East Asia at the expense of imports from Oceania, Australia, the United States, South East Asia and South Asia.

Keywords: Non-tariff barriers; Sanitary and phytosanitary measures; Gravity modelling; Computable general equilibrium modelling

JEL classification: D58, F14; Q17

INTRODUCTION

Non-tariff measures (NTMs),[1] including sanitary and phytosanitary (SPS) measures, can have significant impacts on international trade, creating barriers to trade that are often much higher than tariffs (Shepherd 2016). The estimated effects of NTMs can vary widely, depending in part on the type of measures, the sectors considered and the methodology used (Beghin, Maertens, and Swinnen 2015). However, in general, SPS regulations have been found to be more likely to impede agricultural and food trade exports from developing countries (Li and Beghin 2012).

To date, the literature on quantifying NTM impacts has generally focused on aggregate measures of NTMs that do not capture important differences in their nature. In the current

* Corresponding author: Associate Professor Anna Strutt, Department of Economics, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand, Ph +64 7 838 4958, anna.strutt@waikato.ac.nz.

[1] Non-tariff measures, of which non-tariff barriers (NTBs) are a subset, are defined as "policy measures, other than customs tariffs, that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both" (UNCTAD 2014).

paper, we focus on the particular example of fruit and vegetable phytosanitary measures applied by New Zealand, specifically, the restriction preventing non-authorized countries from exporting these products to New Zealand. We develop a novel method to model the impact of these types of geographically restrictive NTMs. This enables comparison of current import profiles with the counterfactual scenario where all fruit and vegetable products can be imported, regardless of their origin. In addition to examining the impacts on New Zealand, we are able to quantify which regions are most likely to benefit from increased exports of these products, including impacts on developing countries.

A growing body of work is focused on incorporating NTMs into computable general equilibrium (CGE) models (see, for instance, Fugazza and Maur 2008, Winchester 2009, and Vanzetti, Peters and Knebel 2014, which utilized econometric work published in Cadot, Asprilla, Gourdon, Knebel and Peters 2015). Various other studies also focus on geographical restrictions, using a CGE framework to study an NTM applied by a single country. These include two recent analyses of Russia's import ban on specified agri-food products from certain countries (Boulanger, Dudu, Ferrari and Philippidis 2015 and Kutlina-Dimitrova and Narayanan 2015), as well as studies of a hypothetical EU import ban on GM soybeans and maize/oil seeds from Argentina, Brazil and the USA (Philippidis 2010 and Henseler et al. 2013). Our geographical restrictions focus is much broader, exploring the impact of a policy that differentially affects all exporting countries.

In addition to offering insights into the effect of New Zealand's SPS restrictions on different exporting regions, this paper contributes to the more general NTM literature by presenting a new approach to modelling, within a CGE framework, NTMs that restrict imports. This has potentially wide application to other types of NTMs. The approach is well-suited to analyzing policies that affect countries to different extents, for instance, where there are geographical restrictions on eligibility preventing the import of specified products from particular countries.

The paper is organized as follows. The New Zealand SPS regime is outlined in section 2. Section 3 develops our new Geographical Restrictions Index and explains how it can be used to estimate the trade effects of extending phytosanitary access. This index is used, in section 4, as an explanatory variable in a gravity model of New Zealand fruit and vegetable imports over the period 1994-2013 to assess the validity of the approach. In section 5, we present CGE simulation results, using the Global Trade Analysis Project (GTAP) model to assess the potential impact of New Zealand approving all fruit and vegetable imports from all countries. The final section concludes.

THE NEW ZEALAND SPS REGIME

Under the World Trade Organization's SPS Agreement, countries are able to set their own measures for food safety and animal and plant health, which should be based on: recognized international standards; science, including a scientific approach and a temporary precautionary principle in the absence of international standards or scientific evidence.[2] The New Zealand SPS regime, established by the Biosecurity Act 1993, reflects that New Zealand is a major agricultural producer and an island nation, free from many diseases and pests affecting international animal and plant product trade.[3] Animal and plant products that present a potential biosecurity risk for the introduction of pests and diseases cannot be

[2] See https://www.wto.org/english/thewto_e/whatis_e/tif_e/agrm4_e.htm.

[3] See WTO Trade Policy Review of New Zealand 2009, particularly the Record of Meeting with Questions and Answers from Members. http://www.wto.org/english/tratop_e/tpr_e/tp_rep_e.htm.

imported until a risk analysis assessment, consistent with international standards, has been completed. This process, triggered by a request from a country interested in exporting the product, involves the development of an import health standard that mitigates the risk associated with importing that product. As fresh produce can serve as vectors for the introduction of pests, such as fruit flies, that affect other products, import health standards also cover products that are not grown commercially in New Zealand, such as bananas. There are approximately 200 import health standards that cover a particular commodity or category of commodity; these may be generic, covering all countries, or country-specific.[4]

The development of an import health standard is resource intensive for both New Zealand and the potential exporting country. The responsible government agency, the Ministry for Primary Industries, notes that they "set priorities for developing new import health standards, and it may take some years to finalise [a] request."[5] More specifically, the Ministry for Primary Industries explains that requests are prioritised by assessing the following: importance to New Zealand; strategic fit with New Zealand government goals; net benefit for New Zealand in the longer term; feasibility of being able to do the work; whether the barriers can be surmounted; and the amount of work expected.[6] Government-funded resources are allocated to the top priority import health standard work with remaining applicants offered the option of funding the cost of their application themselves.

An implication of New Zealand's approach of not allowing imports of potentially risky animal and plant products until an import health standard is in place, is that many countries are unable to export particular commodities to New Zealand. In other words, this NTM can be a binding restriction on exports. While this may seem restrictive, similar processes apply in other countries, for instance the United States requires exporting countries to be authorized for each fruit and vegetable exported (see Jouanjean, Maur, and Shepherd 2012, Karov, Roberts, Grant and Peterson 2009, and Seale, Zhang and Traboulsi 2013) and Australia has, for many years, applied strict phytosanitary requirements (James and Anderson 1998). Phytosanitary restrictions in Europe are discussed in Helmy (2010).

Detailed information on New Zealand's phytosanitary measures has recently been collated as part of an international effort to collect comprehensive data on NTMs.[7] The data use a common classification methodology to consistently categorize non-tariff measures for a wide range of countries at a given point in time (UNCTAD 2013 and 2014). Within this classification framework, countries that are unable to export a particular product to New Zealand, due to the absence of import health standards, are recorded as facing a measure classified as A12 "Geographical Restrictions on Eligibility." The focus of the current study is on this measure.

The New Zealand import health standard approach has the advantage of being transparent about the import conditions, including through establishing a date from which specified countries can export particular products; therefore, we are able to extend the UNCTAD NTM data to provide a time series covering approval dates for imports of fresh fruit and vegetables (see Appendix 1). The current study is timely as the New Zealand Ministry for Primary Industries – which administers New Zealand's biosecurity regime - is

[4] See http://www.mpi.govt.nz/importing/overview/import-health-standards/. The countries that are covered by New Zealand's import health standards for the products in the fruit and vegetable sector that we model, along with the relative importance of each commodity are summarized in Appendix 1.

[5] https://www.mpi.govt.nz/importing/food/fresh-fruit-and-vegetables/steps-to-importing/

[6] https://www.mpi.govt.nz/importing/overview/import-health-standards/requesting-a-new-ihs/.

[7] The New Zealand data were collected by two authors of the current paper, as part of a project led by UNCTAD and the World Bank. These data are publicly available: http://i-tip.unctad.org/.

moving towards a new format for import health standards that will enable additional countries to be more readily approved for each commodity.[8]

A GEOGRAPHICAL RESTRICTIVENESS INDEX

The first step in our analysis is to calculate an index of the degree to which each country's fruit and vegetable access to New Zealand is impeded by geographical restrictions on eligibility.[9] We propose a Geographical Restrictions Index for each exporting region i (GRI_i), calculated as follows:

$$GRI_i = \frac{\sum_j X_{ij}.D_{ij}}{\sum_j X_{ij}} \quad (1)$$

where the subscript i denotes the exporter and the subscript j denotes each individual Harmonized System (HS6)[10] subheading within the much broader fruit and vegetable sector that we model using the GTAP database. X_{ij} is the value of total exports to the world of country i in HS subheading j. D_{ij} is a dummy that is equal to 1 if country i is authorized to export products in HS subheading j to New Zealand i.e., an import health standard is in place.[11]

This Geographical Restrictions Index summarizes the proportion of a region's total fruit and vegetable exports that are comprised of products that are eligible for export to New Zealand. As shown in Table 1, generally this index is higher for countries that have close trade and biosecurity links with New Zealand. For instance, the GRI was 0.97 for Pacific Island countries in 2011; this can be interpreted as products accounting for 97% of the Pacific's total fruit and vegetable exports to all countries were approved for export to New Zealand. The GRI is also relatively high for regions such as Australia (0.89) the United States (0.85) but is much lower for other regions, particularly for some countries in Africa and Latin America. The GRI is also relatively low for Europe, with only a small number of countries having access for a limited number of fruits.

The Geographical Restrictions Index can be used to adjust current exports of fruit and vegetables to New Zealand to obtain an estimate, for each region i, of the value of exports to New Zealand assuming the region had access to export all fruit and vegetable products to New Zealand. We refer to this as unrestricted exports, u_i:

$$u_i = x_i / GRI_i \quad (2)$$

where x_i = total current fruit and vegetable exports to New Zealand from region i. (We use

[8] While this new format is not currently used for fruit and vegetables, an example for meat products is the standard for turkey meat, available at https://www.mpi.govt.nz/document-vault/1978.

[9] Recall that when there is no import health standard covering a particular product from a particular country, that country cannot export to New Zealand.

[10] The HS uses code numbers to define traded products, with six-digit codes (HS6) being the most detailed level at which common (harmonized) codes are used by all countries.

[11] The data to calculate this index are HS6 import data obtained from the UN COMTRADE Database, see http://comtrade.un.org/. Import Health Standards are often applied to highly specific products, thus a 6 digit HS subheading may contain both products that do, and do not have access to New Zealand. We use data for 2011 to correspond to version 9 of the GTAP database that we use in our simulations. Where a country was approved to export a commodity in 2011, we weight exports by the number of months for which the country had access. We classify a country as having access for a given HS 6 digit subheading if they have access for at least one product in this subheading. The index will be too high (i.e., will understate the level of restrictions) if a region is only approved for some products within a HS 6 digit sub-heading or for exports from some parts of the region, however, this distortion is generally likely to be small.

a lower case x for exports to New Zealand to distinguish from exports to the world which is denoted with a capital X.) The rationale for this formula is as follows. The proportion of total fruit and vegetable exports that region i exports to New Zealand is $\frac{x_i}{X_i}$ but the ratio of fruit and vegetable exports to New Zealand to total exports of fruit and vegetables that region i is approved to export to New Zealand is this value divided by the GRI i.e., $\frac{x_i}{X_i.GRI_i}$. Therefore, if we assume that a region would export the same proportion of total exports of fruit and vegetables to New Zealand for products for which it currently does not have access as for products for which it does have access, we can obtain an estimate of unrestricted exports by dividing current exports by the GRI i.e., equation 2.[12] Table 1 summarizes current fruit and vegetable exports to New Zealand, the GRI and unrestricted exports for our base year 2011.

Table 1. Current exports, the Geographical Restrictions Index and export expansion (based on 2011 data)

Region	Current Fruit and Veg Exports to NZ (x_i) (US$ millions)	Average GRI	Unrestricted Fruit and Veg Exports to NZ (ux_i) (US$ millions)
Australia	55.30	0.89	62.07
Oceania (Pacific Island Countries)	13.51	0.97	13.92
East Asia	9.75	0.56	17.34
South East Asia	75.24	0.83	91.12
South Asia	3.55	0.64	5.50
USA	68.46	0.85	80.21
Rest of Americas	26.55	0.32	82.52
Europe	3.48	0.16	21.93
Middle East and Africa	23.18	0.22	106.31
World	279.02	0.58	NA

Source: Authors' calculations using the GTAP version 9 database and UN COMTRADE data for the GRI.

[12] Implicit here is the assumption that, for each region, the access conditions in new import health standards for products currently without access are on average as stringent as the import health standard conditions for products that are currently approved. Sections 4 and 5 allow for the case where, for products not previously approved, a smaller proportion of the exporter's total global exports would be exported to New Zealand than was the case for products previously approved.

It should be noted that the estimate of "unrestricted exports" if a region had access for all fruit and vegetable products to New Zealand does not take into account potential substitution between exporters if other regions also have improved market access, or shifts of productive resources between competing uses within a country. As some countries gain market access, other countries may lose market share. To obtain an estimate of exports if SPS access for all products were approved for all countries, we need a framework that allows for substitution between exporting regions and ensures the resource constraints of each economy hold. This is provided by the CGE framework presented in Section 5. Before turning to the CGE analysis, we first use econometric estimation to validate our approach.

GRAVITY ANALYSIS

Econometric analysis of the effect of an increase in the GRI on exports to New Zealand provides an opportunity to assess our approach to obtaining unrestricted exports. We examine this through a modified version of the conventional gravity model. Methodological underpinnings of gravity modelling and estimation issues are addressed in Anderson and van Wincoop (2003), Santos Silva and Tenreyro (2006) and Helpman, Melitz and Rubinstein (2008) among others. A useful summary is provided by Shepherd (2013), while van Bergeijk and Brakman (2010) present a contemporary survey of gravity models.

While using the same framework, our approach differs slightly from most gravity model applications in two ways. First, while most gravity models include a number of importing countries, we only include New Zealand. Examples of gravity models with a single country include Alam, Uddin, and Taufique (2009) which considers Bangladesh's imports and Li, Saghaian, and Reed (2012) which examines US seafood exports. Second, our model focuses on a single sector, fruit and vegetables, which has implications for how we control for productive capacity in the exporting country – see Schlueter, Wieck, and Heckelei (2009), and Karov et al. (2009) for examples of sector specific applications. The model estimated is;

$$x_{it} = \beta_1 \ln(GRI_{it}) + \beta_2 \ln(X_{it}) + \beta_3 \ln(distance_i) + \beta_4 comlang_i + \gamma_i + \theta_t + \varepsilon_{it} \tag{3}$$

where x_{it} is New Zealand fruit and vegetable imports from country i in year t; GRI_{it} is the Geographical Restrictiveness Index for country i in year t. Each exporting country's fruit and vegetable productive capacity is captured by X_{it} which is the total export of fruit and vegetables of country i to the world in year t. We use total fruit and vegetable exports because a nominal measure of fruit and vegetable production (both for domestic consumption and exports) across all countries is not available. As we are only concerned with the fruit and vegetable sector – and are only explaining exports to New Zealand – this is a more appropriate measure of the productive capacity of the exporting country than the GDP variable more commonly used for gravity model estimations, particularly for aggregate trade. As is typical in gravity models, we include observable factors affecting trade between two countries: their geographic distance ($distance_i$) and a dummy variable reflecting whether New Zealand and the exporting country have a common language ($comlang_i$). Other variables commonly used in gravity modelling such as a common border or a "land locked" variable are inappropriate given that New Zealand is the only importer and an island state. Similarly, sharing a common or past colonial link was inappropriate as it only covers two countries - New Zealand was a British colony and Samoa was a colonial territory of New Zealand. We did not include a FTA variable as this may be endogenous, see the discussion in Li, Saghaian and Reed (2012). Multilateral trade resistance, discussed in Anderson and van Wincoop (2003) is accounted for through exporter fixed effects (γ_i). Time fixed effects (θ_t) account for, inter alia, changes in New Zealand fruit and vegetable demand.

Trade data are obtained from the UN COMTRADE database - using values reported by importers. The gravity variables are obtained from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).[13] In particular, we use CEPII's widely used distance measure that calculates distance between major cities weighted by each city's population (Mayer and Zignago 2011). We use data from 1994 (the year after the New Zealand Biosecurity Act came into force) until 2013. As there is no change in the products for which all countries have access, we confine our analysis to the 30 countries which have gained (or lost) access for specific fruit and vegetables. Appendix 1 summarizes the countries that have access for each product as well as the date this was granted.

We apply the widely used Poisson pseudo maximum likelihood approach (Santos Silva and Tenreyro 2006; Schlueter, Wieck, and Heckelei 2009; Li, Saghaian and Reed 2012; Zenebe, Wamisho, and Peterson 2013; and Owen and Winchester 2014, provide relevant applications). This is one of two main methods used in contemporary gravity model applications: it avoids issues of heteroscedasticity which are particularly problematic with instances of zero trade as is typically found in sectoral applications of the gravity model (see Santos Silva and Tenreyro 2006 and Yang, Reed, and Saghaian 2013 for a discussion of these issues). The Heckman selection approach (Helpman, Melitz and Rubinstein 2008), which is also widely used in contemporary gravity analysis, is not suitable for our purposes: since we are only examining exports to one country, New Zealand, we do not have sufficient variation to identify a regressor that affects only the probability that a country exports but not the volume of trade.

Our estimation results are summarized in Table 2. In this framework, all variables are statistically significant at the 1% significance level. The coefficients for regressors expressed in log form can be interpreted as elasticities (Santos Silva and Tenreyro 2006). Therefore the method of obtaining "unrestricted exports" presented in the previous section i.e., the value of exports if all countries had access to export all products, implies a coefficient on ln (*GRI*) of unity: a country will export the same proportion of total exports of fruit and vegetables to New Zealand for products for which it currently does not have access as for products for which it does have access. A coefficient of less than unity implies that, for products not previously approved, a smaller proportion of the exporter's total global exports would be exported to New Zealand than was the case for products previously approved. While our point estimate is 0.677, the standard errors are relatively large, with the difference between 1 and 0.677 being slightly over one standard deviation – thus a coefficient value of unity is comfortably within the confidence intervals and the econometric evidence is not inconsistent with our approach to calculating "unrestricted exports". Nevertheless, as a robustness check, our CGE simulations make use of both estimates based on a coefficient of unity and the econometric estimate of this coefficient.

[13] See http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp

Table 2. Gravity equation estimates for New Zealand fruit and vegetable imports

	Coefficient Estimate	*Z* Value
ln *(GRI)*	0.677 (0.325)	2.085
ln *(X)*	0.923 (0.141)	6.538
ln *(distance)*	-2.314 (0.239)	-9.67
Comlang	1.904 0.247	7.694
Exporter Fixed Effects	Yes	
Year Fixed Effects	Yes	
N	600	
Pseudo R^2	0.943	

MODELLING FRAMEWORK AND RESULTS

A CGE framework is able to capture interactions between sectors and economies in a fully consistent framework. This enables us to account for substitutions between potential exporters as well as other inter-sectoral and inter-regional linkages. We use the GTAP model (Hertel 1997), along with the version 9 data base (Aguiar, Narayanan and McDougall 2016). GTAP is a well-known and fully-documented CGE model that has been widely used for a variety of policy applications.[14] The GTAP model specifies trade bilaterally, with imperfect substitution between foreign and domestic goods and between imports from different sources. The version 9 database used offers a base year of 2011 for 140 countries or regions and 57 sectors.[15] We aggregate the GTAP sectors to "fruit and vegetables" along with eight others, while we aggregate the regions to New Zealand along with nine other regions of interest.

Our approach involves first applying, separately to each region, the percentage shock to real exports that would increase exports to the unrestricted export value. From this simulation we can calculate the endogenously determined shifter needed for New Zealand's imports from each country.[16] We then simultaneously incorporate the shifters derived for each individual region to simulate an overall estimate of the change in exports from each region to New Zealand, accounting fully for price adjustments and substitution between exporters.

A similar approach to achieve an empirically derived change in bilateral imports was undertaken in Trewin, Vanzetti and Thang (2015). Their modelling results indicated that a 1% decrease in the stringency of the tetracycline standard in pork increases trade by 0.59%. A conceptual framework for this can be found in Andriamananjara, Ferrantino and Tsigas (2003) which discusses how SPS measures, technical barriers to trade and other regulatory measures may create efficiency losses, describing these as institutional frictions or "sand

[14] See www.gtap.org for detailed and updated information on the model and database, along with wide-ranging applications.

[15] This latest version 9 database is particularly useful since it includes updated input-output data for New Zealand (Strutt and Siameja, 2015).

[16] See Minor (2013) for in-depth discussion of modelling changes in trade facilitation within the GTAP framework.

in the wheels." Further discussion of approaches to incorporating NTMs into the GTAP model can be found in Fugazza and Maur (2008).

Our simulation results are summarized in Table 3 and Figures 1 and 2. We estimate, based on the theoretically derived coefficient of unity, that extending SPS access to all countries would lead to increased fruit and vegetable imports from Europe (302% increase), Middle East and Africa (255% increase), the Americas (excluding USA) (127% increase), and East Asia (10% increase) at the expense of imports from Oceania (37% decrease), Australia (30% decrease), USA (26% decrease), South East Asia (22% decrease) and South Asia (5% decrease). Some of these increases are, however, from a low base: Europe in particular still only accounts for 4.2% of New Zealand fruit and vegetable imports. This is shown in Figure 2 and discussed in more detail below.

Table 3. Results of implementing the Geographical Restrictions Index: Estimated change in real fruit and vegetable exports to New Zealand, percentage change and millions of 2011 USD

Region	Estimates based on direct calculation (coefficient = 1)		Utilizing point estimate from gravity estimation (0.677)	
	Percentage change	Change in US$ million	Percentage change	Change in US$ million
Australia	-29.9	-16.5	-22.4	-12.4
Oceania (Pacific Island Countries)	-36.9	-5.0	-27.8	-3.8
East Asia	10.4	1.0	9.0	0.9
South East Asia	-22.0	-16.5	-16.4	-12.3
South Asia	-5.1	-0.2	-3.0	-0.1
USA	-25.8	-17.7	-19.3	-13.2
Rest of Americas	126.8	33.7	92.7	24.6
Europe	302.2	10.5	233.5	8.1
Middle East and Africa	255.6	59.2	183.1	42.4
World	17.4	48.6	12.3	34.3

The changes are more modest (on average 70% of the magnitude) if the point estimate from the gravity equation is used, which reflects that this estimate is 0.677 rather than 1.[17] These estimates, together with results calculated from the 95% confidence interval of estimates of the coefficient on ln (*GRI*) in our gravity equation are shown in the vertical line in Figure 1.[18]

Changes in market share are illustrated graphically in Figure 2. The major changes stem from the increase in market share of the Middle East and Africa (from 8% to 25%) and the Rest of Americas (from 10% to 18%), whereas market shares of South East Asia, USA and Australia decrease (from a collective total of 72% of New Zealand fruit and vegetable imports, these reduce to 46%). The fact that South Africa, Zimbabwe and Zambia, the three African countries holding country-specific approvals to export fruit or vegetable products to New Zealand, all utilize their access shows that improved access can lead to increased imports from such regions.

[17] Given the general equilibrium interactions in the GTAP model, the changes will not be not exactly 67.7% of the original.

[18] For clarity of exposition, we do not present sensitivity analysis for our assumed coefficient of unity; the results from the gravity estimation (and confidence intervals) show the effect of different values of this coefficient.

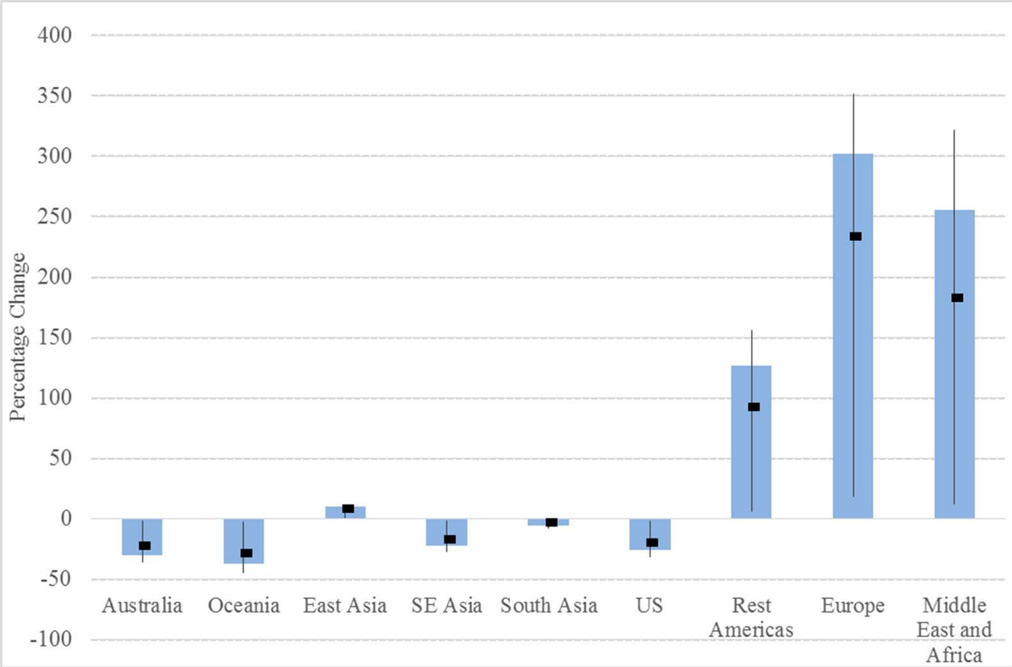


Figure 1. Estimated change in fruit and vegetable exports if all products from all countries were approved[19].

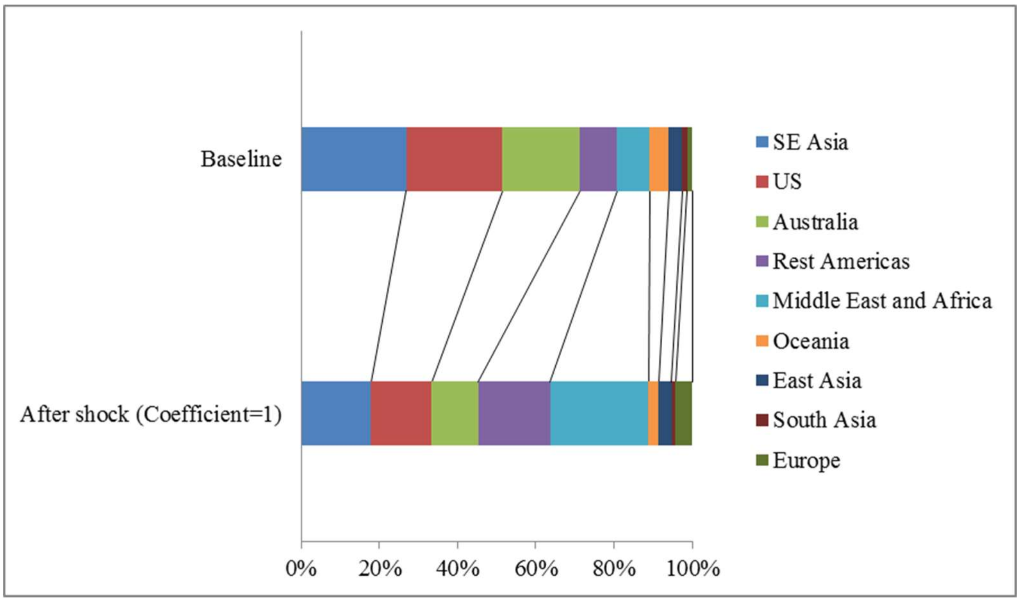


Figure 2. Change in share of NZ fruit and vegetable imports.

In aggregate, the 17.4% increase in real imports of fruit and vegetables (Table 3) is associated with a 3.2% contraction of real output in the New Zealand fruit and vegetable sector, while the New Zealand processed food sector expands by 0.5% (based on the assumed coefficient of unity). New Zealand increases its own real fruit and vegetable

[19] In this figure, the height of bar shows results using the theoretically derived coefficient of one, whereas the black rectangle shows results using the econometric point estimate with the vertical line showing results from the 95% confidence interval around this point estimate.

exports to other regions by between 0.1 and 0.6%, with processed food exports increasing by 0.7% in aggregate.

CONCLUSION

This paper examined a particular feature of the New Zealand biosecurity regime: the requirement for animal and plant products presenting a biosecurity risk to be covered by an import health standard. In the absence of an import health standard, a country cannot export a particular commodity. Our new approach shows not only how such geographical restrictions on export eligibility for SPS reasons can be modelled but, more generally, how NTMs that lead to foregone or reduced trade may be incorporated within a CGE framework, thus providing a more general contribution to the NTM literature.

We proposed a new Geographical Restrictions Index as a way of quantifying the extent to which fruit and vegetable trade from individual trading partners is restricted by these geographical restrictions on eligibility. We found that for regions such as Australia, the USA and Pacific Island countries in Oceania, with which New Zealand has a relatively extensive trade and biosecurity relationship, there is a relatively high Geographical Restrictions Index. In contrast, some African and Latin American states can only potentially export a relatively small proportion of their global fruit and vegetable trade to New Zealand. We were able to use the Geographical Restrictions Index to obtain an estimate of how New Zealand fruit and vegetable imports would shift if a country had access for all products, validating this approach with econometric estimation. Import shifts are incorporated into a CGE framework, using the GTAP model, with simulations quantifying the projected aggregate changes in real imports of fruit and vegetables if all countries were approved to export any fruit and vegetables to New Zealand.

Our analysis does not take into account the costs of developing import health standards covering all countries and all products, nor does it take into account the risks of damage to New Zealand's horticultural industry, should changes in phytosanitary policy lead to the introduction of damaging pests and diseases. Rather, we show how New Zealand's phytosanitary regime influences the sources of New Zealand's fruit and vegetable imports.

We find that if all countries were able to export all fruit and vegetables, imports from Europe, Latin America, Middle East and Africa and East Asia would increase at the expense of imports from Australia, Oceania, South East Asia, South Asia and North America. This pattern holds even if we vary the strength of the response of New Zealand fruit and vegetable imports from a country to changes in that country's Geographical Restrictions Index.

Our results show a more nuanced view of the impact of phytosanitary restrictions than has previously been found in the literature, which often suggested that developing countries are most impacted by such food and agricultural measures (Li and Beghin 2012). From our results, we cannot say that developing countries are more adversely affected by the regulations than developed countries as we find substantial variation between impacts on different developing regions. In particular, we find that if New Zealand were to remove current restrictions, the largest negative effect would be on exports from developing Pacific Island countries, whereas the developed region of Europe is expected to be see the largest percentage growth in exports. The relatively privileged position of Pacific Island countries in the current regime, in terms of access to markets requiring import health standards, can perhaps be explained by New Zealand's geographic proximity, close relationship and development objectives in the Pacific. The methodology in this paper provides a way of obtaining a relatively detailed picture of how different regions may be affected by SPS measures.

Our simulations show that the development of import standards which enable all countries to export all fruit and vegetables to New Zealand are likely to lead to an approximate 17% overall expansion of New Zealand's imports in this sector. This is not as dramatic a change as some might expect, suggesting that approvals currently in place already provide reasonable coverage of potential exporters of particular fruit and vegetables to New Zealand. Nevertheless, there may well remain significant opportunities to enable greater imports from the Americas, Africa and the Middle East, which will benefit New Zealand consumers and industry (including processed food manufacturers). This may be facilitated through recent changes to the format of New Zealand's import health standards, enabling additional countries to be more readily approved for exporting each commodity.

Appendix 1: Coverage of New Zealand Fruit and Vegetable Import Health Standards

HS Code	Product	Countries covered by Import Health Standards (in 2011)	NZ Imports 2011 (US$)	Share of total NZ imports in Fruit and Vegetable Sector in 2011	Share of World Fruit and Vegetable Trade in 2011
070110	Seed potatoes	None[20]	144	0.00%	0.68%
070190	Other potatoes, fresh or chilled	None	0	0.00%	2.81%
070200	Tomatoes, fresh or chilled	Tonga (1998) and Australia (1993)	4,235,768	1.46%	6.23%
070310	Onions and shallots, fresh or chilled	USA (1993) and Japan (1993). Both only for onions.	1,575,297	0.54%	2.11%
070320	Garlic, fresh or chilled	USA (1993) and China (1993)	3,939,158	1.36%	1.49%
070390	Leeks and other alliaceous vegetables, nes	Fiji (1993)	0	0.00%	0.27%
070410	Cauliflowers and headed broccoli, fresh or chilled	Australia (1993)	531,869	0.18%	0.63%
070420	Brussels sprouts, fresh or chilled	Australia (1993)	0	0.00%	0.08%
070490	White and red cabbages, kohlrabi, kale...etc	Samoa (1993), Tonga (1993), Vanuatu (2012). All only for Island cabbage/pele.	27,787	0.01%	1.01%
HS Code	Product	Countries covered by Import Health Standards (in 2011)	NZ Imports 2011 (US$)	Share of total NZ imports in Fruit and Vegetable Sector in 2011	Share of World Fruit and Vegetable Trade in 2011
070511	Cabbage lettuce, fresh or chilled	New Caledonia (1993)	0	0.00%	0.64%
070519	Lettuce, fresh or chilled, (excl. cabbage lettuce)	Australia (1993), China (1993) and USA (1993). Considered "approved processed commodities"	976,752	0.34%	0.89%

[20] The recording of imports in this subheading may be an error or reimports of New Zealand products. In general the values are relatively low.

070521	Witloof chicory, fresh or chilled	None[9]	44	0.00%	0.08%
070529	Chicory, fresh or chilled, (excl. witloof)	None	0	0.00%	0.11%
070610	Carrots and turnips, fresh or chilled	Australia (1993), China (1993), South Africa (1993) and USA (1993) (considered "approved processed commodities")	14,879	0.01%	0.84%
070690	Beetroot. radishes and other similar edible roots	Fiji (1993)	15,001	0.01%	0.42%
070700	Cucumbers and gherkins, fresh or chilled	Australia (1993), New Caledonia (1993) and Vanuatu (1999). All only for cucumbers.	143,689	0.05%	1.48%
070810	Peas, fresh or chilled	USA (1993), South Africa (1997), Zambia (894) and Zimbabwe (1997)	774,193	0.27%	0.26%
070820	Beans, fresh or chilled	Australia (1993), Zimbabwe (1997), South Africa (1999), New Caledonia (1999) and Vanuatu (1998)	5,151,909	1.77%	0.64%
070890	Leguminous vegetables, fresh or chilled, nes	None[9]	81,260	0.03%	0.06%
070920	Asparagus, fresh or chilled	USA	301,958	0.10%	0.87%
070930	Aubergines, fresh or chilled	Vanuatu, Fiji, New Caledonia, Samoa and Tonga	983,120	0.34%	0.32%
070940	Celery, fresh or chilled	None	0	0.00%	0.17%
070951	Mushrooms, fresh or chilled	None[9]	787	0.00%	0.78%
070952	Truffles, fresh or chilled	All	124,429	0.04%	0.48%
070960	Fruits of genus Capiscum or Pimenta, fresh or chilled	Australia (1993), Netherlands (1993) and New Caledonia (1999). All for capsicum only. Cook Islands (1993), Fiji (1993) and Tonga (2001). All for chilli only.	2,408,691	0.83%	3.31%
070970	Spinach, fresh or chilled	Fiji (1993). Khatta/roselle leaves only.	10,838	0.00%	0.14%

Appendix (Continued)

HS Code	Product	Countries covered by Import Health Standards (in 2011)	NZ Imports 2011 (US$)	Share of total NZ imports in Fruit and Vegetable Sector in 2011	Share of World Fruit and Vegetable Trade in 2011
070990	Other vegetables, fresh or chilled, nes	Australia (1993), Fiji (1993), New Caledonia (1993), Niue (1993),	5,792,872	2.00%	2.16%

		Papua New Guinea (2006), Samoa (1993), South Africa (1997), Thailand (1993), Tonga (1993), Vanuatu (1998) and Zimbabwe (1997) all have at least one vegetable in this group approved.			
071310	Dried peas, shelled	All	413,845	0.14%	1.38%
071320	Dried chickpeas, shelled	All	1,685,747	0.58%	0.67%
071331	Dried beans, shelled	All	0	0.00%	0.00%
071332	Dried adzuki beans, shelled	All	0	0.00%	0.00%
071333	Dried kidney beans, incl. white pea beans, shelled	All	6,403,931	2.21%	1.12%
071339	Dried beans, shelled, nes	All	486,379	0.17%	0.32%
071340	Dried lentils, shelled	All	893,991	0.31%	1.03%
071350	Dried broad beans and horse beans, shelled	All	20,934	0.01%	0.31%
071390	Dried leguminous vegetables, shelled, nes	All	283,951	0.10%	0.46%
071410	Manioc, fresh or dried	Cook Islands (1993), Fiji (1993), Niue (1993), Papua New Guinea (1993), Samoa (1993), Solomon Islands (1993), Tonga (1993), Vanuatu (1993)	787,441	0.27%	1.25%
071420	Sweet potatoes, fresh or dried	Fiji (1993), Niue (1993), Papua New Guinea (1993), Samoa (1993), Tonga (1993), Vanuatu (1993)	141,204	0.05%	0.15%
071490	Roots and tubers with high starch content, fres	Cook Islands (1993), Fiji (1993), Niue (1993), Papua New Guinea (1993), Samoa (1993), Solomon Islands (1993), Tonga (1993), Vanuatu (1993)	8,597,055	2.96%	0.27%
080111	Coconuts, desiccated	All	5,887,267	2.03%	0.53%
HS Code	Product	Countries covered by Import Health Standards (in 2011)	NZ Imports 2011 (US$)	Share of total NZ imports in Fruit and Vegetable Sector in 2011	Share of World Fruit and Vegetable Trade in 2011
080119	Coconuts (excl. desiccated)	Cook Islands, Fiji, Kiribati, New Caledonia, Papua New Guinea, Niue, Philippines, Samoa, Solomon Islands,	664,451	0.23%	0.20%

		Tokelau, Tonga, Tuvalu and Vanuatu. As older HS nomenclatures combined desiccated and fresh coconuts, all were treated as approved in our analysis.			
080121	Brazil nuts in shell, fresh or dried	All	0	0.00%	0.01%
080122	Brazil nuts, shelled, fresh or dried	All	2,997,711	1.03%	0.18%
080131	Cashew nuts in shell, fresh or dried	All	888	0.00%	1.36%
080132	Cashew nuts, shelled, fresh or dried	All	18,424,644	6.35%	1.80%
080211	Almonds in shell, fresh or dried	All	1,155	0.00%	0.50%
080212	Almonds without shells, fresh or dried	All	12,035,769	4.15%	2.00%
080221	Hazlenuts in shell, fresh or dried	All	0	0.00%	0.07%
080222	Hazlenuts without shells, fresh or dried	All	1,748,222	0.60%	1.09%
080231	Walnuts in shell, fresh or dried	All	1,184	0.00%	0.46%
080232	Walnuts without shells, fresh or dried	All	3,844,148	1.32%	0.82%
080240	Chestnuts, fresh or dried	All	22,053	0.01%	0.18%
080250	Pistachio, fresh or dried	All	1,040,771	0.36%	1.45%
080260	Macadamia nuts	All	4,272,579	1.47%	0.26%
080290	Other nuts, fresh or dried, nes	All	3,806,614	1.31%	1.19%
080300	Bananas, including plantains, fresh or dried	Australia (2006), Ecuador (1993), Fiji (1999), Mexico (1993), Niue (1993), Panama (1993), Philippines (1993), Samoa (1993) and Tonga (1993)	62,039,979	21.37%	10.06%
080410	Dates, fresh or dried	All	3,162,399	1.09%	0.52%

Appendix (Continued)

HS Code	Product	Countries covered by Import Health Standards (in 2011)	NZ Imports 2011 (US$)	Share of total NZ imports in Fruit and Vegetable Sector in 2011	Share of World Fruit and Vegetable Trade in 2011
080420	Figs, fresh or dried	All	672,544	0.23%	0.28%

080430	Pineapples, fresh or dried	Australia (1993), Ecuador (1999), Fiji (1999), New Caledonia (1993), Philippines (1993), Thailand (1993) and Vanuatu (1999). (Malaysia has access for peeled and chopped pineapples as "approved processed commodities".)	7,101,755	2.45%	1.76%
080440	Avocados, fresh or dried	Australia (1998) and Tonga (1999)	0	0.00%	1.61%
080450	Guavas, mangoes and mangosteens, fresh or dried	Australia (2004), Cook Islands (1997), Ecuador (1999), Fiji (1993), Mexico (1993), New Caledonia (1999), Peru (1999), Philippines (1993), Taiwan (2004), Thailand (1993), Tonga (1998), USA (2011), India (2012), Vietnam (2011), Indonesia (2013). Samoa has access for peeled and chopped mango as an "approved processed commodity".	5,718,572	1.97%	1.21%
080510	Oranges, fresh or dried	Australia (1993), Egypt (2006), Mexico (1993), Spain (1999), USA (1993) and Vanuatu (2006).	13,197,343	4.55%	3.46%
080520	Mandarins, clementines, wilkings...etc, fresh or dried	Australia (1993), Egypt (2006), Japan (2000), USA (1993) and Vanuatu (2006)	7,448,704	2.57%	3.09%
080530	Lemons and limes, fresh or dried	Australia (1993), Egypt (2006), New Caledonia (1993), Samoa (2009), USA (1993) and Vanuatu (2006)	362,994	0.13%	0.74%
080540	Grapefruit, fresh or dried	Australia (1993), Egypt (2006), USA (1993) and Vanuatu (2006)	2,667,055	0.92%	1.51%
080590	Citrus fruit, fresh or dried, nes	None	80,450	0.03%	0.04%
080610	Fresh grapes	Australia (1993), Chile (1993), China (2010), Italy (2002), Mexico (1993), Korea (2011) and Peru (2012).	28,818,855	9.93%	5.56%

HS Code	Product	Countries covered by Import Health Standards (in 2011)	NZ Imports 2011 (US$)	Share of total NZ imports in Fruit and Vegetable Sector in 2011	Share of World Fruit and Vegetable Trade in 2011
080620	Dried grapes	All	20,459,107	7.05%	1.27%
080711	Watermelons, fresh	Australia (1993), New Caledonia (1993) and Tonga (1993).	2,289,645	0.79%	0.79%

080719	Melons (excl. watermelons), fresh	Australia (1993) and New Caledonia (1993) (both for honey dew and rock melon only)	3,721,773	1.28%	1.22%
080720	Papaws (papayas), fresh	Australia (2006), Cook Islands (1993), Fiji (1999), Philippines (2000), Samoa (2004), Tonga (1998), USA (1993) and Vanuatu (2006).	1,719,402	0.59%	0.18%
080810	Apples, fresh	Chile (1993), Japan (1993) and USA (1993)	1,729,275	0.60%	4.77%
080820	Pears and quinces, fresh	Australia (1993), China (1993), Korea (1999) and USA (1993)	4,389,950	1.51%	2.00%
080910	Apricots, fresh	USA (1993)	3,440	0.00%	0.31%
080920	Cherries, fresh	USA (1993)	664,109	0.23%	1.10%
080930	Peaches, including nectarines, fresh	USA (1993)	2,895,576	1.00%	1.59%
080940	Plums and sloes, fresh	Chile (1993), USA (1993)	1,033,081	0.36%	0.64%
081010	Strawberries, fresh	Australia (1993), New Caledonia (1993) and USA (1993)	1,735,722	0.60%	1.71%
081020	Raspberries, blackberries, mulberries and logan	None[9]	19,563	0.01%	0.73%
081040	Cranberries, milberries...etc, fresh	None[9]	42,178	0.01%	0.89%
081050	Kiwifruit, fresh	Italy (1993) and USA (1993). As older HS nomenclatures combined 081050, 081060 and 081090 our analysis also had to combine them.	1,101,963	0.38%	1.53%
081060	Durians, fresh	Thailand (2008). As older HS nomenclatures combined 081050, 081060 and 081090 our analysis also had to combine them.	97,732	0.03%	0.31%
081090	Other fruit, fresh, nes	Australia (2008), Fiji (1999), New Caledonia (2000), Samoa (2004), Taiwan (2007), Thailand (1993), Tonga (1999) and	804,864	0.28%	1.71%

Appendix (Continued)

080620	Dried grapes	All	20,459,107	7.05%	1.27%
		USA (1993) all have at least one fruit in this HS subheading approved. As older nomenclatures			

		combined 081050, 081060 and 081090 our analysis also had to combine them.			
081310	Dried apricots	All	7,498,448	2.58%	0.34%
081320	Dried prunes	All	3,315,492	1.14%	0.33%
081330	Dried apples	All	555,714	0.19%	0.14%
081340	Other dried fruit, nes	All	2,334,544	0.80%	0.41%
081350	Mixtures of dried fruit and nuts, nes	All	1,120,920	0.39%	0.19%

Source: Trade data are import data obtained from the UN COMTRADE database and information on countries covered by Import Health Standards is based on the authors' extension of the UNCTAD NTM database for New Zealand.

References

Aguiar, Angel, Badri Narayanan, and Robert McDougall. 2016. An Overview of the GTAP 9 Data Base. *Journal of Global Economic Analysis* 1 (1): 181-208.

Alam, Md Mahmudul, Md Gazi Salah Uddin, and Khan Md Raziuddin Taufique. 2009. Import Inflows of Bangladesh: The Gravity Model Approach. *International Journal of Economics and Finance* 1 (1): 131-140.

Anderson, James E., and Eric van Wincoop. 2003. Gravity with Gravitas: A Solution to the Border Puzzle. *The American Economic Review* 93 (1): 170–92.

Andriamananjara, Soamiely, Michael Ferrantino, and Marinos Tsigas. 2003. Alternative Approaches in Estimating the Economic Effects of Non-Tariff Measures. *Office of Economics Working Paper*. U.S. International Trade Commission.

Beghin, John, Miet Maertens, and Johan FM Swinnen. 2015. Non-Tariff Measures and Standards in Trade and Global Value Chains. *Annual Review of Resource Economics* 7.

Bergeijk, Peter A. G. van, and Steven Brakman, eds. 2010. *The Gravity Model in International Trade: Advances and Applications*. Cambridge; New York:
Cambridge University Press.

Boulanger, Pierre H., Hasan Dudu, Emanuele Ferrari, and George Philippidis. 2015. "The Cost of Import Prohibition for Political Reason: CGE Analysis of the Russian Ban on Agri-Food Products." Paper presented at the 18th Annual Conference on Global Economic Analysis, Melbourne.

Cadot, Olivier, Alan Asprilla, Julien Gourdon, Christian Knebel, and Ralf Peters. 2015. Deep Regional Integration and Non-Tariff Measures: A Methodology for Data Analysis. *UNCTAD Policy Issues in International Trade and Commodities Research Study Series*, no. 69.

Fugazza, Marco, and Jean-Christophe Maur. 2008. Non-Tariff Barriers in CGE Models: How Useful for Policy? *Journal of Policy Modeling* 30 (3): 475–490.

Helmy, Omneia. 2010. Competitiveness of Egypt in the EU Market for Fruits and Vegetables. *Journal of International Agricultural Trade and Development* 6 (2): 221.

Helpman, Elhanan, Marc Melitz, and Yona Rubinstein. 2008. Estimating Trade Flows: Trading Partners and Trading Volumes. *The Quarterly Journal of Economics* 123 (2): 441–87.

Henseler, Martin, Isabelle Piot-Lepetit, Emanuele Ferrari, Aida Gonzalez Mellado, Martin Banse, Harald Grethe, Claudia Parisi, and Sophie Hélaine. 2013. On the Asynchronous Approvals of GM Crops: Potential Market Impacts of a Trade Disruption of EU Soy Imports. *Food Policy* 41 (August): 166–76.

Hertel, Thomas W., ed. 1997. *Global Trade Analysis: Modeling and Applications*. Cambridge ; New York: Cambridge University Press.

James, Sallie, and Kym Anderson. 1998. On the Need for More Economic Assessment of Quarantine Policies. *Australian Journal of Agricultural & Resource Economics* 42 (4): 425-444.

Jouanjean, Marie-Agnès, Jean-Christophe Maur, and Ben Shepherd. 2012. Reputation Matters: SpilloverEffects in the Enforcement of US SPS Measures. In Olivier Cadot and M Malouche, ed. *Non-Tariff Measures – A Fresh Look at Trade Policy's New Frontier*. Washington, D.C.: The International Bank for Reconstruction and Development/The World Bank.

Karov, Vuko, Donna Roberts, Jason H. Grant, and Everett B. Peterson. 2009. "A Preliminary Empirical Assessment of the Effect of Phytosanitary Regulations on US Fresh Fruit and Vegetable Imports." Paper presented at the Annual Meeting of the Agricultural and Applied Economics Association, Milwaukee, WI.

Kutlina-Dimitrova, Zornitsa, and Badri Narayanan. 2015. "The Economic Impact of the Russian Import Ban." Paper presented at the 18th Annual Conference on Global Economic Analysis, Melbourne.

Li, Xiaoqian, Sayed Saghaian, and Michael Reed. 2012. The Impact of HACCP on U.S. Seafood Exports: The Case of Fish, Mollusks, and Shellfish Other Than Mollusks. *Journal of International Agricultural Trade and Development* 8 (2): 111–23.

Li, Yuan, and John C. Beghin. 2012. A Meta-Analysis of Estimates of the Impact of Technical Barriers to Trade. *Journal of Policy Modeling* 34 (3): 497–511.

Mayer, Thierry, and Soledad Zignago. 2011. *Notes on CEPII's Distances Measures: The GeoDist Database*. CEPII Working Paper No. 2011-25.

Minor, Peter J. 2013. *Time as a Barrier to Trade: A GTAP Database of Ad Valorem Trade Time Costs*. ImpactECON.

Owen, P. Dorian, and Niven Winchester. 2014. The Impact of US Fresh Milk Production Standards on Dairy Trade. *Journal of Policy Modeling* 36 (6): 1008–21.

Philippidis, George. 2010. EU Import Restrictions on Genetically Modified Feeds: Impacts on Spanish, EU [European Union] and Global Livestock Sectors. *Spanish Journal of Agricultural Research* 8 (1): 3–17.

Schlueter, Simon W., Christine Wieck, and Thomas Heckelei. 2009. Regulatory Policies in Meat Trade: Is There Evidence for Least Trade-Distorting Sanitary Regulations? *American Journal of Agricultural Economics* 91 (5): 1484–90.

Santos Silva, J. M. C., and Silvana Tenreyro. 2006. The Log of Gravity. *The Review of Economics and Statistics* 88 (4): 641–58.

Seale, James L., Lisha Zhang, and Mohamad R. Traboulsi. 2013. U.S. Import Demand and Supply Response for Fresh Tomatoes, Cantaloupes, Onions, Oranges, and Spinach. *Journal of Agricultural and Applied Economics* 45 (3): 435–52.

Shepherd, Ben. 2013. *The Gravity Model of International Trade: A User Guide.* ARTNeT Books and Research Reports.

Shepherd, Ben. 2016. "Did APEC's Trade Facilitation Action Plans Deliver the Goods?" *Journal of Asian Economics* 43 (April): 1–11. doi:10.1016/j.asieco.2016.01.003.

Strutt, Anna, and Papu Siameja. 2015. "Regional Input-Output Data: New Zealand." In Narayanan, Badri, Angel Aguiar and Robert McDougall, ed. *Global Trade, Assistance, and Production: The GTAP 9 Data Base: Center for Global Trade Analysis*. Purdue University: Global Trade Analysis Project.

Trewin, Ray, David Vanzetti, and Tran Cong Thang. 2015. "Lowering of SPS Settings to International Standards Offers Big Gains All Round: The Case of Vietnamese Pork

Trade." Paper presented at the Australian Agricultural and Resource Economics Society 2015 Conference (59th), Rotorua, New Zealand.

UNCTAD. 2013. Classification of Non-Tariff Measures: February 2012 Version. UNCTAD/DICT/TAB/2012/2. New York and Geneva.

UNCTAD. 2014. *Guidelines to Collect Data on Official Non-Tariff Measures: September 2013 Version*. UNCTAD/DITC/TAB/2013/3. New York and Geneva.

Vanzetti, David, Ralf Peters, and Christian Knebel. 2014. Sand in the Wheels: Non-Tariff Measures and Regional Integration in SADC. *UNCTAD Policy Issues in International Trade and Commodities Research Study Series*.

Winchester, Niven. 2009. Is There a Dirty Little Secret? Non-Tariff Barriers and the Gains from Trade. *Journal of Policy Modeling* 31 (6): 819–34.

Yang, Shang-Ho, Michael Reed, and Sayed Saghaian. 2013. International Pork Trade and Foot-and-Mouth Disease. *Journal of International Agricultural Trade and Development* 9 (1): 1–19.

Zenebe, Addisalem, Kassu Wamisho, and E. Wesley F. Peterson. 2013. The Impact of the African Growth and Opportunity Act (Agoa): An Empirical Analysis of Sub-Saharan African Agricultural Exports to the United States. *Journal of International Agricultural Trade and Development* 9 (2): 165–88.

CHAPTER V: MODELLING THE IMPACT OF NON-TARIFF MEASURES ON SUPPLY CHAINS IN THE ASIA PACIFIC REGION

This paper has been prepared for journal submission.

Modelling the Impact of Non-Tariff Measures on Supply Chains in the Asia Pacific Region

Mike Webb*
Anna Strutt†*
John Gibson*
Terrie Walmsley#

*Department of Economics, University of Waikato, Hamilton, New Zealand
ImpactECON and LeBow College of Business, Drexel University, USA

Abstract

This paper explores the impact of non-tariff measures (NTMs) on supply chains in the Asia-Pacific region, with a focus on exports to major ASEAN countries. Generally defined, NTMs are policy measures, other than tariffs, which may have an impact on international trade. The database of NTMs used was compiled as part of a multi-agency project led by UNCTAD. This database contains detailed and comprehensive data on NTMs obtained from teams of researchers working systematically through all laws, rules and regulations which may affect merchandise trade. These measures are then set within a common classification framework and assigned to tariff lines within the World Customs Organization's Harmonized System.

We first use the detailed NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into major ASEAN countries, using a gravity model framework. We then use these econometric estimates in a global computable general equilibrium model to examine the impact of unilaterally eliminating the types of NTMs that are found to have significant negative effects on trade. We use a newly available Global Supply Chain Model, based on the well-known Global Trade Analysis Project (GTAP model). By utilizing this model, we can capture the effects of reducing NTMs identified as particularly problematic separately on products sold for intermediate production and those sold to final consumers. Moreover, we can separate the effects of NTM liberalization depending on whether the obligation and its cost is directed at exporters or importers. This facilitates quantification and in-depth analysis of the impact of NTMs on supply chains.

JEL: F13, F14, F17, F68

Keywords: Non-tariff measures; Supply chains; ASEAN; Gravity model; CGE modelling; International trade.

† Corresponding author: Anna Strutt, Economics, Waikato Management School, University of Waikato, Private Bag 3105, Hamilton 3240, New Zealand, anna.strutt@waikato.ac.nz.

INTRODUCTION

Non-tariff measures (NTMs) are generally defined as policy measures, other than tariffs, which may have an impact on international trade in goods and services (UNCTAD, 2013). They constitute a wide variety of measures imposed for a wide range of reasons, including legitimate public policy objectives such as the protection of consumer health or for biosecurity reasons. Nevertheless, such measures do affect trade; see Beghin, Maertens, and Swinnen (2015) for a useful survey of NTM research. The impact of NTMs on "supply" or "global value" chains is attracting increased attention by researchers (Cadestin, Gourdon, and Kowalski, 2016, and Kowalski, Lopez Gonzalez, Ragoussis, and Ugarte, 2015). The effects of NTMs and other trade costs can compound in a supply chain where semi-finished goods cross international borders multiple times: "the effect of a marginal increase in trade costs everywhere in the supply chain is much larger than would be the case if there were a single international transaction" (Ferrantino, 2012).

While there are now many examples of studies which incorporate econometric estimates of the effect of NTMs into computable general equilibrium (CGE) models, there remains significant scope to refine the methodologies used in both the econometric estimation and the CGE modelling of NTMs, as well as the link between them (see the discussion in Walmsley and Minor, 2015; Berden and Francois, 2015 for a survey of recent CGE work; and Walmsley et al., 2018 for a recent application). Some key issues, addressed in this paper, include the importance of differentiating between NTMs on intermediate versus final goods, and the need to distinguish between NTMs that impose costs on the importer and those that impose costs on the exporter. Moreover, this paper estimates the restrictiveness of NTMs for direct application in a CGE framework. This is in contrast to modelling applications which may use econometric estimates originally developed in another context or for another purpose.

In this paper we use a detailed NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into six major ASEAN countries, using a gravity model framework. We then use these econometric estimates to identify the types of NTMs that are found to have significant negative effects on both imports of products sold for intermediate production and those sold to final consumers in these ASEAN countries. Next, we consider the extent to which these NTMs can be eliminated, as well as whether the NTMs are more likely to impact the importer or exporter's costs. Finally, we simulate a reduction in these NTMs using the ImpactECON Global Supply Chain Model (IESC) based on the well-known Global Trade Analysis Project (GTAP) model.

Our approach is novel because we estimate the effect of different types of NTM, both on intermediate inputs and final consumption. Moreover, we model the effect of the removal of burdensome NTMs differently depending on whether the effect is predominately on exporter or importer costs.

We focus on the six largest ASEAN countries. These major ASEAN economies are well linked into regional and global supply chains and are likely to have a broadly similar regulatory environment; thus we are not combining a disparate group of countries from different regions. Updated NTM data have recently been collected and publicly released for these countries, while data for many other major Asian economies, including Japan, Korea, China and India, are not currently available.

Econometric Methodology and Data

The NTM database

The database of NTMs that we use has been compiled in a multi-agency project led by UNCTAD.[1] This database - recently relaunched with expanded and updated country coverage - contains detailed and comprehensive data on NTMs obtained from teams of researchers working systematically through all laws, rules and regulations which may affect merchandise trade.[2] These measures are then set within a common classification framework as well as assigned to tariff lines within the World Customs Organization's Harmonized System (HS). Cadot and Gourdon (2016), Cadot, Asprilla, Gourdon, Knebel and Peters (2015), Strutt et al. (2018) and Vanzetti, Peters, and Knebel (2014) provide examples of applications of this database.

The classification developed by UNCTAD and the Multi-Agency Support Team (MAST) which underpins the NTM database has 16 chapters (UNCTAD

[1] http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures.aspx

[2] Two authors of the current paper were responsible for contributing the New Zealand data to this database.

2013 and UNCTAD 2014), as presented in table 1. Within each chapter, there is a hierarchy of classification, for instance the grouping A5 *Treatment for elimination of plant and animal pests and disease-causing organisms in the final product e.g. post-harvest treatment* includes the subgroupings: A51 *Cold/heat treatment*, A52 *Irradiation*, A53 *Fumigation* and A59 *Treatment for elimination of plant and animal pests and disease-causing organisms in the final product, n.e.s.* (UNCTAD, 2013).

Table 1: Classification of non-tariff measures

Technical measures	**A**	**Sanitary and Phyto-sanitary Measures**
	B	Technical Barriers To Trade
	C	Pre-Shipment Inspection And Other Formalities
Non-technical measures	D	Contingent Trade-Protective Measures
	E	Non-Automatic Licensing, Quotas, Prohibitions And Quantity-Control Measures Other Than For SPS Or TBT Reasons
	F	Price-Control Measures, Including Additional Taxes And Charges
	G	Finance Measures
	H	Measures Affecting Competition
	I	Trade-Related Investment Measures
	J	Distribution Restrictions
	K	Restrictions On Post-Sales Services
	L	Subsidies (Excluding Export Subsidies Under P7)
	M	Government Procurement Restrictions
	N	Intellectual Property
	O	Rules Of Origin
Exports	P	Export-Related Measures

Source: UNCTAD (2013)

Estimation methodology and data

Our research examines the effect of NTMs on imports in six major ASEAN markets (Singapore, Malaysia, Indonesia, Thailand, Viet Nam and the Philippines). We use a gravity model framework which is commonly used for this type of application (see Beghin, Disdier, and Marette, 2015, Carrère and De Melo, 2011 and the widely cited paper Kee, Nicita, and Olarreaga, 2009).

We apply the most widely recognized gravity model estimator, the Poisson pseudo maximum likelihood estimator (ppml) proposed by Santos Silva and Tenreyro (2006). This estimator, which adapts a count data framework, is widely used in gravity model applications because it is robust to heteroskedasticity and also addresses the issues of zero trade values which arise in disaggregated trade data given not all countries export all goods.[3] In contrast to negative binomial regression and zero inflated negative binomial estimators, the ppml estimator is scale invariant (Shepherd, 2013)

We adapt the estimator proposed in Santos Silva and Tenreyro (2006) to provide the following gravity equation (equation 1):

$$
\begin{aligned}
m_{ide} &= \sum_k \beta_{\mathrm{NTM\_}k} D_{NTM\_k_{id}} + \beta_2 \ln\left(\text{consumption}_{jd}\right) + \beta_3 \ln\left(\text{production}_{je}\right) \\
&+ \beta_4 \text{AVE tariff}_{ide} + \beta_5 \text{specific tariff}_{ide} + \beta_6 \ln(\text{distance}_{de}) \\
&+ \beta_7 \ln(\text{contiguity}_{de}) + \beta_8 \ln(\text{common legal}_{de}) \\
&+ \beta_9 \text{RTA}_{ide} + \sum_e \beta_{\mathrm{exporter\_}e} D_{exporter\_e_{ide}} + \sum_d \beta_{\mathrm{importer\_}d} D_{importer\_d_{ide}} \\
&+ \sum_j \beta_{\mathrm{sector\_}j} D_{sector\_j_i} + \beta_{10} \ln(\text{world imports}_{di}) + \varepsilon_{ide}
\end{aligned}
$$

The UNCTAD NTM data are cross-sectional, capturing up to 62 different types of NTMs in force in our ASEAN countries of interest in 2015. Our econometric framework is therefore also cross-sectional. Therefore, in equation 1, m_{ide} is imports of product *i* (at the HS 6 digit level), by importer *d*, from exporter *e* in 2015.[4] Our error term is denoted ε_{ide}, and other variables are described in the section that follows.

We examine imports that originate from any one of a group of 119 exporting countries. This corresponds to the almost all individual countries included in version 9 of the GTAP database, including the 6 major ASEN countries (Aguiar, Narayanan, and McDougall, 2016).[5] With 6 importing countries, 118 possible partners, and 5,203 HS level 6 "products" in the 2012 version of the HS system that

[3] Google scholar lists over 3,500 papers that cite Santos Silva & Tenreyro (2006).

[4] While the UNCTAD data are collected at the more detailed tariff line level, the harmonized system is only consistent at up to the HS 6 digit level, with countries able to adopt their own codes at the more detailed (i.e., HS 8 or HS 10 levels etc.) level. We therefore work with data at the HS 6 digit level for consistency across countries. Moreover, the widely used UN COMTRADE database, which we use as the source of import data, is only available at the 6 digit level (https://comtrade.un.org/).

[5] We, however, exclude the US territory of Puerto Rico as gravity data variables are not available and we also exclude Taiwan, which is not widely internationally recognized as a country and therefore is not included in the UN COMTRADE database.

we use, our gravity database includes almost 3.7 million observations although most of these involve zero trade.[6]

Our NTMs are incorporated through dummy variables ($D_{\mathrm{NTM}\_k,id}$) for each different type of NTM; these equal to unity if the importing country d applies NTM k on imports of product i from at least one exporting country.

The gravity model framework requires data on "consumption" in the importing country and production in the exporting country. As we do not require time series data, we are able to make use of sectoral data from the GTAP database for 2011 (Narayanan et al., 2015). In this database, each HS 6 digit product is mapped to one of 43 aggregate sectors (denoted with a subscript j in equation 1). For "consumption" data (consumption_{jd}), we use data on private consumption (VPA in the GTAP database) when estimating the impact of NTMs on imported consumption goods, and firm purchases (VFA) when estimating the impact on imported intermediates. We use sectoral output data from the GTAP database for "production" data in the exporting country (production_{je}).[7]

Tariff data is obtained from the WTO and World Bank, depending on availability.[8] Data for Viet Nam, Singapore, Indonesia and the Philippines for 2015 is obtained from the WTO. Data for Malaysia and Thailand are not available directly from the WTO, so we use data from the World Bank WITS database, which has data for Thailand (for 2015) and Malaysia (for 2014). With data from both databases, we incorporate applied ad valorem equivalent (AVE) rates (AVE tariff_{ide}) and include a separate dummy variable where a specific tariff applies (specific tariff_{ide}). As the gravity model works with logarithms and the logarithm of a zero tariff is undefined, some transformation is required; we apply an inverse hyperbolic sine transformation whereby $ihs(x) = \ln(x + (x^2 + 1)^{0.5})$ gives an identical result to using logarithms for non-zero values while avoiding the need to make ad hoc adjustments to zero values (Gibson, Datt, Murgai, and Ravallion, 2017).

[6] 88 percent of our observations are zero. It should also be noted that we exclude HS subheadings 27.05.00 and 27.16.00 as these are typically classified as services.

[7] Given the theoretical underpinnings of the gravity model are based on using nominal GDP, we multiply both our consumption and production data by the ratio of 2015 nominal GDP to 2011 nominal GDP from the World Bank World Development Indicators to generate sectoral data by country that takes account of both the growth of the economy and changes in exchange rate.

[8] http://tariffdata.wto.org and http://wits.worldbank.org/

Other gravity data variables typically included as controls - distance (distance_{de}), contiguity (contiguity_{de}), common legal system (common legal_{de}) and the existence of a regional trade agreement (RTA_{de}) - are obtained from the widely used CEPII database.[9] As data on the existence of a RTA are only available until 2006, we update this by adding new agreements that enter into force from 2006 to 1 January 2015 and which are notified to the WTO.[10]

We control for importer, exporter and sector fixed effects, through the dummy variables $D_{exporter\_e_{ide}}$, $D_{importer\_i_{ide}}$, $D_{\text{importer}\_d,idedie}$ and $D_{\text{sector},ji}$. Moreover, as some HS subheadings contain a lot of products potentially traded and others contain fewer, we include the natural log of the value of world imports of product i by country d ($\ln(\text{world imports}_{id})$).[11] This is an alternative to using product level fixed effects (as used in, for instance, Crivelli and Gröschl, 2016 and Kee and Nicita, 2016). We prefer to control for world imports because it avoids the issues of multicollinearity that we encountered with product fixed effects, where NTMs applied by ASEAN countries on any given product were found to be correlated. Moreover, the use of the world imports as an independent variable is possible in our paper as we only look at a small number of importing countries, whereas the above-mentioned papers, which look at a larger set of countries, are not able to avoid endogeneity through excluding imports from the countries of focus.

We estimate separately the effects of NTMs on two broad sectoral aggregations: Food and Agriculture, and Non-Agriculture Products, based on aggregations of the GTAP sectors as set out in appendix 1. NTMs in these two broad sectors are applied for different reasons and can have different effects, hence separation improves the accuracy of estimates.

For our two broad sector aggregations, we further estimate separately the effects of NTMs on imports of consumer goods and intermediate/capital goods. We distinguish between these two categories of products through a conversion table between HS2012 subheadings and the Broad Economic Classification (BEC) available from the UN Statistical Division.[12] Under the BEC framework, products are classified as either intermediate, consumer or investment (capital goods) or are

[9] http://www.cepii.fr/cepii/en/bdd_modele/bdd.asp.
[10] http://rtais.wto.org/UI/PublicMaintainRTAHome.aspx.
[11] In order to avoid issues of endogeneity we exclude imports from our six major ASEAN markets.
[12] https://unstats.un.org/unsd/trade/conversions/HS%20Correlation%20and%20Conversion%20tables.htm

listed as “not classified”. This is consistent with the approach taken in compiling the IESC database detailed in Walmsley and Minor (2016), although they supplement the concordance with additional information from the GTAP database. We consequently run four separate regressions.

Estimation results

Our estimation results with the ppml estimator for consumer goods and intermediate/investment goods in both the agriculture and food and non- agriculture product groupings are summarized in tables 2 and 3. As can be seen in table 2, our control variables are generally as would be expected, for instance: trade decreases with distance, particularly for food and agricultural products that are inputs for further processes; and higher ad valorem tariffs decrease trade (although the effect is only statistically significant for food and agricultural products for final consumption and for non-agricultural intermediate inputs).

Table 2: Econometric estimates (control variables)

	Food and Agriculture		Non Agriculture	
VARIABLES	Consumption	Intermediates	Consumption	Intermediates
Preferential tariff	-0.131***	0.00817	-0.0763	-0.134***
	(0.0371)	(0.0601)	(0.0494)	(0.0394)
Specific tariff	0.0251	-0.616	-0.0663	0.743**
	(0.326)	(0.686)	(0.677)	(0.289)
Consumption/use	-0.105	-0.0144	0.0466	0.559***
	(0.0987)	(0.0720)	(0.0822)	(0.0747)
Production	1.026***	1.099***	0.672***	0.955***
	(0.122)	(0.137)	(0.0743)	(0.0654)
World imports	0.931***	1.133***	0.810***	0.893***
	(0.0378)	(0.0852)	(0.0337)	(0.0210)
Distance	-0.541***	-1.055***	-0.409***	-0.505***
	(0.180)	(0.386)	(0.144)	(0.166)
Contiguity	0.187	0.428*	0.137	0.227
	(0.228)	(0.248)	(0.154)	(0.203)
Common legal system	-0.173	-0.355***	0.0205	0.150
	(0.132)	(0.127)	(0.115)	(0.105)
RTA	0.0119	0.284	0.269	-0.0535
	(0.173)	(0.191)	(0.179)	(0.162)
R-squared	0.110	0.324	0.131	0.340
Importer/Exporter/Sector FE	YES	YES	YES	YES
N (including zero trade obs)	422430	200368	527730	2.483e+06

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3 shows the NTM coefficients, converted to percent changes in imports that would result from elimination of the NTM.[13] These illustrate the effects of diverse types of NTMs and how these effects vary, including depending on whether they are applied to food and agricultural products or non-agricultural products and whether they are applied on products for final consumption or to intermediate inputs. To illustrate, applying a microbiological (hygiene) requirement (a410) to imports of food and agricultural for final consumption is expected to decrease imports by 63 percent, whereas applying a certification requirement (b830) to a non-agricultural intermediate good is expected to decrease imports by 32 percent. Of the NTMs that have a statistically significant impact, their effect is greatest on agricultural intermediates (an average impact of 74 percent on affected products) and smallest for non-agricultural products for final consumption (an average of 49 percent on affected products).

[13] Given the log-linear nature of the model, coefficients of dummy variables provide percent change through the following formula: $\widetilde{\beta_\iota} = e^{\beta_\iota} - 1$ (See WTO, 2012).

Table 3: Estimated effect of NTM reductions (for NTMs found to reduce trade that are statistically significant at the 90 percent level)

		Food and Agriculture		Non-Agriculture	
NTM	Description	Consumption	Intermediates	Consumption	Intermediates
Sanitary and Phytosanitary Measures					
a110	Temporary geographic prohibitions	65%***	59%***	---	---
a140	Authorisation requirements (for importers)	62%**	---	---	49%***
a210	Residue tolerance limits	49%*	---	---	---
a220	Restricted use of substances	---	---	36%***	---
a320	Marking requirements	---	---	---	78%**
a330	Packaging requirements	---	43%**	---	---
a410	Hygienic requirements: microbiological requirements	63%***	---	---	---
a490	Hygienic requirements	---	97%***	---	93%**
a590	Treatment requirements nes	---	81%***	---	---
a640	Storage and transport requirements	38%**	---	---	78%**
a690	Other production requirements	---	---	---	98%***
a820	Testing requirements	---	---	---	60%*
a840	Inspection requirements	---	---	---	62%***
a851	Traceability (origin)	65%***	---	---	---
a852	Traceability (processing history)	---	---	---	49%***
a859	Other traceability requirements	49%***	---	---	---
a890	Other conformity requirements	---	82%*	90%*	---
Technical Barriers to Trade					
b110	Prohibitions	---	86%***	---	---
b210	Residue tolerance limits	---	---	---	80%**
b320	Marking requirements	62%*	---	---	---
b330	Packaging requirements	---	---	---	32%**
b410	Production process requirements	---	---	---	48%**
b420	Storage and transport requirements	---	---	43%***	---
b700	Performance standards	---	---	40%**	---
b810	Product registration requirements	---	54%***	---	---
b830	Certification requirements	---	---	---	32%***
b840	Inspection requirements	49%**	---	---	---
b850	General traceability requirements	---	---	30%*	---
b859	Other traceability requirements	---	90%**	54%**	---
b890	Conformity assessments nes	84%***	---	52%**	37%**
b900	Other TBT requirements	93%***	---	---	71%***
c300	Direct consignment requirements	47%***	48%*	---	---
c400	Import monitoring requirements	---	88%***	---	---
c900	Customs formalities	---	87%*	---	---
	Number of statistically significant NTMs	11	10	7	14
	Number of NTMs in regression	61	62	40	61
	Percentage of statistically significant NTMs	20%	18%	18%	23%
	Average estimated effect of a statistically significant NTM	68%	74%	49%	65%

*** p<0.01, ** p<0.05, * p<0.1

Approximately 20 percent of NTMs are found to have a statistically significant negative effect on trade at the 10 percent level. This is less than we would expect, which is likely to reflect the somewhat limited statistical power of our estimations given we do not have access to panel data; comprehensive NTM data is available for a single year. If panel data are available in future, more precise estimates would be possible and we would expect to find more NTMs having a statistically significant negative impact on trade.

On the other hand, the relatively large number of NTM variables does introduce the statistical implication that a number of statistically insignificant coefficients could be treated as significant. With a 10 percent significance level we would expect to fail to reject the null hypothesis of no effect for one in every 10 variables that did not in fact affect the dependent variable. However, controlling for these "family wise" errors, such as through a Holm sequential Bonferroni regressive procedure is often seen as too conservative and not appropriate in all circumstances. (Roback and Askins, 2005 and Fiedler, Kutzner, and Krueger, 2012).

From the discussion above, we are also conscious that the statistical power of our tests is somewhat limited given we only have cross-sectional NTM data. (This is illustrated by the low proportion of coefficients that are statistically significant at the 5 or 1 percent level). Moreover, as discussed earlier, there is a clear theoretical rationale to expect negative effects given NTMs raise costs. This contrasts with many applications of multiple hypothesis testing which are based on analysis of scientific experiments for which there may not be an underlying theoretical explanation for the effect of each coefficient.

We therefore chose not to utilize family-wise error corrections as we do not consider the inherent tradeoff, between reducing the number of coefficients found (incorrectly) to be statistically significant at the expense of discounting too many potential NTMs, to be appropriate for our application.[14] Instead, we address the

[14] The Holm sequential Bonferroni correction divides the α value for the most significant coefficient in each family by the number of variables in the family e.g. for a family of 3 variables the α for a 10 percent significant level is reduced from .1 to 0.033, so a variable significant at the 5 percent level may no longer be significant. As can be seen in table 3, many of our coefficients are significant at the 5 or 10 percent level, so would no longer be statistically significant following this correction. When applying this procedure, we did, however, find some coefficients to still be significant depending on how we defined a "family" for the purposes of this procedure. For instance, when we treat certification requirements within each of the UNCTAD chapters as a "family" for the purposes of the Holm sequential correction, we still obtain some statistically significant estimates (at the 10

issue through our actionability assumption – as discussed in the following section we only assume that 20 percent of the gains from NTM elimination are realizable. This allows a margin in case we have included NTMs that in fact have zero impact on trade. Multiple testing issues could be addressed more fully in the future if panel data on NTMs were available, which would significantly increase the power of our tests.

CGE MODELLING OF NTM LIBERALIZATION

The next stage in the analysis incorporates the economic estimates of the effect of NTMs into the IESC model (Walmsley and Minor, 2016), which is a modified version of the GTAP model using its own database alongside the GTAP version 9 databases (Aguiar, Narayanan and McDougall, 2016). We conduct our simulations of the effect of NTM liberalization by the ASEAN countries on all trading partners in a specification with seven sectors; two from the Food and Agriculture grouping and four from the Non Agriculture grouping, as well as a services sector – see appendix 1. Our specification of the IESC model has 15 regions.[15]

Channels to incorporate NTMs: Importer and exporter effects

An important innovation that we use in the current study is the inclusion of a CGE modelling mechanism to shock export efficiency (Walmsley and Strutt, 2018). This channel is the counterpart of the import augmenting technological change described below, as it reduces the amount of exports needed to meet a given level of import demand. When modelling reductions in NTMs through this mechanism, the principal benefits accrue to exporting countries. This is appropriate for the liberalization of many NTMs which directly affect the cost of exporting.

In other cases, however, the obligation of meeting NTM requirements falls on the importer. For these types of NTM we use an approach to incorporating NTM reductions, which is widely used in the literature: import-augmenting technological

percent level). Similarly, treating the four NTMs within the UNCTAD classification chapter C (Pre-shipment inspection and formalities) as a family and applying a Holm sequential Bonferroni correction retains some coefficients as statistically significant.

[15] The regions are Singapore, Thailand, Malaysia, Viet Nam, Philippines, Indonesia, Other ASEAN, New Zealand, Australia, Japan, Korea, China, India, United States and the Rest of the World.

shocks (see, for instance, Hertel, Walmsley, and Itakura, 2001, and Francois, Van Meijl, and Van Tongeren, 2005). [16] As explained in Walmsley and Minor (2015) this has two main effects: (1) it reduces the importers price causing a substitution towards that good and an increase in quantity demanded and (2) it reduces the amount that needs to be imported to satisfy a given demand. As a result of the second effect, firms in the importing country require less imported intermediates for a given production level and households and governments can satisfy an initial demand with less imports (from the perspective of the exporter); this increases GDP in the importing countries. These effects mean that the principal benefits accrue to the importing countries affected.

By modelling benefits accruing to both exporters and importers, our approach is a significant advance on previous approaches where benefits of NTM liberalization principally accrue to importers, even when this is not consistent with economic theory or empirical evidence. Other ways to enable exporters to be affected include incorporating NTMs as import tariffs or export taxes. (See Fugazza and Maur, 2008 for a discussion and Arita, Beckman, and Mitchell, 2017, Kawasaki, 2015, and Andriamananjara, Ferrantino, and Tsigas, 2003, for three illustrative examples of how this separation is made in practice.) The challenge with this approach is that NTMs are generally not associated with an additional tax or fee collected by government. In contrast, our approach captures these as inefficiencies affecting the cost of exporting or importing in a manner that is consistent with the conventional GTAP framework.

Obtaining NTM quantity shocks to calibrate the IESC model

To calibrate the IESC model we need four sets of shocks: (i) import-augmenting technological shocks to imports of intermediate goods (including capital goods); (ii) import-augmenting technological shocks to imports of consumption goods; (iii) import-augmenting technological shocks to imports of goods for government consumption; (iv) exporting efficiency shocks to exports of

[16] An alternative approach is the "willingness to pay" framework proposed in Walmsley and Minor (2015). We, however, focus on the technological shock variables to enable a direct comparison between these approaches. See Walmsley and Strutt (2018) for detailed exploration of the impact of alternative CGE modelling mechanisms.

all goods.[17] These shocks differ across importing and exporting region to reflect the different NTMs applied by different importers, and differences in the products imported from different regions.

The three different import-augmenting shocks reflect the three different agents who use imported goods in the IESC model. The division between the first three sets of shocks (the import-augmenting shocks) and the exporting efficiency shock depends on our analysis of whether the cost of meeting an NTM is directed at the exporter or importer, or is split between both (in which case a weighting of between 25 and 75 percent is applied). As an example, production requirements impose costs on exporters, whereas the cost of meeting importer registration requirements is expected to fall on the importer. In some instances, for example testing requirements, we split the cost of NTM compliance between importers and exporters.[18] Our separation between importers and exporters is shown in appendix 2.

<u>Weighting by imports</u>

As each of the identified NTMs only apply to some products within a sector, we need to weight the shock by the proportion of imports, from each exporting region, that are covered by a particular NTM. These are then aggregated to obtain the effect of the removal of all problematic NTMs on a particular sector. As firms are the only agent who exports, the exporting efficiency shock is calculated in the following way:

$$\Delta M_{jde} = \frac{\sum_{i \in j}\left(\sum_k -\tilde{\beta}_{NTM\_k} \cdot D_{NTM,\_k_{id}}\right) \cdot m_{ide}}{\sum_{i \in j} m_{ide}} \qquad (2)$$

Where: m_i is imports of product i by importer d from exporting region e (using COMTRADE import data at the HS 6 digit level); ΔM_{jed} is the change in imports of all products mapped to the aggregate sector j (43 aggregate commodities in GTAP) by importer d from exporting region e; $\tilde{\beta}_{NTM\_k}$ is the elasticity calculated from the coefficient for NTM k that has been found to have a statistically significant

[17] Unlike with imports, where there are different purchasers of intermediates and consumption goods, there is only one agent involved in exporting in the IESC model (firms). Therefore, while the IESC model provides for different import-augmenting technological shocks for imports of intermediates and consumption goods, there is only one type of export-augmenting technological shock.

[18] A more precise separation of division of these costs could be obtained from surveys of exporters and importers, and thus is an area for future research.

effect on trade (as discussed above); and $D_{NTM\_k,id}$ is a dummy variable equal to one if importer *d* applies NTM *k* on product *i* and – as discussed below – not all major ASEAN countries apply this NTM (see discussion above). For each aggregate sector j, we therefore have separate values of ΔM_{jde} for the change in imports by each of the 6 major ASEAN importing countries (*d*) from each of the 15 exporting regions (*e*).

The calculation of the three import-augmenting technological shocks is more complex because the calculation is done separately for goods classified as intermediate goods (including capital goods) and private consumption goods:

$$\Delta M_{intermediate,jde} = \frac{\sum_{i\in j}\left(\sum_k -\widetilde{\beta}_{NTM\_k} \cdot D_{NTM\_k_{id}}\right) \cdot m_{intermediate,ide}}{\sum_{i\in j} m_{intermediate,ide}} \quad (3)$$

$$\Delta M_{consumption,dej} = \frac{\sum_{i\in j}\left(\sum_k -\widetilde{\beta}_{NT\quad\_k} \cdot D_{NTM\_k_{id}}\right) \cdot m_{consumption,ide}}{\sum_{i\in j} m_{consumption,ide}} \quad (4)$$

<u>Restrictions on the effect of NTMs and actionability assumptions</u>

We limit the effect of NTMs in three ways. First, we only consider NTMs that have a statistically significant negative effect on the level of imports at the 90 percent level.[19] Second, we do not simulate the removal of an NTM from a product when all six major ASEAN countries apply this NTM to that product. This reflects the fact that the NTM – despite being found to be "problematic" in that it negatively affects trade – might be the only feasible way to address a legitimate public policy concern.[20]

Third, we assume that only a portion of the set of NTMs identified as problematic through our econometric estimation can be removed. There is an emerging body of literature on the extent to which NTMs are actionable, given they frequently target public policy objectives, for instance, Berden and Francois (2015) suggest that approximately 50 percent of NTMs are actionable. In our simulations, we assume that 20 percent of the potential increases in imports from full NTM liberalization are realizable through targeted efforts, including as part of economic integration initiatives. This is comparable with similar studies, for instance,

[19] This is a conservative approach that could be missing the effect of some NTMs which could have a negative effect (including those for which we might find a statistically significant effect if we had access to panel data on NTMs i.e. with a time dimension).
[20] This is a conservative assumption in some cases all 6 countries might apply an NTM for which there is a non, or less, trade restricting alternative.

Fontagné et al. (2013) use a 25 percent reduction for their reference scenario. Our assumption is at the lower end because the universe of NTMs we consider for potential liberalization is larger than other studies, because of the breadth of NTM data collected in the UNCTAD database; in contrast, other studies often focus on a subset of NTMs, for instance those identified in surveys.[21] Our NTM liberalization scenario can be interpreted as any combination of the following: removing some requirements i.e. removing some regulations; applying existing to rules to fewer products; or applying these in a less onerous way e.g. inspecting a smaller proportion of total shipments or harmonizing requirements to make it easier for traders to comply.[22]

Calculated shocks

Our approach therefore takes econometric estimates of the effect of different types of NTMs and allocates them to the different channels in the IESC model depending on the type of good affected (consumption, intermediate or government purchase) and by whether the NTM obligation falls on importers or exporters. As these are weighted by the value of imports affected these import quantity shocks vary by importer and also across the regions exporting to each major ASEAN county to reflect their different export profile. Appendix 3 shows, for each ASEAN country, the trade weighted average shocks to quantities of imports from the other 14 regions that are allocated to each of the four transmission channels modelled.[23] In other words, these tables show the estimated percentage change in imports that would result from implementing each of these shocks. The overall effect on imports is their combined effect from each of these channels.

Table 4 shows the relative contribution of the three main shocks and summarizes the contribution of the three main types of shocks (exporter, consumer imports and firm imports) to the overall estimated change in imports in the modelling described subsequently.[24] While we have allocated NTMs depending on

[21] Moreover, as noted above, this also includes a margin to allow for the statistical possibility that we can fail to reject a null hypothesis of no effect, for some variables that do not in fact affect trade.
[22] While the UNCTAD database does not summarize information on the stringency of requirements or other procedural details, a liberalization scenario can assume that less burdensome application of some types of existing NTMs will reduce the trade effects of these NTMs.
[23] While the appendix shows a trade weighted average, we calculate and use separate shocks for imports from each exporting region.
[24] Government purchases are excluded from this table due to their small value (see table 5).

our assessment of whether exporters and importers are targeted, and their effect is calculated depending on the value of trade in products affected, our detailed analysis provides a useful rule of thumb for future work: approximately half of NTM shocks can be allocated to the exporter channel with the other half allocated to an importer channel.

Table 4: Percentage of shocks and effects corresponding to NTM channels

	Exporter effect (%)	Consumer imports effect (%)	Firm imports effect (%)
Singaporean imports	57	24	19
Thailand imports	62	19	20
Malaysia imports	39	42	19
Viet Nam imports	53	11	36
Philippines imports	43	17	40
Indonesia imports	51	30	19
Total import shocks	51	20	29

IESC model calibration

The approach outlined in the previous section provides an estimate of the change in imports which is exogenous in the CGE framework. We then utilize the IESC model to take account of the general equilibrium interactions by endogenizing the change in imports. To do this, we implement the shocks summarized in appendix 3 into the IESC model to calibrate, for each exporting region, the necessary import-augmenting technological change required to achieve each of the required changes in consumption, firm use and government purchases i.e. those that correspond to 20 percent of the change in imports implied by the econometric results for full elimination of all "problematic" NTMs whose cost is directed at importers.[25] Likewise, in separate simulations, we calibrate, for each exporting region, the necessary exporting efficiency change required to achieve each of the required changes in exports i.e. those that correspond to 20 percent of the change in bilateral imports implied by the econometric results for full elimination of all

[25] In the IESC framework, we consider separately the estimated increases in imports of consumption goods (*qpms),* intermediate inputs (*qfms)* and government purchases (*qgms*). As government purchases are a mixture of products classified as consumption and intermediate goods in the BEC framework, we weight these shocks based on each countries' imports within each aggregated sector. In our simulations, the calibration exogenises exports to all six ASEAN countries by one exporting region at a time to determine the necessary technological change variables. We create new variables that remove the "iceberg" productivity/efficiency effects from *qpms*, *qfms* and *qgms* when calibrating the shocks.

“problematic” NTMs whose cost falls on exporters.[26] This provides the import augmenting technological shocks and exporting efficiency changes. This approach, for calibrating import augmented technological shocks, is discussed in further detail in Webb et al. (2017).

Results: Examining the impact of reducing NTMs

To obtain the overall effect of NTM liberalization by major ASEAN countries, we apply the import augmenting technological shocks and exporting efficiency change, calibrated in the manner described in the previous section, into the IESC model. These are implemented simultaneously to enable general equilibrium interactions between sectors and regions. While imports from all regions are stimulated through the reduction in ASEAN NTMs, there is considerable variation in the changes in each region’s exports to the six major ASEAN countries. With the inclusion of general equilibrium interactions in our modelling, some regions export less of particular products to ASEAN countries.

The effects on GDP, welfare, output and trade of our simulated NTM liberalization are shown in tables 5-7.

[26] Given the direct link between exports and imports, we have to conduct the calibration separately for import-augmenting and exporting efficiency shocks as otherwise we would effectively be trying to identify two unknowns in a single equation.

Table 5: Simulated changes in GDP

	Total change in real GDP (2011US$ m)	Total change in real GDP (%)	Due to exporter effect (%)	Due to consumer imports effect (%)	Due to firm imports effect (%)	Due to government imports effect (%)
Singapore	686	0.25	0.049	0.115	0.086	0
Thailand	721	0.209	0.086	0.06	0.063	0
Malaysia	824	0.285	0.075	0.144	0.066	0
Viet Nam	1,739	1.283	0.311	0.263	0.708	0.001
Philippines	974	0.434	0.042	0.122	0.27	0
Indonesia	744	0.088	0.033	0.033	0.021	0
Other ASEAN	35	0.037	0.036	0.001	0	0
New Zealand	70	0.043	0.041	0.001	0.001	0
Australia	165	0.012	0.012	0	0	0
India	263	0.014	0.013	0.001	0	0
Japan	107	0.002	0.002	0	0	0
Korea	93	0.008	0.009	0	-0.001	0
China	635	0.009	0.008	0	0	0
US	207	0.001	0.001	0	0	0
ROW	1,304	0.004	0.004	0	0	0

We find that real GDP increases in all countries as a result of NTM liberalization in ASEAN (see table 5). As expected, the greatest gains are to the ASEAN 6 countries who liberalize NTMs, particularly Viet Nam and the Philippines. For our scenario of a 20 percent reduction in “problematic” NTMs we find an increase in Viet Nam’s GDP of 1.3 percent and a 0.4 percent increase for the Philippines. For ASEAN 6 countries, the majority of this increase in GDP occurs through the import augmenting technological shocks channels which reflects that importing countries themselves benefit directly from NTM liberalization. (This ranges from 59 percent for Thailand to 90 percent for the Philippines.) While the percentage of overall GDP and welfare gains that the IESC model attributes to import augmenting technological shocks aligns with their contribution to total shocks (49 percent, as shown in table 4), these import augmenting shocks account for a higher contribution to welfare and GDP gains in the ASEAN 6 since their effect is concentrated on the ASEAN 6 countries who liberalize NTMs and therefore benefit from import augmenting technological shocks.

The GDP gains to countries other than the ASEAN 6 are relatively modest, with the largest percentage increases accruing to New Zealand (0.043%) and the

"Other ASEAN grouping" (0.037%).[27] The modest effects on countries other than the ASEAN 6 can be understood by noting that there are two effects: on one hand they benefit from increased export efficiency (with the exporting efficiency change) when ASEAN countries reduce NTM barriers to all trading partners. However, this impact is dampened since ASEAN competitors become more competitive as a result of using imported intermediates more efficiently. In contrast, ASEAN countries liberalizing their NTMs benefit from both increased export and import efficiency.

Table 6: Simulated changes in welfare (2011 US$m)

	Contribution of different components			Total change
	Allocative efficiency	Improved trade efficiency	Terms of trade*	
Singapore	35	651	504	1,191
Thailand	150	572	261	982
Malaysia	34	790	70	894
Viet Nam	456	1,289	1,281	3,026
Philippines	107	867	628	1,602
Indonesia	116	628	85	829
Other ASEAN	2	33	-15	19
New Zealand	6	64	-21	49
Australia	-1	166	-170	-5
India	28	235	-151	112
Japan	-36	142	-208	-102
Korea	-27	120	-151	-58
China	29	606	-551	84
US	-2	209	-397	-190
ROW	0	1,304	-1,165	139

* Changes in relative prices of exports and imports (including small impacts due to investment and savings prices).

Almost all countries see an increase in welfare (as measured by an equivalent variation in income (EV) (see table 6). Consistent with our GDP results, the largest gains are to the ASEAN 6 countries who liberalize NTMs, particularly Viet Nam and the Philippines. In general, the greatest contribution is from "improved trade efficiency" which incorporates the efficiency gains to both exporters and importers from NTM liberalization. Some countries, particularly Viet Nam, Thailand and Indonesia also see significant changes in allocative efficiency as NTM elimination leads to improved allocation of resources. The contribution to

[27] The other ASEAN grouping comprises Brunei, Myanmar, Laos and Cambodia which have distinctly different economies to the major ASEAN countries.

welfare of changes in the terms of trade, due to changes in the relative prices of imports and exports, can also be sizable. In some cases, particularly Singapore, Viet Nam and the Philippines, changes in the terms of trade make relatively strong contributions to welfare. Negative terms of trade effects can dampen the positive efficiency gains, even leading to small decreases in total welfare for some regions: Australia, Japan, Korea and the United States.

Table 7: Simulated changes in output and exports (%)

	Exports to ASEAN 6			Exports to Non-ASEAN 6			Output		
	Plant Products	Animal Products	Other	Plant Products	Animal Products	Other	Plant Products	Animal Products	Other
Singapore	9.9	18.6	0.4	9.1	9.7	0.1	4.2	-1.7	0.1
Thailand	4.0	5.2	0.4	1.0	0.9	0.0	-0.3	-0.4	0.1
Malaysia	6.1	-2.2	0.3	1.9	4.1	-0.1	-0.2	-0.8	0.1
Viet Nam	12.7	-2.3	0.1	1.0	2.9	-0.4	-1.3	-0.9	0.9
Philippines	0.9	1.0	0.4	2.2	2.0	-0.3	-1.7	-0.2	0.4
Indonesia	3.6	10.5	0.6	0.8	1.9	0.3	-0.2	-0.5	0.1
Other ASEAN	2.7	-2.1	1.1	-0.2	0.0	-0.2	0.0	0.0	0.0
New Zealand	3.1	11.2	1.5	-0.4	-0.7	-0.4	-0.1	0.6	0.0
Australia	2.9	6.5	0.0	-0.1	-0.1	0.0	0.1	0.3	0.0
India	8.4	18.1	0.1	-0.3	-0.4	-0.1	0.1	0.1	0.0
Japan	6.7	-2.0	-0.2	0.0	0.1	0.1	0.0	0.0	0.0
Korea	2.9	-1.4	-0.3	-0.1	0.0	0.0	0.0	0.0	0.0
China	5.8	5.1	0.7	-0.1	-0.1	0.0	0.0	0.0	0.0
US	0.2	4.9	0.2	-0.1	0.0	0.0	0.0	0.0	0.0
ROW	3.1	4.0	1.0	-0.1	0.0	0.0	0.0	0.0	0.0

Overall, regions typically increase their exports of most products to the ASEAN 6 region as a result in the reduction in NTMs. The largest effects are in the plant and animal products sectors, which are the sectors most affected by NTMs. For instance, Japan, China and India all increase their exports of plant products to ASEAN 6 countries by between 6 and 8 percent while Australia, New Zealand and India increase their exports of animal products to ASEAN 6 countries by between 7 and 18 percent (see left-hand columns of table 7). For countries already closely linked to the ASEAN 6 countries (New Zealand, Australia, India and other ASEAN countries), we see a modest substitution away from exporting to other markets as the reduction in NTMs makes ASEAN 6 countries more attractive markets (see center columns of table 7).

Looking at changes in sectoral output – right-hand columns of table 7 – we typically see a modest decrease in real output in ASEAN 6 countries in sectors most affected by NTMs as imports become relatively cheaper. Resources are shifted to other sectors in the economy which expand and which are a much larger part of the economy.

CONCLUSIONS

This paper illustrates the effects, both on the major ASEAN countries themselves and their trading partners, from partial liberalization by the major ASEAN countries of their most trade distorting types of NTMs. Such liberalization increases the GDP of all countries, and is particularly pronounced for the major ASEAN countries, especially Viet Nam and the Philippines. As trade in plant products and animal products is particularly affected by NTMs, these sectors show the largest expansion of trade. We find a modest decrease in output in major ASEAN countries in these sectors as imports become relatively cheaper, with resources shifted to other sectors in the economy.

The paper takes a novel approach of allowing different types of NTM to have different effects, including for these effects to differ depending on whether they are applied to intermediate production or final consumption or to food and agriculture, or other sectors. This is an important advance in recognizing and accounting for the heterogeneity of NTMs: there is no such thing as a typical NTM.

By modelling the impact of different types of NTMs separately we are able to consider whether their cost is directed at exporters or importers. This consideration has generally been overlooked in the literature, but can have significant effects, as shown in our results. Reductions in NTMs that affect importers in major ASEAN countries have only a minimal effect on the GDP of countries other than the six major ASEAN countries examined in this paper. In contrast, we find much larger effects, for other regions, from reductions in NTMs that affect exporters when ASEAN countries reduce NTM barriers to all countries. The fact that importers are the principal beneficiaries of shocks modelled through the import augmenting channel is often obscured by the fact that most applications involve liberalization on both sides. In focusing solely on NTM reduction by ASEAN countries, we can see how modest the gains to exporting countries are from liberalization incorporated through the import augmenting channel. From detailed assessment of the extent to which exporters and importers are targeted by different types of NTMs, and calculating their effect depending on the value of trade in products affected, our analysis provides a useful rule of thumb for future work with this model – approximately half of NTM shocks can be allocated to the exporter channel.

Our paper has significant policy relevance, demonstrating the channels through which both importing countries and their trading partners can benefit from reducing the trade implications of NTMs. In particular, we demonstrate that it is the ASEAN importing countries themselves who can expect to see the largest increases in GDP and welfare. This helps demonstrate that improvements in regulatory regimes - including finding less trade distorting ways of achieving the same regulatory objectives - should not be seen as a concession to trading partners, including in trade agreements, but rather a tool for encouraging economic growth.

Our approach also lays the groundwork for future studies that can examine more closely which types of NTMs are harmonized or liberalized as a result of economic integration objectives, including ASEAN's efforts working towards a common market as well as its active network of FTAs, including the ongoing negotiations for the Regional Comprehensive Market. Approaches such as ours, which recognize the different types of NTMs, are well positioned to incorporate research on which NTMs are candidates for liberalization or harmonization.

References

Andriamananjara, S., Ferrantino, M. J., & Tsigas, M. E. (2003). *Alternative Approaches in Estimating the Economic Effects of Non-Tariff Measures: Results from Newly Quantified Measures* (United States International Trade Commission Office of Economics Working Papers No. 15872.) Retrieved from https://ideas.repec.org/p/ags/uitcoe/15872.html

Arita, S., Beckman, J., & Mitchell, L. (2017). Reducing transatlantic barriers on U.S.-EU agri-food trade: What are the possible gains? *Food Policy, 68*, 233–247. https://doi.org/10.1016/j.foodpol.2016.12.006

Beghin, J. C., Disdier, A.-C., & Marette, S. (2015). Trade restrictiveness indices in the presence of externalities: An application to non-tariff measures. *Canadian Journal of Economics/Revue Canadienne D'économique, 48*(4), 1513–1536. https://doi.org/10.1111/caje.12157

Berden, K., & Francois, J. (2015). *Quantifying Non-Tariff Measures for TTIP*. (Paper No. 12 in the CEPS-CTR project 'TTIP in the Balance' and CEPS Special Report No. 116). Retrieved from http://www.ceps.eu/publications/quantifying-non-tariff-measures-ttip

Cadestin, C., Gourdon, J., & Kowalski, P. (2016). Participation in Global Value Chains in Latin America. *OECD Trade Policy Papers*. Retrieved from http://www.oecd-ilibrary.org/content/workingpaper/5jlpq80ts8f2-en

Cadot, O., Asprilla, A., Gourdon, J., Knebel, C., & Peters, R. (2015). *Deep Regional Integration and Non-Tariff Measures: A Methodology for Data Analysis*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series 69). Retrieved from http://www.researchgate.net/profile/Julien_Gourdon/publication/272086370_Deep_Regional_Integration_and_Non-Tariff_Measures_A_Methodology_for_Data_Analysis/links/54da01100cf25013d0439fd6.pdf

Cadot, O., & Gourdon, J. (2016). Non-tariff measures, preferential trade agreements, and prices: new evidence. *Review of World Economics, 152*(2), 227–249. https://doi.org/10.1007/s10290-015-0242-9

Carrère, C., & De Melo, J. (2011). Notes on detecting the effects of non tariff measures. *Journal of Economic Integration, 26(*1) 136–168.

Crivelli, P., & Gröschl, J. (2016). The impact of sanitary and phytosanitary measures on market entry and trade flows. *The World Economy, 39*(3), 444–473.

Fiedler, K., Kutzner, F., & Krueger, J. I. (2012). The Long Way From α-Error Control to Validity Proper: Problems With a Short-Sighted False-Positive Debate. *Perspectives on Psychological Science, 7*(6), 661–669. https://doi.org/10.1177/1745691612462587

Fontagné, L., Gourdon, J., Jean, S. (2013). *Transatlantic trade: whither partnership, which economic consequences?* (CEPII Policy Brief). Retrieved from http://www.ifoinstitut.net/dms/ifodoc/docs/Akad_Conf/CFP_CONF_VSI/VSI_2014/vsi14-rmd-Felbermayr/Papers/vsi14-rmd-Gourdon.pdf

Francois, J., Van Meijl, H., & Van Tongeren, F. (2005). Trade liberalization in the Doha Development Round. *Economic Policy, 20*(42), 350–391. https://doi.org/10.1111/j.1468-0327.2005.00141.x

Fugazza, M., & Maur, J.-C. (2008). Non-tariff barriers in CGE models: How useful for policy? *Journal of Policy Modeling, 30*(3), 475–490.
Gibson, J., Datt, G., Murgai, R., & Ravallion, M. (2017). *For India's rural poor, growing towns matter more than growing cities.* (World Bank Policy Research Working Paper Series No. 7994.) Retrieved from https://ideas.repec.org/p/wbk/wbrwps/7994.html

Hertel, T. W., Walmsley, T., & Itakura, K. (2001). Dynamic Effects of the "New Age" Free Trade Agreement between Japan and Singapore. *Journal of Economic Integration, 16*(4), 446–484.

Kawasaki, K. (2015). The relative significance of EPAs in Asia-Pacific. *Journal of Asian Economics, 39*, 19–30. https://doi.org/10.1016/j.asieco.2015.05.001

Kee, H. L., Nicita, A., & Olarreaga, M. (2009). Estimating Trade Restrictiveness Indices. *The Economic Journal, 119*(534), 172–199. https://doi.org/10.1111/j.1468-0297.2008.02209.x

Kowalski, P., Lopez Gonzalez, J., Ragoussis, A., & Ugarte, C. (2015). *Participation of Developing Countries in Global Value Chains*. *(OECD Trade Policy Paper.).* Retrieved from http://www.oecd-ilibrary.org/content/workingpaper/5js33lfw0xxn-en

Narayanan, B., Aguiar, A., & McDougall, R. (eds.). (2015). *Global Trade, Assistance, and Production: The GTAP 9 Data Base*. Purdue University: Center for Global Trade Analysis. Retrieved from http://www.gtap.agecon.purdue.edu/databases/v9/v9_doco.asp

Roback, P. J., & Askins, R. A. (2005). Judicious Use of Multiple Hypothesis Tests. *Conservation Biology, 19*(1), 261–267. https://doi.org/10.1111/j.1523-1739.2005.00269.x

Santos Silva, J. M. C., & Tenreyro, S. (2006). The Log of Gravity. *The Review of Economics and Statistics*, *88*(4), 641–658.

Shepherd, B. (2013). *The gravity model of international trade: A user guide*. ARTNeT Books and Research Reports. Retrieved from http://www.unescap.org/sites/default/files/full-report-gravity-model-2013.pdf

Strutt, A., Knebel, C., Peters, R., & Walmsley, T. (2018). *Modelling the Harmonizing of Non-Tariff Measures: An application to Goods Trade in the*

Trans-Pacific Partnership Region. Paper presented at the 21st Annual Conference on Global Economic Analysis, Cartegena.

T. Walmsley, & Minor, P. (2016). *ImpactECcon Supply Chain Database: Documentation of data sources and the construction process of IE-SC_v2.0*.

UNCTAD. (2013). *Classification of Non-tariff Measures: February 2012 Version*. New York and Geneva.

Vanzetti, D., Peters, R., & Knebel, C. (2014). *Sand in the Wheels: Non-Tariff Measures and Regional Integration in SADC*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series No 71.) Retrieved from http://unctad.org/en/PublicationsLibrary/itcdtab73_en.pdf

Walmsley, T., & Strutt, A. (2018). *Improving the Modelling of Non-Tariff Measures in a CGE Framework*. Paper presented at the 21st Annual Conference on Global Economic Analysis, Cartegena.

Walmsley, T., Strutt, A., Minor, P. J., & Rae, A. N. (2018). *Impacts of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership on the New Zealand Economy*. ImpactEcon Report for the New Zealand Ministry of Foreign Affairs and Trade.

Walmsley, T., & Minor, P. (2015). *Willingness to Pay in CGE Models*. (ImpactECON Working Paper No. 04.)

Walmsley, T., & Minor, P. (2016). *ImpactECON Global Supply Chain Model: Documentation of Model Changes*. ImpactECON Working Paper No. 06.

Webb, M., Strutt, A., & Rae, A. N. (2017). Impacts of Geographical Restrictions: New Zealand Fruit and Vegetable Imports. *Journal of International Agricultural Trade and Development, 10*(2).

Appendix 1: GTAP Sectors and Aggregations

Aggregation	GTAP Sector
Plant products (Agriculture and food)	PDR - Paddy rice; WHT - Wheat; GRO - Cereal grains n.e.c.; V_F - Vegetables, fruit, nuts; OSD - Oil seeds; C_B - Sugar cane, sugar beet; OCR - Crops n.e.c.; VOL - Vegetable oils and fats; PCR - Processed rice; SGR – Sugar; OFD - Food products n.e.c.; B_T - Beverages and tobacco products
Animal products (Agriculture and food)	CTL - Bovine cattle, sheep and goats, horses; OAP - Animal products n.e.c.; RMK - Raw milk; FSH – Fishing; CMT - Bovine meat prods; OMT - Meat products n.e.c.; MIL - Dairy products
Wood products (Non Agriculture)	FRS - Forestry; LUM - Wood products; PPP - Paper products, publishing
Textiles, apparels, leather etc (Non Agriculture)	PFB - Plant-based fibers; WOL - Wool, silk-worm cocoons; TEX - Textiles; WAP - Wearing apparel; LEA - Leather products; FRS - Forestry; LUM - Wood products; PPP - Paper products, publishing
Machinery and equipment (Non Agriculture)	MVH - Motor vehicules and parts; OTN - Transport equipment n.e.c.; ELE - Electronic equipment; OME - Machinery and equipment n.e.c.
Other manufactures (Non Agriculture)	COA – Coal; OIL – Oil; GAS – Gas; OMN - Minerals n.e.c.; P_C - Petroleum, coal products; CRP - Chemical, rubber, plastic products; NMM - Mineral products n.e.c.; I_S - Ferrous metals; NFM - Metals n.e.c.; FMP - Metal products; OMF - Manufactures n.e.c.; ELY - Electricity; GDT - Gas manufacture, distribution
Services	Other

Appendix 2: Division of NTM Obligations

NTM	Description	Exporter weight (proportion of cost directed at exporter)	Importer weight (proportion of cost directed at importer)	Explanation
Sanitary and Phytosanitary Measures				
a100	General prohibitions/restrictions	0	1	Since these do not impose any costs on exporters who are able to export.
a110	Temporary geographic prohibitions	0	1	Since these do not impose any costs on exporters who are able to export.
a120	Geographical restrictions on eligibility	0	1	Since these do not impose any costs on exporters who are able to export.
a130	Systems approach	0.5	0.5	Since involves a combination of measures, which may affect importers or exports
a140	Authorisation requirements (for importers)	0	1	Since the importer has to be authorised
a150	Importer registration requirements	0	1	Since the importer has to register
a190	Prohibitions/restrictions nes	0	1	Since these do not impose any costs on exporters who are able to export.
a210	Residue tolerance limits	1	0	Since affect production processes
a220	Restricted use of substances	1	0	Since affect production processes
a310	Labelling requirements	0.75	0.25	As labelling can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer
a320	Marking requirements	1	0	Since would be done prior to shipment i.e. by exporter
a330	Packaging requirements	0.75	0.25	As packaging can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer
a410	Hygienic requirements: microbiological requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a420	Hygienic requirements during production (until final consumption)	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a490	Hygienic requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a500	General treatment requirements	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a510	Cold/heat treatment	0.5	0.5	Since this treatment can be done by either the exporter or the importer

a520	Irradiation requirements	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a530	Fumigation requirements	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a590	Treatment requirements nes	0.5	0.5	Since this treatment can be done by either the exporter or the importer
a610	Plant-growth processes	1	0	Since affect production processes
a620	Animal raising/catching requirements	1	0	Since affect production processes
a630	Food and feed processing requirements	1	0	Since affect production processes
a640	Storage and transport requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
a690	Other production requirements	1	0	Since affect production processes
a810	Product registration requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a820	Testing requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a830	Certification requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a840	Inspection requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a850	General traceability requirements	0.5	0.5	Both importer and exporters need to keep records
a851	Traceability (origin)	0.5	0.5	Both importer and exporters need to keep records
a852	Traceability (processing history)	0.5	0.5	Both importer and exporters need to keep records
a853	Traceability (distribution and location after delivery)	0	1	Borne by final seller i.e. importer
a859	Other traceability requirements	0.5	0.5	Both importer and exporters need to keep records
a860	Quarantine requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a890	Other conformity requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
a900	SPS measures nes	0.5	0.5	As there is no information to identify whether the cost would be borne by the exporter or the importer
Technical Barriers to Trade				
b110	Prohibitions	0	1	Since these do not impose any costs on exporters who are able to export.

b140	Authorisation requirements (for importers)	0	1	Since the importer has to be authorised
b150	Importer registration requirements	0	1	Since the importer has to register
b190	Prohibitions/restrictions nes	0	1	Since these do not impose any costs on exporters who are able to export.
b200	Tolerance limits nes	1	0	Since affect production processes
b210	Residue tolerance limits	1	0	Since affect production processes
b220	Restricted use of substances	1	0	Since affect production processes
b310	Labelling requirements	0.75	0.25	As labelling can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer.
b320	Marking requirements	1	0	Since would be done prior to shipment i.e. by exporter
b330	Packaging requirements	0.75	0.25	As packaging can be done by either the importer or the manufacturer, but is more likely to be done by the manufacturer.
b400	General production or post-production requirements	0.5	0.5	As there is no information to identify whether the cost would be borne by the exporter or the importer
b410	Production process requirements	1	0	Since affect production processes
b420	Storage and transport requirements	0.5	0.5	Since cover the process until final sale, therefore affecting both importers and exporters
b490	Production requirements	1	0	Since affect production processes
b600	Product identity requirement	1	0	As goes to the product itself i.e. how manufactured
b700	Performance standards	1	0	Since affect production processes
b810	Product registration requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b820	Testing requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b830	Certification requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b840	Inspection requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
b850	General traceability requirements	0.5	0.5	Both importer and exporters need to keep records
b851	Traceability (origin)	0.5	0.5	Both importer and exporters need to keep records
b852	Traceability (processing history)	0.5	0.5	Both importer and exporters need to keep records
b853	Traceability (distribution and location after delivery)	0	1	Borne by final seller i.e. importer

b859	Other traceability requirements	0.5	0.5	Both importer and exporters need to keep records
b890	Conformity assessments nes	0.5	0.5	As the cost may be borne by either the importer or the exporter
b900	Other TBT requirements	0.5	0.5	As there is no information to identify whether the cost would be borne by the exporter or the importer
c100	Pre-shipment inspection	1	0	Since it is before shipment
c300	Direct consignment requirements	0.5	0.5	As the cost may be borne by either the importer or the exporter
c400	Import monitoring requirements	0	1	As the cost is more likely to be borne by the importer.
c900	Customs formalities	0	1	As the cost is more likely to be borne by the importer.

Appendix 3: Allocation of changes in ASEAN6 imports (Trade weighted average increase)

	Singapore	Thailand	Malaysia	Viet Nam	Philippines	Indonesia
Importer Augmented Technological Change (Private Consumption)						
PlantProds	17.07	14.43	17.33	14.24	21.20	8.06
AnimalProds	18.46	20.60	10.22	20.93	17.33	18.71
WoodProds	0.01	0.00	0.00	0.32	0.00	0.90
TexLeaWap	0.05	0.00	0.00	0.00	0.00	2.07
MachinEquip	2.76	1.43	0.00	0.29	4.43	2.10
OtherManuf	1.93	1.67	1.36	6.12	1.67	1.43
Importer Augmented Technological Change (Firm Use)						
PlantProds	7.61	1.18	3.11	9.41	29.64	1.55
AnimalProds	10.75	1.7152	2.6751	3.43	47.3933	4.97
WoodProds	0.064	0.732	0.079	10.243	4.627	0.016
TexLeaWap	0.00	0.02	0.73	4.11	1.09	0.00
MachinEquip	0.02	0.50	0.18	3.34	0.64	0.67
OtherManuf	0.56	0.33	0.28	4.52	3.05	0.27
Importer Augmented Technological Change (Government Purchases)						
PlantProds	15.35	7.73	9.54	11.09	25.87	3.16
AnimalProds	16.50	10.22	7.73	8.74	27.23	9.44
WoodProds	0.05	0.64	0.06	9.82	3.62	0.09
TexLeaWap	0.05	0.01	0.25	3.75	0.57	0.27
MachinEquip	0.13	0.53	0.17	3.17	0.75	0.69
OtherManuf	0.49	0.44	0.30	4.20	2.52	0.26
Exporting Efficiency Change						
PlantProds	14.20	7.29	5.64	15.60	8.31	3.74
AnimalProds	19.78	8.96	9.09	10.39	1.98	10.74
WoodProds	0.05	0.75	0.02	6.79	2.94	0.32
TexLeaWap	0.05	0.01	0.00	3.59	0.45	0.38
MachinEquip	0.19	0.73	0.17	3.17	0.81	0.85
OtherManuf	1.13	0.78	0.36	4.63	5.12	0.39

CHAPTER VI: CONCLUSION AND SYNTHESIS

The research presented in this PhD makes various significant contributions to the field concerned with investigating the impact of NTMs in trade. I proposed new approaches to econometrically estimating the effect of NTMs and took novel approaches to modelling these effects in a computable equilibrium (CGE) framework. In order to utilise these econometric and CGE techniques to contribute to an improved understanding on the impacts of NTMs it was necessary for me to gather new data on New Zealand NTMs. This data will assist future researchers, policy makers and businesses to be able to analyse NTMs of key importance to them. Moreover, the specific questions addressed in each chapter are of interest to both future researchers and policy makers.

Chapter two examined the effect of foot and mouth disease (FMD) and bovine spongiform encephalopathy (BSE) on beef trade. The approach in this chapter recognises that the barriers and costs placed on exporters - in other words NTMs - vary depending on the disease status of both importing and exporting countries, which can manifest itself in restrictions or requirements placed on some countries by others (typically by disease free countries on those that present risks). My approach therefore made a novel contribution, accounting for official FMD status and for the impact of recent disease outbreaks. My research found that during and after a FMD outbreak, exporting countries substitute away from markets recognised as FMD-free toward lower value markets not recognised as FMD-free. Similarly, my research found that a country that has experienced BSE will export less to markets that have not experienced BSE and more to markets that have. Regaining official recognition of FMD-free status may aid recovery but does not negate the effects of a recent FMD outbreak.

The chapter has implications for economic modelling of FMD impacts. I showed that models should incorporate these market-switching effects, while analysis of FMD outbreaks should not focus solely on the loss of markets but rather should incorporate our finding that these loses are somewhat mitigated by market substitution. Moreover, these results are of direct relevance to policy makers, who are concerned both with the impact of the disease but also the benefits of obtaining official recognition of a foot and mouth free status, which provides the opportunity to substitute towards higher value FMD-free markets.

Chapter three used data from the UNCTAD NTM database for four developed markets (Canada, New Zealand, the European Union and the United States) to show that NTMs which impose a conformity requirement, i.e. testing, certification or inspection, will reduce the number of countries exporting to these markets in some cases by significant amounts. By concentrating on the number of countries exporting a product, I could utilise a parsimonious regression approach, which is novel in this area of the literature, and which abstracts from the level of detail about each of the importer-exporter dyads that is required in gravity model estimation. The differences this application finds between countries is informative for other researchers suggesting that pooling of cross country panels should be done carefully, using groups of countries that are as similar as possible.

My findings on the impact of NTMs on the number of countries exporting have significant policy implications. Regulators in importing countries that are considering imposing compliance measures should be aware that these are likely to reduce the number of exporters to their country. This is likely to affect product variety and, potentially, competition and so may lower the welfare of their own consumers. On the other hand, policy makers in exporting countries should not only be concerned with NTMs in the markets that they export to, but also note the likelihood that NTMs – particularly compliance measures – may be preventing their firms from profitably exporting to other markets. Finally, to the extent that rich countries are concerned with ensuring access of poor countries to their markets, compliance measures may hinder this access.

Chapter four used data that I collected on the geographical restrictions imposed by New Zealand, which mean that plant products presenting a biosecurity risk cannot be imported unless the exporting country is covered by an import health standard for that particular commodity. I found that if, in a counterfactual scenario, all countries were able to export all fruit and vegetables, imports from Europe, Latin America, Middle East and Africa and East Asia would increase at the expense of imports from Australia, Oceania, South East Asia, South Asia and North America.

These results present a more nuanced view of the impact of phytosanitary restrictions than has previously been found in the literature, which often suggested that developing countries are most impacted by such food and agricultural measures. From the results in this chapter, it cannot be said that developing countries are more adversely affected by the regulations than developed countries as we found substantial variation between impacts on different developing regions. In particular, I found that if New Zealand were to remove current restrictions, the largest negative effect would be on exports from developing Pacific Island countries, whereas the developed region of Europe is expected to be see the largest percentage growth in exports.

Chapter five explored the impact of NTMs on supply chains, with a focus on exports to major ASEAN countries. I first used the detailed UNCTAD NTM database to obtain econometric estimates of the effect of different types of NTMs on imports into major ASEAN countries, using a gravity model framework. I then used these econometric estimates in a global computable general equilibrium model to examine the impact of eliminating the types of NTMs that are found to have significant negative effects on trade.

This chapter illustrated the benefits, both to the major ASEAN countries themselves and to their exporting partners, from the partial liberalisation by ASEAN countries of their most trade distorting types of NTMs. Such liberalisation increases the GDP and welfare of all countries, and is particularly pronounced for the major ASEAN countries especially Viet Nam and the Philippines. As trade in plant products and animal products is particularly affected by NTMs, these sectors showed the largest expansion of trade.

The chapter took a novel approach of allowing different types of NTM to have different effects, including for these effects to differ depending on whether they are applied to intermediate production or final consumption or to food and agriculture, or other sectors. My approach also took into account the degree to which the costs of meeting NTMs are directed at importers or exporters. These are important advances to accounting for the heterogeneity of NTMs.

This research has significant policy relevance, in particular, it demonstrated that it is the importing countries themselves who could expect to see the largest increases in GDP and welfare from the liberalistion of NTMs. This helps show that improvements in regulatory regimes – including finding a less trade distorting way of achieving the same regulatory objective - should not be seen merely as a concession to trading partners, including in trade negotiations, but rather a tool for encouraging economic growth.

While gravity modelling techniques are fairly settled, my thesis makes various innovations particularly in terms of model specification and data. In Chapter two, these included building a dataset from information available in a range of sources, particularly the International Animal Health Organisation (OIE) to allow for official disease status and recent disease outbreaks to affect trade. In Chapter five, these included allowing different types of non-tariff measure to have different effects, including for these effects to differ depending on whether they are applied to intermediate production or final consumption or to food and agriculture, or other sectors. This is an important advance in recognising and accounting for the heterogeneity of NTMs – it is my firm view that there is no such thing as a typical NTM.

Moreover, in chapter three, I showed how count data models, particularly the Poisson and Negative Binomial Regression model can be applied as a parsimonious regression approach, which abstracts from the level of detail about each of the importer-exporter dyads that is required in gravity model estimation.

There is scope for continued refinement of the approaches to incorporating NTMs into computable general equilibrium models. The methodology proposed for phytosanitary restrictions in Chapter four, can be used to model how NTMs that lead to foregone trade in some products from some countries can be incorporated within a

CGE framework. More generally, I proposed an approach that directly incorporates estimated partial equilibrium increases in imports into a CGE framework to allow for general equilibrium interactions. In Chapter five, through using a "supply chain model", I could more accurately capture the effects of removing NTMs that affect exporters.

There is also still substantial scope for further research utilising data from the UNCTAD database to which I contributed. For instance, if data is collected for additional years then panel data techniques can be applied to the data. A second area of further research could be to combine the NTM database with firm level data, which would build on papers such as El-Enbaby, Hendy, and Zaki (2016) and Fontagné, Orefice, Piermartini, and Rocha (2015) who examine the effect of examine sanitary and phytosanitary measures notified to, or raised as concerns at, on exports by Egyptian and French firms respectively. Third, research teams could utilise the UNCTAD NTM data for detailed econometric (and ultimately CGE analysis) of regulatory heterogeneity building on the work of Cadot et al. (2015) and Winchester et al. (2012). Fourth, there is considerable value in research exploring the extent to which NTMs can, or should, be removed or modified – their "actionability". Finally, the detailed data collected on the measures themselves, with hyperlinks to the underlying rules provide the ability to use techniques based on textual analysis (see, for example, Allee, Elsig, and Lugg, 2017).

In short, my PhD research developed new and more nuanced approaches for econometric and CGE modelling of NTMs, contributed an important body of data to a major international database, and also shed light on some of the policy questions that can be investigated with these data and new techniques. A key theme of all my applications has been a desire to provide a more refined analysis of the impact of non-tariff measures, and to avoid oversimplifying these considerations. My work on the impact of non-tariff measures on the extensive margin showed that NTMs that impose compliance measures have quite different effects to standards themselves, and that this effect can differ even amongst developing countries. My research on New Zealand phytosanitary restrictions provided a more nuanced view than the common view that it is developing countries who are disadvantaged by SPS measures, given the privileged access of Pacific Island countries. Research on NTMs in ASEAN breaks new ground in allowing for different types of NTM to have different effects. Finally, my research on FMD and BSE showedthat these animal diseases have persistent effects, so analysing their effects is not simply a case of considering whether or not there is a disease in the current year. I hope that with further improvements in data and methodologies, we can continue to address more sophisticated and nuanced questions in this important topic for international trade.

REFERENCES

Allee, T., Elsig, M., & Lugg, A. (2017). The Ties between the World Trade Organization and Preferential Trade Agreements: A Textual Analysis. *Journal of International Economic Law, 20*(2), 333–363. https://doi.org/10.1093/jiel/jgx009

Cadot, O., Asprilla, A., Gourdon, J., Knebel, C., & Peters, R. (2015). *Deep Regional Integration and Non-Tariff Measures: A Methodology for Data Analysis*. (UNCTAD Policy Issues in International Trade and Commodities Research Study Series 69). Retrieved from http://www.researchgate.net/profile/Julien_Gourdon/publication/272086370_Deep_Regional_Integration_and_Non-Tariff_Measures_A_Methodology_for_Data_Analysis/links/54da01100cf25013d0439fd6.pdf

El-Enbaby, H., Hendy, R., & Zaki, C. (2016). Do SPS measures matter for margins of trade? Evidence from firm-level data. *Applied Economics, 48*(21), 1949–1964. https://doi.org/10.1080/00036846.2015.1111987

Fontagné, L., Orefice, G., Piermartini, R., & Rocha, N. (2015). Product standards and margins of trade: Firm-level evidence. *Journal of International Economics, 97*(1), 29–44. https://doi.org/10.1016/j.jinteco.2015.04.008

Winchester, N., Rau, M.-L., Goetz, C., Larue, B., Otsuki, T., Shutes, K., … Nunes de Faria, R. (2012). The Impact of Regulatory Heterogeneity on Agri-food Trade. *The World Economy, 35*(8), 973–993. https://doi.org/10.1111/j.1467-9701.2012.01457.x

APPENDIX I: NON-TARIFF MEASURES IN NEW ZEALAND (DATA COLLECTION)

This report will be published as a chapter in an upcoming publication by the Economic Research Institute for ASEAN and East Asia (ERIA) and the United Nations Conference on Trade and Development (UNCTAD) (Webb and Strutt, 2018). The version in this PhD includes an additional introduction on the UNCTAD NTM database.

INTRODUCTION

The report that follows provides information on the New Zealand NTM data initially collected between September 2014 and June 2015 and then updated with changes in NTMs to May 2016. The final version of this database (as at May 2016) includes 3,096 measures from 530 regulations made pursuant to 59 Acts. As detailed in the report that follows, this required an extensive investigation of all rules and regulations in force in New Zealand, as well as meetings with key regulatory agencies. The data is publicly available at http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures/NTMs-Data.aspx

Each of the 3,096 measures was entered into a datasheet provided by UNCTAD. This required entering detailed information. In addition to detailed information about the measure, we were required to classify the NTM using the UNCTAD classification framework set out in UNCTAD (2012) and detailed throughout this PhD. Furthermore, all the tariff codes of products covered by the measures needed to be found. The tariff coding was a significant exercise because measures rarely listed the tariff lines affected. Indeed, this is a key contribution of the project.

The table that follows shows the information for a single measure relating to product safety standards for cigarette lighters under the Product Safety Standards (Cigarette Lighters) Regulations 1998.

Document Sheet	
Document_Title_Full	Fair Trading Act 1986
Document_Symbol	Public Act 1986 No 121
Document_Description	The purpose of this Act is to contribute to a trading environment in which— (a)the interests of consumers are protected; and (b)businesses compete effectively; and (c)consumers and businesses participate confidently. To this

	end, the Act— (a)prohibits certain unfair conduct and practices in relation to trade; and (b)promotes fair conduct and practices in relation to trade; and (c)provides for the disclosure of consumer information relating to the supply of goods and services; and (d)promotes safety in respect of goods and services.		
Language	en		
Document_Publication_Date	17/12/1986		
Document_Url	http://www.legislation.govt.nz/act/public/1986/0121/latest/DLM96439.html?src=qs		
Regulations Sheet			
Source_Name	Legislation NZ		
Document_Title	Fair Trading Act 1986		
Regulation_Title_Short	Product Safety Standards (Cigarette Lighters) Regulations 1998		
Regulatory_Agency	Ministry of Business, Innovation, and Employment (Consumer Affairs)		
Regulation_Implementation_Date	15/02/1999		
Regulation_Repealed_Date			
Regulation_Description	Sets safety standards and labelling requirements for cigarette lighters.		
Regulation_Full_Text			
Regulation_Url	http://www.legislation.govt.nz/regulation/public/1998/0451/latest/DLM270728.html?src=qs		
Notes	Pursuant to section 29 of the Fair Trading Act 1989		
Measures Sheet			
Document_Title	Fair Trading Act 1986		
Regulation_Title_Short	Product Safety Standards (Cigarette Lighters) Regulations 1998		
NTM_Code	B7		
Measure_Implementation_Date	15/02/1999		
Measure_Repealed_Date			
Measure_Description	Safety standards (and compliance requirements) for cigarette lighters		
Measure_Reference	Regulations 4,6,7 and 8		
Affected_Products_Description	Cigarette lighter means a flame-producing device that is designed to light cigarettes, cigars, and pipes; and is either— (a)disposable; or (b)designed to be refilled with fuel and has a customs value of less than $3.50		
Affected_Regions_Description	World		
Measure_Objectives	Public Safety		
Measure_also_domestic	Yes		
Notes	Requires compliance with clauses of the International Safety Standard for Lighters—Safety Specification (ISO 9994:1995E) set out in the Schedule together with the variations specified in that schedule, as well as imposes additional child resistance requirements.		
"Measures Affected Products" Sheet			
Product_Code_Type	HS_Code	HS_Code	HS_Code

Product_Code	961310	961320	96138019
Partial_Coverage	No	Yes	Yes
Partial_Coverage_Indication		With a customs value of less than $3.50	Cigarette lighters with a customs value of less than $3.50. (Cigarette lighters fall under the 10 digit statistical key 9613.80.19.11H)
Date_In	15/02/1999	15/02/1999	15/02/1999
Date_Out			
"Measures Affected Countries" Sheet			
Inclusion/Exclusion	Inclusion		
Country	World		
Date_In	15/02/1999		
Date_Out			
"Measures Objectives" Sheet			
Objective	Protection of human life and health		

Most regulations provide more than one measure. For instance, Product Safety Standards (Cigarette Lighters) Regulations 1998 also includes labelling requirements (classified as a B31 requirement in the UNCTAD framework) and a certification requirement classified as a B83 requirement in the UNCTAD framework). For these two measures, all the details are the same as in the above table except for the information in the “Measures sheet” section.

Furthermore, the same measure may need to be listed various times as the database does not allow the assignment of specific products to specific countries; the same measure can be used only if the same set of products is covered for each country (which is not the case particularly for a standard relating to fresh fruit and vegetables).

Non-tariff Measures in New Zealand

Report prepared for ERIA and UNCTAD

by Mike Webb and Anna Strutt[1]

University of Waikato, New Zealand

Contents

[1] We gratefully acknowledge support provided by UNCTAD and ERIA throughout this project. Detailed comments and very helpful suggestions were provided by staff in these agencies, including: Guillermo Abramowitz, Santiago Fernandez De Cordoba, Fabien Dumesnil, Maxim Gubarev, Samuel Munyaneza, Ralf Peters and Denise Penello Rial from UNCTAD, as well as Rizqy Anandhika and Lili Yan Ing from ERIA. We are particularly grateful to Peter Bailey, New Zealand Ministry of Foreign Affairs and Trade, for his strong support of this project as the nominated government official, including attending international workshops to work alongside the New Zealand team undertaking this study and assisting with organising a stakeholder workshop in Wellington, New Zealand. We are also grateful to other officials from a range of key New Zealand agencies who have provided assistance, including the Ministry of Foreign Affairs and Trade, Ministry for Primary Industries, Customs New Zealand, the Treasury, Standards New Zealand, New Zealand Trade and Enterprise, Ministry of Business, Innovation and Employment. This report, however, reflects the views of the authors and not any Government agency.

Background

New Zealand's overall regulatory regime is well regarded internationally, for example, New Zealand ranks first in the World Bank's Ease of Doing Business 2018 Index.[2] Non-tariff measures (NTM) are a subset of this regulatory regime: the regulations that may affect trade. A major feature of New Zealand's NTM regime is the relatively stringent sanitary and phytosanitary (SPS) measures, reflecting that that New Zealand is a major agricultural producer and an island nation, free from many diseases and pests affecting international animal and plant product trade (see Webb, Strutt and Rae, 2017).

New Zealand has actively participated in the negotiation of free trade agreements (FTAs) which contain provisions covering both SPS and technical barriers to trade (TBT) issues. Bilateral agreements are currently in force with China, Australia, Hong Kong, Malaysia, Singapore, Thailand and Korea. Regional agreement in force include the AANZFTA (with ASEAN members and Australia) and the P4 Agreement (with Singapore, Brunei and Chile). New Zealand has also concluded the Trans-Pacific Partnership Agreement, PACER Plus (with Pacific Island countries) and a FTA with the Gulf Cooperation Council. New Zealand is currently involved in negotiations for the Regional Comprehensive Partnership (RCEP) and the Pacific Alliance, as well as bilateral agreements with the European Union and India.[3]

New Zealand is also an active member of international standard settings organisations, including Codex Alimentarius (the International "Food Code") and the OIE (World Organisation for Animal Health), as well as a party to various international conventions that are relevant to the establishment of NTMs.[4]

New Zealand's legal system

Legislation passed by Parliament, known as Acts, is the highest form of law in New Zealand's legal system.[5] Acts may contain detailed rules which serve as NTMs, for instance the Anti-Personnel Mines Prohibition Act 1998 prohibits the use (and

---

[2] See http://www.doingbusiness.org/rankings.

[3] https://www.mfat.govt.nz/en/trade/free-trade-agreements/.

[4] These include the International Plant Protection Convention, Montreal Protocol and Vienna Convention, Single Convention on Narcotic Drugs, Convention on Psychotropic Substances, Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, Convention on International Trade in Endangered Species of Wild Fauna and Flora, Chemical Weapons Convention, Basel Convention (on the control of transboundary movements of hazardous wastes and their disposal), Rotterdam Convention (for certain hazardous chemicals and pesticides) and the Stockholm Convention on Persistent Organic Pollutants. Full details of New Zealand's international treaty obligations are available at http://www.treaties.mfat.govt.nz/.

[5] Further information is available at http://www.parliament.nz/en-nz/about-parliament/how-parliament-works/our-system/00CLOOCHowPWorks111/our-system-of-government. All legislation is publicly available from an official government website www.legislation.govt.nz.

import) of anti-personnel mines. There are approximately 2000 Acts in force in New Zealand, of which 59 either contain or authorise NTMs.

In practice, however, most legislation in New Zealand is not passed by Parliament, but rather by other persons or bodies under powers granted or delegated by Acts of Parliament.[6] Such legislation is generally known as delegated legislation and all delegated legislation must be based on authority conferred by an Act of Parliament.

There are various forms of delegated legislation in New Zealand, including Order in Council and "Notices" made by Ministers. For instance, Section 29 of the Fair Trading Act 1986 empowers the making, by Order in Council, of regulations setting Product Safety Standards. A specific example is the Product Safety Standards (Cigarette Lighters) Regulations 1998, which includes performance standards and labelling requirements for cigarette lighters. In some cases, delegated legislation is made by the head of a government department and published on their website. For instance, Import Health Standards with rules for the import of primary products are issued by the Director-General under the Biosecurity Act 1993 and are available on the website of the Ministry for Primary Industries.[7] Most information on Acts and regulations is readily available and New Zealand Customs provides guides for exporters and importers.

Some of New Zealand's international obligations under FTAs and other international treaties are reflected directly in Acts. In other cases, international obligations are reflected in delegated legislation or the rules, practices and procedures of regulatory agencies.

Data Collection and Update

NTM data for New Zealand were initially collected by our team between September 2014 and June 2015:[8] these were included in the NTM database publicly launched in July 2016. For the current ERIA-UNCTAD project, we updated the data with changes made to measures between September 2014 and May 2016.

Initial data collection process

To gather comprehensive information on New Zealand's NTMs, a five-stage process was initially used:

1. We undertook a survey of the websites of all Government agencies considered likely to administer regulations that might affect trade.
2. Official documents that purported to include an inventory of measures e.g. Schedules of Prohibited Imports and Exports from Customs New Zealand[9] and

[6] Further information is available at http://www.parliament.nz/en-nz/about-parliament/how-parliament-works/ppnz/00HOOOCPPNZ_291/chapter-29-delegated-legislation.
[7] www.mpi.govt.nz.
[8] Under the guidance of UNCTAD, consistent with the guidelines and classifications in UNCTAD (2013) and (2014). This project was undertaken with support from the World Bank, and the "NTM data collection for TPP countries" project supported by GRIPS.
[9] http://www.customs.govt.nz/features/prohibited/Pages/default.aspx.

a Standards New Zealand database of all standards referred to in legislation[10] were used to identify Acts and regulations. Additional regulations were then found through searching the Gazette and Legislation websites for regulations issued under the same Act, and by examining the information available on the websites of the regulatory agencies.

3. Meetings were held with key agencies to raise awareness of the project, to identify possible gaps in information recorded and to follow up on any information that may not be publicly available. Meetings were held with: the Ministry of Foreign Affairs and Trade; the Ministry of Business, Innovation and Employment; the Ministry for Primary Industries; and Standards New Zealand. There was strong interest and support for the project.[11]
4. A search of all references to the word "import" and "export" in Acts and Legislative Instruments available from www.legislation.govt.nz was undertaken to find any legislation and measures that might otherwise have been missed.
5. The database was then crosschecked against data available from Customs New Zealand showing the regulatory agency for each tariff line where "permits" or other authorisations might be necessary.[12] While this did not identify any new measures, it identified extra tariff lines that had not been assigned to some measures.

Data update

In updating the data, we systematically worked through all regulations to look for changes since the data were originally collected. This was facilitated by the New Zealand Government legislation website (www.legislation.govt.nz), showing details and dates of any amendments and whether a regulation has been revoked. The following changes were identified:

- The United Nations (Iran—Joint Comprehensive Plan of Action) Regulations 2016 replaced the United Nations Sanctions (Iran) Regulations 2010.
- The Customs Import Prohibition Order 2014 replaced the Customs Import Prohibition Order 2011.
- The Customs Import Prohibition (Trout) Order 2015 replaced the Customs Import Prohibition (Trout) Order 2010.
- Customs Export Prohibition (Toothfish) Order 2015 replaced the Customs Export Prohibition (Toothfish) Order 2009.

[10] http://shop.standards.co.nz/default.htm?mod=catalog&action=browseLegStandards.
[11] Including at a roundtable discussion held with representatives from key government agencies, 26 July 2016.
[12] http://www.customs.govt.nz/features/prohibited/Pages/default.aspx.

- The Hazardous Substances (Classes 6, 8, and 9 Controls) Regulations 2001 were amended, leading to new measures applying to the poison "1080", as recorded in the database.
- The Product Safety Standards (Children's Nightwear and Limited Daywear Having Reduced Fire Hazard) Regulations 2016 replaced the Product Safety Standards (Children's Nightwear and Limited Daywear Having Reduced Fire Hazard) Regulations 2008.

Moreover, we also identified two major sets of changes: (1) Changes to the Australia New Zealand Food Standards Code and (2) Changes Associated with the Food Act 2014.

A major set of revisions needed to the New Zealand data in the 2016 update arose from a complete overhaul of the Australia New Zealand Food Standards Code that took effect from 1 March 2016 (see www.foodstandards.govt.nz/code/Pages/default.aspx and Box 1). While the structure remained largely the same, a significant number of changes have been made to various components in the database.

The new Food Act 2014 came into force on 1 March 2016. This will gradually replace the previous Food Act 1981 as the principal Act governing food safety in New Zealand. There is a transition programme until the Food Act 2014 takes full effect on 28 February 2019.[13] We used information from the Ministry for Primary Industries to identify which regulations previously in the database have been replaced by new regulations.[14]

The following regulations under the Food Act 1981 have now been repealed:

- Food (Importer Listing) Standard 2008
- Food (Prescribed Foods) Standard 2007
- Food (Importer General Requirements) Standard 2008
- New Zealand Food (Supplemented Food) Standard 2013
- Food (Imported Milk and Milk Products) Standard 2009
- New Zealand (Maximum Residue Limits of Agricultural Compounds) Food Standards 2014

The following new regulations have been included in the database:

- New Zealand Food (Supplemented Food) Standard 2016
- Food Notice: Maximum Residue Levels for Agricultural Compounds
- Food Notice: Importing Food

[13] http://www.mpi.govt.nz/food-safety/food-act-2014/transition-timetable/.
[14] http://www.mpi.govt.nz/food-safety/food-act-2014/requirements/.

As part of the update process, we identified Acts that authorised the making of delegated legislation that could provide new regulations. These are the areas where new regulations could be added without passing or amending Acts of Parliament, as shown in Table 1.[15]

Table 1: Acts that provide scope for new regulations

Act	Delegated Legislation
Fair Trading Act 1996	Unsafe Goods Notices, Product Safety Standards and Consumer Information Standards
United Nations Act 1946	Sanctions (which may be passed as Acts)
Gas Act 1992	Notices
Resource Management Act 1991	National Environmental Standards
Radiocommunications Regulations 2001	Notices
Contraception, Sterilisation, and Abortion Act 1977	Standards
New Zealand Horticulture Export Authority Act 1987	Horticultural Prescribed Products Orders and New Zealand Horticulture Export Authority Orders
Hazardous Substances and New Organisms Act 1996	Group Standards, Regulations, Hazardous Substances Notices (following the Hazardous Substances and New Organisms Amendment Act 2015)
Biosecurity Act 1993	Import Health Standards – we included 9 new Import Health Standards and revised measures where Import Health Standards were updated.

In the 2016 update, with the exception of the aforementioned United Nations (Iran—Joint Comprehensive Plan of Action) Regulations 2016 under the United Nations Sanctions (Iran) Regulations, there were no new regulations passed pursuant to any of these Acts.

We also checked the websites of key agencies, to find any new types of regulations made under new powers conferred by changes to Acts of Parliament. This identified an amendment to the Hazardous Substances and New Organisms Act 1996, which enabled the making of Hazardous Substances Notices, of which one has been enacted.

[15] We recommend that researchers updating New Zealand NTM data in the future look for new regulations under these Acts.

Furthermore, we undertook a search of the Government legislation website for any new Acts passed which contain NTMs. In a relatively mature regulatory system such as New Zealand's, we did not expect to find many (if any) instances of this. Any new regulatory issue that arises will generally be resolved either within the existing regulatory framework e.g. a new Unsafe Goods Notice, or will involve revoking/amending existing legislation so will be noted through that mechanism. In this update, we identified the Radiation Safety Act 2016; however, we did not include new measures under this Act since it does not enter into force until 2017.

Box 1: Joint Food Standards and Australia New Zealand Economic Integration

The current joint food standards regime between Australia and New Zealand stems from the Agreement between Australia and New Zealand establishing a System for the Development of Joint Food Standards signed in December 1995. This treaty aimed to harmonise food standards, reduce compliance costs and remove regulatory barriers to trade. It created a new agency — the Australia New Zealand Food Authority (ANZFA) — which was established in July 1996 and renamed Food Standards Australia New Zealand (FSANZ) in 2002. The joint Australia New Zealand Food Standards Code was developed over several years, guided by a Ministerial Council with representation from Australia and New Zealand. It was agreed in 2000 and phased in over a two-year period.[a]

The Food Standards Code is given effect through domestic Australian and New Zealand legislation, and not all provisions apply to New Zealand (for instance, New Zealand sets its own maximum residue limits.) However, under the Trans-Tasman Mutual Recognition Arrangement, food - and other products - produced or imported into one country that meets that country's standards, may be legally sold in the other country. In practice, this means that most food exported to Australia from New Zealand is not assessed for compliance with Australian food standards, and vice versa.[b]

The joint Australia New Zealand Food Standards Code, and Trans-Tasman Mutual Recognition Arrangement, are part of a wider project of economic integration between Australia and New Zealand. This stems from the Closer Economic Relations Treaty of 1983, which includes the freedom for Australians and New Zealanders to live and work in the other country. A current focus is the Single Economic Market project under which New Zealand and Australia are committed to creating a seamless trans-Tasman economic environment.[c]

[a] See www.foodstandards.govt.nz/about/foodlawandtreaties/history/pages/default.aspx

[b] See www.agriculture.gov.au/import/goods/food/importing-food-from-new-zealand

[c] See www.mfat.govt.nz/en/trade/free-trade-agreements/free-trade-agreements-in-force/nz-australia-closer-economic-relations-cer/

NTM Data Summary

Tables 2 - 4 provide overview statistics in a format consistent with other data collected as part of this project. In total, we collated and coded 3,096 measures from 59 Acts, administered by 14 institutions.

Table 2: Overview statistics

Comprehensiveness Indicator	Number
Total number of coded regulations	530
Total number of coded regulations reported to the WTO[16]	754
Total number of coded NTMs	3,096
Total affected products (HS lines, national tariff lines)	
a. Total number of affected products	5,082*
b. Share of the number of affected products to the number of total products	67.7%*
Total number of issuing institutions	14

* *Note:* all products are subject to a goods and services (value added) tax (measure F71) and an import entry transaction fee (measure F61). Moreover, any good that infringes copyright is subject to a NTM (measure E315). Therefore we exclude these in our calculations.

[16] From https://i-tip.wto.org/goods/.

Table 3: Issuing institutions

No	Issuing Institution	Number of NTMs	% of total number of NTMs
1	Ministry for Primary Industries	1705	55.07%
2	Ministry for the Environment	1189	38.40%
3	Ministry of Business, Innovation and Employment	63	2.03%
4	Ministry of Health	35	1.13%
5	Ministry of Foreign Affairs and Trade	28	0.90%
6	Ministry of Transport	25	0.81%
7	Ministry of Justice	16	0.52%
8	New Zealand Customs	15	0.48%
9	Department of Internal Affairs	6	0.19%
10	Department of Conservation	5	0.16%
11	Other institutions	4	0.29%
	Total	3096	100.00%

Due to its role in administering the Biosecurity Act 1993, the New Zealand Ministry for Primary Industries is responsible for issuing over half of all NTMs recorded for New Zealand.[17] As we explain later, the high number of measures recorded is also a function of the database structure: different measures are recorded when different requirements apply to different products from different countries.

Under the Biosecurity Act, animal and plant products that may present a biosecurity risk for the introduction of pests and diseases cannot be imported into New Zealand until a risk analysis assessment, consistent with international standards, has been completed.[18] This process is triggered by a request from a country interested in exporting the product and involves the development, by the Ministry for Primary Industries, of an Import Health Standard that mitigates the risk associated with importing that product, pursuant to the Biosecurity Act 1993. There are approximately 200 Import Health Standards that cover a particular commodity or

[17] It should be noted that the Ministry for Primary Industries has responsibility for Agriculture, Forestry, Fisheries and food safety more generally.

[18] The rationale for this is that New Zealand's geographic isolation and biosecurity measures have meant that it is free from many OIE listed diseases that are common throughout much of the world. See the WTO Trade Policy Review of New Zealand 2009, particularly the Record of Meeting with Questions and Answers from Members. http://www.wto.org/english/tratop_e/tpr_e/tp_rep_e.htm.

category of commodities: these may be generic, covering all countries, or country-specific.[19] They are all listed as distinct "regulations" within the database.

The largest single source of New Zealand SPS measures is "MPI Standard 152.02: Importation and Clearance of Fresh Fruit and Vegetables into New Zealand", covering fresh fruit and vegetables and consolidating a large number of country-specific Import Health Standards for Fruit and Vegetables.[20] Despite the existence of this consolidated standard for fresh fruit and vegetables, the data collation nevertheless required separate measures be listed for each exporting country. This is because the database does not allow the assignment of specific products to specific countries; the same measure can be used only if the same set of products is covered for each country (which is not the case).

Over a third of the measures in the database stem from the Hazardous Substances and New Organisms Act 1996 (HSNO Act) which is administered by the Ministry for the Environment to regulate pesticides, dangerous goods, household chemicals and other dangerous substances.[21] As with measures issued by the Ministry for Primary Industries, the high number of measures recorded is partly a function of the way in which regulations are structured and the database structure. While there are some general regulations under the HSNO Act, such as the Hazardous Substances (Identification) Regulations 2001, the precise conditions for the majority of hazardous substances are contained in Group Standards issued by the Environment Protection Agency pursuant to section 96A of the HSNO Act. Group Standards apply to 34 categories of goods such as "Cosmetic products" and "Surface coatings and colourants". For each category of substance, between 1 and 24 Group Standards apply, depending on the combinations of hazards inherent in the substance e.g. whether they are combustible, corrosive, or combustible and corrosive.[22] In total there are 172 Group Standards entered into the database as regulations, leading to 1164 measures. Moreover, some hazardous substances (fireworks, pesticides, veterinary medicines, timber treatment chemicals, fumigants or vertebrate toxic agents) are not covered by Group Standards, but instead are governed by specific rules that can be traced to regulations made under the HSNO Act.

[19] See http://www.mpi.govt.nz/importing/overview/import-health-standards/.

[20] Available from http://www.biosecurity.govt.nz/files/ihs/152-02.pdf.

[21] http://www.epa.govt.nz/hazardous-substances/about/Pages/default.aspx.

[22] http://www.epa.govt.nz/hazardous-substances/approvals/group-standards/Pages/default.aspx.

Table 4: NTMs by type

Code	NTMs by type	No of NTMs	%	No of affected products (national tariff lines)	%
A	Sanitary and phytosanitary (SPS) measures	1,569	50.68%	2,592	34.51%
B	Technical barriers to trade (TBT)	1,424	45.99%	4,511	60.07%
C	Pre-shipment inspection and other formalities	29	0.94%	87	1.16%
D	Contingent Trade Protective Measures	3	0.10%		
E	Non-automatic licensing, quotas, prohibitions and quantity control measures other than SPS or TBT reasons	2	0.06%	7,510	100.00%
F	Price control measures including additional taxes and charges	5	0.16%	7,510	100.00%
J	Distribution restrictions	3	0.10%	95	1.26%
K	Restriction on post-sales services				
L	Subsidies (excluding export subsidies under P7)				
M	Government procurement restrictions				
N	Intellectual property				
O	Rules of origin				
P	Export related measures	61	1.97%	7,517	100.00%
Total coded NTMs		3,096	100.00%		100.00%

Table 5 sets out the most common NTMs applied in New Zealand. We have also calculated, using data on New Zealand import values from the world in 2016, the percentage of imports in tariff lines covered by these NTMs. We present these as a range because some NTMs have "partial coverage" i.e. they only apply to some products within a tariff line.[23]

[23] In calculating the "minimum", we excluded the value of all imports under tariff lines with partial coverage as it is possible that all trade was in parts of the tariff line not subject to the non-tariff

Table 5: Most common NTMs (in chapters A – C)

NTM	Description	Percentage of Tariff Lines Affected	Percentage of Imports Affected (Min)	Percentage of Imports Affected (Max)
B310	Labelling requirements	42.7%	32.7%	43.1%
B140	Authorisation requirements (for importers)	23.9%	31.4%	32.3%
B700	Performance standards	18.9%	32.6%	44.7%
A690	Other production requirements	18.5%	10.5%	11.6%
A220	Restricted use of substances	17.1%	14.0%	14.9%
B150	Importer registration requirements	16.9%	21.8%	24.1%
B490	Production requirements	16.2%	13.7%	26.6%
A590	Treatment requirements n.e.s.	16.0%	2.2%	30.5%
A310	Labelling requirements	15.4%	9.3%	10.4%
A210	Residue tolerance limits	14.9%	9.3%	9.3%

Figure 1 shows how the incidence of multiple NTMs varies across sectors. We limit our analysis to UNCTAD chapters A, B and C because, as noted in Table 2, all products are subject to a goods and services (value added) tax (measure F71), an import entry transaction fee (measure F61) and any good that infringes copyright is subject to a NTM (measure E315).

Figure 2 illustrates where individual tariff lines are affected by multiple different types of NTMs (in Chapters A, B or C the UNCTAD NTM classification). Approximately one third of all tariff lines are not subject to any NTM in these chapters. The most regulated products are meat, along with fresh fruit and vegetables; these are subject to a range of SPS measures for both biosecurity and food safety as well as some measures classified as TBT e.g. labelling requirements. Tariff lines that attract very high numbers of NTMs - i.e. more than 25 types of NTM – are generally miscellaneous categories such as food preparations n.e.s. (HS subheading 2106.90) and animal products n.e.s. (HS subheading 0511.99) or tariff lines that contain a range of different products e.g. tariff line 0804.50.00 that covers guavas, mangoes and mangosteens.

measure. The "maximum" assumes that all trade in a tariff line with partial coverage was affected by the NTM.

Figure 1: Incidence of Multiple NTMs by Sector

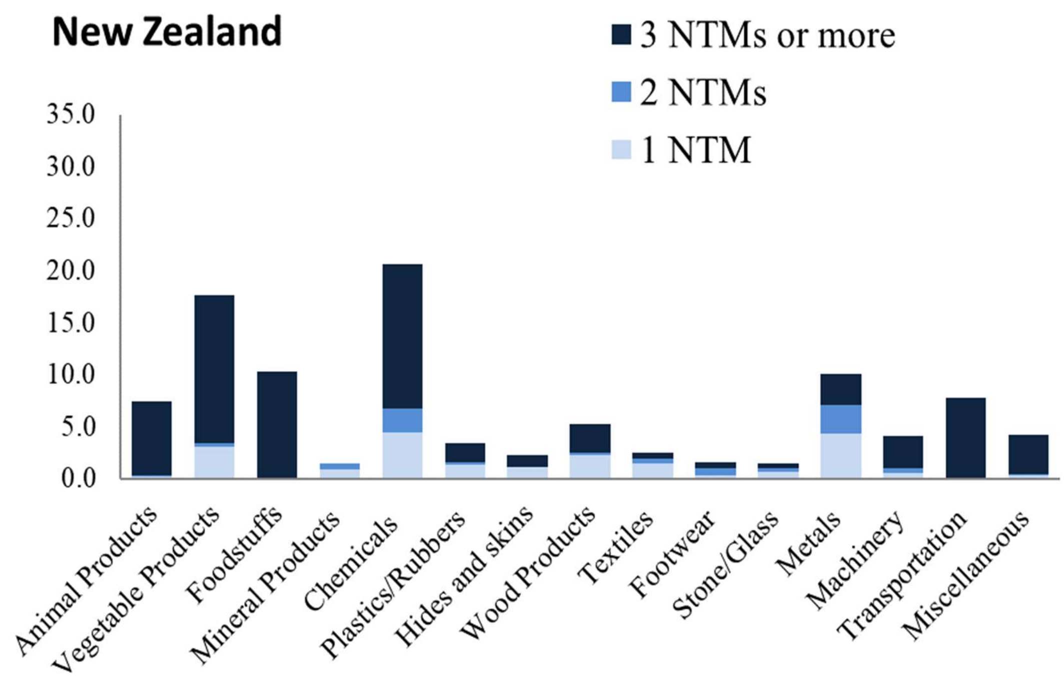
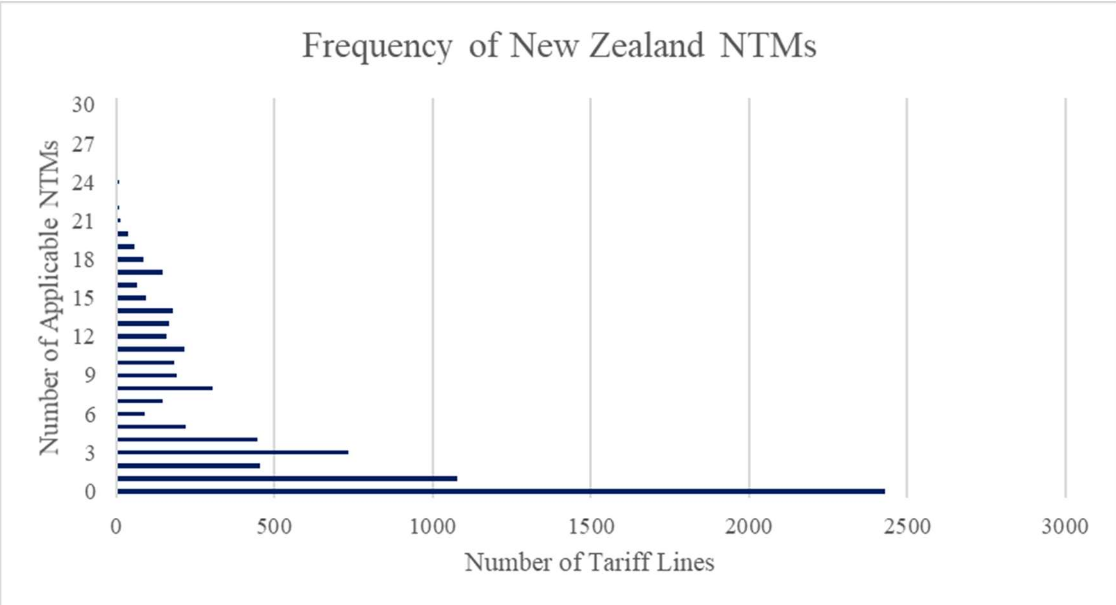


Figure 2: Frequency of Multiple NTMs (in Chapters A, B and C)



Policy Recommendations

We are confident that we have collected comprehensive and high quality data for New Zealand.[24] This is in part due to the relatively transparent legislative system operated by New Zealand, as well as key agencies being willing to provide information, including on NTMs.

We note that regulations associated with NTMs are often dealing with complex issues and that some NTMs will be challenging to reduce or harmonise. We also note that progress has already been made by New Zealand in reducing the effect of regulations on trade, such as harmonised Food Standards with Australia, providing treatment options for fresh fruit and vegetables under Import Health Standards and choices of international standards, particularly in the vehicle sector. We suggest, however, that the following areas may be particularly useful for New Zealand policy makers to consider making further improvements:

- Support the Ministry for Primary Industries' efforts to move to a generic Import Health Standard for each product, rather than separate standards for each exporting country.
- Further investigation could be undertaken of the complex regime for hazardous substances, with various standards depending on the properties of a substance e.g. if it is corrosive or flammable etc. It may be useful to explore the extent to which this poses a barrier to exporters and whether this regime can be simplified.
- Further investigation could be undertaken of possibilities for harmonisation of regulations with Australia and other trading partners, building for example on experience with joint food standards between New Zealand and Australia.
- Although already fairly widely practiced in New Zealand, investigation of scope to further recognize international standards might be useful in a range of areas.
- As proposed by the New Zealand Productivity Commission (2014), all regulations should be available from a single source such as www.legislation.govt.nz.
- Continue active involvement in FTA negotiations, particularly regional agreements such as RCEP, which may provide a basis for further regulatory alignment, including eventual harmonisation or mutual recognition.

Given the potential gains from reducing NTMs, it will be important for policy makers and officials, in New Zealand and other countries, to carefully examine

[24] Though of course there will be limitations to the data collected. For example, most of New Zealand's NTMs do not indicate the particular tariff lines covered; therefore, some judgement is required in assigning tariff codes, particularly for complex areas such as those under the Hazardous Substances and New Organisms Act 1996. We also note that the database is just a snapshot in time, as at May 2016.

areas where non-tariff barriers to trade may be reduced, while still achieving legitimate objectives of the various NTMs.

References

New Zealand Productivity Commission (2014). Regulatory institutions and practices. Wellington.

UNCTAD (2013), Classification of Non-tariff Measures: February 2012 Version, UNCTAD/DICT/TAB/2012/2, New York and Geneva.

UNCTAD (2014), Guidelines to Collect Data on Official Non-Tariff Measures: September 2013 Version, UNCTAD/DITC/TAB/2013/3. New York and Geneva.

Webb, M. Strutt, A and Rae, A. (2017), Impacts of Geographical Restrictions: New Zealand Fruit and Vegetable Imports. *Journal of International Agricultural Trade and Development* 10(2): 203-224.

APPENDIX II: CO-AUTHORSHIP FORMS

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter II: The Impact of Diseases on International Beef Trade: Market Switching and Persistent Effects published in Food Policy (2018) 93-108.

Nature of contribution by PhD candidate	Lead author. The research topic was proposed by Mike. Mike did all data and econometric work as well as drafting the paper, including leading the response to journal referees.
Extent of contribution by PhD candidate (%)	75

CO-AUTHORS

Name	Nature of Contribution
Anna Strutt	Guidance and critical feedback.
John Gibson	Guidance and critical feedback, particularly on the econometric approach. Revised the paper so that it was suitable for publication. Corresponding author.

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Mike Webb	M. Webb	24/5/18
Anna Strutt	Anna Strutt	2/5/18
John Gibson	John Gibson	2/5/18

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter III: Market Access Implications of Non-Tariff measures: Estimates for Four Developed Country Markets currently at a revise and resubmit with World Economy.

Nature of contribution by PhD candidate	Lead author. The research topic was proposed by Mike. Mike did all data and econometric work as well as drafting the paper. Mike led the response to journal referees.
Extent of contribution by PhD candidate (%)	80

CO-AUTHORS

Name	Nature of Contribution
Anna Strutt	Guidance and critical feedback.
John Gibson	Guidance and critical feedback, particularly on the econometric approach. Corresponding author.

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Mike Webb	M. Webb	24/5/18
Anna Strutt	A Strutt	2/5/18
John Gibson	John Gibson	2/5/18

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter IV: Impacts of Geographical Restrictions: New Zealand Fruit and Vegetable Imports published in the Journal of International Agricultural Trade and Development (2017) 10(2).

Nature of contribution by PhD candidate	Lead author. The research topic was proposed by Mike. Mike did all data, econometric work and CGE modelling as well as drafted the paper, including leading the response to journal referees.
Extent of contribution by PhD candidate (%)	75

CO-AUTHORS

Name	Nature of Contribution
Anna Strutt	Guidance and critical feedback, including advice and assistance with the CGE methodology. Corresponding author.
Allan Rae	Guidance and critical feedback, including advice on methodology.

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Mike Webb	M Webb	24/5/18
Anna Strutt	A. Strutt	2/5/18
Allan Rae	A. R. Rae	4/5/18

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Chapter V: Modelling the Impact of Non-Tariff Measures on Supply Chains in the Asia Pacific Region

Nature of contribution by PhD candidate	Lead author. The research topic was proposed by Mike. Mike undertook all of the data and econometric work, as well as CGE modelling. He also drafted the paper.
Extent of contribution by PhD candidate (%)	70

CO-AUTHORS

Name	Nature of Contribution
Anna Strutt	Guidance and critical feedback, including advice and assistance with implementing the CGE modelling.
John Gibson	Guidance and critical feedback, including suggesting advice on econometrics.
Terrie Walmsley	Guidance and critical feedback, including detailed advice on methodology (this paper uses new ImpactECON model code developed by Terrie on supply chains and NTMs).

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Mike Webb	M. Webb	24/5/18
Anna Strutt	Anna Strutt	2/5/18
John Gibson	John Gibson	2/5/18
Terrie Walmsley	T. L. Walmsley	3/5/2018

THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

Co-Authorship Form

Postgraduate Studies Office
Student and Academic Services Division
Wahanga Ratonga Matauranga Akonga
The University of Waikato
Private Bag 3105
Hamilton 3240, New Zealand
Phone +64 7 838 4439
Website: http://www.waikato.ac.nz/sasd/postgraduate/

This form is to accompany the submission of any PhD that contains research reported in published or unpublished co-authored work. **Please include one copy of this form for each co-authored work.** Completed forms should be included in your appendices for all the copies of your thesis submitted for examination and library deposit (including digital deposit).

Please indicate the chapter/section/pages of this thesis that are extracted from a co-authored work and give the title and publication details or details of submission of the co-authored work.

Appendix I: New Zealand NTM data contributed to UNCTAD led database, available at http://unctad.org/en/Pages/DITC/Trade-Analysis/Non-Tariff-Measures/NTMs-Data.aspx

Nature of contribution by PhD candidate	Lead data collector. Identified all sources of NTMs, classified them and entered them into UNCTAD datasheet. Drafted project reports,
Extent of contribution by PhD candidate (%)	75

CO-AUTHORS

Name	Nature of Contribution
Anna Strutt	Guidance and critical feedback, including suggesting edits to the draft report. As project lead, was the primary contact point for UNCTAD and ERIA.

Certification by Co-Authors

The undersigned hereby certify that:

- the above statement correctly reflects the nature and extent of the PhD candidate's contribution to this work, and the nature of the contribution of each of the co-authors; and

Name	Signature	Date
Mike Webb	M. Webb	24/5/18
Anna Strutt	Anna Strutt	2/5/18