Impact of global trade distortions

Effects on NZ exports of logs, timber and fibreboard

Final report to MFAT

November 2019

John Ballingall and John Stephenson

SENSE PARTNERS

DATA LOGIC ACTION

Key points

Global trade in logs and wood products is driven by several factors that influence trade costs

- Trade costs are affected by economic geography factors such as distance, size and cultural and institutional links, plus policy costs (e.g. tariffs and non-tariff measures).
- Trade flows between two countries depend not just on the policies, distance and relative size (i.e. trade costs) of those two countries but also on the policies, distance and relative size of all other countries (i.e. trade costs around the world).
- We use a structural gravity model to explore how changes in relative trade costs since 2003 have affected global and New Zealand trade in logs, timber and fibreboard.

New Zealand is highly exposed to shifts in global trade costs

- New Zealand's share of global exports is much higher than its share of global production in logs, timber and fibreboard.
- This is unusual. Most wood products produced in the world are traded domestically rather than internationally.
- Only 6%-7% of global log production is traded internationally, compared to 30% of timber.
- Thus, New Zealand is more exposed than most countries to changes – both positive and negative – in global trade costs for logs and wood products.

Non-tariff measures have a much larger effect than tariffs on global trade in logs and wood products

- We estimate the introduction of non-tariff measures (NTMs) is associated with a reduction in trade of between 13% and 81%, depending on the type of NTM and the product concerned.
- This indicates that global log trade is highly distorted by NTMs.
- An 81% reduction in trade in logs from the introduction of import NTMs is equivalent to the trade effect expected from a 16% tariff on logs. By comparison, actual average global tariffs on logs are around 2%.
- Our modelling also suggests that the introduction of an export NTM (such as an export tax) tends to reduce global trade in timber and fibreboard. This is due to countries deciding to meet domestic demand through domestic processing rather than imports.

Global trade costs in logs and wood products have risen, driven largely by NTMs – especially those related to export constraints

- There have been significant changes in the supply of logs for export over the past two decades, creating a situation of relatively tight market conditions that have contributed to rising log prices.
- Between 1990 and 2006 Russia dominated the global supply of logs for export. Its share of global supply peaked at 39% in 2006. By 2012 that share had shrunk to 16% of global supply, as its export taxes and quotas on logs sharply decreased its exports.
- Policy changes in global markets have affected trade costs for logs and wood products in different ways:
    - The use of export restrictions (e.g. export taxes or bans) has increased, pushing up trade costs. At least 39 countries have log export bans of one kind or another.

    - The use of non-tariff measures appears to have increased, suggestive of increased trade costs.
    - Tariffs have declined as the number of Free Trade Agreements (FTAs) has risen, pointing to a reduction in trade costs. Around 70% of global fibreboard trade takes place between countries with FTAs, as compared to 60% of trade in timber and 50% of trade in logs.[1]
- Global trade costs for logs have risen by an average of 0.7% per year between 2003 and 2018. Timber and fibreboard trade costs have grown by an average of 0.6% and 0.3% per year respectively.

New Zealand's trade costs have risen less rapidly, improving our competitiveness in logs and wood products

- Policy changes and shifting patterns of global demand appear to have been favourable to New Zealand log and wood product exporters, relative to our global competitors.
- While New Zealand trade costs have also increased over the past 15 years, driven largely by policy costs and especially other countries' NTMs, they have grown more slowly and are at lower levels than the global average.
- That is, New Zealand exporters have been less affected by rising trade costs than other exporters.

China has a unique preference for New Zealand logs, although we cannot identify precisely why

- We estimate an index of trade preference for Chinese imports from New Zealand, which shows that preferences for New Zealand logs have more than doubled since 2006.
- This preference has resulted in New Zealand's exports of logs to China being 2.5 times higher than what we would expect in a frictionless (i.e. trade cost-free) world.
- We are unable to determine exactly what drives this significant preference. It may reflect unmeasurable factors that affect trade flows, such as high levels of trust between Chinese and New Zealand firms, a preference for high quality New Zealand products, institutional and political relationships that have flourished due to the FTA, or domestic policy settings.
- China's preferences for New Zealand's processed products have declined since 2006. However, it still exhibits a preference for New Zealand processed products compared to our competitors – it just doesn't import vast amounts of processed wood from any source.

Japan and ASEAN countries have a strong preference towards New Zealand's processed products

- Japan demonstrates a strong preference for New Zealand processed products, potentially due to strong historical supply chain links between Japanese investors and New Zealand wood processors. This also partly explains why New Zealand exports of processed products have not been directed to China.
- A similar preference exists for ASEAN markets, likely reflective of the strengthening economic relationship between New Zealand and ASEAN in the past decade and a half, including through free trade agreements.

---

[1] This reflects tariff escalation. There are larger preference gains from being part of an FTA, compared to being outside it and paying the Most Favoured Nation rate, for producers of highly-tariffed goods.

1. Purpose and scope

This report presents estimates of distortions in international trade in logs and processed wood products.

We analyse New Zealand's largest HS4 log and wood product exports:

- logs (HS code 4403)
- timber (HS code 4407)
- fibreboard (HS code 4411).

Key research questions

- Where would trade go if customers and suppliers were perfectly matched?
- What kinds of trade costs distort the process of matching customers and suppliers?
- How big are the distortions that result from these trade costs?
- Are these trade costs policy-related or just a fact of economic geography?
- What is the balance of effects on New Zealand firms, given that trade costs are not a New Zealand-specific problem?

Our research is limited to a detailed empirical investigation of these issues. We do not consider the overall impacts of these trends on the New Zealand economy nor any potential policy implications.

2. Context

2.1. Global trends in production and trade

Global trends in the production and trade of wood products in the past ten to fifteen years have been dominated by three factors:

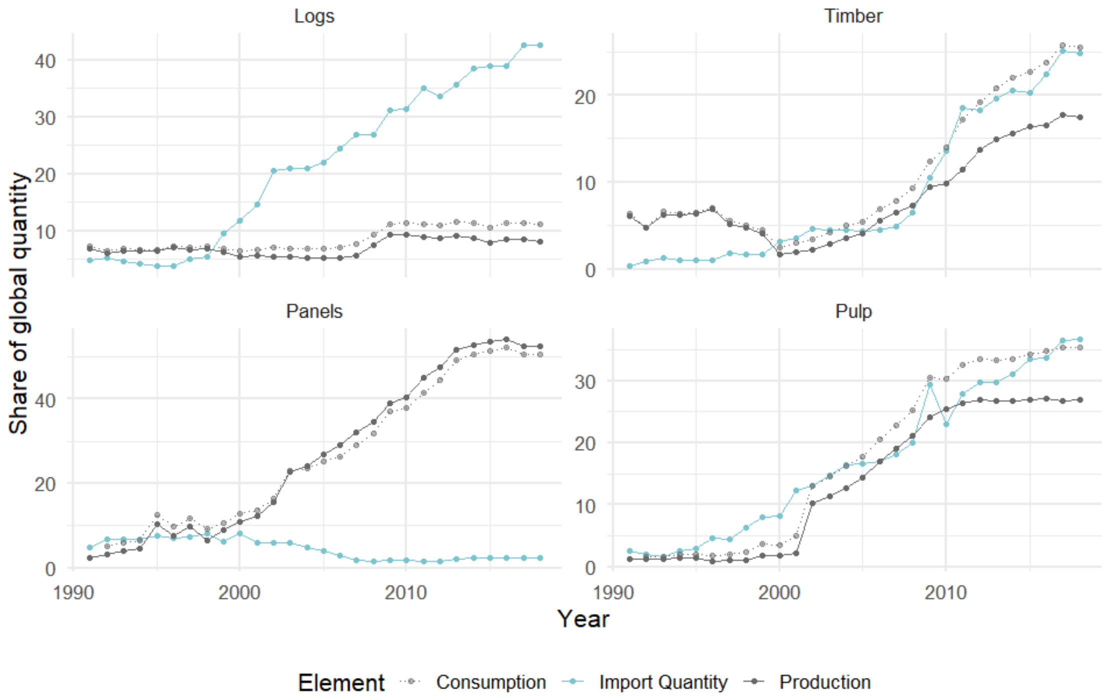
1. China's dominance of growth in production and demand
2. a slump in global demand for fibreboard and timber in the past decade
3. relatively tight market conditions in the supply of logs for export.

These wood product trends reflect wider global economic trends and the shift in economic gravity towards Asia and China in particular.

China consumes more than a quarter of wood products globally

China is the largest market in the world for processed wood products. Demand has grown steadily since the late 1990s (see Figure 1).

FIGURE 1: CHINA'S RISING DEMAND FOR WOOD PRODUCTS
Consumption, imports and production as share of global total (FAO data)[2]



[2] Data is for industrial wood products, excluding fuel wood.

China surpassed the United States as the world's largest market for

- panels, in 2003
- pulp, in 2008
- paper, in 2009
- timber in 2013.

China's dominance of the market for wood products has been mainly due to growth in local demand, bolstered by a decline in demand in North America and Europe – see Table 1.

TABLE 1: CONTRIBUTIONS TO GLOBAL GROWTH IN DEMAND FOR PANELS & TIMBER

2007-2018 compound annual average growth. Global growth averaged 0.9% per year. FAO data.

Top 20 countries	Contribution	Bottom 20 countries	Contribution
China, mainland	1.61%	United States of America	-0.21%
Turkey	0.05%	Brazil	-0.11%
Poland	0.05%	Spain	-0.09%
Romania	0.04%	Germany	-0.08%
Viet Nam	0.04%	Italy	-0.08%
India	0.03%	Japan	-0.07%
Argentina	0.02%	France	-0.06%
Chile	0.02%	Canada	-0.05%
Indonesia	0.02%	Finland	-0.04%
Iran	0.02%	Thailand	-0.04%
Russian Federation	0.02%	Mexico	-0.03%
Belarus	0.01%	Sudan	-0.03%
Egypt	0.01%	Syria	-0.03%
Austria	0.01%	Greece	-0.03%
Uzbekistan	0.01%	United Kingdom	-0.02%
Philippines	0.01%	Sweden	-0.02%
Algeria	0.01%	Ireland	-0.02%
Lithuania	0.01%	Denmark	-0.02%
Australia	0.01%	Czechia	-0.02%
Estonia	0.01%	Ukraine	-0.01%

China's growth in demand has been met mainly by increased domestic production, as can be seen in Figure 1 where production (the black lines) has closely tracked consumption (grey lines). Demand for imports have also grown significantly, even if slightly slower than overall demand growth (the blue lines in Figure 1).

Panels are the notable exception. Since 2004 China has been self-sufficient in production of panels and since 2005 China has been the number one origin for exports of panels (though simultaneously the 10th largest destination market for imports of panels).

The last decade has been characterised by low demand globally

Global demand for wood products has been low in the past decade, despite strong demand growth from China.

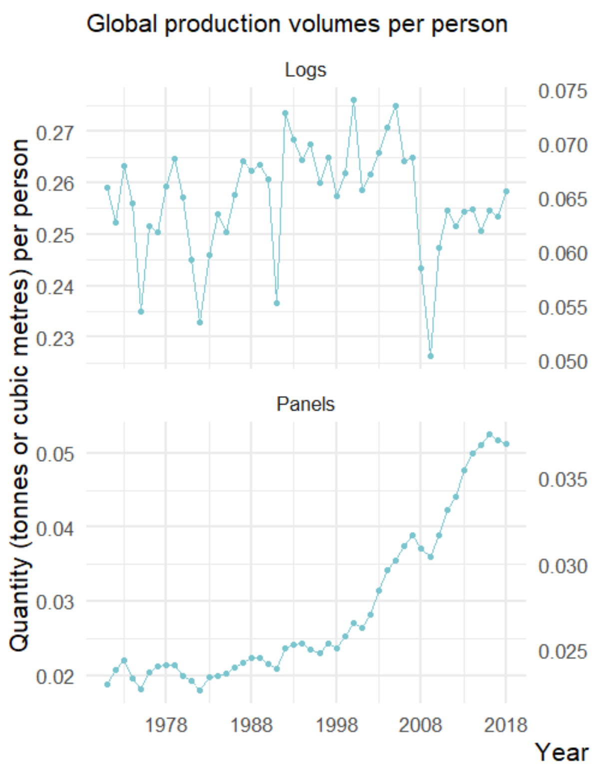
This can be seen most clearly in log production per person in the top left panel of Figure 2.

Log production collapsed in 2009, at the time of the global financial crisis and while it rebounded it has remained at a level that is low relative to historical averages (1% lower than the average for 1961 to 2007) and substantially (5%) lower than the average in the 15 years prior to the global financial crisis.

Panels are an exception. Production of panels, and therefore demand for panels, has grown strongly in the past 10 years.

Timber demand has been particularly slow to recover and has not quite yet recovered to the levels reflected in timber production in 2007.

FIGURE 2: GLOBAL PRODUCTION OF WOOD PRODUCTS (FAO DATA)

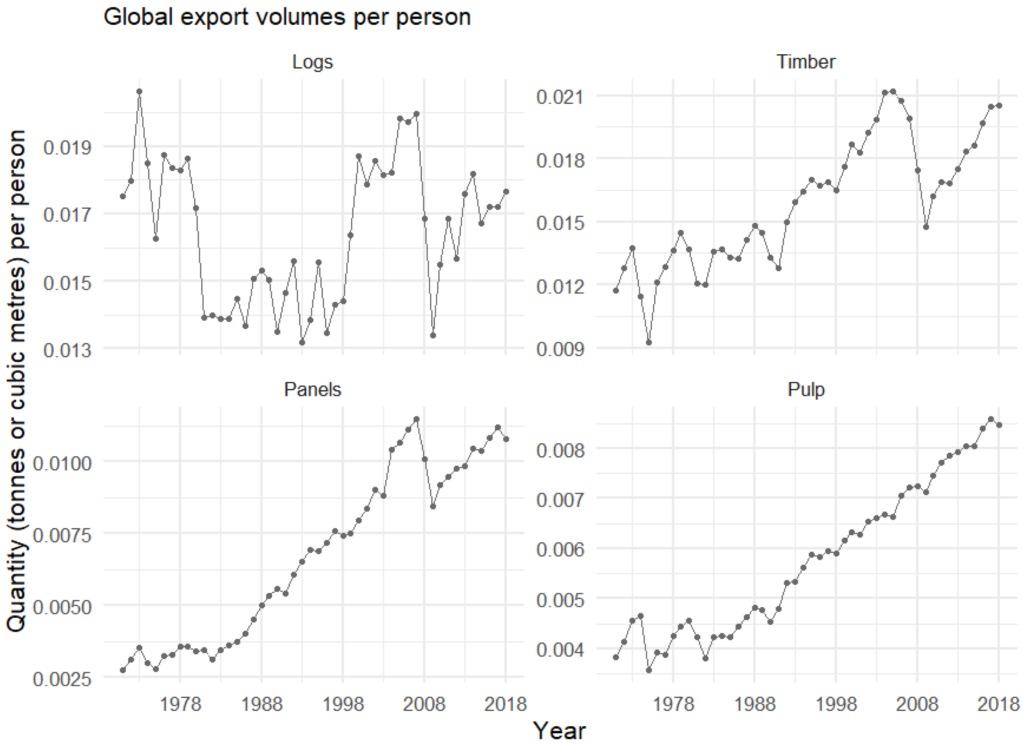


These recent trends in global production and demand are only partially reflected in export demand. Export demand for timber and panels has not recovered to levels prior to the global financial crisis but global demand for log exports, per person, have been relatively high by historical standards (see the bottom panel of **Figure 3**).

These trends point to a **shift in global supply dynamics**, specifically an increased mismatch between locations with abundant processing capacity and demand for processed products and locations with abundant supplies of raw materials.

This mismatch has been reflected in rising prices for logs relative to processed products. The mismatch has also occurred at time when there have been significant changes in supply of logs for export, creating a situation of **relatively tight market conditions that have also contributed to rising log prices**.

FIGURE 3: GLOBAL EXPORTS OF WOOD PRODUCTS (FAO DATA)



Significant changes in supply of logs for export

The global supply of raw materials (logs) for export has changed substantially in the past decade. Between 1990 and 2006 Russia dominated global supply of logs for export (see Figure 4), with its share of global supply peaking at 39% in 2006. By 2012 that share had shrunk to 16% of global supply.

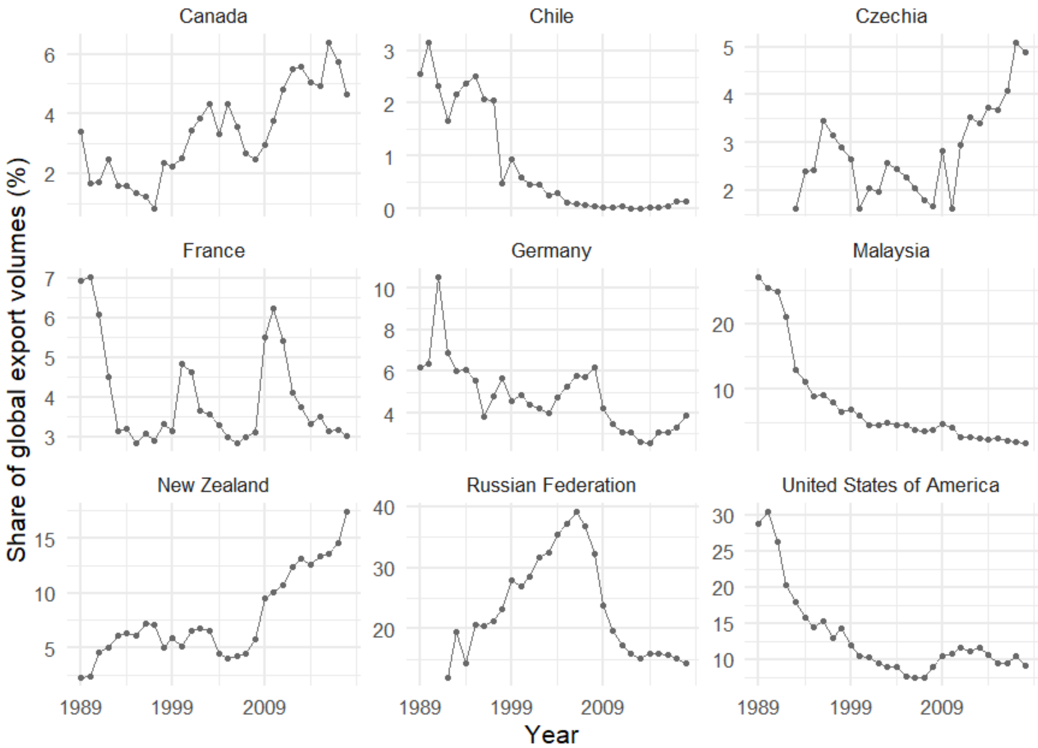
In 2018 New Zealand surpassed Russia as the number one exporter in the world in terms of share of global log exports by volume.

Over the past 50 years global exports of logs have typically been dominated by one or two major suppliers. For example, in the 1980s Malaysia and the United States supplied a majority of log exports and the United States supplied over 30% of global exports. In the 2000s, Russia was the major supplier, averaging 32% of the market.

In the past 7 years the market has been much less concentrated, with the leading exporter supplying 16% of the market on average. The market has been less concentrated in the past 7 years than at any other time since 1961. In short, **the supply of logs has become more widely distributed**.

FIGURE 4: TOP 5 EXPORTERS OF LOGS DURING THE PAST 30 YEARS

Countries that have been ranked in the top 5 at any point in the past 30 years, FAO data



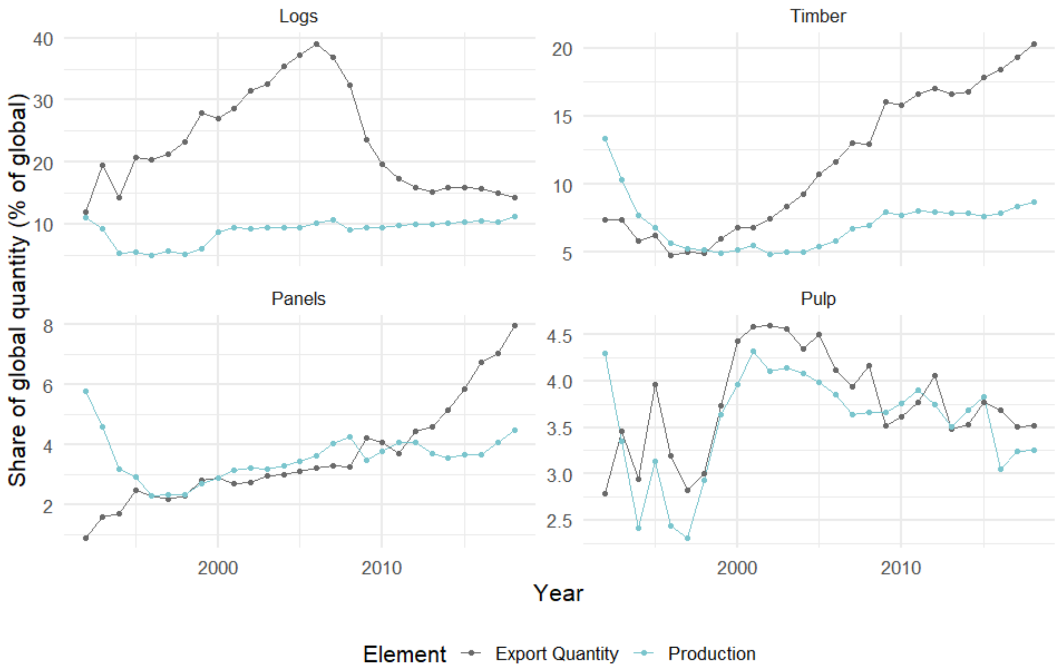
The significant reduction in Russian log exports in the past decade has been due to a shift away from exporting logs rather than a decline in log production. Between 2006 and 2018, Russian consumption of logs increased by 75 million cubic metres (60%) while exports of logs declined by 31.7 million cubic metres (-62%) and production of logs increased by 44 million cubic metres (25%).

The decline in Russian log exports followed the introduction of measures that provide preferential access to logs for wood processors in Russia. In 2006 Russia introduced a 6.5% log export tax and in 2012 this tax was augmented with an export quota and substantially higher taxes on exports of logs outside the quota.

Russia's production and export of processed products has grown following the introduction of the log export tax (see Figure 5 overleaf). The most pronounced change has been in the export of panels. However, growth in Russian timber exports has also grown significantly despite relatively limited growth in demand for timber globally.

Russia's reduction in log exports will have presented a significant risk to processors of wood products in China. China has been the 3rd or 4th largest producer of logs (industrial logs) in the past decade but rapid growth in demand and production of processed products means that China has also been the single largest destination for log imports since 2001 (by volume). In 2018 China imported 43% of all logs imported globally.

FIGURE 5 RUSSIA'S SHARE OF GLOBAL PRODUCTION AND EXPORTS



International trade in logs is relatively thin compared to the market for processed wood products. This partly reflects the low value to weight ratio of logs – making international trade in logs less economic compared to higher valued products.

As a result, **only 6%-7% of global log production is traded internationally** as compared to 30% of timber, for example (see Figure 6, noting different scales on vertical axes between charts).

FIGURE 6: GLOBAL EXPORTS AS A SHARE OF GLOBAL PRODUCTION

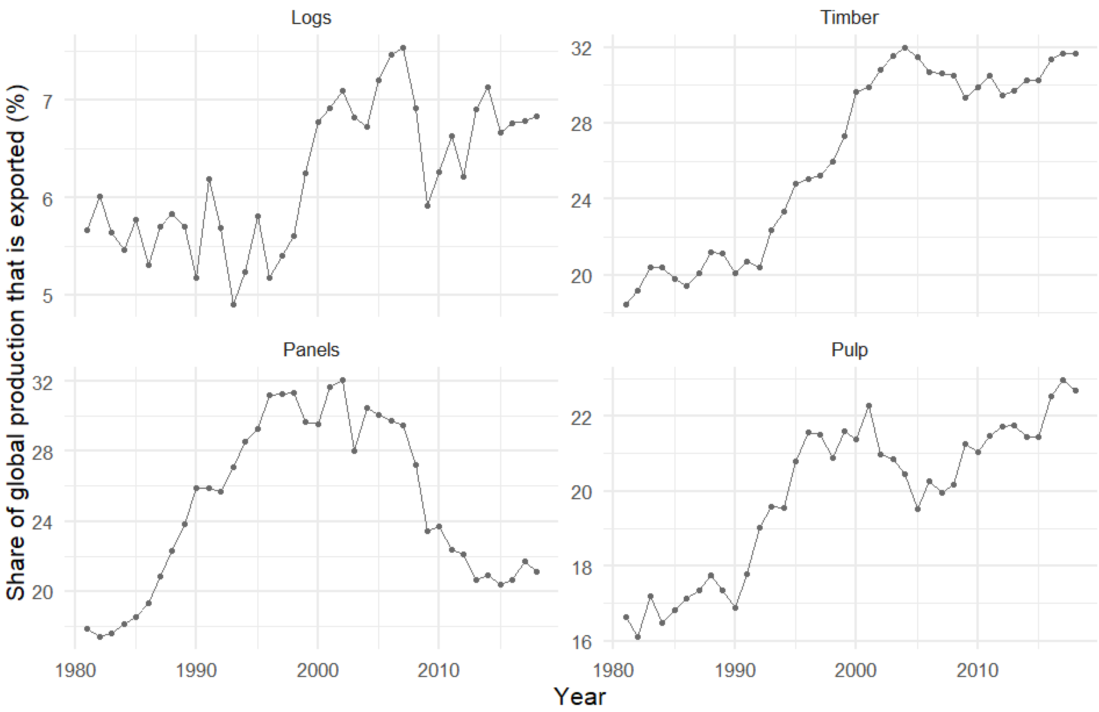


TABLE 2: CONTRIBUTIONS TO GLOBAL GROWTH IN SUPPLY OF UNPROCESSED WOOD

2007-2018 compound annual average growth. Global growth averaged 0.6% per year. FAO data.

Top 20 countries	Contribution
China, mainland	0.25%
Russian Federation	0.14%
Brazil	0.11%
Indonesia	0.11%
Finland	0.04%
Poland	0.04%
Viet Nam	0.04%
New Zealand	0.04%
Chile	0.04%
Turkey	0.04%
Belarus	0.03%
Uruguay	0.03%
Australia	0.03%
Japan	0.02%
Estonia	0.02%
India	0.02%
Argentina	0.01%
Norway	0.01%
Spain	0.01%
Portugal	0.01%

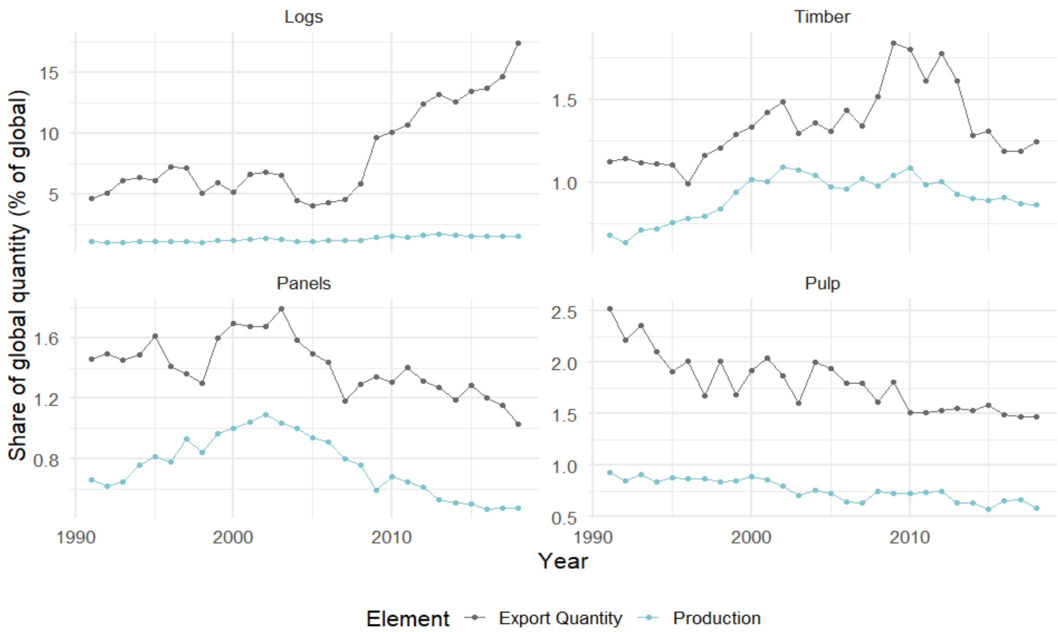
Bottom 20 countries	Contribution
Sudan	-0.12%
Germany	-0.11%
Malaysia	-0.07%
Canada	-0.06%
United States of America	-0.06%
South Africa	-0.03%
Sweden	-0.03%
France	-0.02%
Austria	-0.01%
Switzerland	-0.01%
Romania	-0.01%
Peru	-0.01%
Italy	-0.01%
Venezuela	-0.01%
Greece	0.00%
Gabon	0.00%
Iran	0.00%
Morocco	0.00%
Honduras	0.00%
Latvia	0.00%

2.2. Trends in New Zealand trade and production

New Zealand exports a significant amount of its production of wood and processed wood products. Over the past 50 years New Zealand production has averaged around 150% of domestic consumption, resulting in a significant amount of exports relative to production.

New Zealand's share of global exports is higher than its share of global production in all major wood product categories (see Figure 7). This is unusual. Most wood products produced in the world – and indeed most products more generally – are traded domestically rather than internationally.

FIGURE 7: NEW ZEALAND'S SHARE OF GLOBAL PRODUCTION AND EXPORTS



The composition of New Zealand wood and wood products exports has changed substantially in the past decade and a half, reflecting changes in global production and supply trends:

- log exports have grown substantially, roughly in line with the decline in exports of logs from Russia since 2006
- New Zealand's share of global trade in wood panels has been declining, in line with a rise in exports of panels from China
- New Zealand's share of global timber exports
    - increased for 5 years following the global financial crisis, as New Zealand's exports diversified into Asian markets less affected by the slowdown in demand for timber
    - declined recently in line with rising timber production and exports out of Russia
    - is currently at levels that are high relative to historical averages e.g. 1.25% of global exports in 2018 compared with an average of 1.17% of global exports between 1988 and 2007.

2.3. Trends in factors affecting trade costs

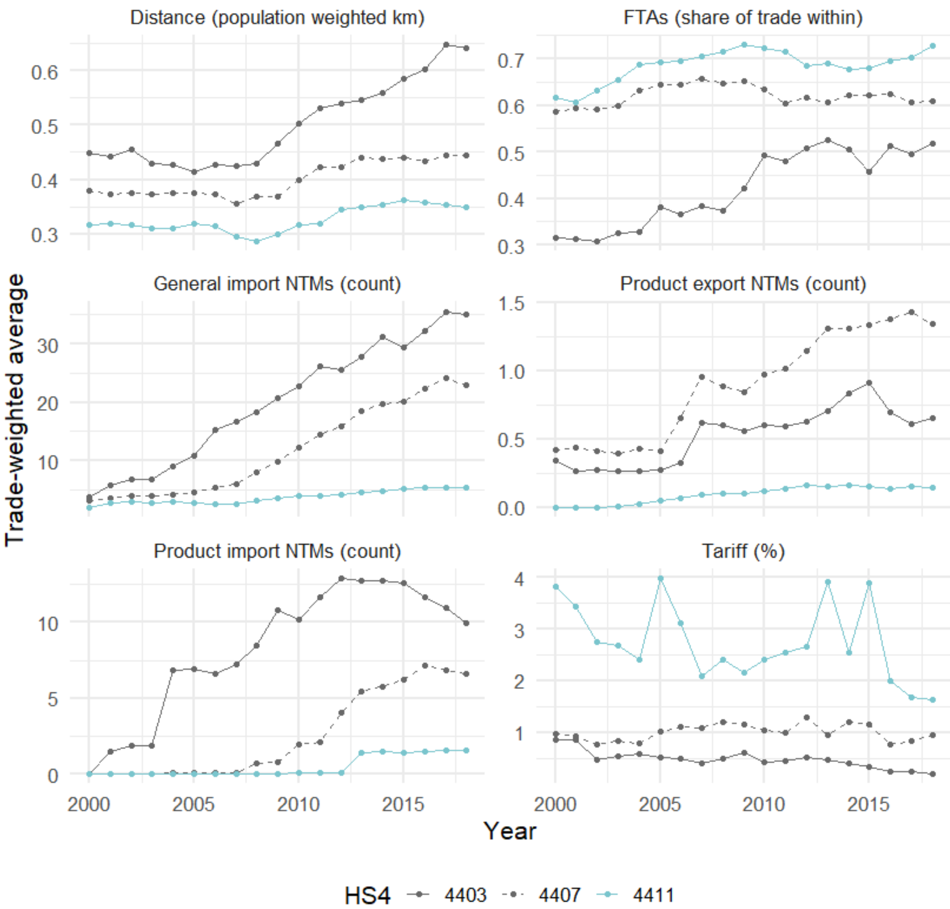
Changes in patterns of wood product demand, production and trade have reflected a mixture of changes to economic fundamentals and policy changes.

In the discussion that follows, trade costs are defined as the sum of policy costs (tariffs, non-tariff measures, etc.) and economic geography or 'gravity' costs (distance, shared language, etc.). The task of this report is to reflect upon the balance of these two effects and to determine which has dominated and the extent of distortions affecting New Zealand trade.

On the face of it, **policies have changed in ways that have both increased and decreased trade costs**, and thus distortions to trade:

- use of export restrictions (e.g. export taxes or bans) has increased, increasing trade costs
- use of non-tariff measures appears to have increased, suggestive of increased trade costs
- tariffs have declined as the number of free trade agreements (FTAs) has increased, pointing to a reduction in trade costs.

FIGURE 8: TRENDS IN FACTORS AFFECTING TRADE COSTS IN LOGS AND WOOD PRODUCTS



Export restrictions widely used

Logs are subject to export controls in a number of countries, partly for environmental reasons (such as New Zealand's restrictions on exports of native timber)[3] and partly to support domestic industry by providing preferential access to raw materials for domestic processors (such as British Columbia's restrictions on log exports, in place since 1906).

At least 39 countries have log export bans of one kind or another.[4] Some of these have very clear environmental objectives. Others often conflate environmental objectives and industry support (Kishor et al, 2004, abstract):

> *An increasing number of tropical timber-producing nations have enacted bans on export of logs arguing that this will reduce deforestation, expand downstream wood processing and improve the scale efficiency of domestic processing, create jobs and retain more value-added nationally.*

Of the 39 bans on log exports that we know of, **at least 16 show clear intent to support domestic processing industries**.[5] Furthermore, these bans are enacted by countries that have significant shares of global log production. For example, in addition to Russia:

- the United States – the world's largest producer of logs – has banned exports of unprocessed timber from the West of the country, since 1990
- British Columbia's long-standing log export restrictions affect around 4% of global production (Canada is the 4th largest producer of logs in the world and around half of Canada's production is in British Columbia)
- the Ukraine imposed a 10-year ban on log exports in 2015 (applying to pine from 2017). The Ukraine produces around a third of the amount of logs as New Zealand (Ukraine is the 34th largest producer of logs).

This support for domestic processing, via log export restrictions, has been prompted by a combination of reductions in local and global demand for processed wood products (since the global financial crisis) and continued growth in demand in China.

The use of restrictions on exports of raw materials of all kinds was also a feature of trade policy trends in the 2000s on the back of rising global commodity demand and significant commodity price increases (Kim, 2010).

---

[3] Many export controls are also in place to protect endangered species and are implemented in accordance with the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

[4] Based on a list completed by the World Resources Institute (https://forestlegality.org/content/logging-and-export-bans), plus Russia's export bans. Some of these of bans have been altered or reversed very recently, however we include them here by way of illustration of the extent of use of such restrictions.

[5] Based on policies that do not ban logging but do ban exports in an unprocessed state. And assuming that bans on exports of logs from natural forests but not plantation forests gives at least some indication of environmental objectives – albeit a low threshold given that these bans on exports of logs from natural forests may also be accompanied by bans on exports of sawn wood but not more highly processed products.

Use of non-tariff measures has been increasing

There is an apparent upward trend in use of non-tariff measures to regulate trade (as shown in Figure 8). This trend has been widely commented on by industry and research on international trade in wood products and in international trade more broadly (Niu, et al, 2018; Maplesden and Horgan, 2016).

In principle, it is unclear whether NTMs increase or reduce trade costs. Though NTMs can certainly be a means of limiting trade, there is also reason to believe that some NTMs reduce rather than increase trade costs, by giving importers and exporters greater certainty that products will meet quality standards and will not be held-up by border officials.

The use of NTMs *does* correlate positively with countries' level of development and may reflect positively on institutional quality and thus commercial environments that facilitate trade. Indeed, data on NTMs is limited to formal regulatory measures, meaning that the prevalence of NTMs is likely to be correlated with the use of formal, predictable and transparent regulations that may facilitate trade.

Tariffs have been declining

Tariffs, in contrast to NTMs, have been declining over time. The average global trade-weighted tariff on fibreboard has declined from 4% in 2000 to 1.6% in 2018.[6]

Tariffs have also been declining at roughly the same rate for log and timber tariffs. That said, tariff escalation – where tariffs are higher for more processed products – is pronounced for wood products. Average global log tariffs (not trade-weighted) are less than 2%, average timber tariffs are approximately 4% and average fibreboard tariffs are 6%.

The relative difference between tariffs on each of these products is also apparent in the case of trade-weighted tariffs in Figure 8, although average tariffs are lower because more trade takes place between countries with lower tariffs.

Increased numbers of free trade agreements

Declining average tariff rates partially reflect increased numbers of trade agreements in the world. Of the countries in our data set, 28% of country-pairs had an FTA with each other in 2018, up from 11% in 2000.

FTAs have larger effects on trade in products that face relatively high Most Favoured Nation tariffs outside of preferential trade arrangements. As noted above, in general the more processed the wood product, the higher the average tariff.

This can be seen by the fact that around 70% of fibreboard trade takes place between countries with FTAs, as compared to 60% of trade in timber and 50% of trade in logs.[7]

[6] Reductions in average fibreboard tariffs not weighted by trade have been even more pronounced, with tariffs halving over time, from 12% in 2000 to 6% in 2018.

[7] Note the chart in Figure 8 shows the fraction of trade occurring under FTAs, rather than the percentage.

Wood products are being traded over longer distances

Figure 8 also shows an increase in the distances that wood products are being traded over the past 10 years.

This implies both increasing and decreasing costs of trade. That is, if products are being traded over longer distances then the aggregate cost of trade will have increased, *other things being equal*.

However, this is likely to have been offset, to some degree, by reductions in other trade costs through improvements in supply chain management, for example. And from the perspective of global production it may be that improvements in productive efficiency, such as in manufacturing, mean that raw materials can be shipped longer distances without increasing global costs of production.

On balance, whether longer distances imply higher global trade costs overall depends on why products are being shipped longer distances. If it reflects a change in the location of more efficient production, then this is not a net cost. It will be a net cost if it is solely due to policy-induced trade distortions or significant negative economic shocks (such as failures of harvests, natural disasters or financial crises).

3. Analytical framework

To measure the effects of trade distortions (or trade costs) one must take a view on:

- what trade distortions are
- which trade distortions are avoidable
- what trade would be in the absence of trade distortions.

Our framework, known as a structural gravity model, starts by taking a view on what trade would be in the absence of all distortions, avoidable or unavoidable.

The key benefit of this approach is that it takes account of a wide range of effects and the multi-dimensional effects of trade distortions on trade (i.e. it considers the effects of relative cost changes across a large number of countries, all with different production and consumption patterns).

This approach introduces considerable complexity into the analysis of trade. It does, however, allow for the creation of summary measures of trade distortions that account for the balance of effects that distortions can have on individual countries.

That is, it allows for both the identification and quantification of costs from distortions and a quantification of the overall distribution of those costs across different countries.

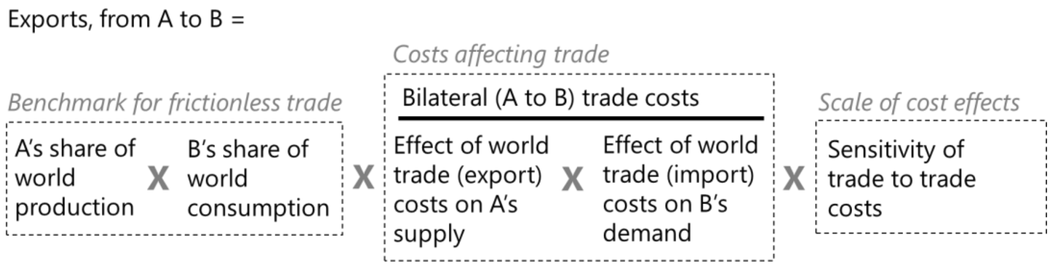
3.1. Structural gravity model

The analytical model we use for understanding trade is a structural gravity model. This model is constructed to explain exports between countries.

As shown in **Figure 9**, the model contains 3 components:

1. a benchmark for frictionless trade, based on shares of production and consumption
2. a measure of trade costs, comprising
    a. bilateral trade costs, specific to trade between two countries, *relative to*
    b. bilateral trade costs between all other countries
3. an estimate of the extent to which trade costs reduce trade.

FIGURE 9: STRUCTURAL GRAVITY MODEL



This model is referred to as a gravity model because it falls within a class of models that explain trade flows using physical distance between markets and physical sizes of markets as if trade was determined by gravitational forces. Relative size determines the absolute value of trade flows while distance creates a friction (or trade cost) that reduces the effects of size on trade.

The model set out in in **Figure 9** is a *structural* gravity model, rather than simply a gravity model, because it is constructed to examine the dependency of trade flows on global interactions and relative trade costs, rather than simply two-way flows.[8]

Patterns of trade reflect relative size of production and consumption

The benchmark for trade between countries in a frictionless world is the product of an exporter's share of global production and an importer's share of global consumption.

If there are truly no costs to trade, then there is no particular reason that trade should flow to one country rather than another except for fundamental differences in the comparative advantage of the exporting country and the size of demand in the importing country.

On this view, if New Zealand produces 1% of the world's logs and another country consumes 10% of the world's logs, we would expect New Zealand's exports of logs to the other country to be 0.1% of world trade (i.e. 1% * 10%).

From an empirical perspective, this approach is predicated on the idea that existing patterns of production and consumption are reasonably strongly correlated with fundamentals affecting the efficiency of production and the scale of local demand, such as climate and human capital.

In practice, trade distortions are likely to affect investment and thus production capacity and, potentially, national income and domestic demand. As a result, these fundamentals are not identifiable.

However, in the case of primary production of commodities, such as logs, production is more likely to be limited by local endowments (such as climate and soil types) than for other more elaborately transformed products.

Frictions that prevent trade from matching demand and supply

Distance is an important predictor of trade costs; however other factors also get in the way of trade flowing from its cheapest location of production to its highest valued use (i.e. the lowest cost matching of supply with demand). Differences in **institutional quality, corruption, or infrastructure** can limit the amount of trade between countries.

Factors that create preferences for trade between groups of countries can also distort patterns of world trade, relative to what simple supply and demand considerations would predict. These factors can, on balance, be positive if they reduce overall trade costs. However, they can also increase trade costs.

[8] There is no single definition of structural gravity models but, technically, they are associated with theory-consistent econometric models typified by use of country-specific fixed effects to ensure the model incorporates a wide range of interaction effects in global trade.

Shared border effects are an example of a positive effect on trade costs. That is, countries that share a land border tend to trade more with each other than countries that do not – holding distance constant.[9]

Some countries trade relatively intensely with each other, despite the distance between them, because of **social, political and cultural similarities**. For example, countries with a shared colonial history tend to have established institutional ties that mean that they trade more with each other – although this effect tends to decline over time (Head et al, 2010). Similar factors that promote trade include having the **same language** or having **similar legal systems**.

A feature of the structural gravity model is that it seeks to control for all these factors that have permanent or highly persistent effects on trade costs between countries. This is important because it helps to distinguish between trade distortions or costs that are avoidable and those that are not.

Trade policy is factor of key interest for understanding trade flows because very often policy is source of avoidable trade costs. Tariffs are an easily observed example of these kinds of costs.

Having said that, tariffs and free trade agreements and other policy measures are likely to be correlated with non-policy predictors of trade costs. That is, it is difficult to determine whether trade is high between two countries because of permissive policy or policy is permissive because the countries are well-matched for trade from an economic, social, political or cultural perspective. The structural gravity model is constructed to try and disentangle the direction of causation between these effects.

Relative costs, network effects and trade diversion

Relative costs are ultimately what determines trade flows, in conjunction with relative size (scale of demand and supply). This means that **trade flows between two countries depend not just on policies, distance and relative size of those two countries but also on policies, distance and relative size of all other countries**.

Failure to account for these interdependencies can lead to misleading conclusions regarding how policies affect international trade. This has come to be known as the "Gold medal mistake" of gravity modelling (Baldwin and Taglioni, 2007).

The structural gravity model accounts for these interdependencies by measuring bilateral trade costs relative to multilateral trade costs.

These multilateral trade costs are reflected in the denominator of the trade costs component of Figure 9. They are measured in terms of the overall propensity of a country to import given global import costs and the propensity of a country to produce for export given overall global costs of exporting. In the literature on gravity modelling these are referred to as inward and outward multilateral resistances (Anderson and van Wincoop, 2003).

[9] One might reasonably assume that distance is always shorter between countries that share a land border than those that do not (at least on average), however the relevant distance measure for understanding trade patterns is one that accounts for distances between major demand and supply centres between countries. Some countries share land borders, but their major cities are long distances from the border. The measure of distance used in this report is the sum of distances between cities weighted by population shares (calculated by CEPII).

3.2. The detail of the structural gravity

Each of the issues canvassed above – bilateral trade costs, global and relative trade costs, and relative market sizes – all come together to determine the scale of trade and the distribution of trade we should expect across countries. Decomposing these widely varying effects can be challenging and requires detailed accounting. This is reflected in the precise detail of the structural gravity model.

The precise, algebraic, version of the structural gravity model set out in Figure 9 is:

$$T_{i,j,t}^{k} = \frac{Y_{i,t}^{k} E_{j,t}^{k}}{\sum_{i} Y_{i,t}^{k}} \left(\frac{t_{i,j,t}^{k}}{\Pi_{\mathrm{i,t}}^{\mathrm{k}} P_{j,t}^{k}} \right)^{1-\sigma_k}$$

Where:

- $T_{ij,t}^{k}$ is exports of good k from origin i to destination j at time t.
- $E_{j,t}^{k}$ is expenditure on good k at destination j
- $Y_{i,t}^{k}$ is the origin (i) country's domestic production of good k
- Y_{t}^{k} is global production of good k
- $t_{ij,t}^{k}$ is a measure of bilateral trade costs
- $P_{j,t}^{k}$ is the importer's ease of market access (or inward multilateral resistance for good k at destination j)
- $\Pi_{i,t}^{k}$ is the exporter's ease of market access (outward multilateral resistance) at origin i
- σ_k is the trade cost elasticity for good k.

3.3. Key measures of costs and distortions

Given the complexity of the relationships in the model, particularly the multilateral resistance terms, our analytical framework focusses on three summary components:

1. the marginal effects of trade policies on bilateral trade, to distinguish the typical (average effects) that trade policies have on distorting trade in wood products
2. estimates of indices of trade costs, to compare changes in trade costs between countries and over time and to determine the extent to which these are costs are, in aggregate, policy related (as opposed to 'gravity' related)
3. a single overall measure of trade distortion that accounts for trade costs between countries relative to overall trade costs.

Aggregate measure of trade distortion - index of trade preference

We construct an index of trade preference to summarise the degree of distortions in international trade and changes in these distortions over time. This index is also referred to as Constructed Trade Bias (CTB):

Constructed Trade Bias (CTB), defined as the ratio of predicted to hypothetical frictionless trade flows for each bilateral pair, measures the general equilibrium effects of all bilateral trade costs on [trade] *volume.* (Agnosteva et al, 2014, p.3)

We prefer to refer to the index as an index of trade preference rather than an index of trade bias as a higher value indicates greater preference for trade between two countries.

The trade preference index ($TP_{i,j,t}^{k}$) by product (k), origin of exports (i), destination of exports (j) and year (t) is defined as:

$$TP_{i,j,t}^{k} = \frac{\hat{T}^{k}{}_{i,j,t}}{\frac{Y_{i,t}^{k} E_{j,t}^{k}}{Y_{t}^{k}}}$$

Where:

- $\hat{T}_{i,j,t}^{k}$ is predicted exports of good k from origin i to destination j at time t.
- $E_{j,t}^{k}$ is expenditure on good k at destination j
- $Y_{i,t}^{k}$ is the origin (i) country's domestic production of good k
- Y_{t}^{k} is global production of good k.

If trade between two countries is proportional to their shares of global supply and demand, then the trade preference index will be equal to 1 – that is, trade is at a level that we would expect based on costless trade and respective demand needs and supply capabilities.

Given that trade is not and never will be costless, one should not read too much into the level of the trade preference index. However, we can observe that on average we would expect the trade preference index to be substantially lower than 1, globally, reflecting the fact that trade costs are unavoidably non-zero.

The principle value of the index is in measuring changes in the effects of trade costs over time, in a single summary measure that can be aggregated over multiple markets. **Increases in the trade preference index indicate more favourable trade conditions and a decrease indicates a deterioration in trade conditions**.

The index of trade preference also allows comparisons between countries. That is, for example, New Zealand exporters can be said to have preferential market access[10] to Japan if the index of trade preference for exports from New Zealand to Japan is higher on average than the weighted average of trade preferences on imports into Japan from all other countries.

A relatively high index of trade preference will not, however, always mean high levels of exports. If a country has low demand overall, then the *level* of exports may still be small (even if a country's *share* of that demand is relatively high).

[10] Note this 'preferential market access' is about more than facing lower tariffs than one's competitors – it takes into account all trade costs, both policy and gravity related.

Similarly, an increase in the index of trade preference doesn't mean that New Zealand exports to that market will increase (or have increased). This is because demand in the importing market may decline or New Zealand domestic production capacity might decline, even as the underlying preference for New Zealand products has improved.

4. Data

4.1. Model data set

Our analysis is based on a data set comprising:

- 104 countries, from a data set of 200 countries with
  - 34 countries excluded due to missing production data
  - 62 countries excluded due to missing trade data.
- 10,694 trade pairs (export origin and destination pairs), out of a total possible 10,712 (with 104 countries in the data set)
- 19 years of observations from 2000 to 2018.

The data contains 615,486 observations (205,162 per product), of exports between origin and destination pairs in nominal values in US dollars.[11]

The data also includes measures of economic, geographic and institutional differences (gravity measures) and of trade policy affecting bilateral trade.

A summary of the data is provided in three tables below, one for each product. The source data is the same for all three.

[11] Deflation of values, to account for inflation, can lead to spurious regression in this context (Baldwin and Taglioni, 2007). Time fixed effects or other controls can be used to address common global inflationary trends when modelling trade using data over time. Thus it is standard to use nominal values in this sort of analysis (Yotov et al, 2016).

TABLE 3: DATA SUMMARY AND SOURCES, LOGS

Data includes observations for 104 countries for years 2000 to 2018, n = 205,162

			Logs (HS 4403)			
Variable	**Type/units**	**Source**	**Mean**	**Min**	**Max**	**Std deviation**
Trade (including internal)	US dollars	World Trade Atlas, FAO, author calculations	19,815,455	0	78,202,786,449	677,798,493
Internal trade	US dollars	FAO, author calculations	1,926,142,148	0	78,202,786,449	6,617,841,889
Common language	Binary	CEPII	0.1	0.0	1.0	0.3
Share border	Binary	CEPII	0.0	0.0	1.0	0.2
Bilateral distance	Population weighted km	CEPII	7,732	8	19,650	4,651
EU, destination	Binary	CEPII	0.2	0.0	1.0	0.4
EU, origin	Binary	CEPII	0.2	0.0	1.0	0.4
FTA	Binary	CEPII, WTO	0.2	0.0	1.0	0.4
Bilateral time difference	Hours	CEPII	4.7	0.0	12.0	3.4
GDP, destination	US dollar millions (PPP)	World Bank	548,493	333	20,494,100	1,770,321
GDP, origin	US dollar millions (PPP)	World Bank	545,949	333	20,494,100	1,763,616
Population, destination	Count	World Bank	56,234,456	69,650	1,392,730,000	178,636,327
Population, origin	Count	World Bank	56,154,005	69,650	1,392,730,000	178,622,200
Applied tariff	Percent	UNCTAD, author calculations	3.4	0.0	30.0	5.6
Export NTMs	Count	UNCTAD TRAINS	1.6	0.0	58.0	4.6
Export NTMs, NT	Count	UNCTAD TRAINS	0.6	0.0	23.0	2.3
Product export NTMs	Count	UNCTAD TRAINS	0.4	0.0	11.0	1.3
Product export NTMs, NT	Count	UNCTAD TRAINS	0.1	0.0	5.0	0.6
Import NTMs	Count	UNCTAD TRAINS	4.2	0.0	60.0	6.1
Import NTMs, NT	Count	UNCTAD TRAINS	0.6	0.0	21.0	2.2
Product Import NTMs	Count	UNCTAD TRAINS	1.1	0.0	71.0	6.3
Product Import NTMs, NT	Count	UNCTAD TRAINS	0.2	0.0	7.0	0.8

TABLE 4: DATA SUMMARY AND SOURCES, TIMBER

Data includes observations for 104 countries for years 2000 to 2018, n = 205,162

			Timber (HS 4407)			
Variable	**Type/units**	**Source**	**Mean**	**Min**	**Max**	**Std deviation**
Trade (including internal)	US dollars	World Trade Atlas, FAO, author calculations	10,896,930	0	60,082,017,313	378,898,813
Internal trade	US dollars	FAO, author calculations	843,863,058	0	60,082,017,313	3,720,856,105
Common language	Binary	CEPII	0.1	0.0	1.0	0.3
Share border	Binary	CEPII	0.0	0.0	1.0	0.2
Bilateral distance	Population weighted km	CEPII	7,732	8	19,650	4,651
EU, destination	Binary	CEPII	0.2	0.0	1.0	0.4
EU, origin	Binary	CEPII	0.2	0.0	1.0	0.4
FTA	Binary	CEPII, WTO	0.2	0.0	1.0	0.4
Bilateral time difference	Hours	CEPII	4.7	0.0	12.0	3.4
GDP, destination	US dollar millions (PPP)	World Bank	548,493	333	20,494,100	1,770,321
GDP, origin	US dollar millions (PPP)	World Bank	545,949	333	20,494,100	1,763,616
Population, destination	Count	World Bank	56,234,456	69,650	1,392,730,000	178,636,327
Population, origin	Count	World Bank	56,154,005	69,650	1,392,730,000	178,622,200
Applied tariff	Percent	UNCTAD, author calculations	5.1	0.0	35.0	6.5
Export NTMs	Count	UNCTAD TRAINS	1.6	0.0	62.0	4.7
Export NTMs, NT	Count	UNCTAD TRAINS	0.6	0.0	23.0	2.3
Product export NTMs	Count	UNCTAD TRAINS	0.4	0.0	8.0	1.2
Product export NTMs, NT	Count	UNCTAD TRAINS	0.1	0.0	5.0	0.5
Import NTMs	Count	UNCTAD TRAINS	4.2	0.0	60.0	6.0
Import NTMs, NT	Count	UNCTAD TRAINS	0.7	0.0	31.0	2.4
Product Import NTMs	Count	UNCTAD TRAINS	1.0	0.0	70.0	6.2
Product Import NTMs, NT	Count	UNCTAD TRAINS	0.1	0.0	8.0	0.8

TABLE 5: DATA SUMMARY AND SOURCES, FIBREBOARD

Data includes observations for 104 countries for years 2000 to 2018, n = 205,162

			Fibreboard (HS 4411)			
Variable	**Type/units**	**Source**	**Mean**	**Min**	**Max**	**Std deviation**
Trade (including internal)	US dollars	World Trade Atlas, FAO, author calculations	10,102,570	0	112,410,031,490	618,362,005
Internal trade	US dollars	FAO, author calculations	975,934,187	0	112,410,031,490	6,229,374,681
Common language	Binary	CEPII	0.1	0.0	1.0	0.3
Share border	Binary	CEPII	0.0	0.0	1.0	0.2
Bilateral distance	Population weighted km	CEPII	7,732	8	19,650	4,651
EU, destination	Binary	CEPII	0.2	0.0	1.0	0.4
EU, origin	Binary	CEPII	0.2	0.0	1.0	0.4
FTA	Binary	CEPII, WTO	0.2	0.0	1.0	0.4
Bilateral time difference	Hours	CEPII	4.7	0.0	12.0	3.4
GDP, destination	US dollar millions (PPP)	World Bank	548,493	333	20,494,100	1,770,321
GDP, origin	US dollar millions (PPP)	World Bank	545,949	333	20,494,100	1,763,616
Population, destination	Count	World Bank	56,234,456	69,650	1,392,730,000	178,636,327
Population, origin	Count	World Bank	56,154,005	69,650	1,392,730,000	178,622,200
Applied tariff	Percent	UNCTAD TRAINS, author calculations	7.8	0.0	45.0	7.5
Export NTMs	Count	UNCTAD TRAINS	0.9	0.0	26.0	2.3
Export NTMs, NT	Count	UNCTAD TRAINS	0.3	0.0	23.0	1.5
Product export NTMs	Count	UNCTAD TRAINS	0.1	0.0	6.0	0.5
Product export NTMs, NT	Count	UNCTAD TRAINS	0.0	0.0	3.0	0.2
Import NTMs	Count	UNCTAD TRAINS	2.7	0.0	33.0	4.3
Import NTMs, NT	Count	UNCTAD TRAINS	0.5	0.0	16.0	1.9
Product Import NTMs	Count	UNCTAD TRAINS	0.4	0.0	5.0	1.0
Product Import NTMs, NT	Count	UNCTAD TRAINS	0.1	0.0	7.0	0.8

4.2. Author calculations

Data from the sources outlined in the above tables have been augmented with the following bespoke calculations:

- EU membership data has been extended (from the CEPII data) to include stages of EU enlargement/accession not included in the CEPII data
- FTA information in the CEPII[12] dataset (for 1948-2015) has been updated to include information on FTAs for the period 2015-2018, using data on FTAs notified to the WTO
- applied (preferential and MFN) tariffs obtained from UNCTAD's TRAINS database[13] have been updated to include tariffs from FTAs concluded in recent years (using published tariff schedules from these FTAs)
- internal (intra-national) trade values have been calculated using FAO forestry statistics[14] on production and trade quantities (internal trade being equal to production less exports) valued at regional average export prices (export values divided by export quantities)[15]
- a single export tariff has been included in the model data, for exports from Russia. This is the only export tariff on which we have found detailed information.[16] This tariff is set at: 0% for 2003-2005, 6.5% in 2006, 15% in 2007, 25% for 2008 to 2012, 20% for 2013 to 2017, and 21.3% in 2018
- an export NTM has been added to trade in logs from Canada to reflect restrictions on trade in logs out of British Columbia, although this NTM is not found in the UNCTAD TRAINS NTM database.

4.3. Factors affecting trade costs

The data set includes several factors reflecting trade costs:

- factors reflecting economic geography:
    - distance
    - whether countries share a border
    - time differences between countries
    - whether countries share a common (land) border
- factors reflecting trade policy:

[12] http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8
[13] Accessed via https://wits.worldbank.org/WITS/WITS/Restricted/Login.aspx
[14] http://www.fao.org/forestry/statistics/80570/en/
[15] Regional export prices are used because local export prices are subject to large variations where export volumes are small.
[16] From the MBIE 'Spotlight Paper' by Forest Economic Advisors (FEA), retrieved from: https://www.mbie.govt.nz/business-and-employment/economic-development/sector-reports-series/forestry-and-wood-processing-spotlight-report-series/

- whether countries are part of a free trade agreement (FTA)
- preferential and MFN tariffs
- non-tariff measures (NTMs), such as border inspection requirements, trade quotas and technical and phytosanitary standards.

The data includes a breakdown of NTMs according to whether they are:

- applied to imports or to exports
- product-specific
    - NTMs that are specific to logs, timber or fibreboard are referred to here as product NTMs
    - NTMs that apply to a wide range of products are referred to as general NTMs
- applied to domestic trade as well as external trade (in Tables 3-5 these are referred to as NT, for National Treatment, as a shorthand[17])

Observed trends in use of NTMs should be treated with caution

In and of itself little can be drawn from observations around the increased use of NTMs. This is because measures of the prevalence of NTMs are imprecise.

Standard measurement methods (and the ones used here) involve counting NTMs, without reflecting on the comparative stringency of different NTMs, in terms of effects on trade.

Empirical analysis can clarify the scale of trade costs created by NTMs but these estimates will be imprecise when each occurrence of an NTM is treated the same as another or when the presence of NTMs of any kind is being compared to cases where there are no NTMs (as is the case in this and most other analyses of NTMs).

Rising trends in the number of measured NTMs is also affected by the gradual development of NTM databases over the past 15 years or so. That is, NTM databases are inclined to have more complete coverage of more NTMs introduced more recently.

[17] This label is simply a shorthand for measures that apply equally to domestic production and international trade, such as technical standards. It is not a comment on the consistency of non-NT NTMs with the principle of National Treatment (i.e. even-handed treatment of domestic and internationally traded goods).

5. Empirical method

5.1. Model

The empirical model, for estimation, is:

EQUATION 1:

$$T_{pijt} = exp(\bar{M}_{pjt} + \bar{X}_{pit} + \bar{B}_{ij} + \beta P_{pijt}) + \epsilon_t$$

T_{pijt} = trade by product (p) from origin (i) to destination (j) in a year (t)

$\bar{M}_{pjt}$ = propensity to import product p to destination j in year t (so-called importer fixed effect)

$\bar{X}_{pjt}$ = propensity to export product p from country i in year t (so-called exporter fixed effect)

$\bar{B}_{ij}$ = propensity to trade between origin (i) and destination (j) (country-pair fixed effects)

P_{pijt}= vector of policies affecting bilateral trade (coefficient β)

The importer, exporter and country-pair fixed effects collectively measure all trade costs that are not captured by policy variables.

The country-pair fixed effects assume the role of standard gravity variables such as distance and any other factors that do not change over time.

The importer and exporter fixed effects capture the effects that global trading conditions have on bilateral trade costs – the so-called multilateral resistances discussed earlier.

Policies included in P_{pijt} are:

- presence of product-specific export NTMs (binary values)
- presence of product-specific import NTMs (binary values)
- presence of general import NTMs (binary values)
- presence of FTAs (binary values)
- tariff rates (measured as the natural logarithm of 1 + the tariff rate).

Estimation of this model produces 3 key results

- estimates of the average **effect of policies** on trade
- estimates of **trade costs**, and changes in
- estimates of **expected trade flows**, given trade costs inclusive of the effects of policies between partners and between all other trading partners in the world.

Effects of trade policies on trade (in percentage form) are calculated as (Yotov et al 2016)

$$(e^{\beta} - 1) \times 100$$

Where β is the coefficient of interest.

Estimates of the average effects of trade policies are converted to tariff equivalent effects using the following formula:

$$\left(e^{\frac{\beta}{-\sigma}} - 1\right) \times 100$$

Where β is the coefficient of interest and $-\sigma$ is the coefficient on tariffs, which measures the response of trade to a change in trade costs (or trade cost elasticity).

As discussed above, estimates of expected trade flows (accounting for trade costs) are compared with a benchmark for frictionless trade (based on shares of global production and demand) to produce an index of trade preference (or constructed trade bias) which measures the extent to which trade has been positively or negatively distorted by trade costs.

Estimation of the model follows a staged process to ensure a complete set of country-pair fixed effects can be estimated. Where there is no trade between two countries, the country-pair fixed effects cannot be identified, but they are important to the extent that they may reflect fixed trade costs that cause trade to be zero.

5.2. Staged estimation

5.2.1. First stage: estimation with non-zero trade

In the first stage the model in Equation 1 is estimated with the data restricted to country-pairs with non-zero trade flows.

The model is estimated in levels using Poisson GLM with log link and data by product is pooled (estimated collectively).

The estimation allows for asymmetric country-pair fixed effects. Every 3 years of data is included, rather than every year, to allow for adjustment of trade flows following the introduction of discrete policies such as FTAs.

Furthermore, this is necessary to ensure the estimation is feasible given that the data set with 15 years of data reaches 47GB.

Estimation is carried out using ridge regression. Ridge regression is used as it accommodates the use of sparse matrices (in R, using the package *glmnet* [18]) which is necessary given the large number of fixed effects being estimated.

5.2.2. Second stage: estimation of missing country-pair effects

The second stage of the estimation involves estimating the relationship between country-pair fixed effects, estimated in the first stage, and standard so-called gravity variables. This then allows for the prediction of country-pair effects, without the use of trade data, for those countries with zero trade

[18] Jerome Friedman, Trevor Hastie, Robert Tibshirani (2010). Regularization Paths for Generalized Linear Models via Coordinate Descent. Journal of Statistical Software, 33(1), 1-22. URL http://www.jstatsoft.org/v33/i01/.

flows. This is possible because we do have data on gravity variables for all countries even if we do not have observed trade flows between all countries.

The model that is estimated is:

EQUATION 2:

$$\hat{B}_{ij} = \exp(\bar{M}_{pjt} + \bar{X}_{pit} + \delta G_{ij}) + \epsilon_t$$

$\hat{B}_{ij}$ = estimated propensity to trade between origin (i) and destination (j), from stage 1 (referred to as time invariant trade costs, measuring non-policy frictions that reduce trade).

$\bar{M}_{pjt}$ = propensity to import product p to destination j in year t, from stage 1 (so-called import fixed effect)

$\bar{X}_{pjt}$ = propensity to export product p from country i in year t, from stage 1 (so-called export fixed effect)

G_{ij}= vector of gravity variables used to predict propensity for trade between two countries (coefficient vector δ)

Gravity variables included are distance, membership of the EU, time difference, language in common, and the sharing of a common border.

As before the model is estimated in levels using Poisson GLM with log link with data by product pooled and ridge regression employed using the R package *glmnet*.

Unlike the first stage estimation this estimation is carried using cross-section data only, for the year 2006 (as the gravity variables do not vary over time it is not reasonable to include a time dimension in this estimation).

5.2.3. Third stage: estimate policy effects and trade costs

In the third stage, we complete our estimation of bilateral trade costs, including policy effects.

In this estimation country-pair fixed effects (time invariant trade costs) enter the model directly, rather than being estimated, using the values estimated and predicted from stages 1 and 2.

The model is:

EQUATION 3:

$$T_{pijt} = \exp(\bar{M}_{pjt} + \bar{X}_{pit} + \hat{B}_{ij} + \beta P_{pijt}) + \epsilon_t$$

T_{pijt} = trade by product (p) from origin (i) to destination (j) in a year (t)

$\bar{M}_{pjt}$ = propensity to import product p to destination j in year t (so-called import fixed effect)

$\bar{X}_{pjt}$ = propensity to export product p from country i in year t (so-called export fixed effect)

$\hat{B}_{ij}$ = estimated propensity to trade between origin (i) and destination (j) – i.e. time invariant trade costs capturing effects of e.g. distance

As before the model is estimated using Poisson GLM with a log link and data by product is pooled.

5.2.4. Fourth stage: fit predictive model of trade

The fourth and final stage refines our estimates of importer and exporter fixed effects, taking trade costs as given, and produces our final estimates of predictable trade volumes given trade costs.

The model is:

EQUATION 4:

$$T_{pijt} = \exp\left(\bar{M}_{pjt} + \bar{X}_{pit} + \hat{C}_{pijt}\right) + \epsilon_t$$

T_{pijt} = trade by product (p) from origin (i) to destination (j) in a year (t)

$\bar{M}_{pjt}$ = propensity to import product p to destination j in year t (so-called import fixed effect)

$\bar{X}_{pjt}$ = propensity to export product p from country i in year t (so-called export fixed effect)

$\hat{C}_{ij}$ = estimated trade costs (capturing time invariant and policy effects), estimated in steps 1-3.

The model is estimated in levels using Poisson GLM (pseudo maximum likelihood, in R with standard *stats* package and function *glm*[19]) with a log link. The model is estimated in cross-sections with each year and product estimated separately.

[19] R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

6. Results

6.1. Effects of trade policies

Estimates of trade policy effects are summarised in **Table 6**. The table includes:

- model coefficients
- trade effects in terms of percentage changes in trade associated with the introduction of NTMs or an FTA, and
- tariff equivalents of the trade effects.

The introduction of NTMs is associated with a reduction in trade of between 13% and 81%, depending on the type of NTM and the product concerned. This is the estimated reduction in trade between two trading partners when the destination country has introduced an NTM.

This is not the reduction in total trade, which requires accounting for all the other options for trade between third countries (i.e. relative costs and trade diversion).

These estimated trade effects do not apply to all countries – they are average effects given typical trade costs and capacities to produce and consume these products. For example, one should expect a smaller effect where two countries share a border, are economically integrated and are at some distance from alternative sources of supply.

An 81% reduction in trade in logs from **the introduction of import NTMs is equivalent to the trade effect expected from a 16% tariff on logs.** A 16% tariff on log trade is extremely high by global standards for logs, although not high compared to tariffs on some primary sector products.

The estimate that a 16% tariff would cause an 81% reduction in log trade partially reflects a high degree of sensitivity in the trade of logs to changes in trade costs.

Trade in logs, timber and fibreboard is estimated to be more sensitive to changes in trade costs than for most goods. Estimates of trade cost elasticities vary a great deal, but a typical trade cost elasticity used for this type of analysis is 5 (Head and Mayer, 2014), as compared to values of 11.3, 7.9, and 6.5 estimated here for logs, timber and fibreboard respectively.

It is to be expected that log trade should be most sensitive to trade costs. This is because logs are heavy relative to their value. That is, log trade is more marginal than trade in more highly processed products.

Our analysis is also likely to find different trade elasticities compared to the typical study because our study is not typical. The level of product detail is unusual for this sort of estimation. And other studies are more focussed on manufactured products that are generally more heavily traded and have higher value relative to trade costs. Furthermore, more aggregated analyses are apt to find smaller trade cost elasticities because of taking averages across products.

FTAs are estimated to increase trade in timber by 75% on average – equivalent to a reduced tariff of -7% of the value of the product. This is not a large effect by the standards of similar analyses. For example, a meta-analysis by Cipollina and Salvatici (2010) find that studies, on average, estimate trade effects in excess of 100% for both the North American Free Trade Agreement (NAFTA) and the Australia-New Zealand Closer Economic Relations agreement (CER).

TABLE 6: AVERAGE EFFECTS OF TRADE POLICIES ON TRADE

	Coefficient	Change in trade (%)	Tariff equivalent (%)
Product-specific export NTM			
Logs	-0.7	-53	7
Timber	-0.1	-13	2
Fibreboard	-0.7	-53	12
Product-specific import NTM			
Logs	-1.0	-63	9
Timber	-0.3	-25	4
Fibreboard	-0.6	-43	9
General import NTMs			
Logs	-1.7	-81	16
Timber	-0.7	-48	9
Fibreboard	-0.9	-59	15
Log export NTM			
Timber	-0.4	-35	6
Fibreboard	-0.4	-35	7
FTA effect			
Logs	--	--	--
Timber	0.6	75	-7
Fibreboard	--	--	--
Trade cost elasticity			
Logs	-11.3	11.3	
Timber	-7.9	7.9	
Fibreboard	-6.5	6.5	

There are no estimates here for the effects of FTAs on trade in logs and fibreboard. The coefficients on FTAs for trade in logs and fibreboard have been dropped during the estimation process because the FTA indicator is strongly correlated with other explanatory variables – meaning that the additional FTA indicators do not add anything to the estimation.

This does not imply no effects of FTAs on trade in logs and fibreboard. It is a technical limitation of the approach taken – though not one that is a problem for this analysis as estimating the effects of FTAs on trade is only a subsidiary objective.

The estimated effect of log export NTMs on trade in timber and fibreboard is negative. Export NTMs can be used to protect processors' access to raw materials (such as via export quotas) and thus promote exports of processed products. However, export NTMs on logs can also be motivated by a desire to support domestic supply for domestic production when domestic supply is scarce.

And they can, in principle, have negative consequences for domestic productivity if they reduce incentives to control costs. The result found here is suggestive of these latter effects dominating, on average – log export NTMs tend to reduce trade in processed wood products.

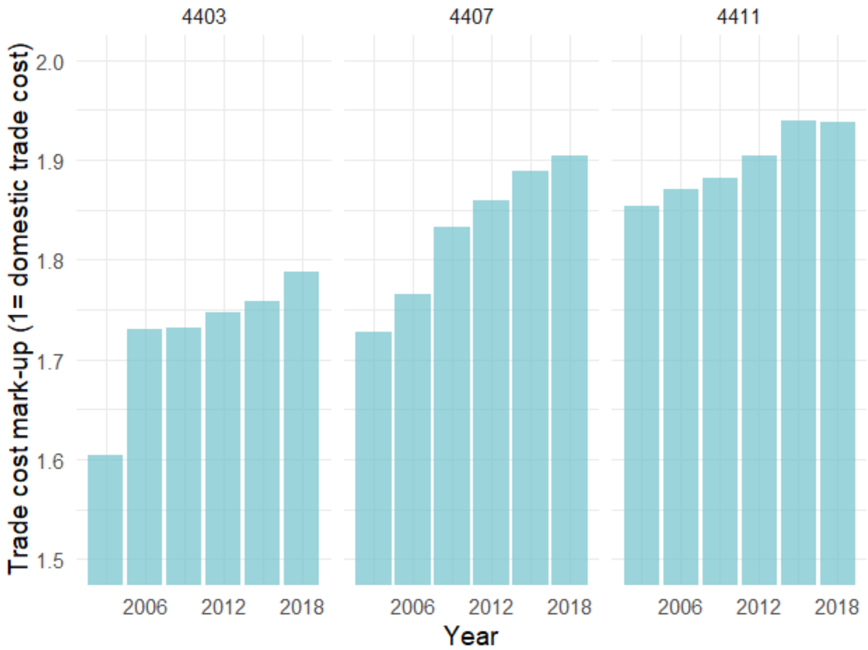
6.2. Indices of trade costs

Trade costs have been rising in the past 15 years. The largest cost increase has been for logs, with trade costs growing 0.7% on average between 2003 and 2018 – although most of that increase occurred between 2003 and 2006, as shown in Figure 10.

Timber and fibreboard trade costs have grown by an average of 0.6% and 0.3% per year respectively.

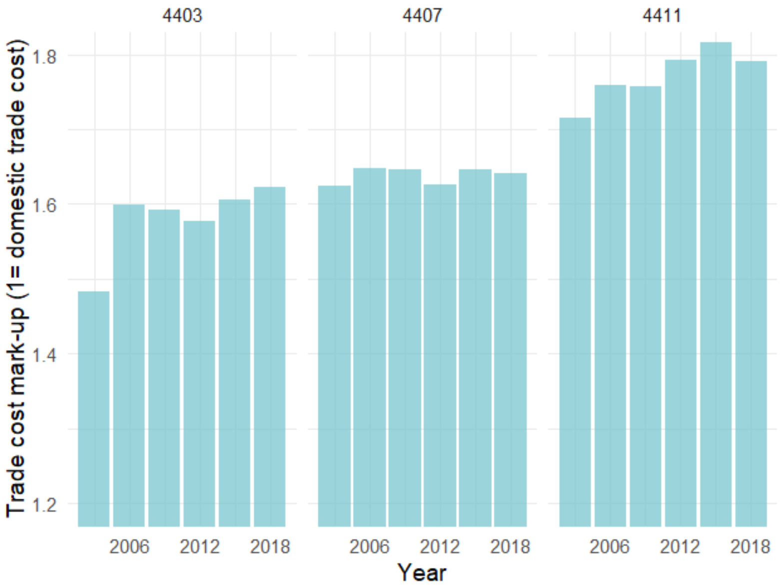
This rise in trade costs reflects a mixture of policy effects and changes to the geographical distribution of world trade – particularly the decline in the share of global trade in wood products taking place in Europe and North America (increasing the average distance across which logs and wood products are traded).

FIGURE 10: RISING GLOBAL TRADE COSTS



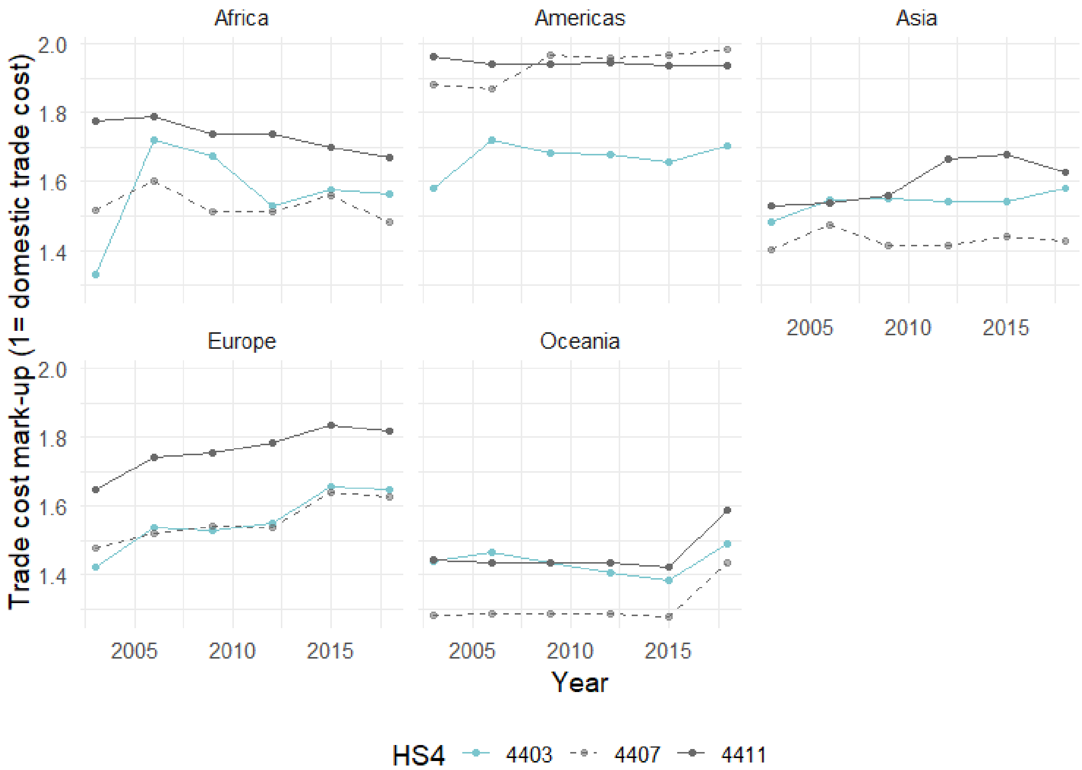
Policy changes and shifting patterns of global demand appear to have been favourable to New Zealand exporters, relative to global competitors. While New Zealand trade costs have increased for logs and fibreboard over the past 15 years they have grown more slowly and are at lower levels than the global average (see Figure 11). Timber trade costs have been flat.

FIGURE 11: NZ EXPORTERS FACE RELATIVELY LOWER TRADE COSTS



New Zealand trade costs are, predictably, lowest close to home (see Figure 12) while trade costs are highest for processed products exported to the Americas. The largest cost increases (in percentage changes) have been in trade to Europe, potentially due to changes in EU standards.

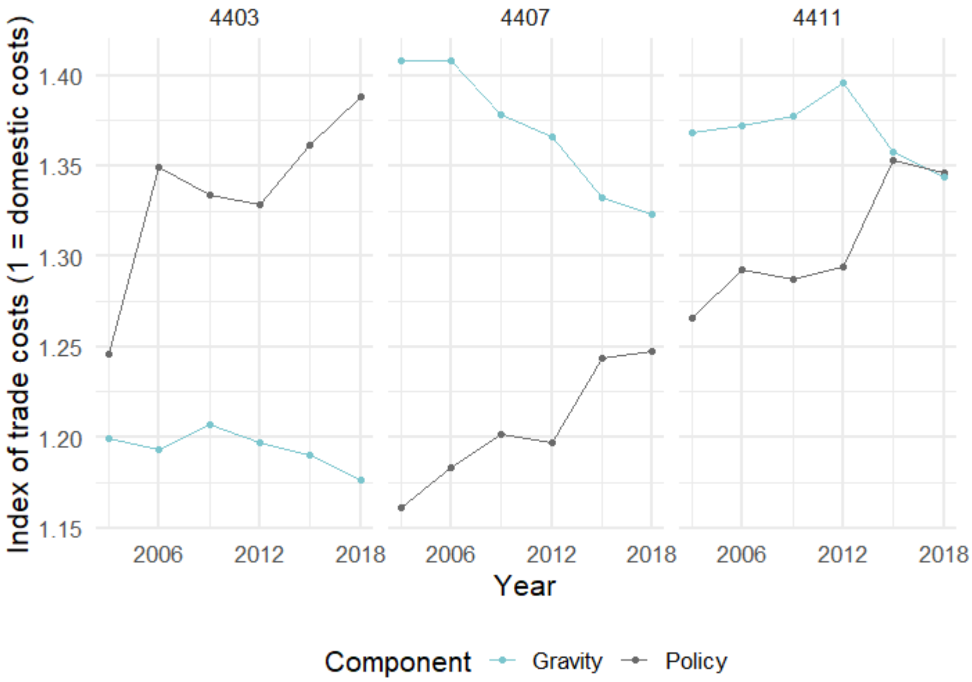
FIGURE 12: NZ EXPORTER TRADE COSTS BY REGION



New Zealand exporters have faced a decline in non-policy trade costs over the past 15 years. This is reflected in the reductions in trade costs labelled as gravity costs in Figure 13 (see the blue lines, by product).

Gravity costs are time invariant trade costs that are due to distance and institutional and cultural differences. These costs only change over time when the geographical composition of demand for wood products changes. For New Zealand exporters, the gravity measure of trade costs declines when demand increases in countries where gravity costs are lower than the global average.

FIGURE 13: TRADE POLICIES HAVE CAUSED NZ EXPORT TRADE COSTS TO INCREASE



In contrast, **policy-related trade costs have been increasing**. This increase in policy-related trade costs is shown in Figure 13, with average policy costs weighted by import demand. The increase in policy-related trade costs reflects a general increase in policy-related trade costs globally. It also reflects the changing composition of import demand where:

- demand for logs has increased in countries with higher than average policy-related trade costs, with roughly one tenth of the percentage increase in policy-related trade costs due to an increase in import demand for logs in countries with higher than average policy-related trade costs
- demand for timber has increased in countries with below average policy-related trade costs, reducing by roughly 20% the effect that rising policy related trade costs are having on trade costs faced by exporters
- demand for fibreboard has increased in countries with above average policy-related trade costs, increasing by roughly 20% the effect that rising policy related trade costs are having on trade costs faced by exporters.

6.3. Measures of trade preference

Overall improvement in competitiveness of NZ exports

Recall that a trade preference above 1 implies that New Zealand exports are more likely to go to that market than others because, relative to other suppliers, New Zealand suppliers are geographically closer, have stronger political, commercial or cultural relationships, or the destination market confers preferential market access to NZ exports.

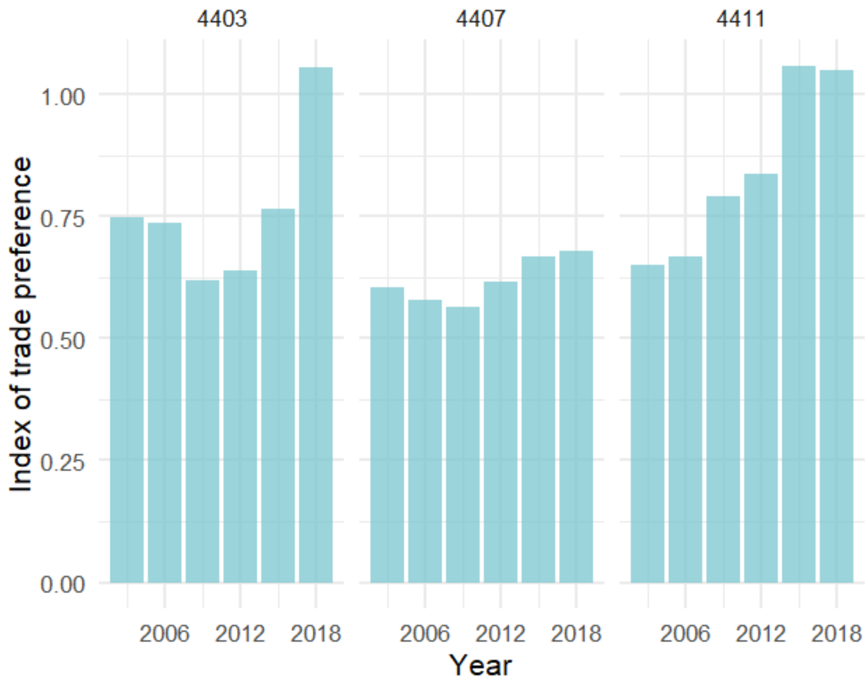
Specifically, a trade preference of (say) 2 indicates relative trade costs result in trade being twice what it would be if there were no distortions in the world.

Results show an **improvement in the competitiveness of New Zealand exports of logs and wood products** as measured by increasing preferences for exports from New Zealand (see **Figure 14**). This is despite rising trade costs globally and reflects the fact New Zealand exporters have been less affected by rising trade costs than other exporters.

The change in trade preference has been largest for fibreboard and the improvement in preferences has occurred for some time. Log exporters face a similar degree of preference as fibreboard exporters, however the improvement in market access conditions has occurred relatively more recently.

Timber exporters, in contrast, face substantially lower preferences for their products with little improvement over time.

FIGURE 14: EFFECTS OF TRADE COSTS ON PREFERENCES FOR NZ EXPORTS
Higher index values indicate easier export conditions



NZ exporters have benefitted from the shift in global demand

The overall improvement in export competitiveness reflects a combination of changes in market conditions and changes in the geographical distribution of global demand, much as they did for changes in trade costs.

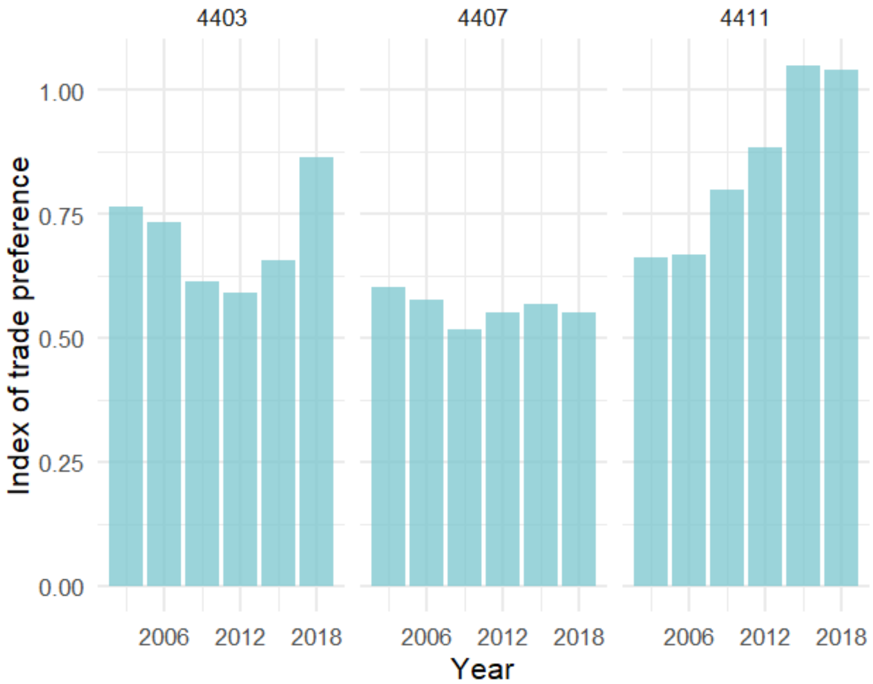
Changes in demand have had a marked effect on the measure of trade preference for trade in timber and for trade in logs. The slight increase in trade preference for timber – shown in the middle panel of Figure 14 – is entirely due to a shift in the composition of world demand towards countries with higher than average preference for New Zealand exports.[20]

This can be seen in **Figure 15** which charts changes in trade preference over time weighted by global demand in 2006.

Similarly, increased global preferences for New Zealand log exports have been significantly affected by the shift in global demand.

Without the shift in demand – towards Asia – global preferences for New Zealand log exports declined between 2006 and 2015, and was only 10% higher in 2018 than 2006, compared with an approximate 40% improvement in the trade preference index between 2006 and 2018 once we include global demand changes in the calculation.

FIGURE 15: CHANGES IN TRADE PREFERENCE EXCLUDING CHANGES IN DEMAND
Holding global demand at 2006 levels



[20] Technically, the weightings used are propensities measured by importer and exporter year-specific fixed effects.

China has been the main cause of increased preferences for NZ logs

The vast majority of the increase in preferences for New Zealand log exports has come from China. The index of trade preference for Chinese imports from New Zealand shows that **preferences for New Zealand logs have more than doubled since 2006** (**Figure 16**).

In contrast, **China's preferences for New Zealand's processed products have declined since 2006**.

The decline in China's preference for processed products from New Zealand is reflected in China's imports from all countries (on average) – China's import demand for these products globally has not been strong.

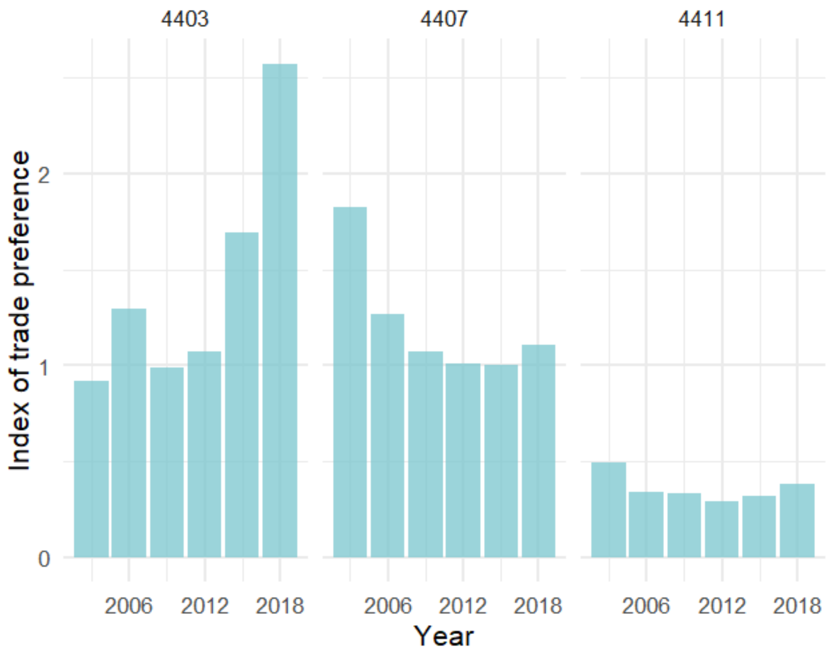
Notably, New Zealand exporters do have preferential access for all products to China – logs, timber and fibreboard – relative to the average for exporters from all other countries (weighted by propensity to export).

This is reflective of favourable trade policy settings rather than distance, per se, as New Zealand is not closer to China than most major global producers of wood products.

New Zealand exporters' relative competitiveness in exports to China is reflected in trade preference indices that are:

- 3 times higher than average, for trade in logs
- 4 times higher than average for trade in timber and
- 5 times higher than average for trade in fibreboard.

FIGURE 16: CHINA'S PREFERENCES FOR NZ EXPORTS



The extent of these preferences – and any others on a bilateral basis – reflects a mixture of different factors including:

- changes in New Zealand bilateral trade arrangements (e.g. tariffs, customs cooperation etc.)
- changes in New Zealand exporters' commercial relationships (e.g. bilateral investment)
- increased barriers to New Zealand trade into other markets, diverting trade towards the destination market
- competitors in other countries facing increased costs in accessing the destination market
- competitors in other countries facing reduced costs in accessing other markets, diverting trade away from this destination market.

These results also show that New Zealand exporters' competitive advantages in access to China are highest for products where preferential access is generally lowest – so while New Zealand exporters have preferential access, that access is most preferential for products where there is comparatively less trade.

China has a unique preference for New Zealand logs

The preference exhibited for New Zealand log imports to China is unique relative to imports from other parts of the world (see

Figure **17**). Indeed, even in the case of Russia the index of trade preference for exports from Russia to China is no higher than 0.8 as compared to the index for New Zealand exports to China which has almost always been higher than 1 and recently has been higher than 2.5.

We are unable to determine exactly what drives this significant preference of Chinese importers for New Zealand logs. It will be a mix of the drivers listed above, and may also reflect factors that affect trade flows that are unable to be measured due to a lack of data, such as high levels of trust between China and New Zealand, institutional and commercial relationships that have flourished due to the FTA, or domestic policies.

Japan has been a key cause of high preferences for NZ fibreboard

New Zealand exports of fibreboard to Japan are substantially higher than we would expect given global supply and demand balances and trade costs. Indeed, preferences are very high relative to other countries – for example the index of trade preference for fibreboard exports to Japan was more than twice as high in 2018 as the index of trade preference for fibreboard exports to Australia (an index of 2 versus an index of 0.87).

This is potentially due to supply chain links between Japanese and New Zealand wood processors, reflecting the strong Japanese investment that has occurred in New Zealand over the past few decades.

FIGURE 17: CHINA'S OBSERVED PREFERENCES FOR LOG IMPORTS BY REGION

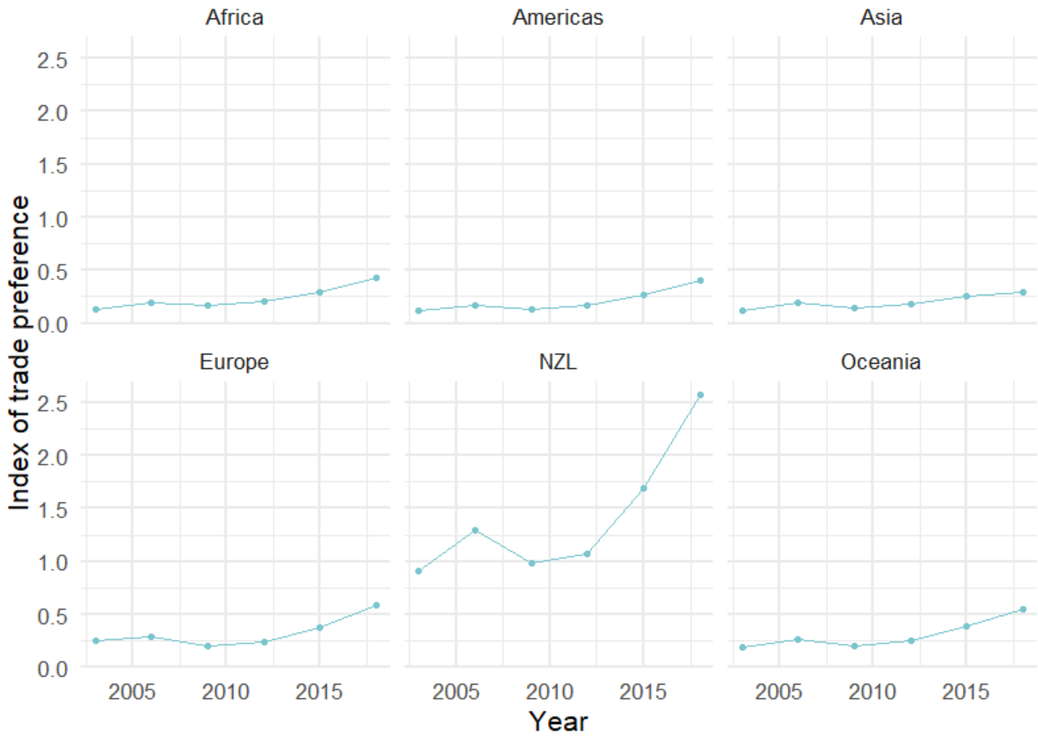
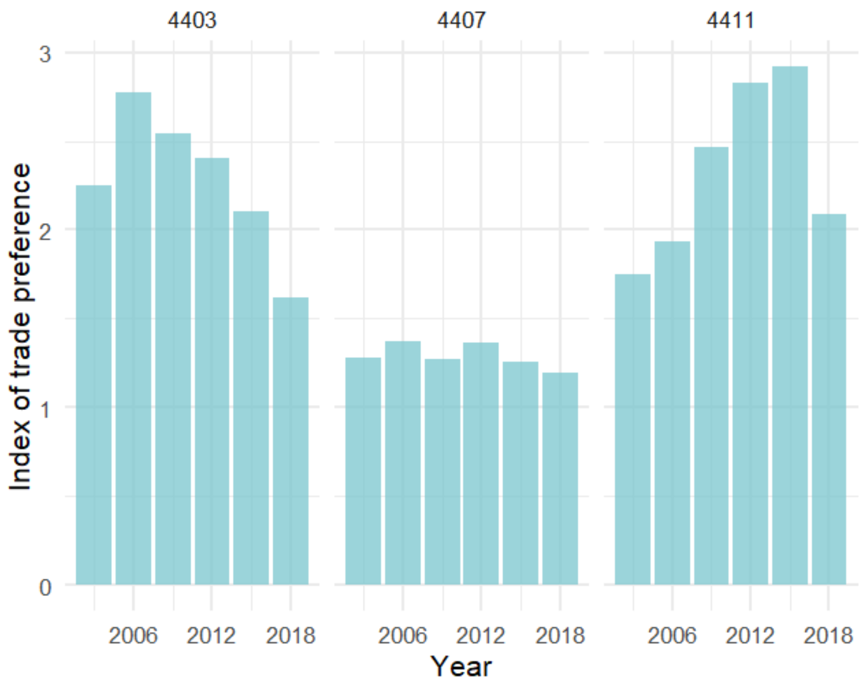


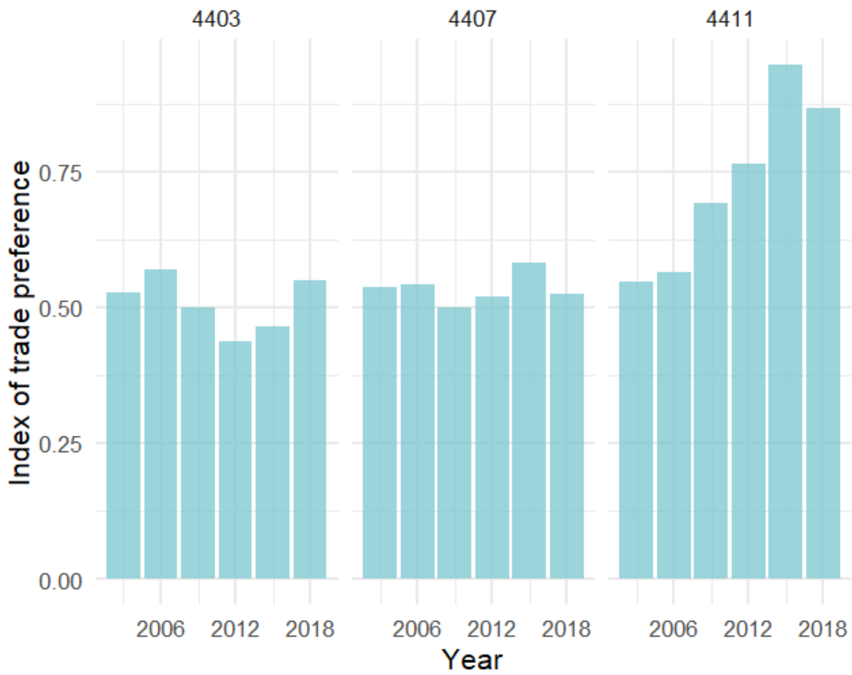
FIGURE 18: JAPAN'S PREFERENCES FOR NZ EXPORTS



Countries in ASEAN also exhibit high preferences for New Zealand exports of fibreboard (e.g. Indonesia and Vietnam) – likely reflective of the strengthening economic relationship between New Zealand and ASEAN in the past decade and a half including through free trade agreements.

Japanese preferences for New Zealand logs and timber have declined over time (albeit only slightly in the case of timber) but remain at high levels. This can be seen by the extent of preferences that Australia has for New Zealand exports of logs, timber and fibreboard – high by global standards but substantially lower than the preference that Japan exhibits for New Zealand exports (see Figure 19).

FIGURE 19: AUSTRALIAN PREFERENCES FOR NEW ZEALAND EXPORTS



Global distortions differ significantly by product and exporter

Disentangling the global effects of distortions on trade in logs and timber and fibreboard is fiendishly difficult given the wide variation that exists in the number and nature of trade barriers, free trade agreements, differences in domestic commercial environments and locations of production and demand and distances between them.

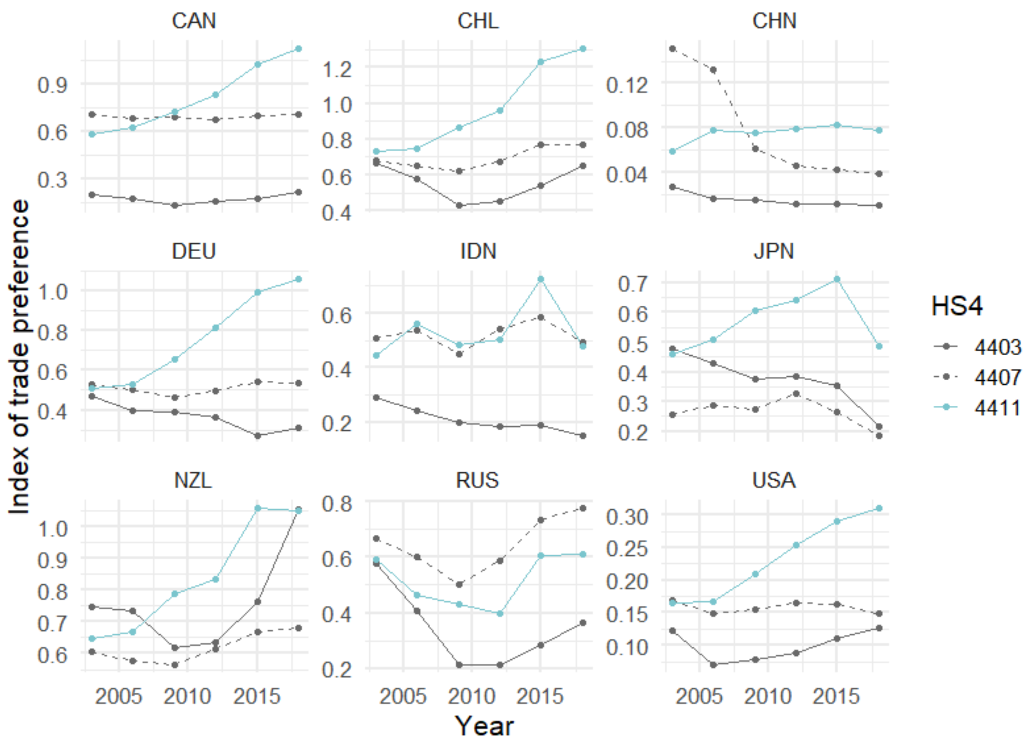
Nonetheless some of the variation in indices of trade preferences for individual countries' exports is suggestive of the nature of trade distortions and the relative degree of distortion across different products.

For example, **most countries exhibit home bias in log trade** i.e. indices of preference for log exports that are typically low compared to indices of trade preference for other products. Even for Russia, where log exports were 40% of global supply in 2006, those exports are not assessed as having preferential access to markets compared to Russian exports of timber and fibreboard. This can be seen in Figure 20, which tracks weighted average trade preference for exports from a range of countries from different regions of the world, all of which are significant participants in markets for trade in wood products.

New Zealand and Japan are the only countries (of the select countries shown in Figure 20) that exhibit higher export preference for logs than at least one processed product.

The patterns of relative preference shown in Figure 20 could be due to a range of factors, including unobservable quality differences (such as if a country typically exports higher quality fibreboard, which shows up as having preferential access to export markets), however they also show some correlation with restrictions on log trade to support domestic processors.

FIGURE 20: EXPORT PREFERENCES FOR SELECTED COUNTRIES' EXPORTS[21]



21 CAN = Canada, CHL=Chile, CHN = China, DEU = Germany, IDN=Indonesia, JPN = Japan, NZL = New Zealand, RUS = Russia, USA = United States of America.

7. Conclusions

This study has used a structural gravity model to investigate the extent and effects on New Zealand exports of trade costs – both policy and economic geographical – for logs, timber and fibreboard.

We find that:

1. Global demand for logs and wood products has been low in the past decade, despite strong demand growth from China. Timber demand has been particularly slow to recover since the global financial crisis.
2. There have been significant changes in the supply of logs for export over the past two decades, creating a situation of relatively tight market conditions that have contributed to rising log prices.
3. Between 1990 and 2006 Russia dominated the global supply of logs for export, with its share of global supply peaking at 39% in 2006. By 2012 that share had shrunk to 16% of global supply, as its export taxes and quotas on logs sharply decreased its exports.
4. The global log market has been less concentrated in the past 7 years than at any other time since 1961. That is, global log trade is no longer dominated by one or two major players.
5. New Zealand's share of global exports is higher than its share of global production in logs, timber and fibreboard. This is unusual. Most wood products produced in the world – and indeed most products more generally – are traded domestically rather than internationally. Only 6%-7% of global log production is traded internationally as compared to 30% of timber.
6. Thus, New Zealand is more exposed to changes – both positive and negative – in global markets for logs and wood products than most countries.
7. Policy changes in global markets have affected trade costs for logs and wood products in different ways:
    a. The use of export restrictions (e.g. export taxes or bans) has increased, increasing trade costs. At least 39 countries have log export bans of one kind or another.
    b. The use of non-tariff measures appears to have increased, suggestive of increased trade costs.
    c. Tariffs have declined as the number of FTAs has increased, pointing to a reduction in trade costs. Around 70% of fibreboard trade takes place between countries with FTAs, as compared to 60% of trade in timber and 50% of trade in logs. This reflects tariff escalation.
8. Relative costs are ultimately what determines trade flows, in conjunction with relative size (scale of demand and supply). This means that trade flows between two countries depend not just on policies, distance and relative size of those two countries but also on policies, distance and relative size of all other countries. An obvious example is that trade between

New Zealand and China has been significantly affected by the decision by Russia to restrict its exports of logs.

9. Our modelling estimates the introduction of NTMs is associated with a reduction in trade of between 13% and 81%, depending on the type of NTM and the product concerned. This is the estimated reduction in trade between two trading partners when the destination country has introduced an NTM.
10. An 81% reduction in trade in logs from the introduction of import NTMs is equivalent to the trade effect expected from a 16% tariff on logs. This indicates that global log trade is highly distorted by NTMs.
11. Our modelling also suggests that the introduction of an export NTM (such as a tax) tends to reduce global trade in timber and fibreboard. This is due to countries deciding to meet domestic demand through domestic processing rather than imports.
12. Global trade costs (the sum of policy and economic geographical costs) have been rising in the past 15 years. The largest cost increase has been for logs, averaging 0.7% per year between 2003 and 2018. Timber and fibreboard trade costs have grown by an average of 0.6% and 0.3% per year respectively.
13. Policy changes and shifting patterns of global demand appear to have been favourable to New Zealand exporters, relative to global competitors. While New Zealand trade costs have also increased over the past 15 years, driven largely by policy costs and especially NTMs, they have grown more slowly and are at lower levels than the global average. That is, New Zealand exporters have been less affected by rising trade costs than other exporters.
14. The index of trade preference for Chinese imports from New Zealand shows that preferences for New Zealand logs have more than doubled since 2006.
15. We are unable to determine exactly what drives this significant preference of Chinese importers for New Zealand logs. It may reflect factors that affect trade flows that are unable to be measured due to a lack of data, such as high levels of trust between China and New Zealand, institutional and commercial relationships that have flourished due to the FTA, or domestic policies.
16. In contrast, China's preferences for New Zealand's processed products have declined since 2006. However, China still exhibits a preference for New Zealand processed products compared to our competitors.
17. Japan, however, demonstrates a strong preference for New Zealand processed products, potentially due to strong historical supply chain links between Japanese investors and New Zealand wood processors.
18. A similar preference exists for ASEAN markets, likely reflective of the strengthening economic relationship between New Zealand and ASEAN in the past decade and a half including through free trade agreements.

8. References

Agnosteva, D.E., Anderson, J.E., Yotov, Y.V., 2014. Intra-national Trade Costs: Measurement and Aggregation (Working Paper No. 19872). National Bureau of Economic Research.

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

Baldwin, R., Taglioni, D., 2007. Trade Effects of the Euro: a Comparison of Estimators. Journal of Economic Integration 22, 780–818.

Cipollina, M., Salvatici, L., 2010. Reciprocal Trade Agreements in Gravity Models: A Meta-Analysis. Review of International Economics 18, 63–80.

Head, K., Mayer, T., Ries, J., 2010. The erosion of colonial trade linkages after independence. Journal of International Economics 81, 1–14.

Head, K., Mayer, T., 2014. Gravity Equations: Workhorse, Toolkit, and Cookbook, in: Gopinath, G., Helpman, E., Rogoff, K. (Eds.), Handbook of International Economics, Handbook of International Economics. Elsevier, pp. 131–195.

Kim, J., 2010. Recent Trends in Export Restrictions (OECD Trade Policy Papers No. 101). Organisation for Economic Co-operation and Development, Paris.

Kishor, N., Mani, M., Constantino, L., 2004. Economic and Environmental Benefits of Eliminating Log Export Bans – The Case of Costa Rica. World Economy 27, 609–624.

Maplesden, F., Horgan, G., 2016. Non-tariff barriers to New Zealand forest products trade (Report prepared for the Wood Council of NZ).

Niu, Z., Liu, C., Gunessee, S., Milner, C., 2018. Non-tariff and overall protection: evidence across countries and over time. Rev World Econ 154, 675–703

Yotov, Y.V., Piermartini, R., Monteiro, J.-A., Larch, M., 2016. An Advanced Guide to Trade Policy Analysis: The Structural Gravity Model. WTO.

SENSE PARTNERS

DATA LOGIC ACTION