Complexity and Fragility:

An Assessment of New Zealand Trade Relations

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ABSTRACT

In the decade 2010-2019, international trade relationships started to show some new patterns with complex and fragile features. These patterns are attributed to various factors, including globally slower demand, greater participation in Global Value Chains (GVCs), and the application of non-tariff measures (NTMs). These factors considerably increase the difficulty of measuring and predicting future trade relationships at the sectoral and the firm level.

In order to provide a practical and empirical contribution to the literature on international trade and policy, especially New Zealand trade policy, this thesis assesses the past performance, identifies the determinants, and predicts the future patterns of New Zealand trade relationships using emerging methodologies. It consists of five separate but interconnected studies, of which one is published, one is under review, and two are about to be submitted to academic journals for publication.

The first study provides an overview of New Zealand's participation in GVCs and identifies the key determinants of all OECD countries' participation. It finds that New Zealand has limited participation in GVCs. Also, it observes that most underlying drivers considered have a diverse impact on the domestic and international component of GVCs. Specifically, GDP growth, R&D, tariffs, credit availability, corruption perception and port infrastructure are the most significant factors influencing OECD countries' participation.

The second, third and fourth studies assess New Zealand trade relationships by investigating the duration and survival of imports and exports in multiple sectors. Results from these studies can help uncover the past trade performance of New Zealand different agricultural products in details. A common empirical approach employed in

these studies includes a decomposition of the observed trade relationships by sequence and an application of the discrete-time hazard model of survival analysis.

To be more specific, the second study examines New Zealand horticulture imports from 1989 to 2019. The results indicate that around 58 per cent of the trade relationships had survived only one year, and approximately one-quarter of them attempted to enter the New Zealand market multiple times. As regards the determinants, duration of the sequence, the number of entries, distance, GDP per capita, import prices, domestic production, the number of import origins and export destinations are found to be the significant factors affecting the hazard rate of import survival. Most importantly, the estimated impacts of the sanitary and phytosanitary (SPS) measures required by the New Zealand Import Health Standards (IHS) are mixed, depending on the type of treatment and the exporting countries' level of development.

The third study, following the same methodology, focuses on New Zealand dairy exports. It indicates that dairy export relationships are dynamic with numerous entries and exits to and from foreign markets. At the sequence level, around half of the relationships survived for 1-2 years only. As regards the determinants, duration of the sequence, left-censoring, initial export, decomposed sequences, export price, the number of cows available for dairy production, the number of import origins and export destinations, and destination partner's GDP, are the most significant factors reducing the hazard rate of export relationships. Most importantly, the results indicate that technical barriers to trade significantly decrease the hazard rate. Only pre-shipment inspection and contingent trade protective measures are significant impediments to New Zealand dairy export relationships.

The fourth study examines the short-lived nature of honey trade relationships as a proxy of the competitiveness of 14 globally leading honey exporting countries, including New Zealand. The findings confirm that approximately 62 per cent of the export sequences survived no more than three years across countries. Among the factors examined, longer duration, multiple entries, left-censoring, distance, and the number of suppliers are the most significant determinants decreasing the hazard rate of honey exports. Further, the results provide some evidence that both food safety and security significantly affect countries' export survival. It concludes that among the selected sample of countries, Hungary, Belgium, Germany, China, and New Zealand are relatively 'competitive' as their honey export sequences are associated with lower hazard rates and longer duration.

The last study of this thesis aims to identify the potential destinations of New Zealand dairy exports in the context of dynamic trade networks, using a Link Prediction (LP) approach. It observes that among the algorithms of LP, the Weighted Resource Allocation (WRA) index has the highest accuracy in predicting potential dairy trade relationships. It also anticipates future patterns of those potential trade relationships given their prior export duration and survival patterns. The results indicate no significant 'Weak Ties' effect on dairy trade networks. Indeed, common trade partners with larger trade volume are more important than those with smaller volume in helping two disconnected countries trade. Besides, new dairy trade relationships that are most likely to emerge involve countries such as New Zealand, Ukraine, Peru, and Malaysia. Finally, trade relationships such as between New Zealand and Turkey, Malaysia and Switzerland, and the Czech Republic and the U.S. are predicted to be extremely active with multiple sequences of trade in the future, if no trade promotion policies will be implemented.

Overall, the empirical outcomes of this thesis provide important policy implications for both the New Zealand government and local decision-makers in charge of trade, given the relevant information on the patterns, determinants, and future trade opportunities in multiple sectors.

NOTE ON PUBLICATIONS

Chapter 3: Under review.

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Chapter 1 Introduction

1.1. Motivation

The world economy has been characterised by dramatic growth in the globalisation of economic activities during the last few decades, facilitated by the development of technology and the reduction in the transportation and communication costs (WTO, 2017). However, international trade appears to be at a deceleration stage in recent years as a continuing consequence of the great recession of 2009. After having a temporary growth from 1.3 per cent in 2016 to 4.5 per cent in 2017, the average increase of international trade remained slow in 2018, down to 2.8 per cent (UNCTAD, 2019). Such a sluggish rebound was driven by various factors, including the weak demand from major economies and low commodity prices in the global market. Despite these patterns, international trade relationships have shown some new features.

On the one hand, trade relationships are more sophisticated as the emergence of Global Value Chains (GVCs) decomposes the production process of a product into steps accomplished at different locations (World Bank, 2017). These locations can both be domestic and overseas. This phenomenon frequently happens in the manufacturing sector when imported final products may contain a substantial proportion of local value-added (Blanchard *et al*., 2016). In this way, a country's exported intermediate inputs may return home through embodying in their imported foreign-made final products. The similar feature can be found in the food sector as the exported final products may require a large proportion of imported foreign intermediates during production. Therefore, final goods for trade are often produced by combining domestic and foreign value-added inputs via global supply chains.

Given the concept of GVCs, countries now are able to focus on only a subset of the production in which they are relatively competitive (Alfaro *et al*., 2015; Balié *et al*., 2019). It is believed that this type of trade, especially in value-added and intermediates, is making the global production distribution process more complicated than it has ever been before and it has entirely changed the nature of trade relationships. As a result, these complexities in trade relationships not only considerably increase the efficiency and competitiveness in trade but also alter governments' incentives to impose trade barriers (De Backer and Miroudot, 2013; Blanchard *et al*., 2016).

On the other hand, global trade relationships are more complicated as trade alone (or as a component of the GVCs) appears to be a networked activity. That is, most of the trade happens between at least one large country or business with many trading partners (Bernard and Moxnes, 2018). From a network perspective, this complexity indicates that countries are becoming increasingly interrelated and trade plays as a critical channel facilitating the global exchange of resources in a dynamic network environment. However, monitoring global trade activities within networks appears to be difficult and needs to build upon the availability of enormous cross-country trade data and interdisciplinary methodologies.

Additional to these complexities, recent empirical literature suggests that most trade relationships are short-lived with frequent entries and exits and international trade activities are not always a simple linear and forward-moving process (Peterson *et al*., 2017). Therefore, it is often the case that businesses choose to exit from an offshore market and stay out of it for a few years before re-entry. Such patterns are referred to as the fragility in trade relationships, representing inconsistent foreign involvement, market survival fluctuations, and internalisation flexibility (Chen *et al*., 2019).

In the short run, exiting a market might be beneficial to sectors or businesses that are competing for global market expansion and growth as it reduces the uncertainties of capturing a new market and help optimise their market composition. However, in the long run, frequent entries into and exits from the same market may significantly influence the survival of businesses and hurt their accumulation of knowledge and experiences in trade (Peterson *et al*., 2017).

Since the survival of trade relationships in foreign markets are critical for countries to achieve productivity and income growth, it is of interest to better understand the factors that are important for export and import survival. However, the fluctuations in trade survival are often related to the uncertainties in offshore markets, which tend to be destination-dependent. This characteristic increases the difficulties in understanding trade patterns and formulating policies that allow businesses and governments to capitalise on the complex and short-lived trade relationships, and to mitigate adverse effects.

Given these new features of trade relationships, prediction for future trade relationships based on previously identified patterns is no longer valid. Meanwhile, these observed new features not only increase the difficulty of monitoring global trade patterns but also call for a comprehensive and mature theory to guide local policies based on the dynamic evolution of interrelated trade activities. Before that, more empirical evidence on the nature of trade relationships is crucial at this stage. Therefore, this thesis attempts to provide an assessment and a prediction of New Zealand imports and exports based on their complex and fragile nature.

The reason for choosing New Zealand as the object of study is simple. It is because as a small and dependent economy, imports have long been important to satiate

New Zealand’s domestic demand and improve residents’ wellbeing (NZIER, 2017). Meanwhile, exports have functioned as a critical source of New Zealand’s economic growth. In recent years, total trade made up around 60 per cent of the country’s overall economic activity. Exports alone accounted for more than a quarter of the country’s total GDP and almost NZ$56 billion in 2018 (MFAT, 2018).

Other than trade, however, bottlenecks in housing and inequalities in living standards all raise risks for further growth in New Zealand (OECD, 2015). These are possibly a result of the country’s relatively weak participation in international trade, inadequate skilled-labour, and lack of investment in research and innovation. Hence, it is believed that without sustainable growth in trade, the future of New Zealand’s economy will be uncertain. In particular, the country will likely be more vulnerable and susceptible to large external shocks if there is insufficient participation in GVCs and presence of fragile trade relationships.

At the industry level, the performance of New Zealand also left little room for optimism. For instance, the manufacturing sector’s involvements in GVCs are still limited and mostly in the low value-added phases. In contrast, countries such as China and other Asian countries are moving up the value chain or becoming the next hub of labour-intensive productions and expand technological sectors (WTO, 2017). This gap highlights important opportunities for New Zealand to explore further. To be left behind at this stage would have severe consequences for growth and development.

As a critical contributor to economic growth, the New Zealand agriculture sector is highly productive with minimal government intervention (MPI, 2017). Compared with other countries worldwide, New Zealand is unique since agricultural imports are not subject to import quotas or licensing and tariffs. Also, New Zealand agricultural products have the world's lowest level of agricultural subsidies (MPI, 2017). This feature made local farmers and producers directly exposed to international competitors, who are often heavily subsidised. To some extent, it also potentially influences the persistency of New Zealand trade relationships.

In 2014, the New Zealand Primary Industries Minister Nathan Guy outlined a goal for the primary industry to '*double the value of primary exports by 2025*' in a speech to industries leaders. This vision required an export growth of at least 5 per cent a year. As given in the *Situation and Outlook for Primary Industries* report released by the Ministry for Primary Industries (MPI) in December 2019, New Zealand's primary industry export revenue is predicted to reach NZ$47.9 billion for the year ending June 2020. This will be an increase of 3.3 per cent from the year before (MPI, 2019). However, this growth seems insufficient to reach the vision if New Zealand's current trade relationships indeed are vulnerable and have a lack of international connections.

Given the above context, it is believed that understanding the new features of trade relationships is of extreme importance to help secure a country's trade competitiveness. However, in contrast to many countries in the world, New Zealand has not been able to identify and interpret the main changes in its trade relationships nor prepared well to enter massively into global production networks. As a consequence, businesses and the government are not adequately informed to enable the setting up of strategies that will deal with future uncertainties.

From a macro perspective, large uncertain fluctuations in future trade activities will directly exert significant influence on local producers' welfare, domestic prices, residents' wellbeing, and the country's potential to be a more prosperous economy. Besides, various distortions in the supply chain may prevent businesses from sourcing from their optimal suppliers, which will decrease aggregate productivity and real wages (Bernard and Moxnes, 2018). Therefore, understanding international trade based on network structure matters for maintaining trade relationships as it determines the marginal costs of trade and measured productivity along the supply chain.

Recent trade studies confirmed that increasing trade participation in GVCs (Criscuolo *et al*., 2016; Del Prete *et al*., 2017), supporting existing trade relationships (Monarch and Schmidt-Eisenlohr, 2017), and exploring potential trade opportunities (Felbermayr *et al*., 2015) are the direct sources of a country's trade and economic growth. However, in New Zealand, empirical evidence on the evolving nature and new features of trade relationships is scarce. It limits the country's development of new strategies and policies to encourage further trade integration and to increase returns from trade. Therefore, a better understanding of trade relationships and their past performance is required to inform trade policies targeted at promoting stable trade relationships and discovering future partners.

1.2. General theoretical background

International trade theory has been developed for centuries. Since the notion of comparative advantage was proposed by David Ricardo two centuries ago, the mainstream theories about international trade were based on three classic premises. However, the first premise of '*constant returns to scale*' was shaken with the development of the New Trade Theory in the 1970s. Pioneered by Krugman (1979) and Helpman and Krugman (1985), the theoretical scope of trade argued that markets are imperfectly competitive, and producers operate at increasing returns to scale. This analytical framework provided a plausible explanation for the prevalence of intra-industry trade between countries with similar technology and resource endowments.

Later, the second classic premise of '*an industry consists of homogeneous producers*' was reconsidered following extensive empirical evidence found in the later 1990s (WTO, 2017). The key feature is generalised by Bernard *et al.*'s (1995) and Bernard and Jensen's (1999) examinations on exporters and non-exporters productivity heterogeneity within an industry. Followed by Melitz's (2003) explanations for this feature, newly discovered stylised fact and the predictions of prevailing models established what was later named New-New Trade Theory (WTO, 2017).

With the recently developed concept of the GVCs, the third classic premise of international trade theory '*countries trade only final products*' has been reconsidered further. Not long afterwards, theories such as production fragmentation (Jones and Kierzkowski, 1990) and intermediates trade (Feenstra and Hanson, 1996; Campa and Goldberg, 1997) emerged and along with an increasing number of studies involving diverse countries. Other than that, recent trade literature has begun to focus on topics such as product-level empirics (Dedrick *et al.*, 2008), GVCs sequentiality (Antràs and Chor, 2013), firm-level microdata (Bernard *et al.*, 2010), and input-output analysis utilising firm characteristics (Ma *et al.*, 2015).

1.3. Research questions

This thesis makes contributions to three main objectives. First, assessing the performance of New Zealand's participation in the GVCs. Second, estimating the survival of New Zealand trade relationships. Third, predicting future trade relationships within trade networks. Fulfilling these objectives will help provide a better understanding of the nature of New Zealand trade relationships in multiple sectors. In particular, this thesis asks specific questions including

i. *Is New Zealand trade 'complex'? How does New Zealand participate in GVCs? What are the primary drivers of its participation?*

ii. *Is New Zealand trade characterised by a fragile nature? How well New Zealand import and export relationships survive? What are the major causes of trade fragility?*

iii. *What is the role of New Zealand in the global trade network? Are there appropriate approaches to predicting future trade relationships in a complex network environment? What trade relationships are 'most-likely-to-emerge' for New Zealand?*

1.4. Significance

A significant contribution of this thesis which differentiates it from previous work is that it explores New Zealand trade from a new perspective of '*relationships*'. This requires a thorough analysis of the nature of trade relationships, including assessing how the trade relationships are established within complex value chains, what are the duration and survival patterns in trade relationships, and what are their likely directions in the future.

Specifically, to answer the preceding research questions, this thesis provides the first set of estimates for the complexity attributes of global trade relationships. It highlights the importance of accounting for the fragility of trade relationships in understanding industries' trade performance. The estimated results will help to formulate New Zealand trade policies improving the 'weak links' in the country's future trade participation and may be used for comparison with other small open economies.

Most empirical studies on trade performance of a country in multiple sectors are now somewhat dated if they were dependent on neo-classical trade theories. This thesis contributes to a small number of recent studies in this area. It uniquely applies the discrete-time hazard model in the context of trade relationships, which is more appropriate to capture the fragile nature of trade duration comparing with conventional approaches such as the Kaplan-Meier (KM) estimator (Peterson *et al*., 2017). This application provides valuable information on the survival of New Zealand imports and exports for three specific primary products (i.e. horticulture, dairy, and honey). It highlights a new approach to examine trade performance and identifies critical insights relevant for shaping new developments in trade policy. This information is valuable to both New Zealand and overseas policymakers.

The prediction of trade relationships in this thesis differs from prior trade simulation literature in a number of ways. First, it adopts interdisciplinary strategies to predict trade relationships in a dynamically changing network and uniquely links the complex network and international trade theories. Second, it demonstrates how economic shocks to any single country can be easily transmitted to other countries via trade linkages of any order, explained by the estimates of a set of scientific algorithms. The Link Prediction approach used in this thesis is a recently developed tool which emerged from network prediction in computer sciences. However, only a minimal number of trade studies have attempted to use it. To the best of our knowledge, it is the first study that predicts agricultural trade relationships using the Link Prediction. Results from this thesis are significant to countries (including New Zealand) providing guidance on the selection of future trade partners and the preparation for unexpected trade breakdown.

1.5. Outline of the thesis

The rest of the content is organised as follows. Chapter 2 examines whether New Zealand trade exhibits complexities by focusing on the country's GVCs participation. Chapters 3-5 assess the fragility of New Zealand trade relationships in the horticulture, dairy, and honey sector. Chapter 6 predicts the future of dairy trade relationships by considering New Zealand as one of the many participants within a complex global trade network. Chapter 7 provides a summary and discussion of the research, policy implications, limitations, and recommendations for future research.

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Chapter 2 New Zealand's GVCs Participation

2.1. Introduction

In the early 1800s, David Ricardo illustrated how the exchange of goods happens in two nations, based on the principle of comparative advantage. Two centuries later, the focus of international trade theory is still dominated by analysing transactions of final products (Grossman and Hansberg, 2006). However, a new feature of international trade is that global production has become increasingly fragmented via the rapid growth of GVCs. Given the framework of GVCs, production of a commodity can be divided into sections of specialisation along the chain, and each production activity can be carried out in the country whose costs are competitive (Globerman, 2011). This feature directly encourages trade across international boundaries achieving benefits from efficiencies in various jurisdictions (WTO, 2017).

With the development of the GVCs concept, studies based on conventional measures of trade, such as those dependent on the gross value of transactions, are less efficient to reveal the complete picture of international trade. It is because these studies cannot describe how foreign producers who are located at different position of the value chain are connected to final consumers. However, digging into these details often require a comprehensive analysis of the degree of participation, the number of fragmentation stages, and the position of a country within the GVCs (WTO, 2017).

To date, studies assessing the significance of the GVCs phenomenon have been extensive in many countries, which are largely attributed to the recently available Input-Output (IO) tables (Del Prete *et al.*, 2017). As illustrated in the literature such as Örgun (2014), GVCs can be an important channel through which countries are able to build productive capacity where their domestic businesses can capture a significant share of the value-added. In addition, GVCs are a well-established vehicle for upgrading the industries involved (Criscuolo *et al.*, 2016; Greenville and Kawasaki, 2018). In New Zealand, however, empirical evidence revealing how the country performed in GVCs is scarce.

In the past two decades, many sectors contributed to New Zealand's economic growth through exports. In the meanwhile, a proportion of these exports depends on the import of foreign intermediates for production. In contrast, the use of New Zealand's intermediates in other countries' exports was far less than the use of foreign intermediates in New Zealand's exports, according to a report of the OECD *et al*. (2013). This uneven participation is likely to restrict New Zealand's sustainable development in the future. As GVCs participation can provide access to a larger variety of cheaper or higher quality imported inputs, countries that participate in GVCs are more likely to achieve their economies of scale and further accomplish higher value-added in trade (Criscuolo *et al.*, 2016).

Moreover, according to the concept of the value-added '*smile curves*', both ends of the GVCs bring higher value-added to the product than the middle part (WTO, 2017). They are referred to as the 'upstream' and 'downstream' GVCs participation. In other words, countries which tend to produce the raw materials or intangibles involved at the beginning process or focus on the assembly of processed products and specialise in customer services are more likely to have greater returns from GVCs (WTO, 2017). These characteristics suggest an outline of the value-added potential of each production stage in a value chain for various industries. Before knowing how to move up the value chain and gain higher value-added, it is critical to understand countries' past participation in GVCs.

Based on above context, the first objective of this chapter is to uncover the features of New Zealand’s GVCs status based on the degree of participation, the structure of production fragmentation stages, and the position within the value chains. A range of GVCs indicators is assessed for several discrete years in the period between 1995 and 2011. The second objective of this chapter is to explore the underlying drivers of these indicators using the data of all OECD countries.

To the best of the author’s knowledge, it is one of the first studies assessing New Zealand’s GVCs participation based on the statistics collected from the OECD-WTO Trade in Value-Added (TiVA) database. Results from this chapter will help formulate policies that allow businesses adapting to evolving features of international trade and mitigating adverse exogenous shocks in the future. Furthermore, a proper understanding of the drivers of GVCs is crucial to both the forecast of global trade developments and the formulation of trade policies that can help to shape and upgrade GVCs.

The remainder of this chapter is organised as follows. Section 2.2 provides a literature review. Section 2.3 presents the patterns of New Zealand trade in value-added. Section 2.4 describes the methodologies and data sources for the drivers of GVCs participation. Section 2.5 discusses the empirical results. Section 2.6 conducts robustness checking for the estimates. Section 2.7 provides a conclusion with policy implications.

2.2. Literature review

Prior studies of GVCs can be classified into four main groups. The first group of studies used distinct types of data to measure GVCs at the country and the sector-level. For instance, some studies collected international trade statistics on parts and components (Lall *et al*., 2004; Gaulier *et al*., 2007), customs or transactional data on processing trade (Clark, 2006; Swenson, 2007; Xing, 2012), and IO tables (Chen *et al*., 2005; Amador and Cabral, 2009; Feenstra and Jensen, 2012) to examine GVCs.

The second group focused on identifying the drivers of GVCs from both theoretical and empirical perspectives. For instance, Deardorff (2001) and Debaere *et al*. (2013) discovered the role of services trade in GVCs participation. In addition, the recent availability of the information and communication technologies (ICT) (Abramovsky and Griffith, 2006; Blinder, 2006; Hillberry, 2011), lower trade costs (Markusen and Venables, 2007; Grossman and Rossi-Hansburg, 2008), trade agreement (Orefice and Rocha, 2014; Osnago *et al*., 2016), and large investment in capital (Criscuolo and Timmis, 2016) are found to be the most significant determinants of trade in intermediates and the developments of GVCs.

The third group of studies assessed the consequences of GVCs. One of the well-known benefits of GVCs participation is significant gains in productivity (Goldberg *et al*., 2008; Baldwin and Yan, 2014). This hypothesis has been confirmed by many other studies, such as Choi (2015) and Del Prete *et al*. (2017). In addition, a few studies argued that participation in GVCs might also bring uncertain changes to trade composition, which are often difficult to monitor (Gangnes *et al*., 2014). This is because GVCs are often found to primarily emerge in the durable goods sectors. However, durables tend to be highly elastic to changes in foreign income. Hence, aggregate trade will also be more sensitive to foreign income shocks. As a consequence, the composition of trade is likely to be altered.

The last group of literature attempted to evaluate the evolution of GVCs across different regions. For instance, Abe (2013) investigated the expansion of global automotive value chains in a subregion of South-Eastern Asia (i.e. Cambodia, Lao PDR, Myanmar, Thailand, and Viet Nam). As a result, the author found that less developed countries in this subregion are increasingly integrated into the global automotive value chains. Besides, suppliers who particularly are producing labour-intensive goods are increasingly moving to Cambodia, Lao PDR and Myanmar. De Backer and Miroudot (2013) investigated the performance of OECD countries and found that there was a comparable level of GVCs participation in most countries. Their observations also suggested that large economies tend to produce a more significant share of intermediate products while those small open economies have been heavily relying on international sourcing.

Notwithstanding there is a substantial number of studies have been undertaken since the 2000s, gaps remain in the literature, especially in the country- and industry-level empirical analysis of GVCs. In addition, the impacts of transportation and communication costs, technological progress, and economic barriers to the development of GVCs, as well as their potential complementarities have not been fully understood yet. These determinants are often identified as the critical drivers of bilateral trade (Carrere, 2006). Thus, a similar impact can be expected to explain the patterns in GVCs.

2.3. New Zealand trade in value-added

2.3.1. The structure of New Zealand gross exports

The OECD-WTO TiVA database is a comprehensive and high-quality source of OECD countries' trade in value-added. It facilitates the analysis of GVCs and helps explore new insights about the commercial relations among economies and the process of value and competitiveness creation. This chapter uses data and indicators collected from the third version (2015) of the TiVA database, which provides a specific view to informing policy debates in a range of areas, including trade, innovation, and investment (Kowalski *et al.*, 2015). Before analysing the indicators, it is worthwhile to show the composition of New Zealand exports. An industrial breakdown of gross exports will allow us to identify which sectors are at the core of the country's export-led growth.

Figure 2-1 presents the broad composition of New Zealand gross exports in percentages from 1995 to 2011. It can be noted that the manufacturing sector has been the major sector contributing to around half of the country's total gross exports. Particularly, there was a steady upward trend in manufacturing exports from 2002 to 2008, which can be partly explained by the country's FDI-led production expansion.

Figure 2-1 Composition of New Zealand gross exports by major sector

Source: OECD-WTO TiVA database. Author's compilation.

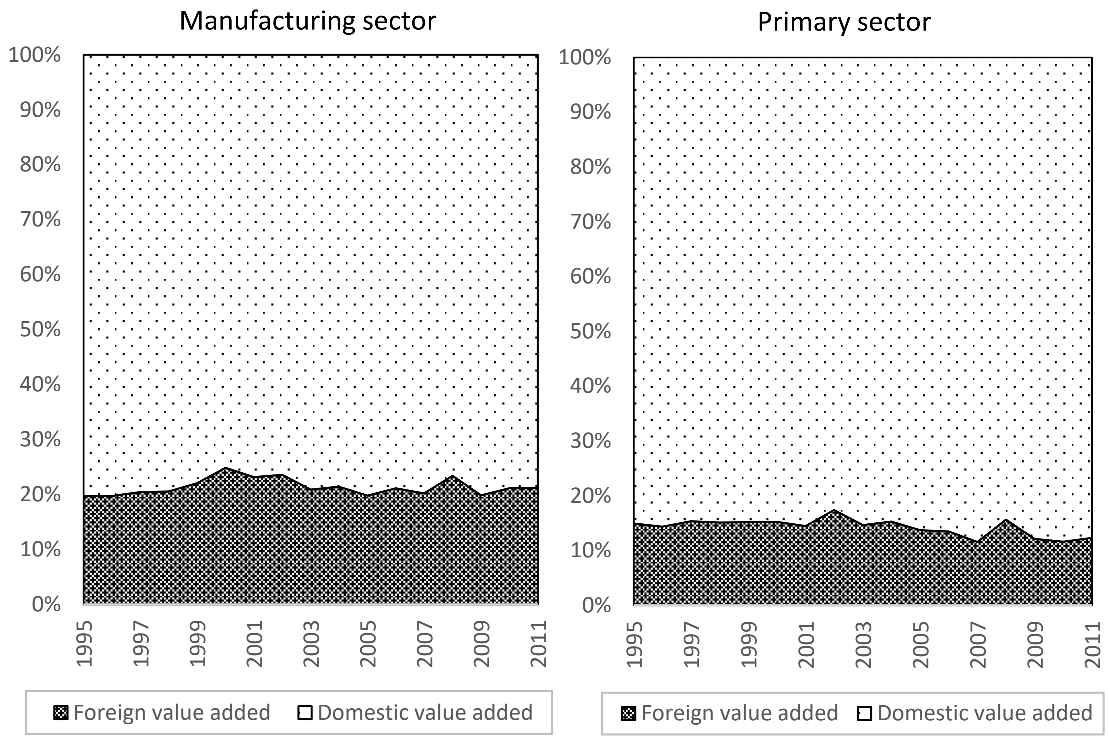
According to NZIER (2016), the stock of FDI in New Zealand manufacturing sector increased by around 24.6 per cent between 2000 and 2008. These investments were mainly made for upgrading and expanding existing production units in the sector. As a result, the total output produced in the manufacturing sector experienced an 80 per cent increase from US$36 million in 1995 to US$60 billion in 2008 (based on the OECD-WTO TiVA database). Meanwhile, it can be noted that the gross manufacturing exports were mainly contributed by the domestic value-added, which is three times as large as the foreign value-added. This reflects the sector's production dependency on domestic intermediates (Figure 2-2).

In the services sector, gross exports have experienced a substantial increase from 1995 to 2011, indicating an increasingly important role of services trade in the New Zealand economy (see Figure 2-1). According to MFAT (2017), educational travel was the major contributor to New Zealand services export growth. However, there were large fluctuations associated with this growth, especially during the period of the global financial crisis. Consequently, New Zealand overall gross exports fell largely due to the rapidly decreased services export.

In comparison, the primary industry (agriculture, forestry, and fishing sector) has seen a relatively smooth upward trend in its gross exports with fewer fluctuations. In Figure 2-2, a further breakdown of the industry indicates that foreign value-added accounted for a small percentage of total output produced. In contrast, domestic value-added as the major contributor to output growth has experienced a significant increase since 2003.

It is important to note that New Zealand's high domestic value-added does not imply that the country's further gains from GVCs participation are limited. Indeed, literature shows that by joining new GVCs or upgrading within GVCs, countries can potentially increase their domestic value-added. This often requires a larger scale or superior agility (Cattaneo *et al.*, 2013).

Figure 2-2 New Zealand manufacturing and primary exports



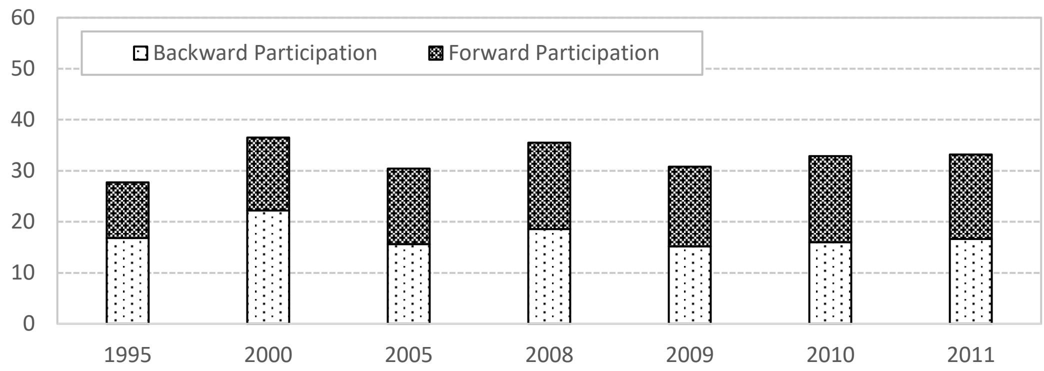
Source: OECD-WTO TiVA database. Author's compilation.

2.3.2. New Zealand's GVCs participation

This section presents evidence on New Zealand's GVCs participation based on a range of indicators. The first one is the GVCs participation index, which is expressed as a percentage of gross exports. It consists of a share of foreign inputs in domestic production (backward participation) and a share of domestically produced inputs used in third countries' exports (forward participation) (De Backer and Miroudot, 2013). Using this index, we can measure the extent to which New Zealand is involved in a vertically fragmented production process (in relative and absolute terms).

According to Figure 2-3, New Zealand had a higher level of participation in GVCs in 2011 compared with its level in 1995, indicating an increase in its vertical specialisation of production. Even though the global financial crisis has led to a slowdown in New Zealand's overall GVCs participation, there was a marginal recovery by 2011. In particular, it can be seen that the country's forward participation in GVCs had a marginal increase during the period considered. This reveals a slightly increased use of New Zealand made intermediates in foreign production. In 2011, both participations were approximately 16.6 per cent and together contributed to around 34 per cent of gross exports.

Figure 2-3 New Zealand's GVCs participation in percentage



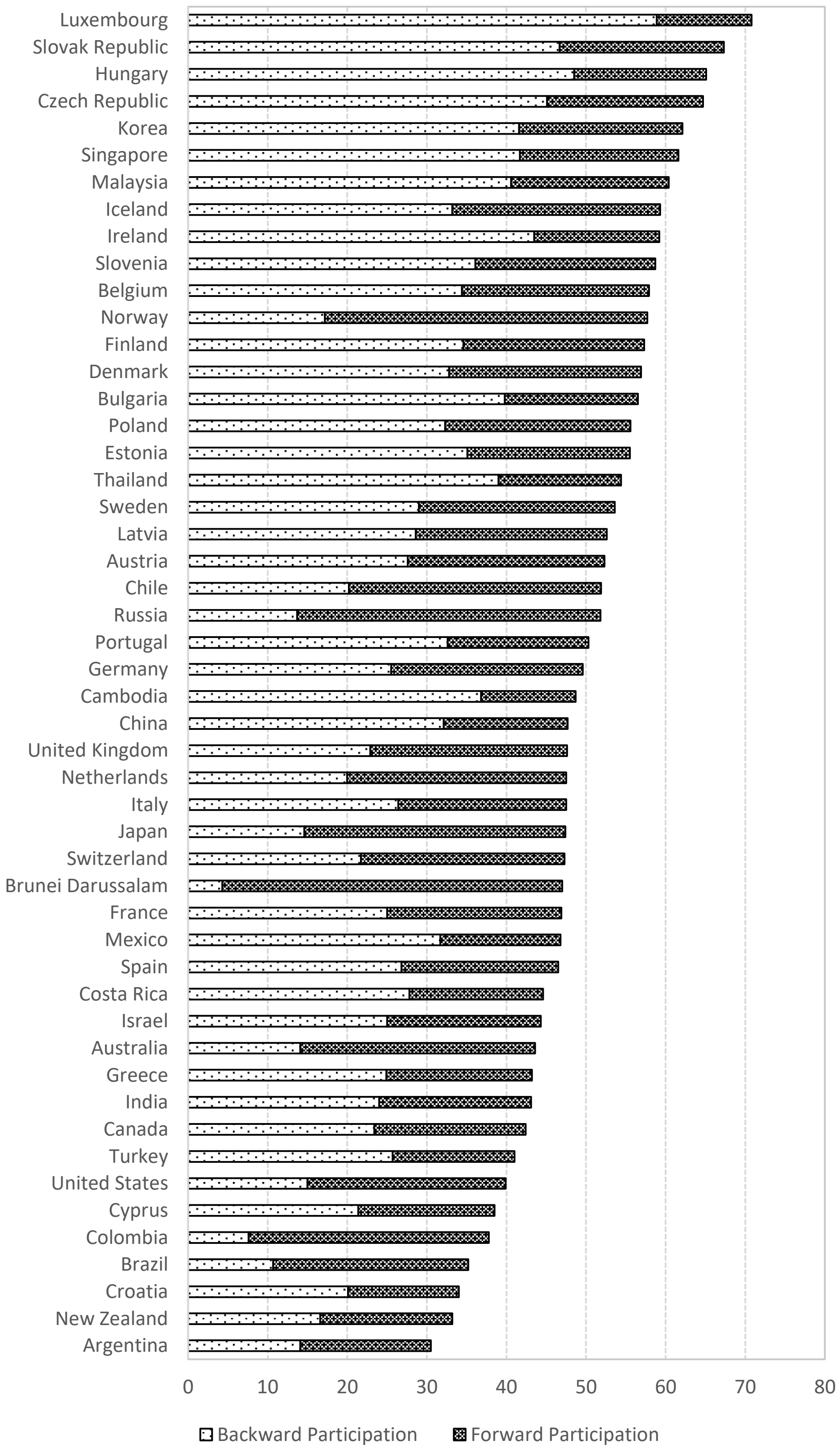
Source: OECD-WTO TiVA database. Author's compilation.

In comparison to other OECD countries, however, New Zealand was one of the countries with the lowest level of participation in 2011 (see Figure 2-4). Given the fact that small open economies such as Luxemburg, Slovak Republic, and Hungary all had predominant GVCs participation in 2011, New Zealand's inadequate participation in GVCs might restrict its potentials to grow further in the international trade market. In addition, it is interesting to note that large economies such as the U.S. and Japan sourced less foreign input via backward participation, and a larger share of their value chains was domestic, due to their size of the economy.

Given the industrial breakdown of the 2011 participation index in Figure 2-5, New Zealand sectors appeared to have uneven participation in GVCs. For instance, the food products, beverage, and tobacco sector participated in the chains mainly through importing foreign intermediate products to produce its exports (backward participation). In comparison, forward participation is found to be dominated in the manufacturing sector (such as the electrical and optimal equipment, textiles, textile products, leather and footwear, motor vehicles, trailers and semi-trailers sector).

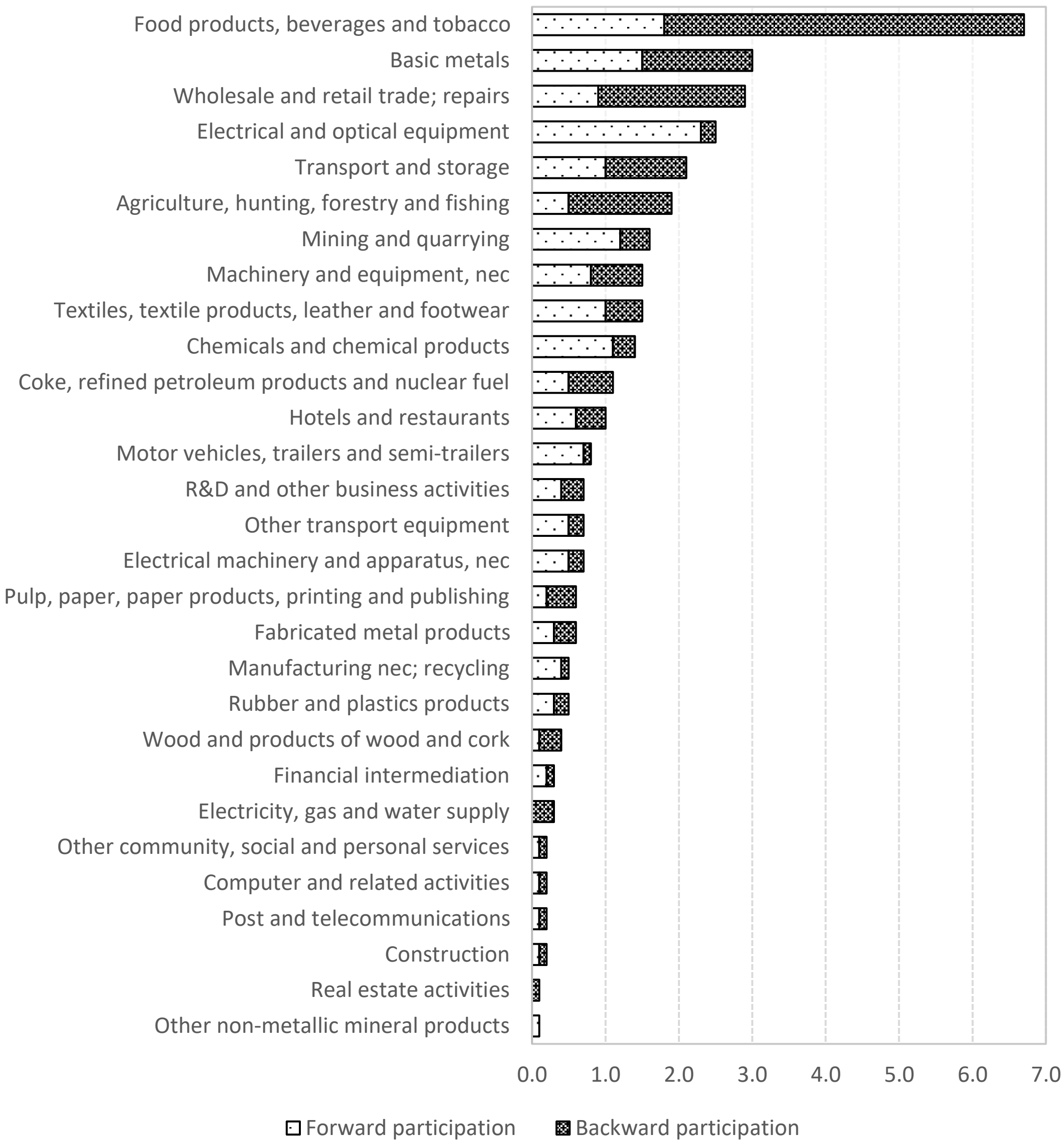
Given the above observations, it is clear that New Zealand overall participation in GVCs is low despite its relatively higher participation in a few primary and manufacturing sub-sectors. Although enhanced participation is likely to increase New Zealand exports and help industries contribute more to the country's economy, it is critical to emphasise that these potential impacts also largely depend on the particular position of the country in GVCs. Therefore, the focus of the country should not be restricted to encouraging intensive participation. Indeed, increasing the domestic value-added is also required as higher levels of domestic endowments indicates greater returns to New Zealand-owned factors of production. This will further boost the living standards of the country.

Figure 2-4 Participation in GVCs across countries, 2009



Source: OECD-WTO TiVA database. Author's compilation.

Figure 2-5 NZ Participation in GVCs across industries, 2009



Source: OECD-WTO TiVA database. Author's compilation.

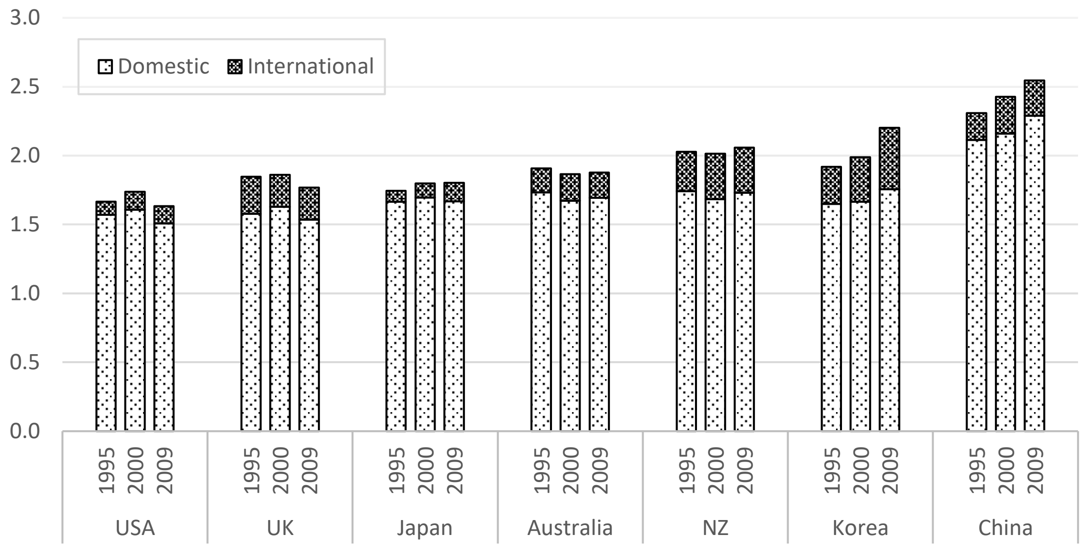
So far, the overall performance of New Zealand GVCs participation has been presented. However, it remains unclear how 'long' the value chains are (De Backer and Miroudot, 2013). Therefore, it is necessary to have an indicator measuring the 'average length of GVCs' to uncover more information on the particular characteristics of GVCs.

The 'length' indicator used in this chapter was developed by Fally (2012). It refers to the average number of production stages between primary inputs and final products that an economy is involved. It equals one if there is a single production stage in the final industry, and it increases as intermediate inputs source from more industries in the production of the final products or services (OECD, 2015). As with the participation index, it can be divided into two components further, the length of international and domestic value chains, respectively. Theoretically, a larger number of international value chains can be explained by the intensive use of foreign inputs and a larger number of domestic value chains typically refers to the abundant use of domestic inputs in a simple chain (OECD, 2015).

In Figure 2-6, the trend in New Zealand's average length of GVCs has been relatively stable. Compared with other countries such as the U.S., UK, Japan, and Australia in the comparison group, New Zealand has a somewhat more extended length of GVCs. Besides, the domestic value chain is much longer than the international part in all countries considered. It represents an intensive usage of domestic inputs in the production. Meanwhile, it can be noted that the overall length of GVCs has shortened slightly in the U.S., UK, and Australia from 1995 to 2009. It can be partly explained by the declining number of production-sharing activities across national borders.

As highlighted in Degain *et al*. (2017), the reduced number of national border crossings for production is found to be closely associated with three patterns. First, the recently rising protection in trade after the global financial crisis has depressed cross-border transactions. Second, several emerging developing countries, such as China, have seen a substitution of domestically produced intermediate inputs for imported intermediate inputs to optimise their production structure. Third, technological innovation and reshoring around the globe have deepened the domestic division of labour for major developed economies, such as Japan and the U.S. As a result, the number of fragmentation stages has shortened in some countries.

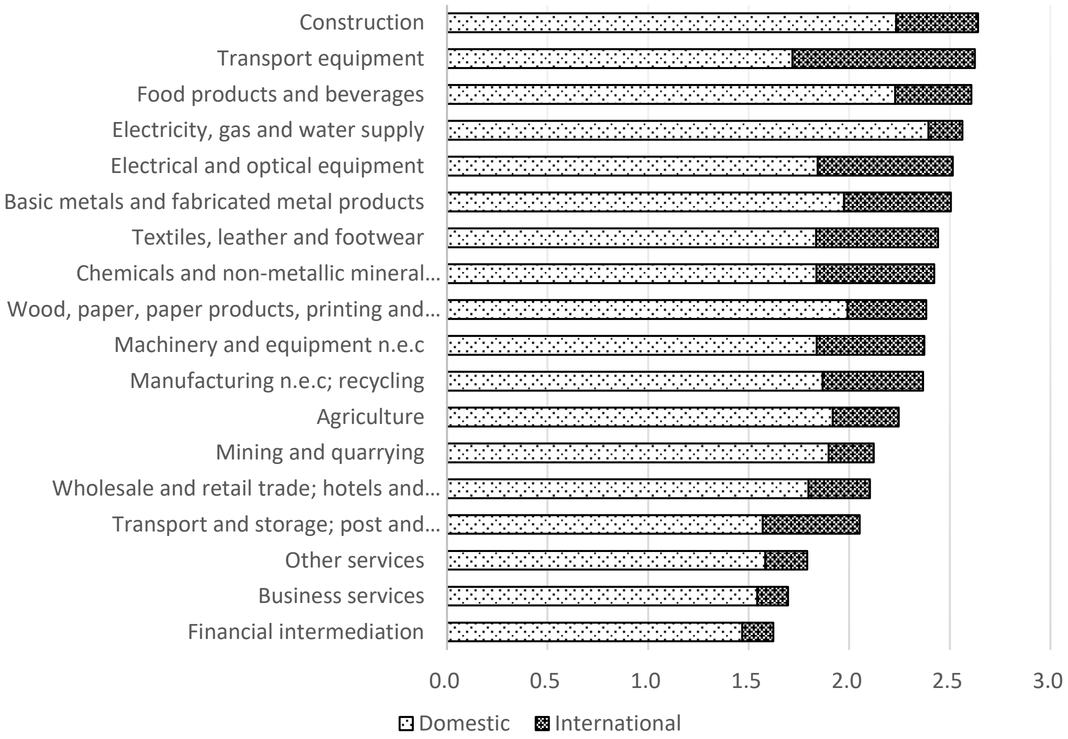
Figure 2-6 Average length of GVCs, 2009



Source: OECD-WTO TiVA database. Author's compilation.

Figure 2-7 presents more evidence on New Zealand's length of GVCs at the industry level. It can be seen that industries with the longest GVCs include the construction, transport equipment, food products and beverages, electricity, gas and water supply, electrical and optical equipment sector. In contrast, services such as the financial intermediation, business services, and transport and storage, post and telecommunications sector have the shortest value chains on average. These differences are influenced by the nature of these industries so that agricultural and manufacturing products are often easier to be fragmented than services (De Backer and Miroudot, 2013). Therefore, the fragmentation of agricultural and manufacturing production processes appeared to be relatively longer.

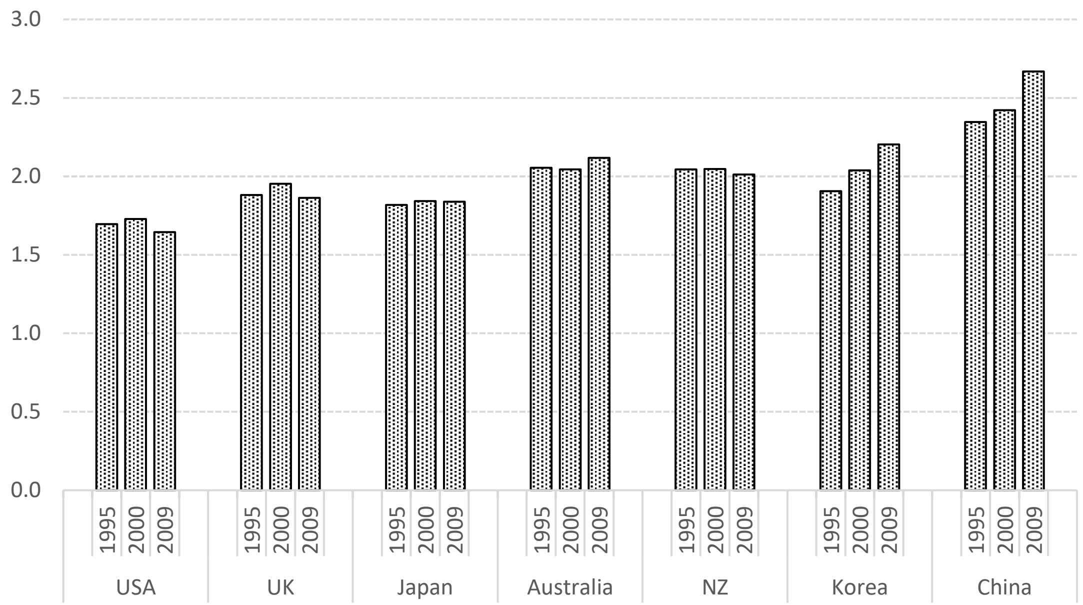
Figure 2-7 New Zealand length of GVCs across industries, 2009



Source: OECD-WTO TiVA database. Author's compilation.

Other than the length of GVCs, we also explore the position of New Zealand in GVCs using the distance to final demand index introduced by Fally (2011) and Antràs *et al*. (2012). In doing so, we can identify how close New Zealand is to the final consumers. As presented in Figure 2-8, New Zealand appeared to have a shorter distance to final demand compared with Korea and China. In the meanwhile, its distance to final demand has decreased marginally between 1995 and 2009, suggesting that New Zealand tends to specialise in goods and services more downstream, such as in the processing and services sector.

Figure 2-8 Average distance to final demand, 2009

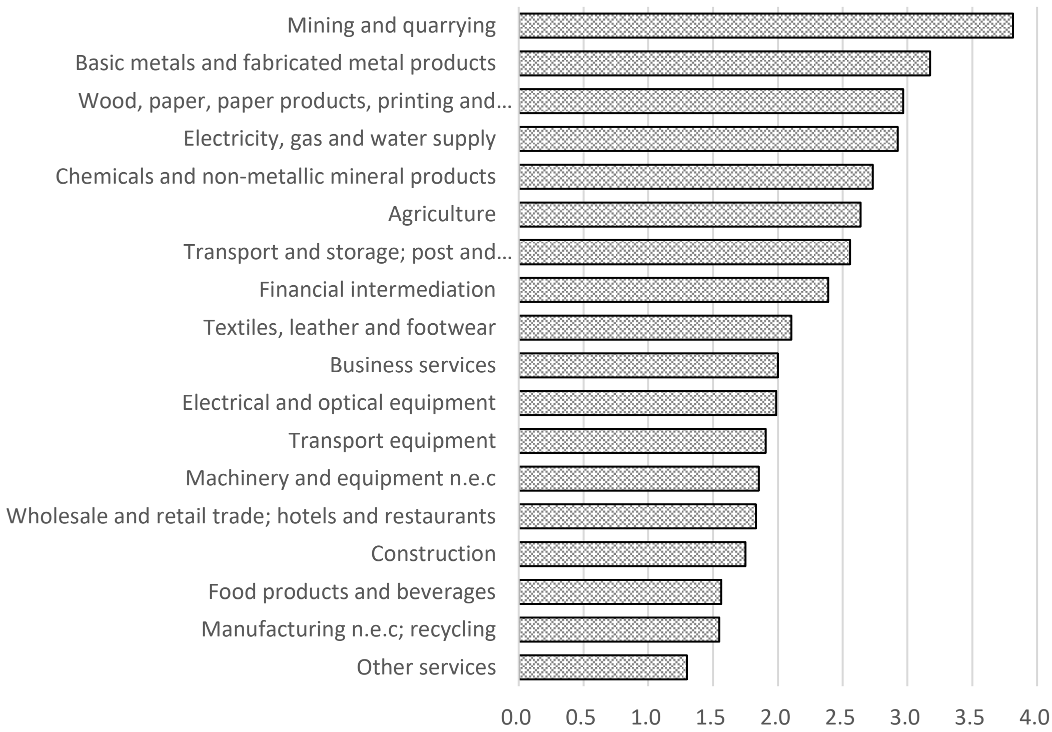


Source: OECD-WTO TiVA database. Author's compilation.

Further, Australia, Korea, and China all have experienced an increase in their distance to final demand. It indicates that these countries are now more specialised in the production of inputs at the beginning of the value chain. This pattern is often closely associated with the overall increase in the length of GVCs and the outsourcing phenomenon. That is, value-added is likely to move back to the industries supplying intermediate inputs when the production of some inputs is outsourced. As a consequence, the distance to final demand increases (De Backer and Miroudot, 2013).

At the industry level, New Zealand's manufacturing, recycling, food products and beverages, and the construction sector show a relatively shorter distance to final demand (see Figure 2-9). In comparison, the mining and quarrying, basic metals and fabricated metal products, wood, paper, paper products sector have the longest distance to final demand. In other words, these sectors are more involved in the initial stages of the production process (upstream) and further away from final consumers.

Figure 2-9 New Zealand's distance to final demand across industries, 2009



Source: OECD-WTO TiVA database. Author's compilation.

2.4. Methodologies and data

As discussed in previous sections, the analysis of GVCs is critical for understanding the international creation and distribution of value and resources, as well as the capacity of countries to prosper in an increasingly independent trade environment. Therefore, this section develops empirical methodologies helping identify the main drivers of GVCs, which is a subject that has not been fully investigated yet.

2.4.1 Methodologies

The empirical methodologies adopted in this chapter builds upon the recent literature on the panel data analysis in Adkins and Hill (2008). The fixed effects (FE) estimator is adopted as the main analytical model, which is a common approach for estimating panel data (Cameron and Trivedi, 2009).

To describe the general approach, this chapter considers a linear model with five groups of explanatory variables:

$$y_{it} = \alpha_i + \beta_1 M_{it} + \beta_2 D_{it} + \beta_3 T_{it} + \beta_4 INS_{it} + \beta_5 INF_{5,it} + u_{it} \qquad (2.1)$$

$$u_{it} \sim IIN(0, \sigma_{it}{}^2)$$

where y_{it} is the dependent variable of concern- country i's GVC participation index; βs are the vector of coefficient. M_{it}, D_{it}, T_{it}, INS_{it}, and INF_{it} are the individual effects that capture the effects of the i^{th} country-specific variables that vary over time. u_{it} is the error term, independently and identically distributed with zero mean and $\sigma_{it}{}^2$ variance. Precisely, M_{it} includes a set of variables representing the macroeconomic development in a country, including GDP growth rate (*gdp*), population growth (*population*), inflation (*inflation*), unemployment rate (*unemployment rate*).

D_{it} represents a few variables capturing the country's potential of technological development. It includes *FDI inflows, labour productivity*, and *R&D*. T_{it} refers to three factors directly influencing countries' trade costs, such as *tariffs* and *taxes*; INS_{it} denotes three institutional variables including *judicial institution*, *credit availability*, and *corruption perception*. It is hypothesised that judicial institutions and the country's perception of corruption can impact the quality of contract enforcement that are critical to setting up a supply chain. Similarly, *credit availability* is expected to directly influence the development in GVCs by supporting businesses particularly those SMEs trade in the international market. INF_{it} denotes a group of variables capturing a country's development in the transportation (i.e. *logistics performance*) and *port infrastructure*.

Allowing the errors u_{it} in model (2.1) to be correlated with the regressors, we have a limited form of endogeneity. This gives us a fixed effects (FE) model:

$$Y_{it} = \beta_1 M_{it} + \beta_2 D_{it} + \beta_3 T_{it} + \beta_4 INS_{it} + \beta_5 INF_{it} + u_{it} \qquad (2.2)$$

$$u_{it} = \mu_i + \lambda_t + \nu_{it}, \text{ or } u_{it} = \mu_i + \nu_{it}, \text{ or } u_{it} = \lambda_t + \nu_{it}$$

$$v_{it} \sim IID(0, {\sigma_{it}}^2)$$

Note that the fixed intercept α is not explicitly included in equation (2.2). Instead, α is subsumed under the error components. Therefore, Y_{it} is assumed to be a function of exogenous variables, $M_{it}, D_{it}, \dots \dots, INF_{it}$. In comparison to model (2.1), this FE model (2.2) controls for all time-invariant differences between the individual countries, so the estimated coefficients of the models cannot be biased due to omitted time-invariant characteristics.

2.4.2 Data

Due to the limited data available at the sectoral level, this chapter focuses on a country- and a broad sector-level analysis. The final dataset used for estimation is only the participation index, which is collected from the OECD-WTO TiVA Database. According to Fally (2011), the value of the other two indicators (i.e. length and distance to final demand) is often proportional to the actual number of production stages, therefore dependent on the number of sectors included in the analysis. Due to this reason, they are not considered in the estimation part as we expect their tiny variations across countries may not lead to significant estimates.

Since there were missing values in a few variables, imputation strategies are adopted to create the final balanced dataset. This gave us a total of 245 observations which contains the data of 34 OECD members and four non-OECD economies in five discrete years, 1995, 2000, 2005, 2009 and 2011. This comparatively broad country coverage allows us to assess countries with various level of development and from various geographical regions. Appendix A presents a list of the countries covered in the dataset. Full sources of data are shown in Appendix B.

2.5. Empirical results

Our estimation begins with an explanation of the estimated baseline models using all underlying variables considered in equation (2.1). Appendix C presents the descriptive statistics for the variables included in models. Table 2-1 shows the estimated results from the FE models in different cases. For instance, model (1) and (2) estimate the impacts of covariates on the primary sector's backward and forward GVC participation while model (3) and (4) use the manufacture sector's backward and forward GVC participation as the dependent variables for estimation.

In addition to those commonly used variables in each model, which are assumed to be homogeneous in different sectors of one economy due to data unavailability, *labour productivity* and *tariffs* particularly capture the characteristics of both the primary and the manufacturing sector. Therefore, labour productivity and tariffs in models (1)-(2) and models (3)-(4) represent labour productivity and tariffs of the primary sector and of the manufacturing sector, respectively. Overall, there is a considerable proportion of factors influencing GVC participation differently compared with how they are found to influence trade flows and activities in prior literature such as Carrere (2006). In the following sub-sections, the estimated impact of each variable is explained in detail.

Macroeconomic factors

In Table 2-1, OECD countries' *GDP growth*, *population growth*, *inflation*, *unemployment* and *GFC* dummy are captured to represent the consequences of various macroeconomic factors on GVC participation. Specifically, *GDP growth* appears to have a statistically significant effect on the GVCs participation in model (1) and (2) when explaining the decrease in the primary GVC participation. For instance, the negative coefficient of -0.009 in model (1) suggests that one per cent increase in GDP growth tend to decrease the backward participation of the primary sector by 0.009 per cent.

The above observation is consistent with the recent patterns discovered in a few major developed countries such as the U.S. and Japan. In these countries, there was a consolidation of their production fragmentation, following the global financial crisis (WTO, 2017). According to De Backer and Miroudot (2013), the disruption of some value chains was largely influenced by the increasingly stringent access to trade finance and higher transactions costs due to the uncertainties associated with the supply of some inputs.

In contrast, there is a significantly positive impact of GDP growth on the manufacture GVC participation in model (3) and (4), suggesting that each one per cent increase in GDP growth increases manufacture GVC participation by at least 0.141 per cent in model (4). In other words, this indicates that countries with a higher level of development are more likely to participate in manufacturing trade compared with primary products trade. This finding is consistent with the nature of primary products, that is, its production can hardly be sliced up into a large number of stages compared to the manufacturing production. In addition, given the trade composition of most OECD countries, the manufacturing sector has been the major participant in GVCs across countries. Therefore, countries with a higher level of development tend to participate frequently in manufacture GVCs.

Further, we have evidence revealing that there is a negative relationship between countries' population growth and GVC participation across all models. In particular, population growth decreases manufacture forward participation significantly with an estimate of -1.280 per cent in model (4). It suggests that countries with a large population tend to participate less in GVCs compared with those with a small population. This finding is in accordance with the participation of the small open economies observed in previous sections and consistent with the findings of Kowalski et al. (2015). That is, small countries with limited resources appear to participate more in intermediates trade than those with a larger economy and population as those small economies can hardly produce every input required at a competitive cost.

However, there is no clear evidence suggesting that inflation has a significant impact on both primary and manufacture GVC participation as it influences trade flows. As regards unemployment, we expect that there is a negative association between the unemployment rate and GVC participation since a soar in unemployment may represent a constriction in the sector's constriction. This will not help countries' production and exports, thereby weakening GVC forward participation particularly. According to the results, there is evidence in model (2) and (4) showing that unemployment encourages both primary and manufacture forward participation as expected. In particular, manufacture forward participation decreases by 0.242 per cent when unemployment goes up by one per cent. In other models when backward participation is used as the dependent variable, however, the estimated coefficient of the unemployment rate is not statistically significant.

FDI, productivity and R&D

FDI, productivity and R&D are found to be the key drivers of international trade development, as illustrated in literature such as Kimura and Kiyota (2006). We expect these factors may have a similar impact on GVCs participation. Surprisingly, the estimated results in Table 2-1 suggest that *FDI inflows* appear to have a mixed influence on GVC participation across models (1)-(4). Specifically, the estimated coefficient of

FDI inflows in model (3) and (4) is found to be statistically significant. In model (4), one per cent increase in FDI inflows increases manufacture forward participation by 0.091 per cent. This finding is consistent with prior hypotheses and the positive impact of FDI on trade, suggesting that FDI inflows are one of the critical factors facilitating countries' domestic manufacturing production as well as exports.

Further, there is some evidence suggesting that *labour productivity* improves primary forward participation only in model (2) of Table 2-1. This indicates that countries with a higher level of productivity are able to produce and export more primary products to be used in foreign production. In comparison, there is strong evidence showing that *R&D* affects primary and manufacture GVC participation differently. For example, model (3) and (4) show that the growth in *R&D* is positively associated with manufacture participation while negatively explains primary participation in model (1) and (2).

The above finding is a bit surprising since R&D is expected to facilitate a country's comparative advantage and encourage production and exports expansion (Hejazi and Safarian, 1999). This impact is expected to be true in both the primary and manufacturing sector. Therefore, the negative coefficient of R&D in model (1) and (2) can partly be explained by an alteration in the country's production composition as a result of R&D growth. In other words, countries with large spending on R&D are likely to have enhanced manufacture production and therefore are able to move up their position at the GVCs. Eventually, the country's primary GVC participation will be weakened.

Trade costs

In this chapter, trade costs consider import tariffs and taxes on trade. According to the results in Table 2-1, we have evidence showing that these factors all negatively influence GVC participation in both sectors. For instance, tariffs are found to significantly discourage manufacture forward GVC participation by 0.657 per cent when import tariffs rise by one per cent in model (4).

In comparison, the consequences of increased import tariffs are less significant in model (1) and (2) with a moderate decrease of 0.002-0.008 per cent in the primary sector's GVC participation. This distinction can be partly illustrated by the different level of price elasticity both primary and manufacture products have. It is often the case that primary products are less sensitive to changes in prices caused by fluctuations in tariffs because they are often directly consumed and tend to be normal goods. In contrast, manufactured products especially those manufactured parts/components which are often traded as inputs for further production. Therefore, an increase in their tariffs would be a huge burden for the sector and greatly increase their costs of production.

In terms of taxes on trade, model (1) and (3) of Table 2-1 presents estimates indicating that both primary and manufacturing backward participation can negatively be affected by an upward trend in taxes. This finding is in accordance with our expectations and confirms the sensitivity of GVC participation to fluctuations in trade costs.

Institutional factors

Two institutional factors are captured in models (1)-(4) as underlying determinants of GVC participation. They are hypothesised to impact the quality of contract enforcement that is critical to setting up a supply chain. Overall, the estimated consequences of these institutional factors are found to be positive across the primary and the manufacturing sector. For instance, we have strong evidence confirming that there is a consistently positive relationship between *credit availability* and GVC participation across models (1)-(3). Given the estimates, countries tend to participate more particularly in manufacture backward participation if there is more credit available to facilitate the country's trade activities. In model (3) of Table 2-1, manufacture backward participation increases by 0.684 per cent if the score of getting credit increases by 1. Similarly, the country's corruption perception is found to be another stimulus of GVC participation across all models except model (4). In model (3), every one score of improvement in the corruption perception is likely to increase manufacturing backward GVC participation by 2.244 per cent. These findings greatly confirm the importance of credit availability and the removal of corruption in countries' further development in GVC participation.

Infrastructure

In this chapter, countries' *logistics performance* and the score of *port infrastructure* are used as proxies of trade facilitation. Given the results, both factors tend to have a positive influence on GVC participation. However, it appears to be the case that the primary GVC participation is more likely to be affected by the changes in logistics performance and port infrastructure than the manufacturing GVC participation. For instance, one score up in the country's logistics performance is likely to increase the share of foreign inputs in their domestic production by 0.320 per cent, given the estimates in model (1). In contrast, the impacts on primary forward and manufacture GVC participation are statistically insignificant even though they have an expected sign of coefficient in models (2)-(4).

In addition, port infrastructure is found to be positively associated with GVC participation, particularly with the primary sector. According to the results, countries with a higher score of port infrastructure appear to participate more in GVCs since primary products are more sensitive to the performance of transportation-related infrastructures in a location, which can directly influence the quality and freshness of their primary products. On the contrary, the improvements in infrastructure do not encourage manufacture GVC participation significantly since manufacture products are less sensitive to the changes in weather and transportation conditions.

Table 2-1 Estimated results: Fixed Effects (FE) estimators

Variables	Primary Backward (1)	Primary Forward (2)	Manufacture Backward (3)	Manufacture Forward (4)
Macroeconomic factors				
GDP growth	-0.009 (0.071)*	-0.007 (0.000)***	0.308 (0.026)**	0.141 (0.070)*
Population	-0.042 (0.117)	-0.002 (0.784)	-0.749 (0.331)	-1.280 (0.003)***
Inflation	-0.000 (0.926)	0.000 (0.761)	0.039 (0.550)	-0.021 (0.563)
Unemployment rate	0.001 (0.921)	-0.002 (0.075)*	0.146 (0.336)	-0.242 (0.005)***
FDI, Productivity and R&D				
FDI inflows	-0.001 (0.516)	-0.001 (0.171)	0.011 (0.854)	0.091 (0.006)***
Labour productivity	0.021 (0.140)	0.010 (0.005)***	-0.608 (0.132)	-0.097 (0.666)
R&D	-0.176 (0.000)***	-0.040 (0.000)***	1.928 (0.005)***	1.171 (0.002)***
Trade costs				
Tariffs	-0.008 (0.008)***	-0.002 (0.022)**	0.341 (0.255)	-0.657 (0.000)***
Taxes	-0.025 (0.078)*	-0.004 (0.303)	-0.759 (0.089)*	0.257 (0.304)
Institutional factors				
Credit availability	0.021 (0.007)***	0.008 (0.000)***	0.684 (0.002)***	0.007 (0.957)
Corruption perception	0.063 (0.000)***	0.013 (0.001)***	2.244 (0.000)***	0.260 (0.302)
Infrastructure				
Logistics performance	0.320 (0.000)***	0.011 (0.468)	2.408 (0.153)	1.474 (0.119)
Port infrastructure	0.135 (0.000)***	0.020 (0.009)***	0.280 (0.736)	0.302 (0.518)
Constant	0.533 (0.012)	0.070 (0.176)	42.401 (0.000)	19.017 (0.000)
N	245	245	245	245
F-test (model)	35.24	15.84	46.21	56.27
Degree of Freedom	192	192	192	192
SSE	2.454	0.2964	1447.443	311.266
Root MSE	0.113	0.03929	2.7459	1.2733
Effect test (country)	29.48***	8.53***	41.19***	64.87***
Adjusted R-squared	0.8795	0.7597	0.906	0.922

Note: P-value are reported in parentheses; ***P < 0.01, **P < 0.05, and *P < 0.1.

2.6. Robustness

To further ensure the robustness of the estimates, this section discusses the potential sources of endogeneity issues in prior baseline models and adopts appropriate methodologies to improve the models. During the process of estimation, endogeneity is a common issue occurring when a variable, observed or unobserved, that is not included previously, but indeed is related to a variable we incorporated in our model. This may lead to biased and inconsistent estimates.

For instance, it is likely that GVC participation and unemployment are determined simultaneously. This may violate the assumption that error terms are uncorrelated with observed variables. To deal with the potential endogeneities caused by this simultaneous causality, this section further employs the Instrumental Variable (IV) estimator by including a dummy variable representing the presence of the global financial crisis (GFC). This instrument equals one for all observations in 2008 and 2009 and equals zero, otherwise. In a recession led by the GFC, aggregate demand often falls significantly leading to a decline in output. Therefore, firms will employ fewer workers because they are required to produce fewer products. As a result, GVC participation can be affected.

After incorporating the IV estimator, the results shown in Table 2-2 indicate that the null hypothesis that *GFC* is a weak instrument is rejected given the high F-statistics. It suggests that *GFC* is a significant instrumental variable for unemployment and the use of IV estimator helps improve the estimates. Specifically, most coefficient signs remain consistent with the estimates in Table 2-1. On the one hand, the results given by models (1)-(4) confirm that *labour productivity, R&D, credit availability, logistics performance* and *port infrastructure* are the most significant drivers of the primary sector's GVC participation. As regards the manufacturing sector, corruption perception also plays a critical role in help countries participating in GVCs in addition to those factors significantly influencing that of the primary sector. On the other hand, variables such as *GDP growth, population,* and *taxes* tend to depress the international fragmentation of production and consolidate global chains of production.

Table 2-2 Robustness: IV estimator

Variables	Primary Backward (1)	Primary Forward (2)	Manufacture Backward (3)	Manufacture Forward (4)
Macroeconomic factors				
GDP growth	0.000 (0.934)	-0.004 (0.017)**	0.143 (0.217)	-0.006 (0.018)**
Population	-0.045 (0.443)	-0.004 (0.876)**	-3.918 (0.024)**	-0.750 (0.048)**
Inflation	-0.001 (0.595)	-0.001 (0.158)	0.040 (0.341)	-0.014 (0.502)
Unemployment rate	0.007 (0.717)	0.002 (0.744)	-0.960 (0.070)*	-0.390 (0.063)*
FDI, Productivity and R&D				
FDI inflows	-0.001 (0.361)	-0.000 (0.681)	-0.064 (0.140)	0.004 (0.848)
Labour productivity	0.008 (0.313)	0.006 (0.064)*	-0.051 (0.830)	0.015 (0.904)
R&D	0.041 (0.075)*	0.029 (0.029)**	0.943 (0.495)	1.919 (0.007)***
Trade costs				
Tariffs	-0.003 (0.307)	-0.002 (0.218)	0.098 (0.305)	-0.035 (0.473)
Taxes	-0.010 (0.397)	-0.010 (0.040)**	-2.247 (0.000)***	-0.257 (0.043)**
Institutional factors				
Credit availability	0.000 (0.057)*	0.000 (0.067)*	0.000 (0.957)	0.008 (0.018)**
Corruption perception	0.041 (0.191)	0.005 (0.709)	0.352 (0.001)***	0.230 (0.024)**
Infrastructure				
Logistics performance	0.032 (0.021)**	0.045 (0.005)***	4.093 (0.117)	0.208 (0.876)
Port infrastructure	0.001 (0.990)	0.006 (0.024)**	0.912 (0.017)**	0.889 (0.299)
Constant	0.547 (0.334)	0.041 (0.856)	2.957 (0.189)	12.070 (0.157)
N	245	245	245	245
Instrument	GFC	GFC	GFC	GFC
rho	0.896	0.770	0.903	0.860
corr(u_i, Xb)	-0.339	-0.568	-0.585	-0.239
F-test (model)	24.000	5.440	23.160	24.420
R Squared (within)	0.055	0.235	0.258	0.130

Note: P-value are reported in parentheses; ***P < 0.01, **P < 0.05, and *P < 0.1.

2.7. Conclusion and policy implications

This chapter has investigated New Zealand's past participation in GVCs. According to our findings, New Zealand has experienced a marginal increase in GVCs participation with many fluctuations from 1995 to 2011. However, this growth was far below that of the most OECD countries. This partly reveals New Zealand's trade disadvantages stemming from its remote geographical distance to the rest of the world and limited market size and demand.

At the industry level, the food products, beverage, and tobacco sector were the most active participants in GVCs through importing a large amount of foreign intermediate products. In contrast, the manufacturing sector was strongly dependent on domestic supply chains with fewer overseas value-added content in production. In addition, there was no significant gap between the country's foreign (forward) and domestic (backward) value-added participation in GVCs. Both participations are found to be underdeveloped, compared with the other OECD countries.

In addition, this chapter has identified the critical determinants of OECD countries' GVCs. According to the results, most determinants have a diverse impact on the backward and forward participation as well as on the primary and the manufacturing sector. As regards the primary sector, the most significant drivers of GVCs include productivity, credit availability, corruption perception, logistics performance, and port infrastructure. In contrast, GDP growth and R&D have a significantly negative impact on the primary sector's participation while a positive influence on the manufacture sector's participation. This distinction suggests that countries with a higher level of development and larger R&D investment are more likely to enhance their manufacture trade participation in GVCs compared to those which are less developed. In addition, factors such as population growth and taxes are found to be the common impediments of GVC participation across different sectors.

Other than the preceding observations on the determinants, this chapter has some extra implications for the country's future participation in GVCs. For instance, simply targeting a higher GVCs participation could be inefficient for New Zealand. The appropriate level of participation may depend on the position (i.e. upstream or downstream) that a country within GVCs. Given the fact that dependency on foreign intermediates may not help deal with sudden exogenous shocks, the policy aim for New Zealand should be lifting domestic value-added and moving up the value chain. In doing so, greater returns will be gained using those domestically produced factors of production (such as labour, land, and capital).

Finally, it is necessary to mention that this chapter has some limitations. For example, it focused on a broad sectoral level analysis of GVCs due to the limited size of observation. Meanwhile, only a limited range of factors have been considered in the estimation, as the disaggregated data and indicators of trade in value-added remain scarce in many countries. It is believed that more research, such as on finding an optimal way to maximise returns from both forward and backward GVCs participation and shift away from commodities to higher value-added products, can be done once the data becomes available in the coming decade.

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Appendices

Appendix A Countries considered

OECD (34)		Non-OECD (4)
Australia	Italy	Brazil
Austria	Japan	China
Belgium	Korea, Rep.	Costa Rica
Bulgaria	Latvia	Lithuania
Canada	Luxembourg	
Croatia	Netherlands	
Cyprus	New Zealand	
Czech Republic	Norway	
Denmark	Poland	
Estonia	Portugal	
Finland	Slovak Republic	
France	Slovenia	
Germany	Spain	
Greece	Sweden	
Hungary	Switzerland	
Ireland	United Kingdom	
Israel	United States	

Appendix B Definition and data sources

Variable	Definition	Source
Ptc	Participation Index, percent	OECD-WTO TiVA Dataset
Ptc_bkw	Backward participation, percent	OECD-WTO TiVA Dataset
Ptc_fwd	Forward participation, percent	OECD-WTO TiVA Dataset
GDP growth	GDP growth rate, output approach	OECD. Stat
Population	Population growth (annual %)	World Bank
Inflation	Inflation, consumer prices (annual %)	World Bank
Unemployment	Unemployment, total (% of total labor force) (national estimate)	World Bank
FDI inflows	Inward FDI flows, US$ millions	OECD. Stat
Labour Productivity	Labour productivity, annual change, percent	OECD. Stat
R&D	Business enterprise R&D, US$ dollar, PPP dollars, current prices	OECD. Stat
Tariff	Tariff rate, applied, weighted mean, all products (%)	World Bank
Taxes	Taxes on international trade (% of revenue)	World Bank
Credit availability	Domestic credit to private sector (% of GDP)	World Bank
Corruption perception	The CPI scores and ranks countries/territories based on how corrupt a country's public sector is perceived to be by experts and business executives.	Transparency International
Logistics performance	Logistics performance index: Quality of trade and transport-related infrastructure (1=low to 5=high)	World Bank
Port infrastructure	Quality of port infrastructure (1=extremely underdeveloped to 7=well developed and efficient by international standards)	World Bank

Appendix C Summary statistics (n=245)

Variable	Mean	Std. Dev.	Min	Max
Participation_primary	0.64	0.37	0.10	2.30
Primary_backward	0.40	0.33	0.00	1.80
Primary_forward	0.24	0.08	0.10	0.50
Participation_manufacture	35.01	9.12	13.00	59.10
Manufacture_backward	19.47	8.95	4.70	45.00
Manufacture_forward	15.54	4.55	6.40	29.90
GDP growth	1.98	3.94	-14.43	11.11
Population	0.59	0.75	-2.08	2.67
Inflation	4.23	7.81	-4.48	89.11
Unemployment	7.90	3.90	1.94	22.67
FDI inflows	5.60	9.21	-15.84	73.53
Labour productivity	-0.30	1.28	-6.89	6.60
R&D	1.76	0.97	0.26	4.33
Tariff_all	3.81	2.36	2.12	17.97
Tariff_primary	8.90	6.51	1.37	39.94
Tariff_manufacture	2.91	2.30	0.34	17.89
Taxes	1.19	1.36	-0.02	10.29
Credit availability	11.22	2.70	4.00	16.00
Corruption perception	6.88	1.92	3.00	10.00
Logistics performance	3.55	0.50	2.52	4.34
Port infrastructure	5.08	0.95	2.62	6.67

Chapter 3 Modelling New Zealand Horticulture Import Survival

3.1. Introduction

Trade is a significant factor influencing people's standard of living and a country's potential to become a more vibrant economy. These impacts encourage policymakers around the world searching for strategies to enhance their trade positions at the international market. However, gains from trade cannot always be secured if trade relationships indeed have short longevity. For example, one potential benefit from trade, in the long run, is productivity growth (Gustafsson and Segerstrom, 2010; De Loecker, 2011; Fleming and Abler, 2013). Unfortunately, such growth is unlikely if trade relationships are fragile and only last for a few discrete years.

In addition to this long-term impact, exporters and importers may also be directly affected by short-run fluctuations in trade relationships. For instance, a sudden relationship breakdown could be an unexpected loss for businesses who are keen to gain from ongoing export arrangements. Meanwhile, these unstable and short-lived trade relationships may also threaten the food security of importing countries. As for these importers, how to improve their trade policies and strategies to secure a stable food supply for their domestic market is critical.

In New Zealand, horticulture is one of the steadily growing sectors in terms of imports. As some fruit and vegetables do not grow in the country, there is always a demand for horticulture imports (Horticulture New Zealand, 2017). Based on the statistics collected from UN Comtrade Database, the country's total imports of fresh fruit and vegetable has tripled from between 1989 and 2019. However, this growth is unable to reveal the survival of trade relationships at the disaggregate commodity level.

Given New Zealand's unique geographical location, exploring the survival of trade relationships is crucial to both the industry and the country's development in the long-run. Without a good understanding of how trade relationships performed in the past, small importing countries such as New Zealand are ill-prepared for any future trade failure. This could impose extra costs to both New Zealand and its trading partners.

In a broader context, identifying the primary drivers causing a sudden relationship breakdown will help countries reduce the adverse effects of global demand and supply shocks. As trade interruption is often associated with upward fluctuations in importing country's food prices, the items in the households' consumption basket could be directly affected. Further, this may lead to an unbalanced diet and harm national food security in the long-term. As for global horticulture exporting countries and businesses, export failure means that their income from trade, local producers' incentives to export in the future, and the cost of re-entry would be severely impacted.

Given the above context, this chapter examines the longevity of New Zealand fresh fruit and vegetable imports and identifies the major factors affecting import survival. It contributes to the literature and practical implications in various ways. First, it is the first study on the duration and survival of New Zealand import relationships for fresh fruit and vegetables. It will help not only New Zealand's trade partners but also other countries in the world to enhance trade survival by learning additional information about their destination markets' demand and regulations.

Second, it is one of the first studies that empirically assesses the trade consequences of New Zealand Import Health Standards (IHS) and their relevant sanitary and phytosanitary (SPS) treatments. According to the latest Economic Freedom Index reported by Fraser Institute (2020), New Zealand has the third freest trade market in the world. The average applied tariff rate in New Zealand was 1.4 per cent, and 243 non-tariff measures were in force in 2019. However, it is unclear whether those SPS treatments imposed by New Zealand are a significant impediment of imports as with many other countries which do not have such a free market. Therefore, this chapter aims to fill the literature gap by investigating the potential impact of SPS treatments on import survival. A better understanding of this impact will help both New Zealand and other countries achieve a sound balance between national food security and free trade by reducing the burdens to foreign suppliers caused by unnecessary non-tariff barriers.

The remainder of this chapter is organised as follows. Section 3.2 provides a review of prior studies on trade duration and survival. Section 3.3 presents an overview of the industry and introduces the relevant regulations impacting fresh fruit and vegetable imports. Section 3.4 describes the empirical strategies for estimation and relevant data sources. Section 3.5 presents and analyses the estimated results based on the preferred models. Section 3.6 concludes with a summary of the results and a discussion of the policy implications.

3.2. Literature review

The global literature on trade duration and survival has rapidly emerged since 2000. Most empirical studies have found evidence that trade relationships are indeed short-lived. For instance, early contribution includes Besedeš and Prusa (2006), which indicated that most the import relationships of the U.S. were rather short-lived. This finding is later confirmed by several studies, such as Cadot *et al*. (2013), Gullstrand and Perrson (2015), Peterson *et al*. (2017), and Fertő and Szerb (2018). These studies all presented evidence suggesting that trade relationships on average survived no more than three years at the product level.

However, there are some exceptions, such as in Wang *et al*. (2019). It found that ASEAN seafood exports survive longer than other commodities considered in prior studies. On average, these exports have a mean duration of more than four years. Besides, a few studies concluded slightly different outcomes for manufacturing trade relationships. For example, Obashi (2010) observed that trade relationships in machinery parts and components tend to be longer-lived, compared to that of the finished machinery products as the latter appears more sensitive to the fluctuations in trade costs and exchange rate. Given these findings, it is believed that the duration and survival of trade relationships are dependent on the nature of commodities.

Another strand of studies attempted to identify the major factors influencing the survival of trade relationships. Nitsch (2009) examined the effects of a comprehensive range of factors on German import survival. The results indicated that gravity variables, such as distance, GDP, language, and geographical location, have a similar impact on the duration of trade as they have on trade flows. Hess and Persson (2011) estimated EU imports from the rest of the world and found that export diversification substantially reduces the hazard of trade flows dying. Fertő and Szerb (2018) showed that the standard gravity determinants of the trade, such as market size, level of development, and trade costs affect both export values and duration.

A few recent studies also began to use micro-level data accessing the role of prior experience in the survival of trade relationships (Albornoz *et al*. 2012; Carrère and Strauss-Kahn, 2014; Araujo *et al*., 2016; Padmaja and Sasidharan, 2017). These studies confirmed that prior export experience helps increase the probability of survival upon entry. However, Lawless and Studnicka (2018) found different results suggesting that experienced firms are more likely to fail while attempting to introduce new products to a market. Export experience in these studies is often measured by years of exporting.

Furthermore, a small strand of recent studies has started to focus on the effects of Sanitary and Phytosanitary (SPS) measures on trade. For instance, Liu and Yue (2012) assessed the consequences of SPS standards. They showed that the implementation of the EU Hazard Analysis Critical Control Point (HACCP) standard increases both the consumer welfare and the imports of orange juice. Also, Dal Bianco *et al*. (2016) argued that while SPS measures do not seem to restrict exports, and technical barriers have a varying impact on the world wine trade. More recently, Andersson (2019) examined the trade effect of private food standards and found that certification to GlobalGAP increases both the extensive and the intensive margin of trade. However, these studies did not focus on the duration and survival of imports. Only in Peterson *et al*. (2017), the authors attempted to estimate the effects of the U.S. SPS treatment requirements on import duration. Their results indicated that SPS measures, especially water treatments, have significantly persistent impacts on trade survival.

It can be summarised that survival studies on trade relationships have become popular in recent years. However, further evidence on the influence of policy-related determinants on agriculture trade survival remains scarce, due to the limited data availability of country-specific characteristics. In New Zealand, an underlying factor influencing the imports of fresh fruit and vegetable is the implementation of the Import Health Standards (IHS). In particular, the SPS treatments required by the IHS are of importance to minimise the biosecurity risks of fresh produce imports into New Zealand. Unfortunately, to the best of the authors' knowledge, no studies have ever examined their impacts on import survival. Given this literature gap, an empirical study focusing on the patterns and determinants of New Zealand horticulture import duration and survival is crucial. It would help enrich the existing literature and extend the scope of future studies on trade survival.

3.3. Duration of New Zealand fresh fruit and vegetable imports

Before investigating the duration patterns of New Zealand fresh fruit and vegetable imports, a few key terms need to be clearly defined. A 'trade relationship' is defined as an exporter-commodity pair relationship that a specific commodity being imported by New Zealand from one specific country/partner. A 'sequence' (equivalents to a '*spell*' in some studies such as Hess and Perrson (2012)) is the period with continuous imports of one specific commodity from a specific supplying country. Correspondingly, the duration (or the length) of a sequence refers to the counted number of years a foreign supplier has exported to New Zealand with non-zero import flows. Therefore, a relationship may involve multiple sequences of import, depending on its number of entries and exits at a market. Besides, trade relationships that occurred before 1989 are treated as 'left-censored' relationships as data before the year 1989 are unavailable in the UN Comtrade Database, which is the main data source used for our analysis.

Table 3-1 presents the distribution of trade relationship sequences over the period between 1989 and 2019, using the simple-counting approach. The results reveal that the New Zealand fresh fruit and vegetable imports exhibit some fragilities with a large number of multiple entries and exits during the period concerned. This observation is in line with prior literature such as Peterson *et al*. (2017) and our observations on Ireland's fresh fruit and vegetable imports between 1992 and 2019. The latter is summarised in Appendix B. The similarly small-sized and open economy is the reason of selecting Ireland as the comparator country. This can help us distinguish between the size and distance effect in deriving trade fragilities.

In the case of New Zealand, of the total 558 trade relationships observed, multiple entries with the number of sequences greater than or equal to two account for around 43 per cent. The remaining 57 per cent of the trade relationships have a single sequence. Also, it can be observed that approximately 7 per cent of the relationships attempted at least five times of entry. This indicates a presence of great fluctuations in the New Zealand import market and a large number of exporting countries had difficulties in maintaining their relationships with New Zealand.

Table 3-1 Distribution of survival sequences across fresh fruit and vegetable import market, 1989-2019

by Sequence			by Sequence Length					
No. of Sequences	*No. of Relationships*	*Share (%)*	*Length*	*No. of Sequences*	*Share (%)*	*Length*	*No. of Sequences*	*Share (%)*
1	320	57.3	1	621	58.1	17	9	0.8
2	109	19.5	2	147	13.8	18	1	0.1
3	55	9.9	3	64	6.0	19	2	0.2
4	30	5.4	4	37	3.5	20	3	0.3
5	23	4.1	5	38	3.6	21	3	0.3
6	16	2.9	6	17	1.6	22	2	0.2
7	5	0.9	7	12	1.1	23	2	0.2
Total	558		8	12	1.1	24	4	0.4
			9	10	0.9	25	3	0.3
			10	7	0.7	26	2	0.2
			11	5	0.5	27	5	0.5
			12	4	0.4	28	2	0.2
			13	3	0.3	29	1	0.1
			14	4	0.4	30	4	0.4
			15	5	0.5	31	36	3.4
			16	4	0.4			
						Total	1069	

Overall, these patterns could be a consequence of the relatively small-sized market of New Zealand. Therefore, the import of fresh fruit and vegetables does not build upon a robust and stable domestic demand. In addition, the high standards for imports regulated by the New Zealand government might have ruled out some imports of low quality. This further aggravates the fluctuations in the New Zealand market and directly influence the survival of fresh fruit and vegetable imports.

In contrast with New Zealand, Ireland is expected to have a relatively stable pattern in its imports, given its convenient access to European supplies. However, approximately 47 per cent of Ireland's trade relationships in fresh fruit and vegetables are found to have multiple sequences even though the number of relationships that Ireland had was four to five times larger than that of New Zealand (see Appendix B). This comparison further confirms the common presence of fragilities in trade relationships.

As regards the length of the sequence, we observe that these trade relationships are mostly of short length as around 72 per cent of the sequences survived no more than two years, given the results in Table 3-1. Of which 58.1 per cent only existed for one year over the period concerned. Furthermore, it can be seen that trade relationships with no interruption from 1989 to 2019 only account for 3.4 per cent of the total observed sequences. These observations are also consistent with Peterson *et al*. (2017) and the experience of Ireland's imports confirming that trade relationships have an overwhelming short duration.

This short-lived nature is partly influenced by the decision of re-entering the New Zealand market, which often depends on the cost differences between re-entry and staying. In other words, if foreign suppliers are productive enough to pay the entry costs, they are more likely to stay longer in a market even when their temporary losses are greater than the re-entry costs. However, due to the significant uncertainties in the offshore market, temporary costs may outweigh the benefits of staying in some cases. As a result, exporting countries may first choose to enter the market for testing and then to exit after learning that they will not be able to profit from further staying. This could be one of the reasons for the great fluctuations in the New Zealand fresh fruit and vegetable market.

Table 3-2 presents more evidence at the detailed commodity level. Clearly, New Zealand has large number of trade relationships and sequences in beans, garlics, and capsicums. In particular, the number of trade relationships in beans is larger than that of the other vegetables. There was a total of 30 countries exporting beans to New Zealand over time. Based on the production seasons summarised by The Produce Company Limited (2018), New Zealand vegetables such as beans, capsicums, peas, asparagus, and Brussel sprouts have a limited domestic supply in a few particular months so that the demand has to be partly satisfied by foreign suppliers (see Appendix A). It is likely that these uncertainties in supply could directly lead to the fluctuations in import duration.

As regards the length of sequences, lettuce, Brussel sprouts, cauliflowers and broccoli, and peas tend to survive longer than other vegetables. On average, these trade relationships had survived four to five years during the 1989-2019 period. One possible explanation could be the relatively stable consumption preference of New Zealand households toward cauliflower, lettuce and broccoli (Rush *et al*., 2019). This makes the import of these particular products more stable than those of the others.

In comparison with the fresh vegetables, fresh fruits are imported from a larger number of countries. The dominant products are dates, bananas, coconuts, and mangoes. This feature is closely associated with New Zealand's climate which varies from warm subtropical in the far north to cool temperate climates in the far south. Therefore, those tropical fruits are unable to be produced domestically with New Zealand's complex climate conditions. As a result, the number of trade relationships in these products is larger than that of the other products, representing a large demand in the New Zealand market.

Table 3-2 Distribution of survival sequences by commodity, 1989-2019

Fresh Vegetables	No. of Sequences	No. of Relationship	Av. Length	Fresh Fruit	No. of Sequences	No. of Relationship	Av. Length
<u>*Overall*</u>	<u>356</u>	<u>180</u>	<u>3.4</u>	<u>*Overall*</u>	<u>713</u>	<u>378</u>	<u>4.5</u>
070390 Leeks	15	7	1.7	081030 Currants and gooseberries	5	3	1.0
070190 Potatoes	10	5	2.0	081020 Raspberries and blackberries	13	8	1.2
070511 Cabbage and lettuce	7	2	2.1	081040 Cranberries and bilberries	25	12	1.6
070610 Root, carrots and turnips	14	4	2.4	080710 Melons and watermelons	25	14	3.4
070970 Spinach	23	9	2.4	080510 Oranges	28	18	3.4
070951 Mushrooms	29	12	2.4	080430 Pineapples	57	29	3.6
070820 Beans	53	30	2.8	080440 Avocados	5	4	3.6
070952 Truffles	11	9	3.1	080410 Dates	101	40	3.7
070320 Garlic	49	23	3.3	080810 Apples	16	10	3.7
070960 Capsicum	44	25	3.6	080920 Cherries	9	8	3.8
070310 Onions and shallots	17	11	3.8	080930 Peaches including nectarines	9	4	3.8
070920 Asparagus	16	9	4.0	080530 Lemons and limes	49	23	3.9
070200 Tomatoes	10	6	4.0	080720 Papaws	26	14	4.2
070700 Cucumbers and gherkins	9	8	4.4	080420 Figs	50	25	4.7
070810 Peas	29	11	4.5	080940 Plums and sloes	16	10	4.7
070410 Cauliflowers and broccoli	10	4	4.5	080910 Apricots	4	3	5.0
070420 Brussel sprouts	4	2	5.3	080450 Guavas and mangoes	74	34	5.1
070519 Lettuce	6	3	5.8	080520 Mandarins	18	10	5.1
				080300 Bananas	65	39	5.3
				080110 Coconuts	74	38	5.4
				080540 Grapefruit	10	7	7.0
				080820 Pears and quinces	12	9	8.5
				081010 Strawberries	7	6	8.9
				080610 Grapes	15	10	8.9

It is important to note that grapes, strawberries, pears and quinces, and grapefruit have the longest duration of survival on average. Their sequences survived seven to nine years over the period considered. In comparison, currant and gooseberries, raspberries, and cranberries and bilberries import are extremely short-lived with an average of no more than two years. These significant distinctions reveal not only the characteristics of fruit plantation in New Zealand but also the consumption preference of New Zealand citizens, which requires further analysis of their underlying causes to provide insights into stabilising and maintaining trade relations of New Zealand with other countries.

3.3. Empirical strategies and data

3.4.1. Discrete-time hazard model

This chapter extends the common estimator used with a discrete-time hazard model by incorporating an endogenous model approach to assess the underlying determinants of import survival.

In discrete-time hazard models, the terms 'discrete' captures the feature of observations that trade relationships tend to be discrete units of yearly length. Following Hess and Persson (2012) and Peterson *et al.* (2017), the probability of failure conditional on its survival up to the beginning of the interval can be defined as:

$$h_{ik} = P(T_i < t_{k+1} | T_i \geq t_k, x_{ik}) = F(x'_{ik}\beta + \gamma_k) \tag{3.1}$$

In the equation, we let h_{ik} be the discrete-time hazard rate in a set of discrete-time intervals $[t_k, t_{k+1}, t_{k+2}, \dots, t_{kmax}]$ and when $k = 1$, $t_k = t_1 = i$. T_i refers to a non-negative and continuous random variable that measures the survival time of the i_{th} trade relationship. The subscript i here denotes separate sequences of trade (exporter-product) relationships; $i = (1, \dots, n)$. x_{ik} is a set of time-varying covariates, such as

GDP, exchange rate, production, and import price; γ_k is then a function of time/interval that allows the hazard rate to vary across periods. $F(\cdot)$ refers to an appropriate distribution function that ensures $0 \leq h_{ik} \leq 1$ for all i, k. Since the baseline hazard rate is unknown in practice, γ_k is usually incorporated into the empirical model as a set of dummy variables identifying the duration of each sequence.

Introducing y_{ik} being a binary variable that takes the value one if sequence i is observed to terminate during the k time interval, and zero otherwise, therefore, the log-likelihood function for the observed observations can be given by:

$$ln\mathcal{L} = \sum_{i=1}^{n} \sum_{k=1}^{k_i} [y_{ik} \ln(h_{ik}) + (1 - y_{ik}) \ln(1 - h_{ik})] \quad (3.2)$$

To estimate the model parameters, it is necessary to specify a functional form for the hazard rate h_{ik}. Since equation (3.2) is similar to log-likelihood functions for a binary panel regression model, we adopt the *probit* estimator to represent a normal distribution hazard rate function. In addition, we assume that each sequence is independent of all other sequences as there might be multiple sequences and dependencies across commodities from the same supplier or across suppliers of the same commodity.

3.4.2. Factors

We assume that the conditional probability of import failure or exit is influenced by a set of factors representing both New Zealand's and its trading partners' characteristics. Broadly, these factors can be classified into nine distinct categories. The following baseline model specification is estimated:

$$y_{xit} = F(duration_{xit}, censoring_{xit}, multiple_{xit}, gravity_{xit}, supply_{xit},$$
$$food\ safety\ distance_{xit}, SPS\ treatment_{xit}, market_{xit}, credit_{xit} u_{xit}) \quad (3.3)$$

where the dependent variable y_{xit} equals one if country x terminates exporting commodity i to New Zealand in time t and zero otherwise, and u_{xit} denotes the unobservables. Precisely, *duration* is the number of years that the current sequence of the i_{th} trade relationship with country x has lasted in time t. It is expected that suppliers are most likely to fail in their early stage of exporting due to the high cost of market access and their relations will then be stable as time passes.

Since the earliest trade data available in the UN Comtrade Database is 1989 for most countries, we are not able to determine the actual duration of New Zealand imports. As censoring, especially those left-censored observations, is a major issue that may bias the estimates in survival analysis (Leung *et al*., 1997; Ranganathan and Pramesh, 2012), we capture this effect using a dummy variable *censoring*. It equals one if a particular trade relationship is identified as left-censored (i.e. existed in 1989) and equals zero otherwise. For a left-censored observation, we would expect that the hazard rate will be less affected by an extra year of service than the non-left-censored sequences of service.

multiple is another dummy variable indicating whether the imports have attempted multiple entries. It can be further decomposed into four dummies, including *seq_2*, *seq_3*, *seq_4*, and *seq_5*. We let, for instance, *seq_2* equals one if the importing activity is happened during the second sequence of a trade relationship and zero otherwise. As with *duration* and *censoring*, we hypothesise that trade relationships with multiple sequences are more likely to stay in the market compared with those relationships without prior experience.

The covariate *gravity* represents a set of gravity-type variables. It includes, for example, the natural logarithm of the geographical distance between the supplier's and New Zealand's capital city (*distance*). It also covers a common language dummy (*language*) that takes the value one if two partners have the same official language and zero otherwise; Common colonial history dummy (*colonial*) equals one if two partners have the same colonial history and zero otherwise; Free trade agreement dummy

(*FTA*) takes the value one if a supplier has FTA in force with New Zealand at sequence/time t. GDP per capita (*GDP*) of suppliers in thousands U.S. dollars. Bilateral real effective exchange rate (*reer*) represents the nominal exchange rate between New Zealand dollar and its trading partner's currency-adjusted by the respective consumer price indices; New Zealand annual import price index for a given product (*ipi*).

In the basic gravity model of international trade, trade between two countries is often modelled as an increasing function of their economic sizes and a decreasing function of the distance between them. In addition, factors such as trade integration agreements, national borders, language, and trade costs are also considered as the determinants of trade in the extended gravity models (Kepatsoglou *et al*, 2010). These variables are believed to be underlying drivers influencing trade survival as well.

Following the mainstream view in prior trade literature, this chapter hypothesises that those variables have a similar impact on trade survival as their influences on trade flows and volumes (Brun *et al*., 2005; Carrere, 2006; Lohmann, 2011; Egger and Larch, 2011; Sheldon *et al*., 2013). Specifically, the trade relationship is more likely to continue for a pair of countries with a large economic size, a mutually beneficial free trade agreement, same language, and colonial history. On the contrary, long geographical distance, depreciation of New Zealand dollars, and the increase in import prices are hypothesised to hamper New Zealand's demand for foreign products and disrupt import survival.

The covariate *supply* refers to three variables capturing the variations in the supply of a particular commodity. It first includes New Zealand's domestic production of a given commodity (*production*). It is believed that domestic production growth reduces the shortage in domestic supply and can directly discourage demand for imported commodities. In addition, *supply* also captures the total number of foreign suppliers of a given commodity (*origins*), and the number of markets to which a foreign supplier ships the given commodity (*destinations*). As a measure of foreign supply and import competition, *origins* and *destinations* are likely to have a distinct impact on import survival.

As regards *origins*, an increase in the total number of foreign suppliers of New Zealand might signal both a large demand in New Zealand for diversified foreign products and a potential trade instability due to the tough competition in the New Zealand market. Therefore, the impact of origins on import survival is likely to be mixed. As with *origins*, an increase in *destinations* is expected to associate with a high likelihood of import failure when it reveals the competition in importing from a supplier for New Zealand due to the limited production of a commodity. However, this may also represent the foreign supplier's strategy of export diversification and therefore will help maintain their relations with New Zealand. Given these possible channels, the estimated sign of *destinations* remains uncertain, depending on the difference in these impacts.

food safety distance (or *fsd*) is an indicator calculated as the difference between New Zealand's and its supplying countries' *Food Safety Indicator*. We believe that a relationship between two trade partners can be 'easier' if they belong to two similar countries in terms of food safety standards. If they have very distinct standards, to trade together is more complicated and either the relationship is more difficult. In this case, the trade relationship is likely to be short with multiple sequences, or once they can trade (with high costs to comply with new requirements), the relationships are long and stable.

SPS treatment refers to a dummy variable representing whether a product imported from a particular country was being treated at a sequence. It can be further decomposed into a set of country-specific biosecurity treatments regulated by the New

Zealand Import Health Standards (IHS), which is issued by the New Zealand Ministry of Primary Industries (MPI). This gives us seven dummy variables, including methyl bromide fumigation (*mebr*), cold disinfestation (*cold*), high temperature forced air (*air*), irradiation (*irradiation*), water treatment (*water*), heat treatment (*heat*), and fumigation & cold disinfestation (*combined*) treatment. In line with prior literature such as Peterson *et al*. (2013), Grant *et al*. (2015), and Crivelli and Gröschl (2016), this chapter hypothesise that the experience of being treated increases foreign suppliers' likelihood of failure when exporting to New Zealand by greatly increasing their trade cost.

The covariate *market* controls for the role of the public sector across countries. It is measured as a share of the public sector's employees in the country's total employment. It is hypothesised that countries with a large share of the public sector may have the scale to sustain trade relationships as opposed to other countries in which the public sector does not dominate several industries. Lastly, by controlling for the growth rate of net domestic credit in countries considered (*credit*), we are able to estimate whether or not support from the government helps exports survive their foreign markets.

3.4.3. Endogeneity

Given the factors considered above, a potential endogeneity issue could stem from the bi-directional causality between domestic production and the likelihood of import failure, if consistent imports of a product discourage domestic producers from expanding their production. Therefore, this chapter further utilizes the endogenous *probit* models based on maximum likelihood (ML) estimator (i.e. *IV-probit* model). It provides a consistent estimator under a solid assumption that valid instruments exist, where the instruments z are variables that are correlated with one of the regressors on the right-hand side of equation (3.3) and satisfy $E(\mu_{xit}|z) = 0$. Therefore, changes in z are associated with changes in the regressor but do not lead to changes in y_{xit} (except indirectly via endogenous regressors).

To do so, two instrumental variables are considered, *land_deviation* and *pop*, respectively. *land_deviation* is the percentage change in the land used for the horticulture and *pop* denotes the natural increase in New Zealand's population. It is assumed that both instruments represent shocks to domestic production but are uncorrelated with the error term μ_{xit}. We expect that the deviation in horticultural land use and natural increase in population will most influence domestic production and demand. Meanwhile, large deviations in land use and population growth are expected to have minimal direct effects on import survival. By doing so, our models are expected to have fewer endogeneity issues.

Given the possibility of supplier-dependent characteristics, we may also find that imports from some countries are at a higher probability of failure than from others. However, it is unlikely that those variabilities can be fully captured by observed covariates. Therefore, this chapter also controls for the baseline hazard function by using *year*, *commodity*, and *supplier* dummies across all estimators. The inclusion of these fixed effects will helps reduce the biases stemming from the unobservables which may lead to endogeneity issues.

3.4.4. Data

This chapter utilises the annual import data of New Zealand fresh fruits and vegetables (HS070190-HS81040) from the United Nations Commodity Trade Statistics Database (UN Comtrade) to construct the dataset for estimation. The period considered is from

1989 to 2019 with a total of 31 years. As regards trade partners, we considered 87 countries which had reported fresh fruit and vegetable exports to New Zealand.

The use of the country-level data allows us to easily capture the distinct impact of treatments and the level of development on countries since the New Zealand IHS are applied to countries/regions instead of businesses. For instance, capsicums from Australia are required to have the *mebr* treatment with 32-80g/m^3 for 2-4 hours at a flesh temperature of 17^{o}C and above at a loading of not greater than 50% chamber capacity (MPI, 2018a). This regulation applies to all capsicums imported from Australia. In addition, a set of microeconomic factors this chapter considers are homogeneous at the firm-level. Therefore, country-level data sufficiently satisfy the research demand for this chapter.

The central strategy of creating the dataset for discrete-time hazard model estimation is decomposing all the trade relationships in fresh fruit and vegetables by sequence. For instance, there are two different sequences of the trade relationship if New Zealand imports grapes from the U.S. for two discontinued periods 1990-1993 and 2000-2005. Therefore, the first sequence has a duration of 4 years and the second sequence is 6 years long. After applying the same strategy to deal with all the relationships and coordinating the explanatory data series in equation (3.3) into the sample, our final dataset has 4,053 observations. Besides, the regression imputation approach is adopted to deal with the missing data and balance the final dataset.

In addition to the dependent variable *y* and explanatory variables *duration*, *censoring*, *multiple*, *origins*, and *destinations*, which are constructed using the raw import data collected from the UN Comtrade Database, other covariates are constructed using data from various sources. Specifically, *gdp* and *reer* are collected from World Bank's World Development Indicators (WDI); *distance*, *language*, and *colonial* are available at Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) database; *production* and *credit* are collected from Food and Agriculture Organization of the United Nations (FAO); *ipi* is collected from Statistics New Zealand; *food safety distance* is created using the Food Safety Indicators obtained from World Health Organization (WHO); *treatment* is available at New Zealand Ministry for Primary Industries (MPI) website; *market* is collected from various sources including OECD Statistics, the International Labour Organisation (ILO), and World Bank. Appendix B presents the summary statistics for all the covariates.

3.5. Survival analysis

3.5.1. Baseline results from the discrete-time hazard model

The baseline hazard rate function is first estimated using the discrete-time *probit* and *IV-probit* estimators. Note that *year*, *commodity*, and *supplier* dummy variables are also used in *probit* estimators. In Table 3-3, it can be seen that the coefficients of the estimated *probit* and *IV-probit* models differ. Most variables in the *IV-probit* model are more significant, compared to those in the *probit* estimator where *production* is not regarded as an endogenous regressor.

According to the results of our exogeneity test for *IV-probit* model (3) and (4), the p-value is less than 0.01. This indicates that the unmeasured factors, *land* and *pop*, have a strong predictive value for *production* and the strategy of treating *production* as an endogenous regressor is valid. Therefore, the significance of the model is improved with the specification in (3) and (4). Due to this reason, this chapter will mainly analyse the results given by the *IV-probit* models.

As regards coefficient signs, we can see that *duration* has a significantly negative impact on the probability of import failure across all estimators, indicating that longer duration of a sequence reduces the likelihood of import failure as foreign suppliers are more likely to cope with trade barriers and market uncertainties after staying for a more extended period. In particular, an extra year of staying in the New Zealand market decreases the z-score (or probit index) by up to 0.274 in the model (4), holding all other covariates constant. This finding is in line with Peterson *et al*. (2017), which observes that longer spells of trade reduce the hazard rate of the U.S. imports.

Similarly, the significantly negative coefficient of the dummy variable *left-censoring* implies that the z-score tends to be 0.150-0.169 lower for left-censored trade relationships compared to those non-left-censored in model (3) and (4). This result again confirms the negative impact of *duration* and indicates that the hazard rate of import presents a diminishing trend over time.

For trade relationships with *multiple* sequences of service, the hazard rate significantly decreases in model (1) and (3). This can be partly explained by the experience effect. That is, countries with prior exporting experience are more likely to survive when they attempt to re-enter the market. This is probably because these exporters had already paid the costs of entry when they entered the market for the first time. These experiences can better help them deal with local regulations. As a result, multiple entries are less likely to fail compared to those who are new to the market.

Further, it is interesting to note that as *multiple* is being decomposed into four separate intervals of sequence in (2) and (4), the coefficient of each sequence presents distinct effect and level of significance. Particularly, the fifth entry (*seq_5*) appears to have the most significant and negative impact on the z-score of import failure compared to other sequences in model (4). Since other sequences have a less negative coefficient, experience threshold may exist so that exporters are best able to reduce their probability of failure. Future research examining the presence of experience threshold could arouse great interest. However, it is not the objective of this chapter.

Table 3-3 Baseline model using the full sample

Variables	(1) Probit	(2) Probit	(3) IV-Probit	(4) IV-Probit
ln_duration	-0.584 (0.000)***	-0.592 (0.000)***	-0.238 (0.001)***	-0.274 (0.000)***
censoring	-0.841 (0.000)***	-0.844 (0.000)***	-0.150 (0.101)	-0.169 (0.076)*
multiple	-0.197 (0.012)**	----------------------	-0.168 (0.000)***	----------------------
seq_2	----------------------	-0.156 (0.067)*	----------------------	-0.149 (0.002)***
seq_3	----------------------	-0.309 (0.006)***	----------------------	-0.135 (0.042)**
seq_4	----------------------	-0.175 (0.231)	----------------------	-0.208 (0.018)**
seq_5	----------------------	-0.302 (0.087)*	----------------------	-0.468 (0.000)***
ln_distance	0.629 (0.998)	1.396 (0.996)	-0.131 (0.002)***	-0.130 (0.003)***
language	4.214 (0.993)	4.175 (0.993)	0.003 (0.952)	0.001 (0.983)
colonial	8.397 (0.985)	3.314 (0.994)	0.040 (0.451)	0.053 (0.322)
fta	0.008 (0.960)	0.013 (0.933)	-0.037 (0.499)	-0.024 (0.662)
ln_gdp	0.335 (0.140)	0.347 (0.128)	0.038 (0.035)**	0.039 (0.030)**
ln_reer	0.091 (0.089)*	0.091 (0.091)*	-0.016 (0.060)*	-0.017 (0.055)*
ln_ipi	-2.966 (0.973)	-1.932 (0.982)	0.536 (0.000)***	0.605 (0.000)***
production	-4.726 (0.008)***	-4.771 (0.007)***	-12.244 (0.000)***	-12.170 (0.000)***
origins	0.009 (0.569)	0.009 (0.546)	-0.049 (0.000)***	-0.049 (0.000)***
destinations	-0.015 (0.000)***	-0.015 (0.000)***	0.009 (0.000)***	0.009 (0.000)***
fsd	0.237 (0.926)	0.148 (0.954)	-0.001 (0.643)	-0.001 (0.639)
SPS	-0.515 (0.009)***	-0.507 (0.011)**	0.069 (0.411)	0.052 (0.556)
*SPS*gdp*	-0.011 (0.081)*	-0.012 (0.072)*	-0.003 (0.099)*	-0.003 (0.099)*
market	0.618 (0.958)	0.322 (0.978)	-0.001 (0.621)	-0.000 (0.842)
credit	0.000 (0.432)	0.000 (0.412)	0.000 (0.985)	0.000 (0.998)
Observations	4053	4053	4053	4053
Goodness-of-fit test	0.000	0.000	----------------------	----------------------
Log-likelihood	-1213.6884	-1212.5043	3030.1792	3036.5747
Endogenous variable	----------------------	----------------------	*production*	*production*
Instruments	----------------------	----------------------	*land & pop*	*land & pop*
Wald exogeneity test	----------------------	----------------------	0.000	0.000

Note: (1) and (2) refer to panel probit estimator without endogenous regressor; (3) and (4) refer to panel probit estimator with endogenous regressor. P-value are reported in parentheses; Coefficients on constant are omitted; ***P < 0.01, **P < 0.05, and *P < 0.1.

Additional to the properties of trade relationships, gravity-type factors are expected to play a crucial role in the survival of exporting countries. In the gravity models of international trade theory, trade flows are often determined by a series of factors, including distance, language, economic sizes, population and so on

(Kepaptsoglou *et al*., 2010). These factors are often closely associated with trade costs. It is believed that everything else being equal, higher trade costs would increase the fluctuations in trade relationships and lead to a higher possibility of experiencing adverse external shocks. Therefore, it is hypothesised that gravity-type drivers of the trade such as shorter distance, same language, same colonial history, a signed free trade agreement (FTA), and the similar level of economic development would decrease trade costs and ought to lower the hazard rate.

As shown in model (3) and (4) of Table 3-3, however, only *distance* and exporter *GDP* affect the hazard rate significantly. Given the output in model (4), the z-score of import failure is 0.130 lower as the distance between New Zealand and an exporting country increases by 1,000 kilometres. In comparison, an extra 1,000 dollar increase in exporting countries' *GDP* per capita tends to increase the z-score by around 0.038 in model (3).

Clearly, the findings on *distance* and exporter *GDP* are surprisingly inconsistent with our hypothesis. As regards distance, it is possibly the case that among distant countries only the most productive exporters are able to enter the New Zealand market and therefore are more stable once entered. This finding partly confirms the hypothesis introduced by Clerides *et al*. (1998), Bernard and Jensen (1999), and Melitz (2003), suggesting the self-selection of firms into the export market due to the high fixed export cost.

Given the gravity model of trade, exporter *GDP* is supposed to decrease the hazard rate of failure since a higher level of economic development increases trade flow and decreases the hazard rate. However, it appears not to be the case given the results in the chapter. The surprisingly positive coefficient of *ln_gdp* can be partly explained by the diminishing effects of national wealth on primary product exports. That is, countries may not intensively export the same products at their different stages of development. For instance, developed countries have more advantages in manufacturing exports, compared to those less-developed countries. As a result, exports of primary product such as fresh fruits and vegetables decrease as the level of development is elevated. This in turn directly influences the longevity of trade relationships in fresh fruits and vegetables.

Although the above finding on the influence of GDP differs from the common hypothesis, it is consistent with Hess and Persson (2011) and Peterson *et al*. (2017). These two studies both find exporter GDP increases the hazard rate. Given their explanations, the limited market size of the importing country could be a reason for the positive effect. This suggests that New Zealand could be less competitive to maintain a stable and long-term relationship with the larger economies due to its disadvantage in market size.

Further, variations in the real exchange rate variables (*reer*) and import prices (*ipi*) could be the two factors influencing the foreign supply and the survival of trade relationships. The results in model (3) an (4) confirm that *reer* is a negative and statistically significant factor of the variations in the hazard rate. This suggests that the New Zealand dollar's appreciation would help decrease the z-score of import failure by around 0.016. Similarly, the estimated coefficient of *ipi* appears to be highly significant, suggesting a positive relationship between an increase in import prices and import decisions.

The covariate *production* captures New Zealand's production capacity. It is anticipated that there is a positive relationship between *production* and the hazard rate. An increase in local production may lead to a decrease in imported products since they are substitutes. As a result, trade relationships are more likely to fail if the local supply has been improved. Besides, as mentioned in Section 4.3, a bidirectional causality might exist between domestic production and the probability of import failure. Therefore, *production* in model (3) and (4) are assumed to be endogenous. Given the result of our exogeneity tests, both models are statistically significant when *production* is correctly recognized as an endogenous variable.

In terms of the coefficient of *production*, it can be found that the estimated impact is consistently negative across models, indicating that complementing domestic supply may no longer be the major purpose of imports. In fact, local production and foreign supply may increase simultaneously when the demand for diversified and imported premium products increases substantially. Meanwhile, this result confirms that the deviation in horticultural land use (*land*) and natural increase in population (*pop*) will indirectly influence import survival through increasing domestic demand and production.

The number of New Zealand's import origins (*origins*) and the supplier's export destinations (*destinations*) are two measures for the impacts of import and export diversification on import survival. As a result, the number of *origins* is negatively correlated with the hazard rate in model (3) and (4), suggesting that import diversification help reduce the likelihood of import failure. In contrast, the effects of *destinations* are mixed on New Zealand import survival across different estimators. This suggests that export diversification does not always help countries better survive the New Zealand market particularly when an increase in the number of *destinations* reflects a tough competition in receiving imports. Under this circumstance, there is a positive relationship between *destinations* and the hazard rate as with the estimated coefficient given in model (3) and (4).

The last significant covariates are *treatment* and *treatment*gdp*. Prior literature such as Disdier *et al*. (2008), Fontagné *et al*. (2015), and Peterson *et al*. (2017) all indicate that SPS has a negative effect on trade. Countries who experience SPS are more likely to fail than those who exempt from inspections and treatments while exporting. Given the output in Table 3-3, we surprisingly find that the dummy variable *SPS* has a significantly negative influence on the possibility of failure in model (1) and (2). Import sequences with SPS treatments tend to experience 0.507-0.515 lower z-score of failure than those without treatments. This observation is inconsistent with the hypothesis that SPS as one of the non-tariff barriers is likely to hinder imports. Further, it can be found that the impact of *SPS* appears to be associated with the partner country's level of development as the estimated coefficient of their interaction term *SPS*gdp* is statistically significant at the 10 per cent level in models (1)-(4). It suggests that countries with a higher level of development are less likely to fail when their exports to New Zealand are required to be treated in model (3) and (4) in which production is treated as an endogenous variable.

It is also worthwhile to mention that other variables such as *language*, *fta*, and *fsd*, *market*, and *credit* are statistically insignificant at any level across estimators. Therefore, their impact on import survival remains uncertain, given the current results.

3.5.2. Effects of SPS treatments

This section focuses on the effect of each SPS treatment. To do so, models in Table 3-4 further decompose *SPS* into a set of treatments. Several post-estimation tests were also conducted to ensure the validity of the model specifications. Variables such as *language, colonial, fta, fsd, market*, and *credit* are removed from these models given their insignificant performance in prior baseline models.

In general, there are noticeable distinctions in the sign of each treatment concerned. Of the statistically significant treatments, the positive impacts on import survival are driven by *irradiation* and *combined* treatment. Specifically, *irradiation* treatment both increase the score by 1.81-1.91 in model (1) and (2), and *combined* treatment increases the score the most by 6.26 to 6.65 in model (3) and (4). These results provide some evidence for a positive relationship between SPS measures and the hazard rate of import failure. In addition, there is some evidence in model (1) and (2) showing that *heat* is the only treatment significantly reducing the hazard rate no matter how high the country's level of development is.

As argued in Ferrier (2010), treatment costs could be the reason for the different coefficient signs. For instance, some treatments such as *irradiation* and *combined* are often more complicated and require more inputs such as special containers. In contrast, *air* and *heat* treatment are often less expensive (MPI, 2018a & b). As all treatments required will be carried out at the owner's risk and expense, a high-cost pest mitigation option is expected to greatly increase the cost of trade and the hazard rate of survival. On the contrary, treatment with a marginal cost may even decrease the hazard rate since they can not only help countries better comply with local regulations but also elevate the quality of their products.

Furthermore, the estimated coefficient of *mebr*gdp* and *irradiation*gdp* tends to be significantly negative in different models. It suggests that exporting countries with a higher level of development are most likely to overcome the extra costs associated with SPS measures if they are being treated with *mebr* and *irradiation*. This observation also partly reveals that these treatments might increase the quality and safety of the commodities if they were supplied by countries with a more developed economy. However, less developed countries may find it is harder for them to deal with the consequences of SPS measures. This will further impact their export decisions. Looking from the other side, an import preference may potentially present so that imports without the requirement of SPS measures are much easier to stay in the New Zealand market.

Table 3-4 Decomposition of SPS treatments

	(1)	(2)	(3)	(4)
Variables	Probit	Probit	IV-Probit	IV-Probit
duration	-0.577 (0.000)***	-0.640 (0.000)***	-0.205 (0.004)***	-0.242 (0.001)***
censoring	-0.923 (0.000)***	-0.829 (0.000)***	-0.229 (0.020)**	-0.253 (0.014)**
multiple	-0.213 (0.008)***	---------------------	-0.181 (0.000)***	---------------------
seq_2	---------------------	-0.163 (0.048)**	---------------------	-0.158 (0.001)***
seq_3	---------------------	-0.279 (0.009)***	---------------------	-0.184 (0.006)***
seq_4	---------------------	-0.118 (0.403)	---------------------	-0.164 (0.062)*
seq_5	---------------------	-0.247 (0.139)	---------------------	-0.449 (0.000)***
ln_distance	14.357 (0.048)**	13.614 (0.048)**	-0.102 (0.004)***	-0.108 (0.003)***
ln_gdp	0.299 (0.125)	0.232 (0.221)	0.037 (0.012)**	0.039 (0.009)***
ln_reer	0.094 (0.090)*	0.062 (0.246)	-0.011 (0.139)	-0.011 (0.153)
ln_ipi	-4.814 (0.065)*	-4.819 (0.051)**	0.474 (0.000)***	0.542 (0.000)
production	-3.731 (0.049)**	0.121 (0.758)	-12.739 (0.000)***	-12.652 (0.000)***
origins	0.008 (0.598)	-0.015 (0.029)**	-0.049 (0.000)***	-0.049 (0.000)***
destinations	-0.014 (0.000)***	-0.012 (0.000)***	0.007 (0.000)***	0.007 (0.000)***
mebr	1.128 (0.193)	0.622 (0.364)	0.114 (0.710)	0.097 (0.757)
*mebr*gdp*	-0.943 (0.013)**	-0.315 (0.120)	-0.191 (0.032)**	-0.190 (0.038)**
cold	-2.125 (0.209)	-2.904 (0.056)*	0.346 (0.370)	0.278 (0.498)
*cold*gdp*	0.544 (0.262)	0.701 (0.098)*	0.049 (0.657)	0.063 (0.589)
air	-6.430 (0.412)	-7.442 (0.336)	-1.844 (0.721)	-2.265 (0.665)
*air*gdp*	2.612 (0.407)	3.059 (0.324)	0.712 (0.732)	0.893 (0.672)
irradiation	1.812 (0.007)***	1.908 (0.004)***	0.275 (0.529)	0.301 (0.496)
*irradiation*gdp*	-0.676 (0.001)***	-0.661 (0.001)***	-0.061 (0.620)	-0.078 (0.531)
water	14.542 (0.578)	15.577 (0.554)	3.667 (0.424)	4.432 (0.411)
*water*gdp*	-12.767 (0.556)	-13.528 (0.537)	-3.117 (0.412)	-3.772 (0.399)
heat	-0.790 (0.027)**	-0.769 (0.020)**	-0.167 (0.365)	-0.197 (0.299)
*heat*gdp*	0.275 (0.191)	0.260 (0.212)	0.001 (0.995)	0.004 (0.977)
combined	3.507 (0.485)	12.493 (0.343)	6.261 (0.022)**	6.645 (0.037)**
*combined*gdp*	-1.194 (0.591)	-5.920 (0.327)	-1.458 (0.238)	-1.650 (0.257)
Observations	4053	4053	4053	4053
Log-likelihood test	51.98 (0.000)***	43.41 (0.000)***	50.44 (0.000)***	32.28 (0.000)***
Hosmer-Lemeshow Chi2	10.90 (0.207)	10.81 (0.213)	---------------------	---------------------
Link test	0.583	0.574	---------------------	---------------------
AUC	0.888	0.888	0.686	0.711
Classfication test	83.70%	83.75%	64.45%	69.26%
Wald exogeneity test	---------------------	---------------------	17.56 (0.000)***	19.23 (0.000)***

Note: P-value are reported in parentheses; Coefficients on constant are omitted; Endogenous variable for model (3) and (4) is production. Instruments used are land and population. Log-likelihood test was for the presence of treatments' interaction effects with gdp. ***P < 0.01, **P < 0.05, and *P < 0.1.

3.5.3. *Marginal effects by commodity*

To consider the commodity-specific probability of failure, the average marginal effects are calculated for each commodity based on the estimates of model (2) in Table 3-4. The results are presented in Table 3-5. Particularly, we can see that potatoes have the highest average hazard rate among fresh vegetables. Due to the large production spreads across the country all year round, the domestic supply of potatoes can hardly be impacted by extreme weather conditions in New Zealand (Horticulture New Zealand, 2017). Therefore, potatoes imported from overseas are negligible and often serve as occasional complement, depending on the uncertainties in the domestic market. However, this can hardly be incorporated tested in our models due to data unavailability.

The probability of import failure is found to be 49.9 per cent for tomatoes, which make it the product with the second-highest import hazard rate. The rest of the fresh vegetables are all found to have at least 10 per cent lower hazard rate compared to potatoes and tomatoes. In particular, truffle and lettuce imports of New Zealand are least likely to fail with a hazard rate of survival no more than 20 per cent. Consumption preference could be a reason leading to the low hazard rate of lettuce imports. As regards truffles, one explanation is that truffles as a relatively scarce and highly valued category of vegetables with only a limited number of countries having the production capacity to export. Due to its extremely perishable nature and the unique requirements of its consignment, truffle suppliers may have an incentive to continue their existing exports in order to minimize the cost of re-entry into the New Zealand market. This directly leads to a stable relationship in truffle trade.

Among the categories of fresh fruit, the likelihood of failure is the highest in apples (65.9 per cent), strawberries (65.4 per cent), and apricots (63.3 per cent). Commodities that are best able to survive include figs (15.7 per cent), bananas (15.8

per cent), and dates (16.9 per cent). Besides, the production of some fruits is exclusive to tropical and semitropical regions. Therefore, we can see that imports of these unique commodities, such as bananas, pineapples, guavas, and mangoes, are less likely to fail in a short period.

Table 3-5 Average marginal effects (AME) by commodity

Fresh Vegetables		AME	Fresh Fruit		AME
070190	Potatoes	0.592	080110	Coconuts	0.202
070200	Tomatoes	0.499	080300	Bananas	0.158
070310	Onions and shallots	0.366	080410	Dates	0.169
070320	Garlic	0.230	080420	Figs	0.157
070390	Leeks	0.321	080430	Pineapples	0.206
070410	Cauliflowers and broccoli	0.227	080440	Avocados	0.193
070420	Brussel sprouts	0.345	080450	Guavas, mangoes and mangosteens	0.192
070511	Cabbage (head) lettuce	0.247	080510	Oranges	0.320
070519	Lettuce	0.142	080520	Mandarins	0.216
070610	Root, carrots and turnips	0.290	080530	Lemons and limes	0.193
070700	Cucumbers and gherkins	0.295	080540	Grapefruit	0.281
070810	Peas	0.223	080610	Grapes	0.294
070820	Beans	0.260	080710	Melons (including watermelons)	0.277
070920	Asparagus	0.237	080720	Papaws	0.217
070951	Mushrooms	0.208	080810	Apples	0.659
070952	Truffles	0.170	080820	Pears and quinces	0.183
070960	Capsicum	0.196	080910	Apricots	0.633
070970	Spinach	0.216	080920	Cherries	0.209
-----	-----	-----	080930	Peaches including nectarines	0.555
-----	-----	-----	080940	Plums and sloes	0.343
-----	-----	-----	081010	Strawberries	0.654
-----	-----	-----	081020	Raspberries and blackberries	0.311
-----	-----	-----	081030	Currants and gooseberries	0.438
-----	-----	-----	081040	Cranberries and bilberries	0.299

In addition to the factors assessed in our models, differences in the estimated marginal effects among commodities can be explained by the unexpected weather in the foreign supplying countries, which greatly increases the fluctuations in commodity prices and the likelihood of a relationship breakdown. For example, Australia has been the major supplying country of New Zealand's fresh tomatoes since the 1990s. In late 2010, Queensland experienced its worst-ever flood, which affected horticultural production in Australia significantly. Following the floods, the New Zealand price of tomatoes increased dramatically, from an average of $8.70 per kilogram in July 2010 to a peak of $13.25 per kilogram in July 2011. As a result, New Zealand imports of Australian tomatoes dropped to zero in the year to June 2013 (Statistics New Zealand, 2014). Given that supply has not been able to keep up with demand, this event resulted in an unstable trade relationship in tomatoes between Australia and New Zealand and higher prices for locally grown vegetables. Unfortunately, these uncertainties can hardly be captured by current models due to data unavailability.

3.6. Summary and policy implications

This chapter presents evidence on the survival of New Zealand fresh fruit and vegetable imports from 1989 to 2019. The results are consistent with prior studies on other countries showing large fragilities in trade relations. First, New Zealand trade relationships with multiple sequences account for a large proportion of around 43 per cent in the total 558 trade relationships observed. In extreme cases, five trade relationships involved seven sequences in the New Zealand market.

Second, 72 per cent of those sequences had survived no more than two years. This pattern is found to vary across different commodities. In particular, the import of potatoes, tomatoes, onions, apples, apricots, and strawberries are most likely to fail with a relatively higher estimated hazard rate.

After employing the discrete-time hazard models, we find that duration of the sequence, the number of entries, distance, GDP per capita, production, import prices, the number of import origins and export destinations explained most of the variation in import survival with high significance. This observation confirms the findings of prior studies on trade duration and survival, indicating that import survival is mainly driven by experience, domestic demand, the economic size of and competition among exporters. Therefore, suppliers with accumulated experience and strong comparative advantage are more likely to survive in the New Zealand market.

Further, our estimates indicate that SPS appears to have a mixed impact on import survival. In some cases, the probability of import failure decreases as the commodities are being treated with SPS measures. Moreover, countries with a distinct level of development are differently influenced by those measures. For instance, there is evidence revealing that the fumigation & cold disinfestation combined treatment increases the probability of import failure significantly due to the high cost of application. Unfortunately, only those countries with high growth in GDP per capita can benefit from their experience of being treated with a negative impact on the hazard rate.

In addition, irradiation is found to be another impediment of fresh fruit and vegetable imports. Again, this effect is found to be closely associated with the exporting countries' level of development. One possible explanation could be the increasing public concerns about food safety in recent years. Therefore, to some extent, the experience of being treated reveals the ensured safety and quality of commodities imported from developed economies and therefore potentially lengthen their duration of trade relationships with New Zealand.

The above results entail some relevant considerations and policy implications. First, given the short-lived nature of trade relationships, investigations in trade flows and volumes are unable to uncover the important role of duration and multiple entries and exits in trade relationships. Indeed, given the fragile nature of trade relationships, suppliers need more than their ability to maintain a trade relationship. Therefore, it is critical to help businesses translate their market access opportunities into competitive survival in the long run by understanding the major causes of frequent trade failure in the first place.

Second, the results also inform the debate about the consequences of SPS regulations in the agricultural trade market. Given the story of New Zealand, we have evidence suggesting that SPS measures especially irradiation and fumigation & cold disinfestation combined treatment interrupt the import of fresh fruits and vegetables into New Zealand significantly. One reason could be the high costs associated with the treatment which are carried out at the exporting countries' expense. Therefore, both domestic and international policymakers should be cautious when dealing with the trade-off between securing food safety and stimulating trade growth. To achieve an effective balance, a solid plan for governments is to ensure the transparency of SPS measures, regularly check whether discrimination exists in the practical applications, and appropriately adapt their requirements to commodities from various origins.

The main models in this chapter are best able to estimate the determinants of trade survival instead of to identify a list of potential partners with which trade is most likely to sustain given the dynamic trade environment. Therefore, future research that helps to develop a mechanism illustrating the best trade options for countries and businesses could be meaningful in practice. This will often require interdisciplinary strategies to capture a wide range of factors influencing trade duration and survival within a complex and dynamic trade network.

Another limitation of this chapter is the data and relevant information available. Future studies use firm-level data from multiple countries could help enrich the knowledge of this research area. In addition, a wider range of covariates could be considered if data becomes available. This may include but not limited to economic/political stability, market volatility, technology and innovation, climate change and so on.

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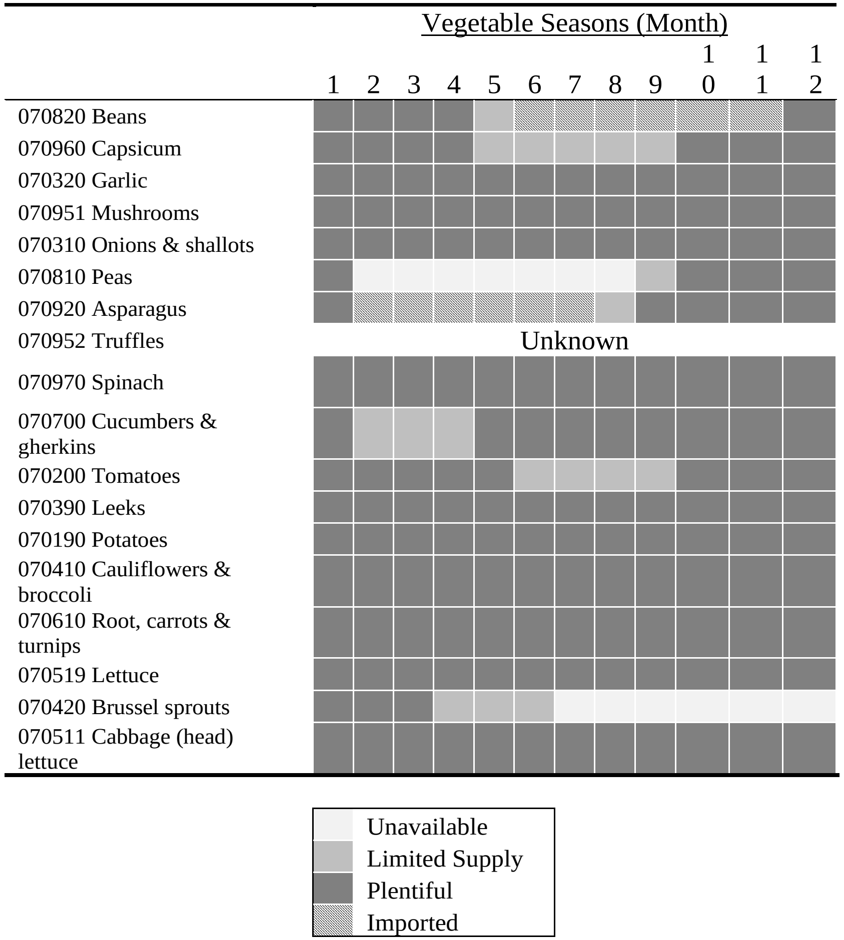
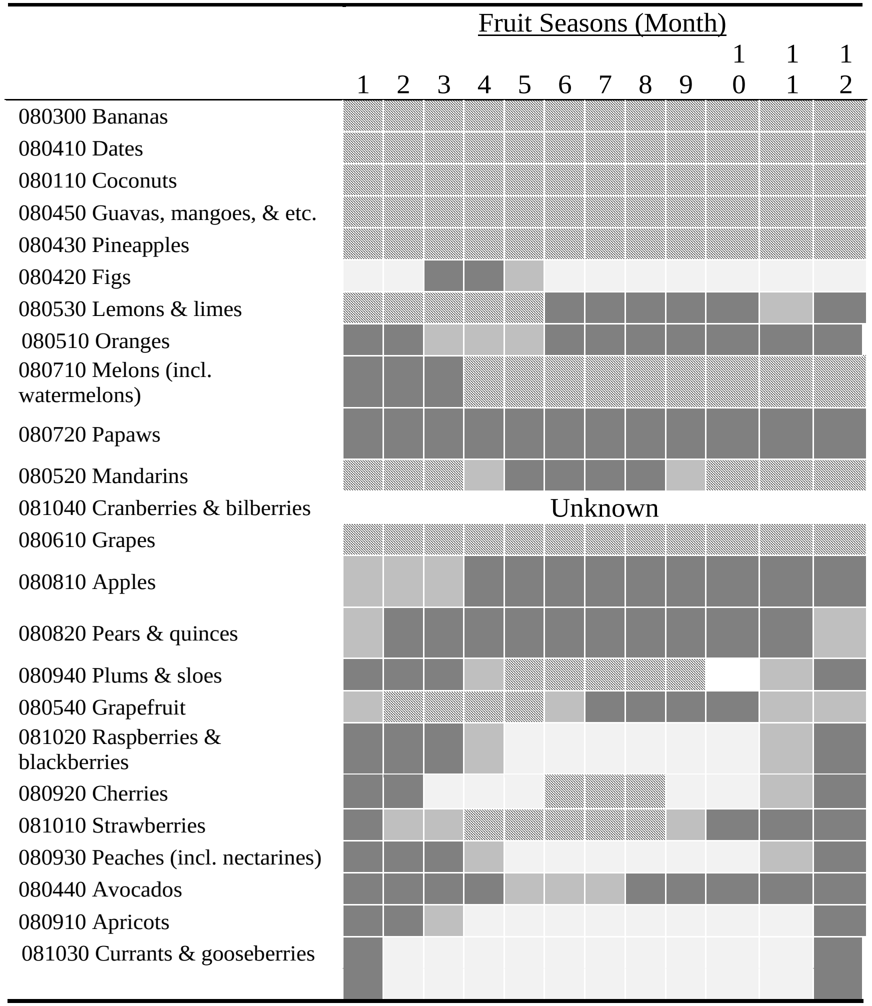
Appendices

Appendix A New Zealand fresh fruit and vegetable seasons by product



Source: Adopted from The Produce Company Limited



Appendix B Distribution of survival sequences across Ireland fresh fruit and vegetable import market, 1989-2019

by Sequence			by Sequence Length					
No. of Sequences	*No. of Relationships*	*Share (%)*	*Length*	*No. of Sequences*	*Share (%)*	*Length*	*No. of Sequences*	*Share (%)*
1	1281	52.5	1	2852	57.5	15	20	0.4
2	479	19.6	2	701	14.1	16	9	0.2
3	310	12.7	3	336	6.8	17	13	0.3
4	183	7.5	4	175	3.5	18	11	0.2
5	113	4.6	5	134	2.7	19	19	0.4
6	49	2.0	6	86	1.7	20	20	0.4
7	18	0.7	7	86	1.7	21	12	0.2
8	8	0.3	8	71	1.4	22	4	0.1
9	1	4.1	9	38	0.8	23	9	0.2
Total	2442		10	32	0.6	24	6	0.1
			11	18	0.4	25	9	0.2
			12	30	0.6	26	6	0.1
			13	27	0.5	27	16	0.3
			14	25	0.5	28	194	3.9
						Total	4959	

Appendix C Summary statistics of the covariates (n=4053)

Variable	Mean	Std. Dev.	Min	Max
ln_d	1.487	1.112	0	3.401
censoring	0.270	0.444	0	1
multiple	0.336	0.472	0	1
ln_distance	2.027	0.740	0.874	2.975
language	0.595	0.491	0	1
colonial	0.595	0.491	0	1
fta	0.292	0.455	0	1
ln_gdp	2.443	1.371	-1.145	4.518
ln_reer	-1.336	2.482	-11.801	6.323
ln_ipi	6.939	0.183	6.604	7.205
production	0.027	0.085	0	0.620
origins	8.438	5.729	1	23
destinations	31.583	25.207	1	144
fs_dist	11.854	14.918	0	74.250
treatments	0.198	0.398	0	1
mebr	0.063	0.243	0	1
cold	0.045	0.207	0	1
air	0.005	0.073	0	1
irradiation	0.023	0.150	0	1
water	0.017	0.128	0	1
heat	0.046	0.210	0	1
combined	0.010	0.101	0	1
market	16.725	10.177	3.093	49.200
credit	1.889	7.024	-6.221	4.334

Chapter 4 New Zealand Dairy Export Survival

4.1. Introduction

Dairy trade has long been critical to New Zealand's economic growth. The development of the dairy industry over the last few decades has not only reflected how dairy products are produced, transported, traded and consumed, but also confirms dairy's role in the economy. In 2018, dairy products accounted for a quarter of the country's total merchandise exports, increasing from 17 per cent in the late 1990s (New Zealand Treasury, 2019). This robust growth is mainly attributed to the relatively high prices for dairy products which are produced utilising the favourable natural conditions.

However, New Zealand dairy exporters are likely to experience challenges given their offshore market composition and the recent fluctuations in global demand. For instance, one challenge could be dealing with the underlying risks stemming from the country's increasing concentration on its Asian markets, notably China. According to the Treasury's *Monthly Economic Indicators Report for July 2019*, export growth to China amounted to NZ$13.1 billion, which is equivalent to 39 per cent of the country's total nominal export growth between 1998 and 2018 (New Zealand Treasury, 2019). In contrast to China, other top importers of New Zealand dairy products, such as the Philippines, the United Arab Emirates, Thailand, Malaysia, USA, Japan, and Australia, all contributed less to New Zealand total dairy exports in recent years (based on statistics from the UN Comtrade Database).

Historically, the picture was entirely different. In the early 2000s, New Zealand dairy export destinations were more diverse. The top 10 markets each accounted for only 3 to 7 per cent of total exports and China did not even present on this list (New Zealand Treasury, 2019). Therefore, it is concerning that the high level of dependency on a dominant market makes the country more vulnerable to slowing demand from that market in the future. One reason behind this high level of dependence could be the fragile nature of trade relationships. That is, most trade relationships are difficult to maintain for a continuous period due to the uncertainties in market demand and destination-specific costs. This makes it challenging to fulfil the government's vision of 'doubling the value of primary industry exports by 2025' (New Zealand Government, 2014).

Another challenge for New Zealand dairy exports is that prices are significantly influenced by marginal changes in global supply and demand. For instance, Russia is the second-largest global importer of dairy products after China. In September 2018, Russia extended its ban on the import of dairy products from Australia, Canada, EU28 and the US to 31 December 2019. Although New Zealand is exempt from the ban, global dairy prices are inevitably affected. Hence, New Zealand farmers' revenue from dairy exports was reduced.

Further, trade impediments such as the non-tariff barriers and temporary import restrictions continue to hinder New Zealand dairy trade exports. For example, the Pakistan government increased its effective import tariff on milk and whey powder from 20 to 45 per cent with the imposition of a 25 per cent 'regulatory duty' in 2016 (USDA, 2016). This high tariff leaves New Zealand farmers at a significant disadvantage and adversely impact New Zealand's dairy exports to Pakistan.

In order to reduce the risks associated with demand slowdown or even sudden breakdown of trade relationships, New Zealand can benefit from further export diversification and the development of long-lasting trade relationships. Strengthening relationships that can continuously adapt to the changing patterns in the global dairy market seems more critical than simple access to new markets. In comparison with the traditional trade strategies that favours on increasing export flows, this strategy highlights the significance of persistent trade relationships in future trade integration. However, to the best of the authors' knowledge, there is no existing literature with an analysis of the New Zealand dairy industry from the perspective of export relationship duration.

To better understand the performance of New Zealand dairy export relationships and explore the underlying factors and strategies, this chapter adopts a duration- and survival-based analysis. It makes two main contributions to the literature. First, it presents the first evidence on the export survival of the dairy industry by summarising the country's dairy export flows by destination from 1989 to 2017. New Zealand has been a prime exporter in the global dairy trade. Numerical evidence on its dairy export duration and survival will reveal the fundamental characteristics of dairy trade relationships and further highlights the potential challenges associated with current trade strategies. Also, observations on whether New Zealand dairy export relationships are able to last longer can help policymakers focus on how to better maintain existing trade relationships.

Second, this chapter empirically examines the impacts of a series of demand, supply and gravity type determinants on dairy export survival using the discrete-time hazard models which control for unobserved heterogeneity among destinations. This methodology enables us to estimate the hazard rate for New Zealand dairy exports at the destination level. To be more precise, this allows us to determine the likelihood of relationship failure after entry and whether this hazard rate changes over time, controlling for the potential determinants. Besides, the estimated impact of underlying factors provides valuable insights about how to facilitate sustainable growth in dairy exports and address future challenges in the global dairy market.

The rest of this chapter is organised as follows. Section 4.2 reviews previous literature on trade duration and survival. Section 4.3 describes the methodology, data, and theoretical framework. Section 4.4 sketches the patterns and trends in New Zealand dairy trade and export duration using a simple-counting approach. Section 4.5 and 4.6 presents and analyses the estimated results using preferred models. Section 4.7 conducts robust testing given by frailty models. Finally, section 4.8 summarises the findings and presents related policy implications.

4.2. Global and New Zealand evidence: the literature

Globally, the puzzle of whether a trade relationship can survive over time has become a focus in recent empirical trade literature (Recalde *et al.,* 2016; Peterson *et al.,* 2017; Turkcan and Saygili, 2018; Anwar *et al*., 2019). Early studies such as Besedeš and Prusa (2006 & 2011) and Besedeš (2008) found that the import duration to the U.S. from 180 countries on average was short, normally for 2-4 years. This evidence is found to be consistent across all Standard International Trade Classification (SITC) (Revision 2) 1-digit industries. Based on these results, the authors argued that global trade relationships tend to be far more fragile and dynamic than expected. Eaton *et al*. (2007) found (using transaction-level merchandise exports data in Colombia) that there are a large number of one-time exporters at the firm level. Bernard *et al*. (2010) revealed that trade relationships in the U.S. manufacturing firms are short-lived and product switching is high. Similar findings have been observed in other regions/countries such as the EU (Hess and Persson 2012), Germany (Nitsch 2009), and African countries (Cadot *et al*. 2013).

In contrast, some studies show that product type might be the reason for different trade relationship patterns. For instance, Obashi (2010) provided some evidence suggesting that the trade relationship of machinery parts and components tends to be longer-lived, compared to the trade relationship of finished machinery products. Wang *et al.* (2019) found that ASEAN seafood export relationships survive longer than other commodities considered in prior studies. On average, the export relationships have a mean value of more than four years.

Emerging studies also focus on the determinants of trade survival. These studies find that both gravity-type variables such as level of development (Fugazza and Molina, 2016), economic integration agreements (Saygili and Turkcan, 2017), and distance and income (Sun and Zhang, 2017) appear to affect trade survival significantly. Other studies tend to assess the crucial role of experience and networks (Stirbat *et al*., 2015), Sanitary and Phytosanitary (SPS) treatments (Peterson *et al*., 2017), and initial export flows (Besedeš, 2008) on export duration and survival.

In New Zealand, agriculture and dairy trade have been a subject that has attracted considerable attention. One strand of literature focuses on assessing the impacts of New Zealand trade integration. For example, Saunders *et al*. (2006) revealed that as a result of trade liberalisation New Zealand producer returns increased. However, greenhouse gas emissions also increase significantly. Cook *et al*. (2011) estimated the social welfare effects of apple imports from New Zealand to Australia. Besides, Huchet-Bourdon and Korinek (2012) investigated the role of the exchange rate in the evolution of the bilateral trade of Chile and New Zealand with three large economies-

China, the Euro area and the United States. Bano *et al*. (2013) investigated the development of trade between ASEAN and New Zealand.

Another strand of studies attempts to provide policy implications for trade integration based on empirical findings concerning the New Zealand industry. Iyer (2010) investigated the determinants of firm-level export intensity in New Zealand's agriculture and forestry and suggested that government action to facilitate exporter entry to new overseas markets would lead to a more significant share of exported output. Saunders *et al*. (2010) examined trends in consumer concerns regarding sustainability in key overseas markets for New Zealand. They suggested that positioning and marketing New Zealand products to a high and safe food standard and developing industry structures can ensure benefits to both consumers and producers. Fabling *et al*. (2011) investigated the factors influencing New Zealand manufacturing firms' export market choices. Their results indicated that prior trade experience was the primary determinant of these firms' future export activities.

Also, Casey and Hamilton (2014) suggested that New Zealand exporters should not concentrate their exports into one or a few overseas markets. Success for these small firms stemmed from higher rates of R&D expenditure and multimarket exporting through company-owned channels in distant markets. Singh (2015) noted a positive and significant long-run relationship between exports, investment and economic growth in New Zealand. He emphasised that both the promotion of exports and increasing investments are crucial for fostering a higher level of output and economic growth in New Zealand. Gani and Scrimgeour (2016) argued that governance plays an essential role in the trade integration between New Zealand and Asian countries. McGiven (2016) provided specific advice for Fonterra on how to deal with future opportunities and challenges.

In considering the future development of New Zealand dairy farms, Jaforullah and Whiteman (1999) suggested that at that time the optimal farm size is 83 hectares with a herd of 260 animals based on their estimates on the scale efficiency of the dairy industry. Ma *et al*. (2019) showed that technical efficiency on New Zealand dairy farms is positively and significantly influenced by feed use intensification, herd size and milking frequency. Westbrooke and Nuthall (2017) argued that farmers' characteristics influence their choice of development strategy and persistence.

While the literature on New Zealand trade and dairy industry has been growing rapidly in recent decades, only a limited number of studies have examined the patterns of export duration, especially in agriculture. Early studies such as Gibson and Harris (1996) found that more significant and lower cost and older plants were more likely to survive the New Zealand trade liberalisation. Recently, except for broadly related work on New Zealand fresh fruit and vegetable import duration (Luo *et al*., 2018), no study has specifically considered the longevity of New Zealand dairy export relationships. The present study, therefore, contributes to the literature by providing an empirical analysis on New Zealand dairy export duration and survival patterns and determinants at both the product and the destination level.

4.3. Survival and Duration of New Zealand Dairy Exports

4.3.1. Concepts

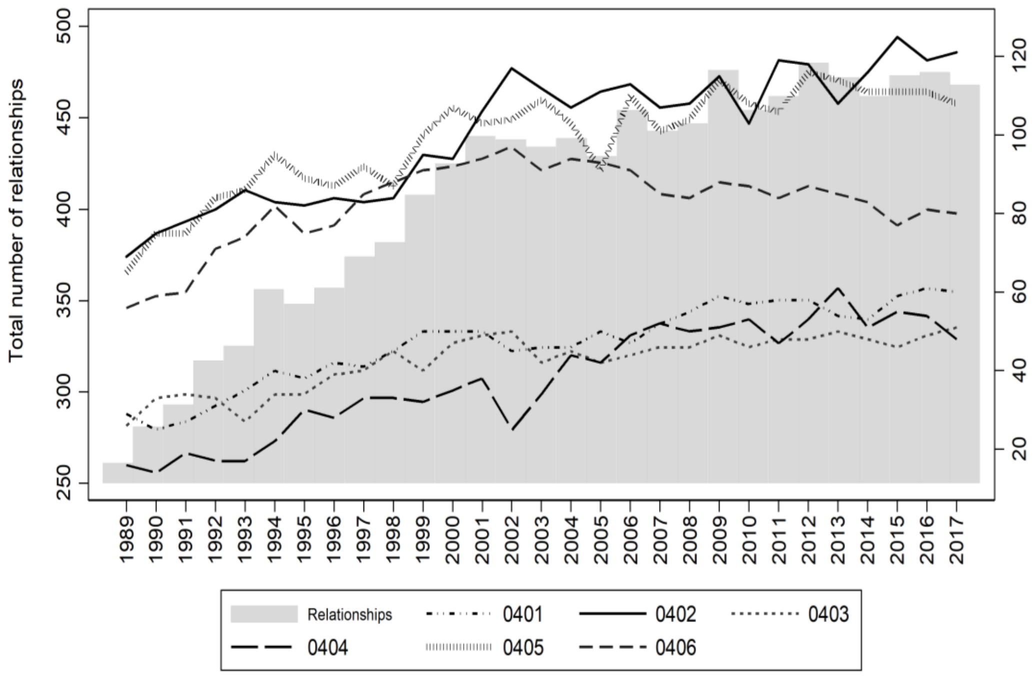
To conduct a survival analysis, it is necessary to define the key terms explicitly. An export relationship, throughout the study, refers to a destination-product pair relationship when there are exports from New Zealand to a trading partner of a specific dairy product. A sequence (equivalent to the term 'trade spell' commonly used in some trade studies) is defined as the period with continuous exports of one given product to a specific destination. In general, one export relationship may involve multiple sequences of exports over the study period. Correspondingly, the duration of a sequence refers to the counted number of years New Zealand has exported to a trading partner with non-zero export flows.

4.3.2. Numerical evidence

Figure 4-1 presents the number of destinations by-product over time. It can be observed that the total number of New Zealand dairy export relationships has increased significantly from around 260 in the late 1980s to more than 460 in 2017. As regards to the number of destinations, concentrated milk and cream (0402) and butter oils (0405) have been the most popular exported dairy products with each being exported to more than 100 countries since 2000. Besides, non-concentrated milk and cream (0401), buttermilk (0403), and whey (0404) have reached a growing number of foreign markets during the period considered; each being exported to 50 to 60 destinations. One exception is the export relationships of cheese and curd (0406) which experienced a downward trend since 2002 and is now supplying a smaller number of destinations than it did in the late 1990s.

It is easy to note that the number of destinations and relationships alone cannot help us fully uncover the past performance of New Zealand dairy exports. We have no adequate information about the duration of each relationship, which is a matter worthy of further exploration. Therefore, we first observe the duration of New Zealand dairy exports (refers to HS0401-06 classification) relationships in the years between 1989 and 2017. Using the exports statistics collected from the United Nations Commodity Trade Statistics Database (UN Comtrade), we are able to decompose export flows of New Zealand dairy products by sequence. All countries that reported dairy import flows from New Zealand are considered. We then summarise the number and duration of sequences by product.

Figure 4-1 Total number of relationships and destinations of New Zealand dairy exports by major category.



Note: The left y-axis is for the total number of relationships- shaded bars; the right y-axis is for the total number of destinations- patterned lines.

Data source: UN Comtrade Database. Author's compilation.

In Table 4-1, our simple-counting summary generally confirms international findings on trade survival, indicating that New Zealand export relationships tend to be short-lived and fragile with multiple entries and exits. On average these relationships tend to survive around 7 years and have a mean sequence of 3. Comparing with Luo *et al*. (2018)'s findings on New Zealand fresh fruits and vegetable import relationships that nearly 70 per cent of sequences survived 1-2 years only, dairy export relationships were much stable. However, sequences that survived less than 3 years in the dairy industry still account for 52 per cent of the total sequences.

Table 4-1 Distribution of survival sequences across NZ dairy export relationships

	All Sequences	
Category	Av. Length	Av. No. of Sequences
0401	7	2
0402	7	3
0403	6	3
0404	5	3
0405	8	3
0406	9	2
Average	7	3

by No. of Sequences			by Sequence Duration					
No. of Sequences	No. of Relationships	%	Length	No. of Sequences	%	Length	No. of Sequences	%
1	403	50.3	*1*	614	37.9	*16*	22	1.4
2	168	21.0	*2*	231	14.3	*17*	13	0.8
3	107	13.4	*3*	111	6.8	*18*	18	1.1
4	77	9.6	*4*	69	4.3	*19*	11	0.7
5	31	3.9	*5*	52	3.2	*20*	3	0.2
6	10	1.2	*6*	48	3.0	*21*	10	0.6
7	4	0.5	*7*	31	1.9	*22*	4	0.2
10	1	0.1	*8*	37	2.3	*23*	4	0.2
Total	801		*9*	30	1.9	*24*	9	0.6
			10	12	0.7	*25*	10	0.6
			11	15	0.9	*26*	14	0.9
			12	24	1.5	*27*	9	0.6
			13	9	0.6	*28*	11	0.7
			14	24	1.5	*29*	161	9.9
			15	15	0.9			
						Total	1621	

At the product level, there are significant heterogeneities in the duration of survival. In Table 4-2, it can be observed that around 62 per cent of buttermilk (0403) and 53 per cent of whey (0404) sequences failed within 2 years. Sequences that survived the whole period from 1989 to 2017 accounted for only 2-6 per cent in these two categories. In contrast, more than 10 per cent of the sequences in butter, cheese and curd (0406), and concentrated milk and cream (0402) survived continuously since 1989. These findings, again, confirm the short-lived nature of trade relationships.

Overall, the New Zealand dairy industry has been performing better than some other global industries in terms of duration. However, the export relationships in buttermilk and whey are found to be relatively fragile and fluctuated. In contrast, the export relationship patterns of milk and cream, butter oils, and cheese and curd tend to survive longer, suggesting for these products it is easier to establish and maintain trade relationships with specific foreign markets.

Table 4-2 Distribution of survival duration across NZ dairy exports by major category

Category	Duration of survival by intervals (in %)				
	<= 2 years	[3,9 years]	[10,19 years]	[20,28 years]	29 years
401	53.6	20.4	12.7	3.9	9.4
402	48.2	27.7	9	4.4	10.8
403	61.6	19.4	8.8	4.2	6
404	56.3	28.1	10.3	3.1	2.2
405	50.6	21.4	10.7	4	13.3
406	48.1	21.4	9.2	7.6	13.7

4.4. Methodology

4.4.1. Baseline discrete hazard function

Generally, existing survival analysis can be grouped into several broad categories, and each has some merits in specific situations (Willett and Singer 2003). This chapter applies a discrete-time hazard model to overcome the potential biases in the commonly used continuous-time Cox hazard model in survival analysis. The discrete-time hazard model is often used to quantify the influence of various factors on trade duration simultaneously. The term 'discrete', as opposed to the 'continuous', captures the nature of trade duration more accurately as observed trade relationships tend to be discrete units of yearly length and many fall into the same category of equal length (Peterson *et al*. 2017).

In a discrete-time framework, the hazard rate is defined as the likelihood that a trade relationship will survive to a certain point in time based on its survival to an earlier time t. Following the same framework and notation of Hess and Persson (2012) and Peterson *et al*. (2017), we let h_{id} be the discrete-time hazard rate. Then the probability of failure conditional on its survival up to the beginning of the interval and given the covariates included in the regression model can be defined as:

$$\begin{aligned} h_{id} &= P(T_i < t_{d+1} | T_i \geq t_d, x_{id}) \\ &= F(\gamma_d + x'_{id}\beta) \end{aligned} \tag{4.1}$$

Equation (1) above forms the conditional probability that a particular trade relationship ceases in a set of discrete-time intervals $[t_d, t_{d+1}, t_{d+2}, \dots, t_{dmax}]$ and when $d = 1$, $t_d = t_1 = 0$. Specifically, T_i refers to a non-negative, continuous random variable that measures the survival time of the i_{th} trade relationship. The subscript i here denotes separate sequences of trade (destination-product) relationships, $i = (1, \dots, n)$. x_{id} is a set of time-varying covariates and β are regression coefficients. $F(\cdot)$ refers to an appropriate distribution function that ensures $0 \leq h_{id} \leq 1$ for all i and d. γ_d is a function of time/interval that allows the hazard rate to vary across periods. Since the baseline hazard rate is unknown in practice, γ_d is usually incorporated into the empirical model as a set of dummy variables identifying the duration of each sequence and characterizing the baseline hazard.

Following Peterson *et al*. (2017), y_{id} is being introduced as a binary variable that takes the value one if relationship i is observed to terminate in the time interval d, and zero otherwise. Therefore, the log-likelihood function for the observed observations is specified as below:

$$ln\mathcal{L} = \sum_{i=1}^{n}\sum_{d=1}^{d_i}[y_{id}\ln(h_{id}) + (1 - y_{id})\ln(1 - h_{id})] \qquad (4.2)$$

Note that each sequence is assumed to be independent of all other sequences as there might be multiple sequences and dependencies across commodities from the same supplier or across suppliers of the same commodity.

4.4.2. Econometric specification

This chapter assumes that the conditional probability of export failure or exit is influenced by a set of supply and demand-related factors in both New Zealand and its trading partners. Broadly, these factors can be classified into six distinct groups. Through incorporating the explanatory variables into the discrete-time hazard model (4.2), the empirical model can be specified as

$$y_{it} = f(Duration_{it}, Left\_censored_{it}, X_{NZ-Dest,i\ initial}, Multiple_{it}$$
$$S_{NZ,it}, D_{Dest,it}, G_{NZ-dest,it}) \qquad (4.3)$$

where the dependent variable y_{it} equals one if trading partner x ceases a trade relationship i with New Zealand in time t and zero otherwise. $Duration_{it}$ is the number of years that the current trade relationship i between a trading partner Dst and New Zealand has lasted in time t.

$Left\_censored_{it}$ is a dummy variable that equals one if a particular trade relationship is left-censored. As argued in prior literature such as Klein and Moeschberger (2006), the issue of censoring, especially left-censored observations, are one of the major risks that may bias the estimates. To deal with this problem, two strategies will be used during estimation, following Peterson *et al*. (2017). First, a sequence of six will be assigned to the beginning year of each left-censored trade relationship. That is because we observe the sequences of a large number of trade relationships were greater than 24 years (from 1994 to 2017) as they have continuously received exports from New Zealand since 1989. Therefore, for a left-censored observation, we would expect that it will be less affected by an extra year of service than the non-left-censored sequences of service. This is based on the assumption that a decrease in the hazard rate from an additional year of service should diminish. Second, we allow the intercepts and coefficients of the hazard function for sequence duration to vary between the left-censored and non-left-censored observations.

$X_{initial}$ refers to the initial weight of exports for a given product in a sequence. We hypothesize that a sequence with higher initial export tends to last for a longer time and is less likely to fail. This is because the extra cost of exit for a relationship with larger export flows tends to be higher, comparing a relationship with negligible export flows. Therefore, exporters may choose to stay in a market if gains from staying are temporarily higher than the extra cost of exit.

$Multiple_{it}$ is a dummy variable representing whether the export relationship is characterised by multiple sequences. For relationships which are continuously existed the whole period from 1989 to 2017, $Multiple_{it}$ equals zero since these relationships do not have multiple sequences. It is expected that multiple sequences directly increase the cost of trade and lead to higher hazard rate of export relationships.

$S_{NZ,it}$ is a set of factors influencing the supply conditions of New Zealand dairy products. It captures both the factor of dairy production ($cows_{NZ}$), the industry's capacity of supply ($no\_markets_{NZ}$), benefits from exports (epi_{NZ}), and weather condition ($temp_{NZ}$). Precisely, $cows_{NZ}$ is measured as the total number of cows in dairy production in New Zealand. It is hypothesised that the larger number of cows available increases dairy production and therefore positively influence dairy exports.

$markets_{NZ}$ is a proxy of import competition and is measured as the total number of markets to which New Zealand ships the given product. epi_{NZ} denotes the New Zealand annual export price index for specific dairy products. If an export price index increases, New Zealand dairy producers are willing to export given the greater returns from trade. As a result, the hazard rate decreases as these exporters tend to maintain their existent trade relationships. $temp_{NZ}$ is measured as the annual temperature change in New Zealand. As dairy production does not favour extreme temperature conditions such as high air temperature and humidity, we assume that there is a negative relationship between changes in $temp_{NZ}$ and dairy export survival.

$D_{Dest,it}$ represents the factors directly affecting foreign demand for New Zealand produced dairy products. It considers how changes in the destination country's demand influence New Zealand dairy export survival. First, we include annual population change in destination (pop_{Dst}) as a proxy of the variations in demand such that higher demand reduces the hazard rate. Second, we summarise the number of suppliers of a given product $suppliers_{Dst}$ to capture the size of demand for diversified dairy products in the destination. It is hypothesised that the sign of the effects on exports survival is mixed. That is, New Zealand dairy exports are less likely to fail if the demand is greater. Meanwhile, it could also be true that an increase in $no\_suppliers_{Dst}$ signals a higher degree of competition in a market.

Another complementary variable capturing the competition in a destination is the geographical characteristics of the country. Here we also include a binary variable $locked$ in the model. It equals one if the destination country is landlocked and equals zero otherwise. It is reasonable to expect that a landlocked destination has more opportunities and it is much easier for them to access foreign dairy products. Therefore, the characteristic of landlocking increase the hazard rate as other foreign-made and New Zealand-produced dairy products tend to be substitute goods.

$G_{NZ-Dst,it}$ captures a set of gravity-related factors. In line with Nitsch (2009) and Ferto and Szerb (2018), we hypothesize that gravity variables have a similar impact on the duration of exports as they have on bilateral trade flows. In this chapter, we focus on the impacts of level development and trade costs on the hazard rate. Specifically, gdp_{NZ} and gdp_{Dst} refer to the annual GDP growth rate of New Zealand and the partner country. Given the theory of gravity model, trade increases as countries have a higher level of development. However, empirical studies such as Hess and Perrson (2011) find that trading with economically large exporters is more likely to fail. One reason could be the potential competition exists in the import market.

Besides, it is possible that exporting countries at the different stage of development might adopt different trade strategies and export different types of products. For instance, countries tend to export primary products the most at their initial development stage, while after a period of rapid growth in their economy they might change their trade composition and focus more on manufacturing exports. Due to this factor, exports of dairy can be influenced negatively by the exporting country's level of development. Given these reasons, we expect that the effect of GDP growth could either be positive or negative.

In this chapter, trade cost is represented by distance and the total number of non-tariff measures ($ntms$) applied to New Zealand dairy products export in a destination. Specifically, $distance$ measures the distance between the two countries' capital city in 1,000 kilometres. $ntms$ can be further decomposed into seven specific measures, including the number of *sanitary and phytosanitary measures* (SPS), *technical barriers to trade* (TBT), *pre-shipment inspection measures, contingent trade protective* *measures*, *quantity control measures*, *price control measures*, and *export-related measures*. As the measures are not available on a destination-by-product basis, we include a set of binary variables to indicate whether a measure has been applied to the New Zealand dairy products for a destination-product pair. It is hypothesised that an increase in $distance$, $ntms$ and an application of any measure directly increases the trade cost of New Zealand dairy exports and this subsequently leads to a higher hazard rate.

4.4.3. Data sources

We collected the annual export data of New Zealand dairy products from the UN Comtrade Database to construct the dataset for later survival analysis. The period covered is from 1989 to 2017 with a total of 29 years. All dairy products are classified by the Harmonized System (HS) code at the four-digit level (See Appendix A for detailed definition). All countries had reported dairy import flows from New Zealand are considered.

One strategy of creating the dataset for discrete-time hazard model estimation is to decompose all the existent trade relationships by separate sequence. For example, New Zealand has exported non-concentrated milk and cream (0401) to Argentina for two periods, 1991-1992 and 1998-2001. In this case, there are two different sequences for this relationship. One sequence has a duration of 2 years, another is 4 years long. After applying the same strategy to deal with all relationships and incorporating the explanatory variables of equation (4.3) into the sample, our final dataset contains 10,438 observations. For missing data, we adopt the regression imputation approach so that the final dataset is balanced.

In addition to UN Comtrade Database, various sources are used to collect the underlying independent covariates (See Appendix B). First, $locked$ and $distance$ are available at the Centre d'Etudes Prospectives et a'Informatins Internales (CEPII). Second, $temp_{NZ}$ and pop_{Dest} are collected from the Food and Agriculture Organization of the United Nations (FAO). Third, gdp_{NZ} and gdp_{Dest} are collected from the World Bank's World Development Indicators (WDI). Fourth, epi_{NZ} and $cows_{NZ}$ are derived from Statistics New Zealand Infoshare Database. Lastly, $ntms$ and the corresponding decomposed measures are available at UNCTAD Trade Analysis Information System (TRAINS).

4.4.4. Unobserved heterogeneity

Given the possibility of destination-dependent characteristics, we may find that exporting to some destination countries is at a higher probability of failure than others. However, it is unlikely that those variabilities can be fully captured by covariates. The presence of unmeasured destination-specific (time-invariant) risk factors leads to unobserved heterogeneity in the hazard, which is also known as the 'frailty' in some studies. If there are destination-specific unobserved factors that potentially affect the hazard, the observed form of the hazard function at the aggregate level will tend to be different from the destination-level hazards. If unobserved heterogeneity is incorrectly ignored in the study, a positive duration dependence will be understated, and a negative duration dependence will be overstated. To allow for unobserved heterogeneity in our discrete-time model (2), we introduce a random effect which represents destination-specific unobservables following Jenkins (2004):

$$\text{cloglog}\ [h\ (j, X \mid v)] = D(j) + \beta' X + \mu \qquad (4)$$

where D characterizes the baseline hazard function estimated from (3) and is a vector of functions of the cumulative duration by interval, X is a vector of covariates with coefficients β'. The 'error' term μ is a random variable with mean zero and finite variance. $\mu \sim N(0, \sigma_{\mu}^{2})$ allows for unobserved heterogeneity between destinations due to time-invariant omitted variables.

Note that there are several discrete-time hazard models with frailty available in Stata. In this chapter, we adopt the discrete-time *cloglog* model with Gamma heterogeneity as proposed by Meyer (1990), using Jenkins' *pgmhaz8* program in Stata.

4.5. Results

4.5.1. Baseline hazard functions

There are several ways to interpret the estimation results from the discrete-time hazard models. For example, a positive estimate means a higher likelihood of terminating a trade sequence and consequently a lower probability of surviving in the particular market, and vice versa.

4.5.2. Nature of export sequences

Table 4-3 presents the results for each determinant using the full dataset with all covariates as specified in equation (4.3) as well as *year*, *commodity*, and *partner* dummy variables to control for fixed effects. Specifically, we have the estimated coefficient of each variable (*Coef.*) and their corresponding robust standard errors (*Std. Err.*) in parentheses. In general, we can see that most factors have a consistent sign of coefficient across *logit* and *cloglog* models except for *cows*, *no_markets*, and *gdp_nz*. Also, most factors are statistically significant at 5 or 1 per cent significance level, especially those being used to represent the characteristics of trade sequences (i.e. *duration*, *censoring*, *exports_initial*, and *multiple*).

In terms of *duration*, as expected, an extra year of staying significantly reduces the hazard probabilities across all models. For instance, export relationships with one year longer in duration experience 0.801-0.917 lower log-odds of failure, holding all other covariates constant. This is reasonable as exporters are better to cope with trade barriers and uncertainties in a market after learning from their past experiences. Similar results can also be found on the coefficients of *left-censored*. It is evident that the hazard rate is significantly lower for left-censored dairy trade relationships compared to non-left-censored ones. For instance, the coefficient of -1.550 in Model (1) indicates that left-censored sequences have a -1.550 lower odds of failure.

The effects of initial exports on the hazard rate are much smaller comparing with *duration* and *left-censored*. The negative coefficient signs of *exports_initial* in Models (1)-(6) suggest that exporters prefer staying if their initial export weight of a sequence was large. Therefore, the hazard rate decreases significantly as the weight of exports increases. This finding is in line with our hypothesis and partly reflects the continuity of trade decisions so that giving up on a market with large exports could be a huge loss for exporters. Due to this reason, exporters may choose to stay even if their temporary loss is greater than their gains from exporting.

In contrast to *duration*, *left-censored*, and *exports_initial*, there is a positive relationship between the hazard rate and multiple sequences of export relationships. Particularly, multiple entries increase the log-odds of hazard by 0.519-0.693. After decomposing *multiple* into the *second*, *third*, *fourth*, *fifth sequence*, and *more than five* *sequences*, there is evidence showing that different sequence has a distinct effect on the hazard rate (see Models (3)-(6)).

To be more precise, New Zealand dairy exporters could even benefit from their past exporting experience within the initial five sequences. During the fourth sequence of exports, the log-odds of failure can be reduced the most by around 0.194-0.277. However, this effect is no longer valid when dairy exporters attempt to enter a market for more than five times. If export relationships are involved more than five sequences, the log-odds of failure increase by 0.552-0.587. This can be partly explained by the extra costs of frequent entries and exits to and from a market. Therefore, the experience effect is only effective in the initial sequences of exporting. After more frequent entries, hazard rate increases as the extra cost of entry is inevitably large so that past experience cannot help these dairy exporters cope with the uncertainties in a foreign market. However, only *seq_2*, *seq_4,* and *seq_5plus* are statistically significant given their *p-value*.

Table 4-3 Estimated coefficients from the baseline discrete-time hazard model

Variable	(1) Logit Coef. (Std. Err.)	(2) Cloglog Coef. (Std. Err.)	(3) Logit Coef. (Std. Err.)	(4) Cloglog Coef. (Std. Err.)	(5) Logit Coef. (Std. Err.)	(6) Cloglog Coef. (Std. Err.)
duration	-0.871 (0.05)***	-0.801 (0.04)***	-0.939 (0.05)***	-0.845 (0.04)***	-0.922 (0.05)***	-0.831 (0.04)***
left-censored	-1.550 (0.13)***	-1.499 (0.12)***	-1.185 (0.15)***	-1.153 (0.14)***	-1.220 (0.15)***	-1.183 (0.14)***
exports_initial	-0.121 (0.02)***	-0.093 (0.01)***	-0.199 (0.02)***	-0.159 (0.01)***	-0.199 (0.02)***	-0.160 (0.01)***
multiple	0.693 (0.10)***	0.510 (0.09)***				
seq_1			-2.753 (0.30)***	-2.564 (0.25)***	-2.685 (0.30)***	-2.519 (0.25)***
seq_2			-2.999 (0.32)***	-2.747 (0.27)***	-2.930 (0.33)***	-2.703 (0.27)***
seq_3			-2.926 (0.34)***	-2.687 (0.28)***	-2.852 (0.34)***	-2.641 (0.28)***
seq_4			-3.316 (0.37)***	-3.028 (0.31)***	-3.231 (0.37)***	-2.971 (0.31)***
seq_5			-3.280 (0.42)***	-2.954 (0.36)***	-3.205 (0.42)***	-2.897 (0.36)***
seq_5+			-2.641 (0.52)***	-2.414 (0.41)***	-2.566 (0.52)***	-2.341 (0.41)***
SUPPLY-SIDE FACTORS						
cows	-0.417 (0.06)***	-0.375 (0.05)***	0.004 (0.08)	-0.021 (0.06)	-0.020 (0.07)	-0.042 (0.06)
no_markets	-0.002 (0.00)	-0.002 (0.00)	0.002 (0.00)	0.002 (0.00)	0.002 (0.00)	0.002 (0.00)
epi	-0.498 (0.18)***	-0.476 (0.16)***	-0.084 (0.18)	-0.035 (0.15)	-0.072 (0.18)	-0.022 (0.15)
temp_nz	0.265 (0.10)***	0.250 (0.08)***	0.165 (0.10)	0.170 (0.09)**	0.168 (0.10)	0.174 (0.09)**
DEMAND-SIDE FACTORS						
pop_dst	-0.047 (0.02)***	-0.043 (0.02)***	-0.011 (0.02)	-0.012 (0.02)	-0.017 (0.02)	-0.019 (0.02)
no_suppliers	-0.014 (0.01)**	-0.009 (0.01)*	-0.032 (0.01)***	-0.029 (0.01)***	-0.033 (0.01)***	-0.029 (0.01)***
landlocked	0.659 (0.14)***	0.532 (0.11)***	0.306 (0.14)**	0.202 (0.11)*	0.308 (0.15)**	0.228 (0.12)*
GRAVITY-TYPE FACTORS						
gdp_nz	-0.006 (0.02)	-0.005 (0.02)	0.048 (0.02)**	0.039 (0.02)**	0.046 (0.02)**	0.038 (0.02)**
gdp_dst	-0.021 (0.01)***	-0.019 (0.01)***	-0.013 (0.01)**	-0.012 (0.01)**	-0.013 (0.01)**	-0.012 (0.01)**
distance	0.070 (0.01)***	0.050 (0.01)***	0.136 (0.01)***	0.112 (0.01)***	0.138 (0.01)***	0.114 (0.01)***
ntms	-0.012 (0.04)	-0.019 (0.03)	-0.003 (0.04)	-0.014 (0.04)		
sanitary & phytosanitary					-0.009 (0.05)	-0.013 (0.04)
technical barriers to trade					-1.504 (0.61)**	-1.405 (0.58)**
pre-shipment inspection					0.570 (0.39)	0.519 (0.35)
contingent trade protective					1.070 (0.77)	0.699 (0.43)
quantity control					-0.365 (0.57)	-0.403 (0.52)
price control					0.029 (0.23)	-0.149 (0.18)
export-related measures					0.119 (0.42)	0.214 (0.34)
Observations	10438	10438	10438	10438	10438	10438
Log-likelihood	-2482.267	-2501.725	-2458.253	-2460.889	-2451.152	-2453.308

Note: † Robust standard errors are in parentheses; *** P < 0.01, ** P < 0.05, and * P < 0.1.

4.5.3. Supply

Among the factors from the market supply side, *no_markets* is the only insignificant variable across all models. It is found to be negatively associated with the hazard rate. Specifically, increasing the number of New Zealand dairy markets by one could reduce the log-odds of failure by 0.001-0.002. This finding partly reflects the significance of trade diversification strategies. Since the global dairy market is highly dynamic and competitive, diversifying markets to some extent can help New Zealand buffer the impact of depressed global dairy product prices effectively. However, this impact is negligible and statistically insignificant, compared to other factors such as *cows* and *epi*.

In terms of *cows*, we can observe that there is a negative relationship between the number of cows for dairy production and the hazard rate across all models. It suggests that export relationships are less likely to fail when more cows are available for dairy production.

Similarly, *epi* is also found to be negatively associated with the hazard rate in all models. In line with the expectation, this means that New Zealand dairy export relationships can last longer for greater benefits from trade if the export price index is higher. Since most New Zealand made dairy products are sold overseas. Dairy prices, thereby, are effective at world market levels. In 2001, the Dairy Industry Restructuring Act (DIRA) was passed in New Zealand. This ensures Fonterra's role in marketing the majority of the country's dairy products. Arguably, it also supports New Zealand farmers to negotiate the best possible prices for their dairy products. Even though the revenue earned (through the market) is influenced by the final winning prices at the Global Dairy Trade (GDT) auction, the dairy prices received by New Zealand farmers are usually higher than their foreign competitors. This advantage enhances New

Zealand farmers' welfare as well as providing a strong basis for competing with other prime suppliers of dairy produce.

Given our results in Table 4-3, *temp_nz* appears to be the only supply-sided determinant significantly increasing the hazard rate across all models. The positive sign of its coefficients suggests that one degree Celsius annual change in temperature can increase the log-odds of the hazard rate by up to 0.265 in Model (1) of Table 4-3. As with other agricultural products such as fresh fruit and vegetables, dairy production is extremely sensitive to the changes in temperature. Therefore, sudden and large variations in temperature could directly influence New Zealand's dairy production, thereby leading to the changes in the hazard rate.

4.5.4. Demand

Variations in foreign demand for New Zealand dairy products are captured by the destination country's population (*pop_dst*), the number of foreign dairy suppliers (*no_suppliers*), and a dummy variable measuring whether the country is landlocked (*landlocked*). In Models (1)-(6), it is evident that all of these factors are statistically significant in explaining the changes in the hazard rate.

In contrast to *no_suppliers* and *landlocked*, *pop_dst* is a more direct measure of a demand shock. Given the results in Table 4-3, it is evident that the hazard rate is negatively influenced by the increase in destination country's population. This means that New Zealand dairy export relationships are less likely to fail if the population of a destination country increases. However, this impact becomes less significant when sequence dummies are decomposed and specified in Models (3)-(6). It partly reveals the potential influence of slowing population growth in recent decades so that demand for foreign products is no longer a major consequence of food shortage in the domestic market. Indeed, importing food products from overseas to some extent is a result of consumer preference towards more diversified food varieties.

Due to the rapidly increased per capita income in developing countries, imports from a large number of suppliers can help meet those countries' increased domestic demand for food. Given the estimated coefficient of *no_suppliers*, we find that an extra foreign supplier reduces the log-odds of failure by from 0.009 to 0.017. This result is inconsistent with our expectation that competition increases the hazard rate. Indeed, it suggests that New Zealand as a prime exporter is more likely to gain benefits when a partner country attempts to import from a larger number of suppliers. This means that New Zealand-made dairy products are more competitive than many other imported dairy products due to their quality.

The only demand factor with a positive effect is *landlocked*, which is being used as a proxy of market competition. According to the prior hypothesis, we expect that landlocked destinations can easier access resources and products from overseas. The estimated result has a good alignment with this hypothesis of competition effect, suggesting that New Zealand dairy exports could have up to 0.659 higher log-odds of failure if the destination country is landlocked.

4.5.5. Gravity

In addition to supply and demand shocks, this chapter also considers the effects of a set of gravity-type variables on the variations in the hazard rate. The first group of variables captures the level of development in both New Zealand and its trade partners.

In Table 4-3, it can be found that the estimated results are consistent with the gravity model of international trade theory but are not in line with prior literature such as Hess and Perrson (2012). That is, *gdp_nz* and *gdp_dst* tend to show similar effects on the hazard rate. We can see that both New Zealand's and the destination country's GDP growth is negatively associated with the hazard rate. Precisely, one per cent increase in New Zealand's GDP growth rate leads to 0.001-0.006 lower log-odds of failure. Also, this impact tends to be statistically insignificant across all models. In contrast, every one per cent growth in the partner country's GDP can reduce the log-odds of failure by up to 0.021. As GDP growth rate in the destination country can also be regarded as a proxy for import demand, it is reasonable that the demand for imported products increases when the country's level of development is enhanced.

To capture the impacts of trade cost, this chapter considers both the 'traditional' and 'emerging' measures in the models. For instance, the 'traditional' measure of trade cost includes the geographical distance between New Zealand and its trading partners (*distance*). As expected, the results in Table 4-3 indicate that *distance* is positively linked to the hazard rate. Every 1,000 kilometres increase in the distance would increase the log-odds of failure by at least 0.050 (as in Model (2)). This finding is found to be statistically significant at the 1 per cent significance level. It confirms that as a measure of transportation cost, *distance* remains a critical driver of New Zealand dairy export decisions.

In addition to geographical distance, another unique factor this chapter considers is the influence of the emerging non-tariff measures (*ntms*). However, it can be seen from Models (1)-(4) that aggregately *ntms* is not a statistically significant factor affecting New Zealand dairy export relationship survival. Furthermore, the estimated sign of impacts tends to be surprisingly negative. Thus, we further decompose *ntms* into seven specific measures, including the number of *sanitary and phytosanitary (SPS)*, *technical barriers to trade (TBT), pre-shipment inspection, contingent trade protective*, *quantity control measures*, *price control*, and *export-related measures*. Overall, the estimated impacts of these measures are mixed.

Given the results in Model (5) and (6), *TBT* is the most significant measure influencing the survival of New Zealand dairy export relationships. However, it reduces the log-odds of failure by 1.510-1.622. This observation does not confirm our hypothesis that nontariff measures appear to be an impediment of trade. This is probably due to the characteristics of *TBT*. That is, *TBT* often refers to the production standard, labelling, testing, and certification requirements for imported products. Hence, the application of *TBT* does not directly hinder New Zealand dairy export relationships. Indeed, these requirements to some extent may help increase the quality of New Zealand exported dairy products so that both exporters and importers prefer to maintain their relationships if the products have satisfied the requirements.

On the contrary, there is evidence indicating that *pre-shipment inspection* and *contingent trade protective measures* are found to positively affect the hazard rate. This observation is consistent with our hypothesis. It is reasonable since both measures can directly influence exporters' trade activities and decisions through increasing their trade costs and reducing their incomes from exports. In contrast, the rest of the measures all insignificantly influence the likelihood of failure, given the results in Model (5) and (6) of Table 4-3.

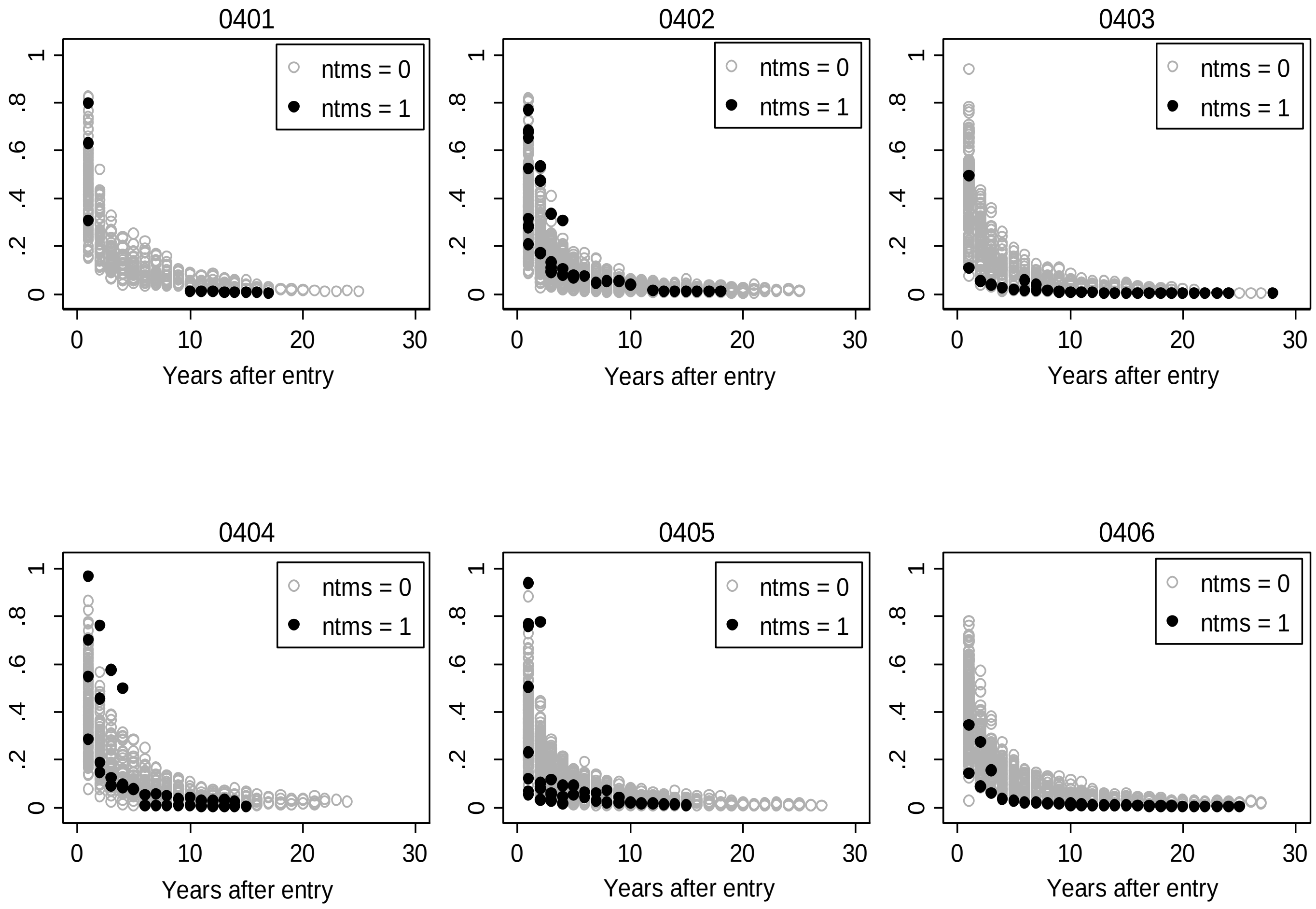
4.6. Estimated hazard probability by product

After estimating the baseline discrete-time hazard model, this article predicts the logistic hazard rate for each product given the estimates of Model (6) in Table 4-3. To do so, we particularly consider derivation in the hazard functions with the specification of different covariate combinations. Precisely, we predict the hazard functions for export relationships with multiple sequences in the case of with (*ntms* = 1) and without (*ntms* = 0) non-tariff measures for each major product.

In Figure 4-2, we can find that the estimated hazard functions are *L-shaped* whether or not non-tariff barriers are applied to New Zealand dairy exports. In general, export relationships initially have a higher probability of failure after entering a market for the first time, due to the high cost of entry at the early stage of exporting. After that, these relationships become stable and tend to experience a lower probability of failure over the years. This pattern is found to be consistent across all major categories of dairy products.

When the impacts of non-tariff barriers are controlled, the pattern of hazard functions is slightly different. For example, concentrated milk and cream (0402), whey (0404), and butter oils (0405) have a relatively higher probability of failure if non-tariff barriers are applied especially in the first ten years. As time passes, the influence of non-tariff measures diminishes. For other products such as buttermilk (0403) and cheese and curd (0406), non-tariff barriers do not increase the probability of failure significantly. On average, export relationships of these two products are 20 per cent lower even when non-tariff barriers are applied.

Figure 4-2 Estimated baseline hazard rates with multiple sequences by product



Source: Authors' own estimation.

4.7. Unobserved heterogeneity

On the topic of unobserved heterogeneity, Abbring and van den Berg (2007) find that in a large class of hazard models with proportional unobserved heterogeneity, the distribution of the heterogeneity among survivors converges to a gamma distribution. Jenkins (2004) provides a command called pgmhaz8. This program approximates the gradient vector and Hessian matrix with numerical derivatives, so maximization can take a significant amount of time. In doing so, we can incorporate a gamma mixture distribution to summarize unobserved individual heterogeneity in our models.

In contrast to the baseline model in Table 4-3, the coefficients of frailty models in Table 4-4 are slightly smaller in absolute value. This means that the baseline model over-estimated the degree of negative dependence (e.g. *duration* and *left-censored*) in the (true) baseline hazard, and under-estimate the degree of positive dependence (e.g. *landlocked* and *distance*). These differences are consistent with Jenkins (2004) and our hypothesis as not accounting for unobserved heterogeneity induces an over-estimate of the extent to which the hazard rate decreases with duration and left-censored and exaggerates the magnitude of the influence of landlocked and distance on the hazard rate.

In frailty models (1)-(4), the size of the variance of the gamma mixture distribution and its corresponding *p-value* for likelihood ratio tests suggest that unobserved heterogeneity is highly significant in these models. That is, the frailty has expected effects on our model parameters. Further, we find that the signs of coefficients are generally consistent with the findings we observed from the baseline models in Table 4-3. Based on the corrected estimates in model (3) of Table 4-4, we further predict the hazard probability for each offshore market of New Zealand dairy exports. To do this, we consider the likelihood of export relationship failure in the condition of all covariates equal to their mean value and whether or not non-tariff measures are applied to New Zealand dairy products.

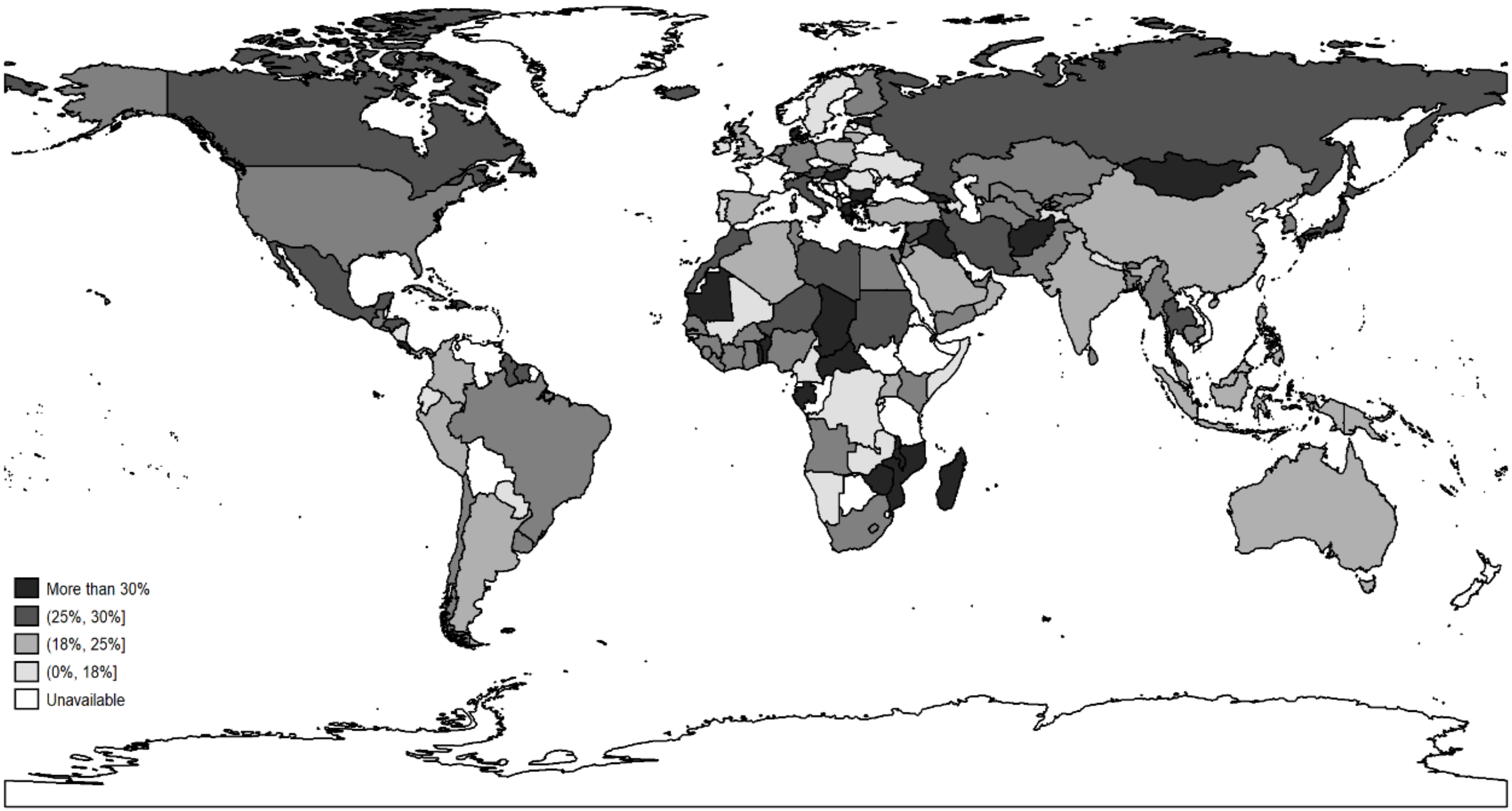
Table 4-4 Discrete-time hazard models with gamma frailty

	(1)		(2)		(3)		(4)	
Variable	Coef.	(Std. Err.)	Coef.	(Std. Err.)	Coef.	(Std. Err.)	Coef.	(Std. Err.)
duration	-0.281	(0.16)*	-0.193	(0.15)	-0.289	(0.15)**	-0.218	(0.15)
left-censored	-2.146	(0.25)***	-2.530	(0.26)***	-2.137	(0.24)***	-2.496	(0.25)***
exports_initial	-0.163	(0.03)***	-0.208	(0.03)***	-0.161	(0.03)***	-0.203	(0.03)***
multiple	0.651	(0.13)***			0.650	(0.13)***		
seq_2			-0.279	(0.14)**			-0.267	(0.13)**
seq_3			-0.034	(0.17)			-0.021	(0.17)
seq_4			-0.403	(0.22)*			-0.376	(0.21)*
seq_5			-0.061	(0.33)			-0.069	(0.32)
seq_5+			0.844	(0.50)*			0.796	(0.49)
SUPPLY-SIDE FACTORS								
cows	-0.494	(0.08)***	-0.455	(0.08)***	-0.506	(0.07)***	-0.466	(0.08)
no_markets	-0.003	(0.00)*	-0.002	(0.00)*	-0.004	(0.00)*	-0.002	(0.00)
epi	-0.482	(0.19)***	-0.403	(0.19)**	-0.447	(0.18)**	-0.367	(0.19)*
temp_nz	0.254	(0.10)***	0.247	(0.10)**	0.254	(0.09)***	0.246	(0.10)**
DEMAND-SIDE FACTORS								
pop_dst	-0.062	(0.02)***	-0.049	(0.03)*	-0.068	(0.02)***	-0.056	(0.02)**
no_suppliers	-0.014	(0.01)*	-0.019	(0.01)**	-0.015	(0.01)**	-0.020	(0.01)**
landlocked	0.803	(0.19)***	0.738	(0.20)***	0.794	(0.19)***	0.734	(0.19)***
GRAVITY-TYPE FACTORS								
gdp_nz	0.003	(0.02)	0.003	(0.02)***	0.001	(0.02)	0.002	(0.02)
gdp_dst	-0.016	(0.01)***	-0.015	(0.01)**	-0.016	(0.01)***	-0.014	(0.01)**
distance	0.086	(0.02)***	0.107	(0.02)***	0.089	(0.02)***	0.109	(0.02)***
ntms	-0.017	(0.05)	-0.013	(0.05)				
sanitary & phytosanitary					-0.038	(0.05)	-0.032	(0.06)
technical barriers to trade					-2.060	(0.75)***	-2.282	(0.80)***
pre-shipment inspection					1.164	(0.56)**	1.059	(0.60)*
contingent trade protective					1.209	(0.62)*	1.320	(0.71)*
quantity control					-0.511	(0.66)	-0.390	(0.67)
price control					0.088	(0.26)	-0.007	(0.28)
export-related measures					-0.029	(0.52)	0.092	(0.56)
Observations	10438		10438		10438		10438	
Gamma variance	0.828		1.049		0.785		0.970	
p-value for LR test	0.000		0.000		0.000		0.000	

Note: † Robust standard errors are in parentheses; *** P < 0.01, ** P < 0.05, and * P < 0.1.

In Figure 4-3, we can see that New Zealand dairy export relationships are associated with a relatively higher probability of failure in specific regions including some European countries, the Middle East, and some African countries. In extreme cases, New Zealand dairy export relationships are 30 per cent likely to fail. In line with our expectation, relationships are most competitive in Asian and some South American markets. On average, the hazard probability is found to be less than 18 per cent in these markets. Therefore, it is clear that the markets of New Zealand dairy exports have been well-diversified in geography. However, more challenges could occur if those export relationships with a high probability of failure cannot be better maintained in the future.

Figure 4-3 Predicted average hazard rates by destination



Note: Made based on frailty model (3) in Table 4-4.

Source: Authors' own estimations.

4.8. Summary and Policy Implications

This article has presented the main patterns of New Zealand dairy export relationships survival over the period between 1989 and 2017. We have also tested the impact of a set of supply, demand, and gravity-type drivers on the survival of New Zealand dairy export relationships using a discrete-time hazard model (with and without frailty).

The results indicate that New Zealand dairy export relationships are well diversified. In contrast to New Zealand fresh fruit and vegetable import relationships, they survived relatively longer. At the destination level, these relationships have an average survival of 7 years with 3 sequences. However, the total number of export relationships that survived the whole period from 1989 to 2017 accounted for 9.9 per cent of the total 1621 sequences. In addition, there are significant heterogeneities at the commodity level. The largest three categories of exported dairy products are milk and cream, butter oils and cheese and curd.

As regards the determinants, duration of sequence, left-censoring, initial export, (decomposed) second sequence, New Zealand export price index, the number of cows available for dairy production, the number of origins and destinations, and destination partner's GDP, are the most significant factors decreasing the hazard rate of export relationships. On the contrary, aggregate multiple dummy, distance, landlocked, and domestic temperature increase the likelihood of failure significantly. It is important to emphasise that we found a mixed effect of non-tariff barriers on export relationships. Only pre-shipment inspection and contingent trade protective measures are positively associated with the hazard rate. On the contrary, there is some evidence suggesting that the technical barriers to trade (TBT) significantly reduce the likelihood of failure. This can be potentially attributed to a higher standard and quality of products after meeting the TBT requirements.

At a disaggregated level, we find that the likelihood of failure is product- and destination-dependent, based on our within-sample predictions. Particularly, New Zealand dairy exporters are more likely to suffer a higher probability of failure when exporting buttermilk and whey products and to the regions including Europe, the Middle East, and some African countries.

Dairy exports toward a globally broad market is a crucial driver of economic growth and development in New Zealand. Therefore, empirical findings on New Zealand dairy export relationships are significant from a trade policy perspective. Given that most New Zealand dairy relationships appear to be fragile over time, enabling public policies to facilitate trade relationships will help reduce the likelihood of failure while trading. Specifically, the policy which aims at addressing a whole range of challenges in the future could potentially maintain New Zealand's leading position in the global dairy trade.

As fulfilling New Zealand government's '*exports double by 2025*' vision will invariably require high levels of trade integration in the future, encouraging the dairy industry to participate in the global value chain could be an optimal method of adopting the best agricultural export practices along with attaining productivity gains and cost competitiveness. In addition, continuous support from a strong financial market and facilitation of innovative technologies will secure a robust development in the New Zealand dairy industry and multilateral trade relationship.

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Appendices

Appendix A HS0 (1992) Classification 4-digit Commodity Codes for Dairy Produce

Code	Description
0401	Milk and cream; not concentrated nor containing added sugar or other sweetening matter
0402	Milk and cream; concentrated or containing added sugar or other sweetening matter
0403	Buttermilk, curdled milk and cream, yoghurt, kephir, fermented or acidified milk or cream, whether or not concentrated, containing added sugar, sweetening matter, flavoured or added fruit or cocoa
0404	Whey and products consisting of natural milk constituents; whether or not containing added sugar or other sweetening matter, not elsewhere specified or included
0405	Butter and other fats and oils derived from milk
0406	Cheese and curd

Appendix B Variables and data sources

Variables	Definition and sources
Trade duration	Constructed using the UN Comtrade data
Left-censoring dummy	Constructed using the UN Comtrade data
Initial export value	Constructed using the UN Comtrade data
Multiple dummy	Constructed using the UN Comtrade data
Cows for production	Data from Statistics New Zealand
Number of markets	Constructed using the UN Comtrade data
Export price index	Data from Statistics New Zealand
Temperature change	Data from FAO
Population	Data from FAO
Number of suppliers	Constructed using the UN Comtrade data
Landlocked dummy	Data from CEPII
GDP Growth	Data from World Bank's World Development Indicators (WDI)
Distance	Data from CEPII
Number of Non-Tariff Measures	Data from UNCTAD Trade Analysis Information System (TRAINS)

Chapter 5 Leading Honey Exporting Countries' Competitiveness

5.1. Background

Beekeeping and associated honey production are agricultural activities that have spanned several centuries in many countries and continue to be significant economic contributors to rural development (Bradbear *et al*., 2002; Babatunde *et al*., 2007; Qaiser *et al*., 2013). Compared with other agricultural products, honey is unique not only because of its nutritional and medicinal value but also due to its distinct varieties which are exclusively produced in limited origins. Moreover, these varieties derived from production in different countries are often influenced by country-specific weather, environment, processing standards, and production technologies. These distinctions are also considered as influential determinants of global honey exports.

With the recent development of global supply chain, consumers not only have access to a wide range of valuable products derived from bees (i.e. honey, pollen, propolis, and bee venom) but also are able to buy these products at a highly competitive price, as a result of greater market access through free trade and the rapid integration of several producers in the world trading environment (Kallas *et al*., 2019). However, global honey production is also subject to several forms of risk. These include the adverse domestic weather conditions, environmental degradation, and high trade costs due to stringent food legislation, quality, and safety standard measures by importer countries (Fallico *et al*., 2006; Wei *et al*., 2012; Pishvaee, 2017).

For instance, beekeepers and honey exporters ought to abide by the standards set by Codex Alimentarius (food code standards set by the Codex Alimentarius Commission in 1981) during the production, processing, and sale of honey. However, honey production in various countries is not always in line with the requirements set by

Codex Alimentarius (1981) due to the high licensing costs and absence of expertise on Codex Alimentarius procedures. For example, China's mode of honey production is found to be below their domestic honey standard (i.e. National Standards of People's Republic of China GB 16740-2014) (García, 2018).

On the other hand, in a high-income country like New Zealand, the New Zealand Ministry for Primary Industries (MPI) developed a robust and sophisticated scientific guideline for Mānuka honey (MPI, 2017). However, an issue arises as there are different requirements for its domestically sold and exported Mānuka honey. This different variant of standards will likely impact the long-run export competitiveness of the country.

A review of the literature (discussed in the next section) reveals that several studies have attempted to identify countries' export competitiveness in honey based on the prices, the export value and volume, and the number of destinations. Studies examining trade competitiveness based on countries' export duration at the foreign markets are rare. Past studies such as Besedeš and Prusa (2006), Nitsch (2009), Hess and Persson (2011), and Peterson *et al*. (2017) are the notable works contributing to this particular strand of literature.

In these studies, the duration of trade relationships is defined as the number of consecutive years an exporting country/firm supplies a given product to a destination. Using empirical models such as the Kaplan-Meier survival function and discrete-time hazard models, these researchers revealed that trade relationships tend to be short-lived with multiple sequences of trade. Specifically, there was a large proportion of trade relationships fail after just one year of service. However, it appears to be a contradiction as some exporters (e.g. those top exporting countries) are expected to be more competitive than the others and therefore are supposed to experience fewer fluctuations in trade. Given the issues raised above, it is crucial to identify if top exporting countries have suffered similar short-lived patterns of trade.

This chapter investigates the survival of the honey industry in the world's 14 leading honey exporting countries. It also identifies the key determinants influencing the differences in these countries' likelihood of exit for the period between 2000 and 2017. The 14 top honey exporting countries considered in this chapter are Argentina, Belgium, Brazil, Canada, China, Germany, Hungary, India, Mexico, Spain, Ukraine, Uruguay, Vietnam, and New Zealand. To the best of the authors' knowledge, this is the first study that has measured honey trade competitiveness based on a duration and survival (i.e. measured by the likelihood of failure) analysis.

It is believed that this chapter will contribute towards improved policies relating to honey exports in two significant ways. First, it will provide valuable export policy implications for both the current and future traders of honey. For example, a precise understanding of how honey producers performed in the past can help them reduce the risks from trade uncertainties and better adjust to the dynamics of demand and prices in international markets.

Second, for importers, a deeper understanding of the supply side constraints of honey is crucial for successfully gauging the present and future short to medium term domestic demand for honey. Supply-side uncertainties will disturb not only demand but also threaten national sufficiency of honey and honey products as well as more extensive national-level food security. It is the export duration of honey that is fundamental, and if short-lived, it can adversely impact both exporting and importing countries as they will be pressured to search for more targeted strategies of maintaining a viable long-term trade relationship.

The rest of the chapter is organised into six sections. The next section provides a review of existing studies on relevant areas. Section 5.3 provides an overview of the global honey market, summarising the general patterns of honey export duration from 2000 to 2017. Section 5.4 outlines the methodology and discusses the data. Section 5.5 discusses the findings followed by a conclusion in section 5.6.

5.2. Literature review

The study of export competitiveness has been an essential element of international trade research over the past few decades (Adams *et al*., 2006; Meade *et al*., 2016; Gilbert and Muchová, 2018). Recent literature on international trade reveals the continuity of research on export competitiveness in a wide range of commodities involving different countries around the world. For example, Bojnec and Ferto (2014) on the competitiveness of exports in dairy; Bojnec and Fertő (2016), Lombardi *et al*. (2016), and Chen (2017) on fruit and vegetables; Gibba (2017) on nuts; Seleka and Kebakile (2017) and Hejazi *et al*. (2019) on meat; Samon and Tansuchat (2016) and Narayan and Bhattacharya (2019) on rice and wheat, are some of the noteworthy studies, among others.

Existing studies reveal a variety of approaches adopted that can be employed to investigate a country’s trade competitiveness. A common approach is the use of price-related measures. For example, Jha *et al*. (2007) and Baiardi *et al*. (2015) use price differences to measure export competitiveness. Similarly, Demont *et al*. (2017) develop revealed price premiums to investigate the determinants of rice export competitiveness.

Besides, there are studies that employ dynamic and static revealed comparative advantage (RCA) indices based approach to gauge the competitiveness of trade flows (e.g. Batra, 2007; Akhtar *et al*., 2013; Esmaeili, 2014; Leromain and Orefice, 2014; Nath and Goswami, 2018). These studies argue that a measure like RCA reflects both relative costs and differences in factor intensities.

However, one limitation of these applications of RCA and the indices-based approach is that they rarely consider the longevity of trade relationships. As noted in Besedeš and Prusa (2006), Obashi (2010), and Cadot *et al*. (2013), trade relationships are generally regarded as vulnerable and short-lived in nature. In particular, traditional measures of trade competitiveness which are solely based on trade prices and flows are insufficient to explain the frequent fluctuations in global agricultural commodity trade.

An emerging area of trade research is an attempt to understand trade relationships based on trade duration and survival. Recent studies attempting to assess trade relationships based on their longevity and survival include Gullstrand and Perrson (2015), Peterson *et al*., (2017), and Straume (2017). They all found that trade relationships are remarkably short for a range of goods and countries. In particular, Peterson *et al*. (2017) employed a discrete-time-hazard model to examine the survival of the U.S. fresh fruit and vegetable imports by capturing a wide range of crucial factors, including variables such as sanitary and phytosanitary (SPS) requirements. In their study, these authors emphasised that this methodological approach is conducive and consistent with the patterns of global trade relationships as trade sequences tend to be discrete units of annual length. As a result, they found that U.S. commodity prices and exporting countries' GDP significantly impacted trade duration.

Other than Peterson *et al*. (2017), studies that have investigated the key factors influencing the survival of trade relationships include Nitsch (2009), Fugazza and Molina (2016), and Fertő and Szerb (2018). The findings of these researchers generally confirm that commonly used gravity variables, diversification, and initial export value are significant in explaining the survival of trade relationships. Precisely, Nitsch (2009) found that exporter characteristics, type of product, and market structure were the main factors influencing German import trade survival. In their study, Fugazza and Molina (2016) observed that export status is greatly influenced by the level of development of both the exporting and importing countries. Fertő and Szerb (2018) confirmed that market size, level of economic growth, and distance significantly impacted the duration of Hungarian maize exports.

No studies specifically examine the trade competitiveness of honey within the framework of the discrete-time hazard model of Peterson *et al*. (2017). Studies investigating the influence of food safety and security on trade relationship survival are sparse.

5.3. The global honey market

This section presents an overview of the worldwide honey market with a focus on the export competitiveness of the worlds-leading honey exporters. Two measures of 'competitiveness' are considered: (1) the number of export destinations and (2) the number and duration of survival sequences, respectively. Therefore, countries tend to be 'competitive' if they are found to export to a large number of destinations, and a large proportion of their export sequences survived an extended period. Sub-sections 5.3.1 and 5.3.2 provide detailed insights into these two measures of competitiveness.

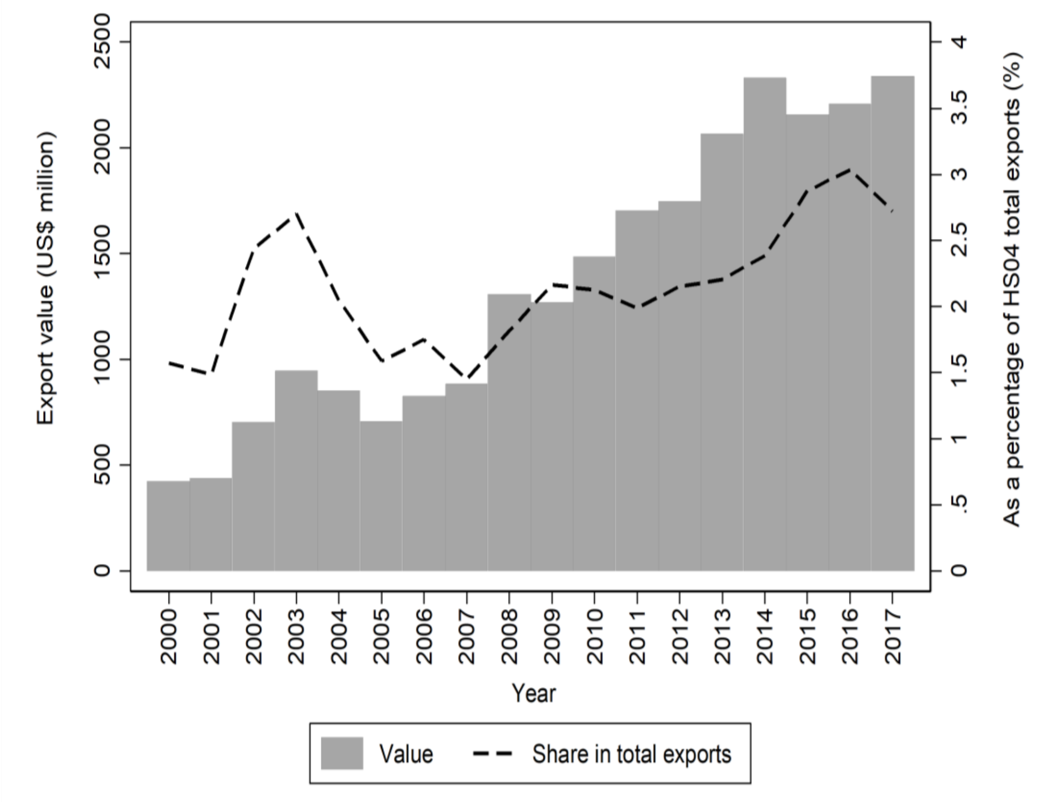
5.3.1. A perspective on competitiveness based on the number of export destinations

Honey consumption and trade worldwide has experienced stable growth in recent decades (García, 2018). Figure 5-1 depicts a five-fold increase in world total honey exports, increasing from approximately US$460 million to US$2,300 million from 2000 to 2017 respectively. Although the share of honey exports in total harmonised system of trade classification, HS04 (*Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included*) exports remains marginal at 2.5-3.0 per cent, recent patterns of trade flows reveal a gradual increase since 2007. This pattern is also reflected in our sample of the 14 exporting countries based on the number of times that they ranked within the top 10 honey exporters since 2000 (see Appendix for detailed rankings).

Table 5-1 presents the honey exports of the sample countries as a percentage of world total honey exports from 2000 to 2017. Overall, countries listed in Table 5-1 constituted approximately 73.8 per cent (85.5 per cent in total net weight) of world total honey exports, among which China (11.6 per cent) and New Zealand (11.5 per cent) were the exporters with the largest share in value in 2017. On a net weight basis, China (19.6 per cent), Argentina (10.7 per cent), and Ukraine (10.3 per cent) were the top honey exporting countries in 2017. Moreover, New Zealand’s honey exports in net weight were surprisingly marginal compared to the dominant position in 2017.

On a long-term basis, New Zealand honey exports in world total grew gradually since 2000. This growth is mainly attributable to New Zealand’s advantages in producing the differentiated Mānuka honey, which is found to be highly beneficial to human wellness due to its antibacterial components (Karasawa *et al*., 2017). The unique beneficial biochemical properties of Mānuka honey are likely to drive significant growth in honey exports from New Zealand in the following decade. In the meanwhile, domestic producers are likely to aggressively engaging in honey production, together with increased investment in bee farming and honey processing infrastructure and growing international awareness and market reputation of New Zealand's honey.

Figure 5-1 World honey exports by value and share in HS04 total, 2000-2017



Source: UN Comtrade Database. Author's compilation.

Table 5-1 Honey exports of leading countries by value and net weight, 2000-2017

	Argentina		Belgium		Brazil		Canada		China		Germany		Hungary	
Year	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %
2000	20.5	24.1	2.2	1.5	0.1	0.1	3.6	5.7	19.8	28.0	8.2	5.7	3.9	3.5
2001	16.3	20.6	2.4	1.9	0.6	0.7	2.9	6.0	21.8	30.1	9.2	6.5	4.4	3.6
2002	16.2	19.8	1.5	0.9	3.3	3.1	3.3	14.1	11.1	18.9	9.0	6.6	5.2	3.7
2003	16.9	18.2	1.1	0.6	4.8	5.0	1.6	12.2	10.9	21.7	8.4	5.5	5.5	4.1
2004	14.1	17.0	1.4	0.9	5.0	5.7	1.6	10.3	10.4	22.1	9.9	5.8	5.9	4.1
2005	18.1	26.7	2.1	1.2	2.7	3.6	1.8	6.2	12.4	21.9	11.3	6.5	6.0	4.7
2006	18.6	24.8	1.5	1.2	2.8	3.5	1.6	7.0	12.7	19.3	9.2	6.1	5.7	4.6
2007	15.2	21.0	1.4	1.1	2.4	3.4	1.9	9.5	10.7	17.0	9.7	6.3	6.7	5.5
2008	13.9	15.1	2.2	2.2	3.3	4.0	2.7	14.6	11.3	18.5	9.2	6.0	6.7	5.3
2009	12.6	14.5	3.1	3.4	5.2	6.5	1.0	10.5	9.9	17.9	8.7	5.5	4.8	3.6
2010	11.7	12.2	3.3	3.9	3.7	4.0	1.0	12.0	12.3	21.6	7.4	4.4	4.1	3.0
2011	13.1	15.0	3.2	3.5	4.2	4.6	0.6	8.1	11.8	20.7	7.1	4.2	3.5	2.6
2012	12.3	15.0	3.1	3.3	3.0	3.3	1.1	14.7	12.3	22.0	7.4	4.6	3.9	3.1
2013	10.3	11.2	3.5	3.8	2.6	2.8	0.6	10.2	11.9	21.5	6.8	4.1	4.4	3.3
2014	8.8	8.9	3.1	3.4	4.2	4.1	0.4	7.5	11.2	21.2	6.5	4.0	4.0	2.8
2015	7.6	7.4	3.7	4.1	3.8	3.6	0.6	8.5	13.4	23.5	6.6	4.3	3.6	2.9
2016	7.7	13.0	3.3	3.3	4.2	3.9	0.8	8.8	12.5	20.6	6.6	4.1	3.4	3.0
2017	7.8	10.7	3.3	3.0	5.2	4.1	0.8	9.2	11.6	19.6	6.3	3.9	4.2	3.6

	India		Mexico		NZ		Spain		Ukraine		Uruguay		Vietnam	
Year	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %	$ %	kg %
2000	0.5	0.5	8.2	8.5	1.2	0.8	3.4	2.1	n/a	n/a	0.7	0.8	0.8	0.6
2001	0.4	0.5	6.4	6.5	1.8	1.1	3.5	2.4	0.3	0.4	2.1	2.7	1.3	1.0
2002	1.3	1.6	8.9	8.5	1.3	0.7	4.9	3.9	0.6	0.8	2.1	2.4	2.8	2.3
2003	1.6	1.8	7.2	6.5	1.7	0.9	4.2	3.1	0.6	0.8	2.5	2.4	2.2	1.9
2004	1.8	2.5	6.7	7.1	2.2	0.8	4.2	2.8	0.8	1.3	3.4	3.6	2.1	1.6
2005	2.3	2.9	4.5	4.7	3.6	1.0	3.9	2.5	0.7	0.9	1.6	2.2	2.0	1.1
2006	3.1	3.7	5.8	6.1	3.2	1.1	3.6	2.6	1.1	1.6	2.1	2.9	2.2	1.4
2007	0.9	1.3	6.4	8.1	4.5	1.5	5.1	3.9	0.6	0.9	2.5	3.7	2.9	3.4
2008	2.9	4.1	6.4	6.5	3.9	1.5	4.7	3.5	0.6	0.7	1.9	2.0	2.6	4.0
2009	1.6	2.5	6.4	6.7	4.7	2.2	4.9	4.0	1.4	1.8	1.3	1.5	2.5	2.0
2010	3.8	4.0	5.7	5.7	4.7	1.4	5.5	4.6	1.3	1.5	1.5	1.7	3.4	3.6
2011	4.5	6.0	5.3	5.6	5.1	1.7	4.6	3.8	1.6	2.0	2.5	3.0	3.9	4.2
2012	3.4	4.9	5.8	6.4	6.0	1.7	4.6	3.9	1.8	2.7	1.7	2.2	3.3	n/a
2013	3.7	5.2	5.4	5.8	6.8	1.6	4.4	3.7	2.6	3.7	1.9	2.1	4.4	4.7
2014	3.3	4.4	6.3	6.4	7.2	1.5	5.2	4.3	4.0	5.9	1.6	1.7	5.7	5.9
2015	5.6	6.6	7.2	6.9	9.3	1.7	4.7	4.9	3.9	5.9	1.9	2.0	4.8	4.1
2016	3.2	5.7	4.2	4.7	9.3	1.5	4.9	4.3	4.4	9.1	0.8	1.2	3.3	2.8
2017	4.5	8.0	4.5	4.2	11.5	1.5	4.7	3.8	5.7	10.3	1.1	1.4	2.7	2.2

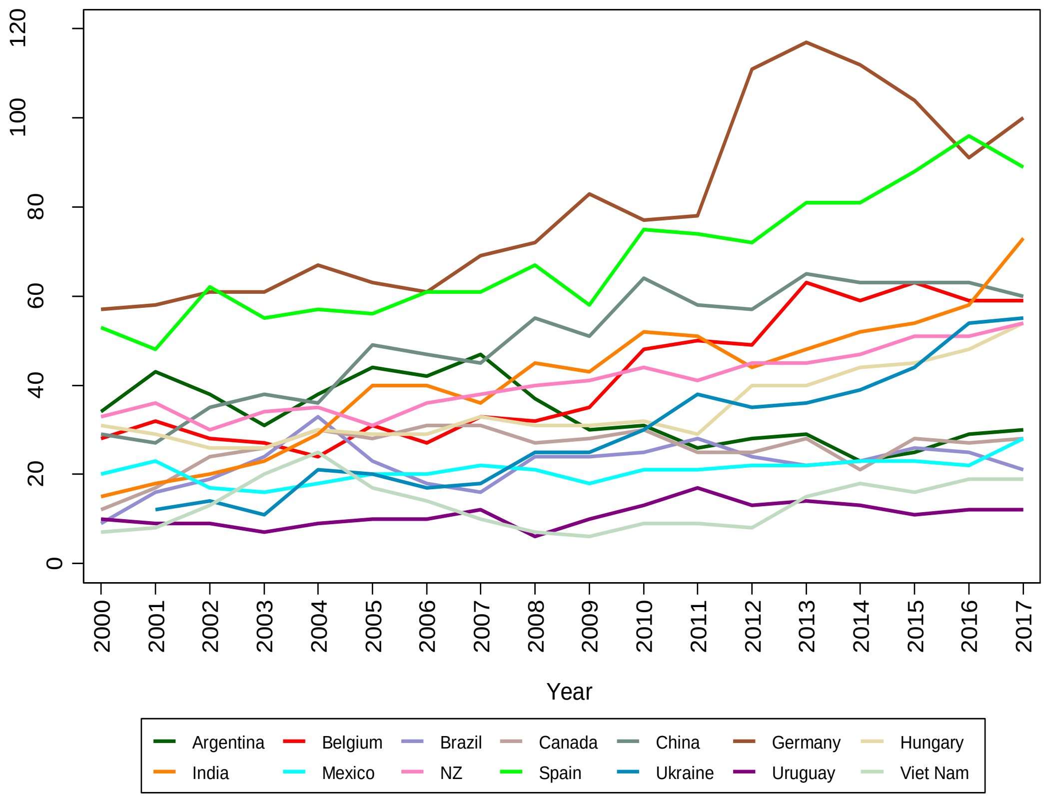
Note: '$' refers to honey exports in US$ million; 'kg' refers to the net weight of honey exports in kg; '%' is the share of the country in world total honey exports. Source: UN Comtrade Database, author's calculations.

Figure 5-2 depicts the total number of export destinations by country over time. According to Figure 5-2, Germany has the most significant number of destinations in most years between 2000 and 2017. In 2013, it exported to over 115 countries. Compared to Germany, export destinations for other large producers were Spain- 90, India- 78, China- 60, and Belgium- 58. Further, countries experiencing massive growth in accessing overseas market include India (300 per cent), Ukraine (260 per cent), Mexico (120 per cent), and Germany (72 per cent).

In contrast, Argentina has experienced significant fluctuations and reduced the number of its export markets between 2000 and 2017. This drop can be partly explained by the anti-dumping duties against its honey exports and the worst drought in recent years. For example, in 2001, as one of the largest importers, the U.S. announced the imposition of steep antidumping duties against honey imports from Argentina and a countervailing duty against Argentina of 5.9 per cent (Nogués, 2003). Also, Argentina's bees were declining 30 per cent every year as a result of mortality among the bee population (Root, 2019). These factors could lead to fluctuations in honey exports from Argentina. Other than Argentina, Uruguay, Vietnam, and Mexico have experienced marginal but stable growth of foreign markets.

Given the patterns depicted in Figures 5-1 and 5-2, it is believed that honey trade relationships have the characteristics of frequent and multiple sequences of trade. This observation is consistent with the literature on the trade duration of agricultural commodities such as Peterson *et al*. (2017).

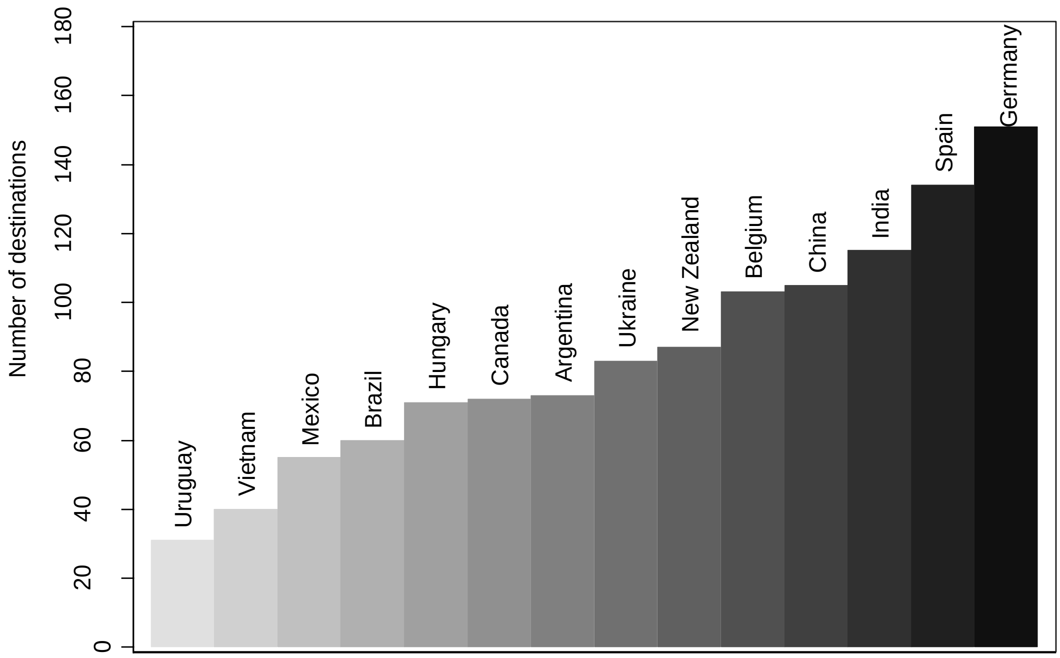
Figure 5-2 Expansion of markets by the exporting country, 2000-2017



Source: UN Comtrade Database, author's calculations.

Considering the observed short-lived nature of trade relationships, honey exports of these 14 countries may have also encountered difficulties of continuity which directly led to the multiple entries and exits at the foreign markets. Therefore, examining the duration of honey exports by country can reveal more information about their export competitiveness. We summarise the broadest coverage of export markets of these countries to illustrate the existence of short longevity of honey trade relationships. According to Figure 5-3, over 150 different countries imported German honey. Yet, it is worth noting that nearly one third (100) trade relationships failed to be maintained given the observed number of relationships of 2017. India, with the fastest growth in the number of foreign markets, also experienced a significant drop in its trade relationships between 2000 and 2017. It achieved 116 different markets in total over the period while only maintained 78 of them in 2017.

Figure 5-3 The total number of destinations during the period 2000-2017 by exporting country



Source: UN Comtrade Database, authors' calculations.

Given the patterns depicted in Figure 5-2 and 5-3, it can be said with much certainty that honey trade relationships have the characteristics of frequent and multiple sequences of trade. This observation is consistent with the literature on the trade duration of agricultural commodities reviewed in previous sections.

5.3.2. A perspective of 'sequence duration'

This section summarises the length of honey export sequences in years by country. In terms of trade competitiveness, a 'sequence' is referred to the period with continuous exports of honey to a specific destination. Correspondingly, the ‘duration’ or ‘length’ of a sequence is defined as the counted number of years a country has exported to a market with non-zero export flows.

According to statistics in Table 5-2, on average, almost half of the selected exporting countries experienced multiple sequences of trade (i.e. the number of sequences were higher than one), and approximately 9.2 per cent of the honey exports attempted more than three times of entry at the foreign markets. In terms of the duration, nearly 62 per cent of the sequences survived 1-2 years only while only 6.9 per cent survived for 18 years from 2000 to 2017. These observations are generally consistent with the findings of prior literature that trade relationships are vulnerable to multiple sequences of trade (Hess and Persson, 2011; Peterson *et al*., 2017).

Table 5-3 and 5-4 present additional evidence for the sequence duration at the country level. According to Table 5-3, Uruguay, Brazil, Canada, and Argentina have fluctuated dramatically during 2000 and 2017. More than 15 per cent of their relationships are observed to experience more than four sequences of trade, which is higher than the average of 9.2 per cent in Table 5-2. In particular, Argentina and Canada even had a relationship with six sequences of trade. In comparison, approximately 80 per cent of Mexico’s, Hungary’s, Vietnam’s, and New Zealand’s relationships are found to experience less than three sequences. However, we need to note that this finding does not lead to the conclusion that these countries tend to be more competitive and last longer in their foreign markets.

Table 5-2 Summary of country average number of sequence and duration

	AVERAGE		Length	AVERAGE	
No. of Sequence	No.	%	(years)	No.	%
1	42	49.7	1	73	46.4
2	22	26.4	2	24	15.5
3	12	14.7	3	12	7.7
4	5	6.4	4	7	4.7
5	2	2.6	5	5	3.3
6	0	0.3	6	5	2.9
Total	84		7	3	1.6
			8	3	1.9
≥ 4 sequences		9.2	9	2	1.5
			10	2	1.3
			11	2	1.1
			12	1	0.9
			13	2	1.0
			14	2	1.3
			15	1	0.7
			16	1	0.8
			17	1	0.5
			18	11	6.9
			Total	157	
			< 3 years		61.9
			≥ 15 years		8.8

Note: 'No.' refers to the number of relationships; '%' refers to the share in total relationships.

Source: UN Comtrade Database, author's own summary.

To further strengthen the 'survival' argument of our selected honey exporters, we summarise their trade relationships by sequence duration in years. In Table 5-4, more than 70 per cent of the relationships of Canada, India, and Uruguay survived less than three years in the 18 years from 2000 to 2017. Specifically, more than half of the relationships of Canada, India, Uruguay, Mexico, and Ukraine only survived one year. These countries are, therefore, relatively less 'competitive' given our criteria. Considering the countries with a large proportion of relationships survived a more extended period, we observe that Hungary, Germany, and New Zealand are most ‘competitive’ compared to the other selected honey exporting countries. More than 15 per cent of their trade relationships existed for at least 15 years.

So far, we have known the general patterns of honey export duration and survival of the selected countries. To learn the experience from those ‘competitive’ countries, this chapter will identify the factors influencing their survival at the foreign markets through empirical analysis within the framework of the discrete-time hazard model, discussed in the next section.

Table 5-3 Distribution of survival sequences by country, 2000-2017

	Argentina		Belgium		Brazil		Canada		China		Germany		Hungary	
No. of Sequence	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	33	45.2	62	60.2	25	41.7	38	52.8	43	41.0	84	55.6	41	57.7
2	20	27.4	21	20.4	17	28.3	16	22.2	38	36.2	39	25.8	18	25.4
3	9	12.3	14	13.6	8	13.3	7	9.7	13	12.4	22	14.6	11	15.5
4	6	8.2	5	4.9	9	15.0	6	8.3	8	7.6	5	3.3	1	1.4
5	4	5.5	1	1.0	1	1.7	4	5.6	3	2.9	1	0.7	0	0.0
6	1	1.4	0	0.0	0	0.0	1	1.4	0	0.0	0	0.0	0	0.0
Total	73		103		60		72		105		151		71	
>= 4 seqs	15.1		5.8		16.7		15.3		10.5		4.0		1.4	

	India		Mexico		New Zealand		Spain		Ukraine		Uruguay		Vietnam	
No. of Sequence	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	44	38.3	33	60.0	50	57.5	56	41.8	35	42.2	19	61.3	24	60.0
2	36	31.3	13	23.6	21	24.1	36	26.9	22	26.5	5	16.1	9	22.5
3	26	22.6	3	5.5	9	10.3	24	17.9	21	25.3	1	3.2	5	12.5
4	3	2.6	2	3.6	7	8.0	12	9.0	4	4.8	5	16.1	2	5.0
5	5	4.3	4	7.3	0	0.0	6	4.5	1	1.2	1	3.2	0	0.0
6	1	0.9	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Total	115		55		87		134		83		31		40	
>= 4 seqs	7.8		10.9		8.0		13.4		6.0		19.4		5.0	

Note: 'No.' refers to the number of relationships; '%' refers to the share in total relationships; The last row represents the share of relationships with more than 4 sequences in total relationships.

Source: UN Comtrade Database, authors' own summary.

Table 5-4 Observed trade relationships by sequence length in years

	Argentina		Belgium		Brazil		Canada		China		Germany		Hungary	
Length (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	69	46.0	75	43.9	58	46.8	81	57.4	82	40.0	97	38.3	44	38.6
2	29	19.3	26	15.2	23	18.5	25	17.7	31	15.1	25	9.9	16	14.0
3	16	10.7	13	7.6	12	9.7	8	5.7	23	11.2	22	8.7	4	3.5
4	2	1.3	9	5.3	8	6.5	3	2.1	10	4.9	11	4.3	6	5.3
5	4	2.7	5	2.9	4	3.2	5	3.5	5	2.4	13	5.1	4	3.5
6	3	2.0	5	2.9	3	2.4	2	1.4	5	2.4	10	4.0	10	8.8
7	2	1.3	2	1.2	4	3.2	3	2.1	3	1.5	5	2.0	2	1.8
8	3	2.0	8	4.7	1	0.8	1	0.7	6	2.9	3	1.2	3	2.6
9	3	2.0	4	2.3	0	0.0	0	0.0	8	3.9	7	2.8	1	0.9
10	1	0.7	1	0.6	3	2.4	2	1.4	5	2.4	4	1.6	1	0.9
11	1	0.7	2	1.2	1	0.8	0	0.0	2	1.0	7	2.8	3	2.6
12	0	0.0	1	0.6	1	0.8	1	0.7	1	0.5	4	1.6	0	0.0
13	0	0.0	3	1.8	0	0.0	1	0.7	7	3.4	2	0.8	0	0.0
14	1	0.7	2	1.2	0	0.0	1	0.7	3	1.5	4	1.6	2	1.8
15	1	0.7	1	0.6	1	0.8	1	0.7	0	0.0	3	1.2	2	1.8
16	0	0.0	1	0.6	2	1.6	1	0.7	6	2.9	1	0.4	0	0.0
17	1	0.7	0	0.0	0	0.0	2	1.4	1	0.5	0	0.0	1	0.9
18	14	9.3	13	7.6	3	2.4	4	2.8	7	3.4	35	13.8	15	13.2
Total	150		171		124		141		205		253		114	
< 3 yrs		65.3		59.1		65.3		75.2		55.1		48.2		52.6
>=15 yrs		10.7		8.8		4.8		5.7		6.8		15.4		15.8

Table 5-4 (Continued)

	India		Mexico		New Zealand		Spain		Ukraine		Uruguay		Vietnam	
Length (years)	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1	134	56.5	50	52.1	65	44.2	123	44.2	82	50.3	31	54.4	31	47.7
2	39	16.5	16	16.7	27	18.4	43	15.5	23	14.1	10	17.5	8	12.3
3	14	5.9	6	6.3	5	3.4	24	8.6	14	8.6	2	3.5	6	9.2
4	11	4.6	5	5.2	6	4.1	12	4.3	12	7.4	3	5.3	6	9.2
5	3	1.3	0	0.0	5	3.4	11	4.0	9	5.5	1	1.8	3	4.6
6	2	0.8	2	2.1	3	2.0	7	2.5	6	3.7	2	3.5	3	4.6
7	3	1.3	1	1.0	2	1.4	4	1.4	3	1.8	1	1.8	1	1.5
8	5	2.1	1	1.0	1	0.7	5	1.8	1	0.6	1	1.8	3	4.6
9	2	0.8	1	1.0	3	2.0	1	0.4	3	1.8	1	1.8	0	0.0
10	3	1.3	1	1.0	2	1.4	3	1.1	2	1.2	0	0.0	1	1.5
11	2	0.8	0	0.0	2	1.4	4	1.4	1	0.6	0	0.0	0	0.0
12	1	0.4	1	1.0	2	1.4	6	2.2	1	0.6	0	0.0	0	0.0
13	4	1.7	1	1.0	1	0.7	3	1.1	0	0.0	0	0.0	0	0.0
14	5	2.1	3	3.1	1	0.7	6	2.2	1	0.6	0	0.0	0	0.0
15	3	1.3	0	0.0	1	0.7	1	0.4	0	0.0	1	1.8	0	0.0
16	1	0.4	0	0.0	1	0.7	1	0.4	3	1.8	0	0.0	0	0.0
17	0	0.0	0	0.0	2	1.4	1	0.4	2	1.2	0	0.0	0	0.0
18	5	2.1	8	8.3	18	12.2	23	8.3	0	0.0	4	7.0	3	4.6
Total	237		96		147		278		163		57		65	
< 3 yrs		73.0		68.8		62.6		59.7		64.4		71.9		60.0
>=15 yrs		3.8		8.3		15.0		9.4		3.1		8.8		4.6

Note: ‘No.’ refers to the number of relationships; ‘%’ refers to the share in total relationships; The last two rows represent the share of relationships with a duration of more than 3 years/at least 15 years in total relationships.

Source: UN Comtrade Database, author’s own summary.

5.4. Methodological approach and data

This section describes the methodological framework from a theoretical perspective and the estimation procedures as well as the data entering the estimation phase. We use the discrete-time-hazard models, and all of the estimations follow the optimal discrete-time-hazard modelling procedure. The estimates are checked for robustness.

5.4.1. The discrete-time-hazard model

This chapter applies a discrete-time hazard model to overcome the potential biases in the commonly used continuous-time Cox hazard model in survival analysis. The discrete-time hazard model is often used to quantify the influence of various factors on trade duration simultaneously. The term 'discrete', in contrast to the 'continuous', captures the nature of trade duration more accurately as observed trade relationships tend to be discrete units of yearly length and many fall into the same category of equal length (Peterson *et al*. 2017).

In a discrete-time framework analysis, the hazard rate (also known as the failure rate) is defined as the likelihood that a trade relationship will survive to a certain point in time based on its survival to an earlier time *t*. In the survival analysis, the key is to form the conditional probability that a particular trade relationship ceases in a set of discrete-time *(d)* intervals $[t_d, t_{d+1}, t_{d+2}, \ldots, t_{dmax}]$ and when $d = 1$, $t_d = t_1 = 0$. Based on this and following Hess and Persson (2012) and Peterson *et al*. (2017) modelling approaches, we let h_{id} be the discrete-time hazard rate. Then the probability of failure conditional on its survival up to the beginning of the interval and given the covariates included in a structural model represented by equation (5.1):

$$h_{id} = P(T_i < t_{d+1} | T_i \geq t_d, x_{id}) = F(\gamma_d + x'_{id}\beta) \quad (5.1)$$

where T_i refers to a non-negative, continuous random variable that measures the survival time of the i_{th} trade relationship. The subscript i here denotes separate sequences of trade (exporter-importer) relationships, $i = (1, \ldots, n)$. $F(\cdot)$ refers to an appropriate distribution function that ensures $0 \leq h_{id} \leq 1$ for all i and k. γ_d is then a function of time/interval that allows the hazard rate to vary across periods. Since the baseline hazard rate is unknown in practice, γ_d is usually incorporated into the empirical model as a set of dummy variables identifying the duration of each sequence and characterising the baseline hazard. x_{id} is a set of time-varying covariates, such as yield and weather in our case, and β are regression coefficients.

Introducing $y_{id,}$ a binary variable that takes the value one if sequence i is observed to terminate in the time interval k_{th}, and zero otherwise (also regarded as a dummy variable). Hence, the log-likelihood function for the observed observations is specified as below:

$$ln\mathcal{L} = \sum_{i=1}^{n} \sum_{d=1}^{d_i} [y_{id} \ln(h_{id}) + (1 - y_{id}) \ln(1 - h_{id})] \qquad (5.2)$$

During the estimation, it is necessary to specify a functional form for the hazard rate h_{id}. The estimation standard functional specifications, including the *probit*, *logit* and *cloglog* model. Also, each sequence is assumed to be independent of all other sequences as there might be multiple sequences and dependencies across commodities from the same supplier or across suppliers of the same product. After incorporating all the potential factors into equation (5.2), the baseline discrete-time hazard model takes the estimable form as outlined below:

$$y_{idt} = f(D_{idt}, C_{idt}, S_{idt}, P_{idt}, Gravity_{idt}, Security_{idt}, Safety_{idt}) \qquad (5.3)$$

where the subscript idt denotes a particular exporting country's i_{th} honey trade relationship with a destination d in time t. The dependent variable y_{idt} equals one if relationship i ceases when trading with destination d in time t and zero otherwise.

D_{idt} refers to two variables. The first is the number of years that the current sequence of the i_{th} trade relationship with destination d has lasted in time t ($duration$). The second is a dummy variable $multiple$, which equals one if the relationship involves multiple sequences of trade. C_{idt} is another dummy variable that equals one if a trade relationship is left-censored (*left-censored*). S_{idt} represents a range of supply-side factors including the number of export destinations (*dest*), the gross production of exporting country in US$ millions (*yield*), beehive stock (*beehive*), and the number of suppliers (*suppliers*). P_{idt} is the estimated trading price of honey exports (*price*) in US dollars using real statistics of export flows and net weight.

The covariate $gravity_{idt}$ is a set of gravity-type variables including the geographical distance between a country-pair (*distance*) in 1,000 kilometres, population of the destination country (*pop*) in 1,000 persons, and level of economic development measured by the annual GDP growth rate of the destination country (*GDP*). $Security_{idt}$ is a set of variables measures the exporting country's food security, including the average dietary energy supply adequacy (*ESA*) index, the political stability and absence of violence/terrorism (*PSV*) index, the prevalence of undernourishment (*PU*) index, and the Producer Price Index (*PPI*). $Safety_{idt}$ denotes a set of measures of the exporting country's food safety. It includes the annual percentage change in forest land (*forest*), total pesticides use in agriculture (*pesticides*) in kilotons, and yearly temperature change (*weather*).

5.4.2. Unobserved heterogeneity

As the hazard rate of exporting tends to be destination-dependent in prior literature, some destinations will encounter a higher probability of failure than others. However, it is unlikely that those variabilities can be fully captured by current covariates. The presence of unmeasured destination-specific (time-invariant) risk factors leads to unobserved heterogeneity in the hazard, which is also known as the 'frailty' in some studies (Jenkins, 2004). If there are destination-specific unobserved factors that potentially affect the hazard, the observed form of the hazard function at the aggregate level will tend to be different from the destination-level hazards. If unobserved heterogeneity is incorrectly ignored in the study, a positive duration dependence will be understated, and a negative duration dependence will be overstated. To allow for unobserved heterogeneity in the discrete-time model (5.2), we introduce a random effect which represents the destination-specific unobservable:

$$\text{cloglog}\ [h\ (j, X \mid v)] = D(j) + \beta' X + \mu \tag{5.4}$$

where D characterises the baseline hazard function (as in equation (5.3)) and is a vector of functions of the cumulative duration by interval, X is a vector of covariates with coefficients β'. The 'error' term μ is a random variable with mean zero and finite variance. $\mu \sim N(0, \sigma_\mu^2)$ allows for unobserved heterogeneity between destinations due to time-invariant omitted variables (Jenkins, 2004).

5.4.3. Data

The analysis is based on annual honey export data for 14 countries (Argentina, Belgium, Brazil, Canada, China, Germany, Hungary, India, Mexico, Spain, Ukraine, Uruguay, Vietnam, plus New Zealand) based on HS040900 classification code. This is sourced from the UN Comtrade Database available online at comtrade.un.org/db/ to construct the duration of each trade sequence and the status of whether a sequence is failed for 18 years from 2000 to 2017. Using the collected export time series, we create variables including *multiple*, *left-censored*, *destinations*, and *suppliers*.

Other covariates are collected from various sources, including the Food and Agriculture Organization (FAO) of the United Nations [www.fao.org/faostat], and the Centre d'Etudes Prospectives et a'Informatins Internales (CEPII) [www.cepii.fr/cepii/en/bdd_modele/bdd.asp]. In particular, *yield*, *beehive*, *ESA*, *PSV*, *PU*, *PPI*, *forest land*, *pesticides*, *weather*, *population*, *GDP* are collected from FAO. The *distance* is sourced from CEPII.

A strategy to create the final dataset for estimation is to decompose trade sequences of the 14 exporting countries at the destination-level in exporter-destination-period form. For instance, for the period from 2000 to 2017, Argentina exported honey to Algeria in four years- 2001, 2004, 2005, and 2008. By decomposing this trade relationship by sequence, we have three sequences of trade/ or three observations for the relationship between Argentina and Algeria. Following the same methodology, we decompose all the trade relationships that each of the 14 countries has during the period concerned. This gives us 8,570 observations. After incorporating the covariates into the decomposed sequences, the final dataset is balanced.

5.5. Results

This section interprets and analyses the results from discrete-time-hazard models. Appendix A presents the summary statistics. Note that the dependent variable is measured by the hazard probabilities (*failed*), meaning that how likely a sequence will terminate given other conditions. The length of trade sequences (*duration*) is incorporated into the model as one of the explanatory variables.

5.5.1. Baseline discrete-time-hazard model

Following the methodological framework of Hess and Persson (2012) and Peterson et al. (2017), we first estimate the baseline hazard rate functions using the discrete-time *logit*, *probit*, and *cloglog* models. This allows us to estimate the full sample data with all covariates as specified in equation (5.3). In Table 5-5, we have the estimated coefficient of each variable (*Coef.*) and their corresponding robust standard errors (*Std. Err.*) in parentheses. It can be seen from the model (1) to (6) that most variables are statistically significant to explain the variations in hazard rates at 5 per cent and 1 per cent significance level. Specifically, measures under D_{idt}, C_{idt}, S_{idt}, $Security_{idt}$, and $Safety_{idt}$ are more significant than P_{idt} and $Gravity_{idt}$.

In terms of D_{idt}, *duration*, as expected, has significantly reduced the hazard probabilities across all models. For instance, an extra year of survival in a foreign market decreases the log-odds of failure by 1.121, holding all other independent variables constant. By calculating the odds ratio, for every one-year increase in export sequence, we expect approximately a 67 per cent decrease in the likelihood of failure. This indicates that longer sequences of export lower countries' hazard rate of failure at their foreign markets as exporters are likely to cope with trade barriers and uncertainties much easier after staying for a more extended period.

Similar results can also be found on the coefficients of the dummy variable *multiple*. It is evident that the hazard rate decreases as the number of multiple sequences increase for trade relationships that experience multiple entries and exits at the foreign markets. This finding is consistent with prior studies such as Peterson *et al*. (2017). It reveals that multiple entries into a market would reduce entry costs as exporting countries had already paid the charges and costs when they attempted to enter the market for the first time.

Similarly, the highly significant coefficient of *left-censored* at 1 per cent significant level implies that the hazard rate is lower for left-censored honey trade relationships compared to non-left-censored ones (i.e. the estimated coefficient is significantly negative). For instance, the coefficient of -1.221 in model (1) indicates that left-censoring sequences have a -1.221 lower odds of failure.

Among the four supply-sided factors, *destinations*, *yield*, and *suppliers* are statistically significant to explain the variations in the likelihood of failure at 1 per cent level. Only *beehive* stock tends to be insignificant at any level. In terms of the sign of coefficient, an extra exporting *destination* lowers the odds of failure by 0.007-0.014. This finding is consistent with the theoretical arguments that market diversification helps countries reduce the risks of failure and maintain their competitiveness in the global market. Hence, the estimated coefficient for *destinations* is statistically significant at 1 per cent for all the estimators in Table 5-5.

Similarly, the gross *yield* of exporting countries has a positive influence (0.001) on the hazard rate as the estimated coefficient is positive and statistically significant. However, a further US$1 million increase in the production only decreases the log odds by 0.001 across all estimators. In terms of the calculated odds ratio of 1.001, this means that yield growth is marginally significant to influence the probability of export failure. This finding is also consistent with Peterson *et al*. (2017).

On the contrary, an extra *supplier* of honey at the destination decreases the odds of failure by 4 per cent. This finding is surprising and inconsistent with Peterson *et al*. (2017) that there is a positive relationship between the number of suppliers and the hazard rate. As mentioned previously, this could be partly explained by the nature of the commodity. That is, honey is a non-essential good, only countries with a history or preference for honey consumption tend to diversify their foreign suppliers. This could further encourage competitive suppliers to survive longer.

In terms of the estimated prices of honey exports, the results in Table 5-5 (models (1) to (6)) reveal that the coefficient *price* is statistically insignificant across all estimations. It is inconsistent with the findings of previous studies (for example, Peterson *et al.*, 2017) which leads to the suggestion that prices have a significantly negative influence on the hazard rate. This can be explained by the naturally occurring attributes of the commodity exported. Comparing with the fresh fruit and vegetables (such as in Peterson *et al*., 2017) which is typically regarded as necessary goods, honey tends to be more origin- and variety-dependent. For instance, Mānuka honey made in both New Zealand and Australia appears to be more expensive due to its unique bioactive properties. It contains dietary methylglyoxal, which forms naturally in the Mānuka flower's nectar and is said to give the honey its healing properties. Therefore, the market price of Mānuka honey has been higher than the other varieties such as the wildflower or clover honey. This characteristic also makes the consumption and exports of this particular variety of honey less elastic to the changes in price.

Considering the influence of gravity variables, models (1) to (6) capture the particular effects of *distance, population,* and *GDP*. However, only *distance* is significantly associated with the hazard rate of honey exports. The odds of exports failure are predicted to be 4 per cent higher with each additional 1,000 kilometres of the distance between a country pair. This observation is in line with the predictions of the gravity model, which suggests that trade flows are inversely related to distance when it proxies for trade barriers (Chaney, 2018). Meanwhile, the insignificant coefficients of population and GDP suggest that the previously significant effects of market size and the level of economic development are diminishing. This could be partly explained by the increasing demand for safer food globally in recent decades. This dramatically changes consumer's preference for imported food and therefore affects production and trade decisions.

To further capture the impacts of exporting country's food security on the survival of honey exports, the baseline hazard models in Table 5-5 consider four indices for *security* and three measures for *safety*. In terms of food security, it can be observed that the *PSV* index is statistically significant at the 5 per cent level to decrease the hazard rate across all estimators. Its coefficient ranges between -0.084 and -0.145. On an odds ratio basis, this means that one unit of increase in *PSV* index lowers the hazard rate by around 13 per cent.

Also, the coefficient of the *PPI* index tends to be highly significant at the 1 per cent significance level. However, one unit increase in the *PPI* index would only marginally decrease the hazard rate by around 1 per cent, on an odds ratio basis. In contrast, the *ESA* and *PU* indices are statistically insignificant in explaining the changes in the hazard rate with negligible coefficients. These results confirm that food security as captured by the stability of the exporting country's domestic environment could help countries survive longer at their foreign markets and being competitive.

We also use *forest*, *pesticides*, and *weather* as the three measures reflecting a particular exporting country's food safety. Theoretically, the expectation is that safer food makes countries' exports more competitive and helps them stay for a more extended period in their foreign markets. In Table 5-5, we can observe coefficients *forest* and *pesticides* are statistically significant effect on the hazard rate in most models. In particularly, a one per cent annual increase in an exporting country's forest land tends to reduce the log odds by up to 0.1 (i.e. model (1)). On an odds ratio basis, this means that the odds of failure are predicted to be 10 per cent lower with one per cent additional increase in the exporting country's forest land. This finding is consistent with our expectations that the expansion of forest land benefits honey production and helps countries export.

However, the usage of pesticides which is assumed to affect food safety and the country's export survival directly has a significant yet marginal influence on the hazard rate. The sign of the coefficient for *pesticides* is positive as expected. This means that pesticides used in agriculture may inversely affect honey production as a result of the destruction of bees' habitat and therefore influence honey exports survival by increasing the likelihood of export failure.

Table 5-5 Estimated coefficients from the baseline discrete-time hazard model

	(1) Logit	(2) Logit	(3) Probit	(4) Probit	(5) Cloglog	(6) Cloglog
Dep. Var: *Failed*	Coef. Std. Err.	Coef. Std. Err.	Coef. Std. Err.	Coef. Std. Err.	Coef. Std. Err.	Coef. Std. Err.
Duration and Multiple (D_{idt})						
Duration	-1.121 (0.05)***	-1.238 (0.07)***	-0.608 (0.03)***	-0.711 (0.04)***	-0.985 (0.04)***	-1.041 (0.06)***
Multiple	-0.289 (0.08)***	-0.405 (0.10)***	-0.168 (0.04)***	-0.263 (0.06)***	-0.244 (0.06)***	-0.295 (0.08)***
*Duration*multiple*	------- -----------	0.053 (0.03)*	------- -----------	0.039 (0.02)**	------- -----------	0.028 (0.03)
Censoring (C_{idt})						
Left-censored	-1.221 (0.12)***	-1.518 (0.16)***	-0.610 (0.06)***	-0.892 (0.08)***	-1.101 (0.11)***	-1.244 (0.14)***
*Duration*censored*	------- -----------	0.086 (0.03)***	------- -----------	0.069 (0.01)***	------- -----------	0.045 (0.03)*
Supply-sided factors (S_{idt})						
No. of destinations	-0.013 (0.00)***	-0.014 (0.00)***	-0.007 (0.00)***	-0.008 (0.00)***	-0.011 (0.00)***	-0.011 (0.00)***
Yield	0.001 (0.00)***	0.001 (0.00)***	0.001 (0.00)***	0.001 (0.00)***	0.001 (0.00)***	0.001 (0.00)***
Beehive stock	-0.030 (0.02)	-0.029 (0.02)	-0.018 (0.01)	-0.017 (0.01)	-0.020 (0.02)	-0.019 (0.02)
No. of suppliers	-0.038 (0.00)***	-0.038 (0.00)***	-0.020 (0.00)***	-0.021 (0.00)***	-0.031 (0.00)***	-0.032 (0.00)***
Price (P_{idt})						
Price	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Gravity variables ($Gravity_{idt}$)						
Distance	0.042 (0.01)***	0.041 (0.01)***	0.024 (0.00)***	0.023 (0.00)***	0.033 (0.01)***	0.033 (0.01)***
Importer Population	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Importer GDP	-0.002 (0.00)	-0.003 (0.00)	-0.001 (0.00)	-0.002 (0.00)	-0.001 (0.00)	-0.001 (0.00)
Security ($Security_{idt}$)						
ESA	0.003 (0.01)	0.004 (0.01)	0.002 (0.00)	0.003 (0.00)	0.002 (0.00)	0.002 (0.00)
PSV	-0.145 (0.06)**	-0.145 (0.06)**	-0.085 (0.04)**	-0.084 (0.04)**	-0.108 (0.05)**	-0.107 (0.05)**
PoU	0.008 (0.01)	0.008 (0.01)	0.007 (0.01)	0.007 (0.01)	0.004 (0.01)	0.004 (0.01)
PPI	-0.002 (0.00)***	-0.002 (0.00)***	-0.001 (0.00)***	-0.001 (0.00)***	-0.002 (0.00)***	-0.002 (0.00)***
Safety ($Safety_{idt}$)						
Forest land	-0.100 (0.05)*	-0.099 (0.05)*	-0.063 (0.03)**	-0.060 (0.03)**	-0.068 (0.04)	-0.067 (0.04)
Pesticides	0.000 (0.00)**	0.000 (0.00)**	0.000 (0.00)**	0.000 (0.00)*	0.000 (0.00)**	0.000 (0.00)**
Weather	-0.077 (0.07)	-0.075 (0.07)	-0.034 (0.04)	-0.032 (0.04)	-0.081 (0.06)	-0.080 (0.06)
Obs	8580	8580	8580	8580	8580	8580
Log-likelihood	-2851	-2846	-2858	-2844	-2852	-2851

Note: Robust standard errors (Std. Err.) are in parentheses; *** P < 0.01, ** P < 0.05, and * P < 0.1.

5.5.2. Decomposition of the multiple sequences

To evaluate the influence of multiple sequences on survival and country-specific hazard rates, we further decompose *multiple* into four separate intervals of sequence and create their corresponding interactions with *duration*. Also, we include both *year* and *exporter* dummy variables to predict the country-specific hazard rates, given the influence of all covariates.

Table 5-6 shows that *duration*, *multiple*, *left-censoring*, *yield*, *beehive stock*, *PSV*, *PU*, *distance*, and the *number of suppliers* are the most statistically significant factors affecting the hazard rate. Most tend to be negatively associated with the changes in the hazard rate, except for the geographical *distance*. This result seems surprising as *yield* and *PSV* are hypothesised to decrease the hazard rate. Also, a few factors such as *PPI*, *forest land*, and *pesticides* become insignificant after controlling for year and country dummies. Furthermore, we can see that *multiple* sequences significantly increase the hazard rate for exporting countries with longer duration of the sequence. On an odds ratio basis, countries are predicted to have approximately 63 to 72 per cent higher hazard rate if they attempt entry two to four times

In comparison, exporters with more than five sequences start to influence the hazard rate negatively. However, these effects tend to be statistically insignificant, given our results. This finding is not in line with Peterson *et al*. (2017) which finds that the hazard rate decreases mainly for countries in their third and fourth spells of service. A possible reason could be the inclusion of *duration* as the interaction terms. This implies that countries with the ability to survive longer at their foreign markets are unable to benefit from the accumulated experience of exports. In this case, multiple entries and exit do not help countries survive. In other words, only countries that have not established trade relationships with their partners for a longer period might gain from the multiple sequences of service. It can be seen that *multiple* overall tends to decrease the odds of failure by up to 0.525. As discussed previously, we know that a large proportion of sequences survived no more than two years. Therefore, the significantly negative coefficient of *multiple* is primarily influenced by a large number of short-lived sequences of exports. That is to say, *multiple* has totally different effects on the countries that can trade for a longer and shorter period.

Table 5-6 Baseline model with the decomposition of multiple sequences (*Multiple*)

	(1) Logit	(2) Logit	(3) Probit
Dependent Variable: *Faile*	Coef. Std. Err.	Coef. Std. Err.	Coef. Std. Err.
Duration and Multiple (D_{idt})			
duration	-1.365 (0.07)***	-1.425 (0.08)***	-0.785 (0.04)***
multiple	-0.525 (0.11)***	-0.492 (0.12)***	-0.330 (0.07)***
*duration*multiple*	0.090 (0.03)***	-0.054 (0.07)	0.057 (0.02)***
*duration*seq2*	------- -----------	0.543 (0.24)**	------- -----------
*duration*seq3*	------- -----------	0.488 (0.25)**	------- -----------
*duration*seq4*	------- -----------	0.509 (0.31)*	------- -----------
*duration*seq5*	------- -----------	-1.968 (1.41)	------- -----------
Censoring (C_{idt})			
left-censored	-1.084 (0.20)***	-1.075 (0.20)***	-0.663 (0.10)***
*duration*censored*	0.063 (0.03)**	0.071 (0.03)**	0.057 (0.01)***
Supply-sided factors (S_{idt})			
destinations	-0.007 (0.00)	-0.007 (0.00)	-0.004 (0.00)
yield	0.001 (0.00)*	0.001 (0.00)	0.001 (0.00)*
beehive	-0.316 (0.15)**	-0.299 (0.15)**	-0.178 (0.08)**
suppliers	-0.041 (0.00)***	-0.041 (0.00)***	-0.023 (0.00)***
Price (P_{idt})			
price	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
Gravity variables ($Gravity_{idt}$)			
distance	0.054 (0.01)***	0.054 (0.01)***	0.030 (0.01)***
population	0.000 (0.00)	0.000 (0.00)	0.000 (0.00)
GDP	-0.004 (0.00)	-0.004 (0.00)	-0.002 (0.00)
Food Security ($Security_{idt}$)			
ESA	-0.008 (0.02)	-0.008 (0.02)	-0.005 (0.01)
PSV	0.259 (0.14)*	0.278 (0.14)**	0.139 (0.08)*
PU	-0.083 (0.05)*	-0.082 (0.05)*	-0.051 (0.03)*
PPI	-0.001 (0.00)	-0.001 (0.00)	-0.001 (0.00)
Food Safety ($Safety_{idt}$)			
forest	0.163 (0.13)	0.161 (0.13)	0.070 (0.07)
pesticides	-0.001 (0.00)	-0.001 (0.00)	-0.001 (0.00)
weather	0.081 (0.09)	0.082 (0.09)	0.045 (0.05)
Observations	8580	8580	8580
Log-likelihood	-2721	-2715	-2720
Lintest (_hatsq P>|z|)	0.190	0.273	0.762

Note: Robust standard errors (Std. Err.) are in parentheses; *** P < 0.01, ** P < 0.05, and * P < 0.1; *year* and *exporter* dummy are used.

Table 5-6 (Continued)

Dependent Variable: *Faile*	(4) Probit Coef. Std. Err.	(5) Cloglog Coef. Std. Err.	(6) Cloglog Coef. Std. Err.
Duration and Multiple (D_{idt})			
duration	-0.809 (0.04)***	-1.116 (0.06)***	-1.165 (0.07)***
multiple	-0.325 (0.07)***	-0.361 (0.09)***	-0.293 (0.09)***
*duration*multiple*	-0.002 (0.04)	0.053 (0.03)*	-0.091 (0.07)
*duration*seq2*	0.236 (0.13)*	------- -----------	0.509 (0.21)**
*duration*seq3*	0.185 (0.13)	------- -----------	0.472 (0.22)**
*duration*seq4*	0.203 (0.17)	------- -----------	0.491 (0.27)*
*duration*seq5*	-1.076 (0.68)	------- -----------	-1.790 (1.35)
Censoring (C_{idt})			
left-censored	-0.656 (0.10)***	-0.911 (0.17)***	-0.904 (0.17)***
*duration*censored*	0.060 (0.01)***	0.025 (0.03)	0.032 (0.03)
Supply-sided factors (S_{idt})			
destinations	-0.005 (0.00)*	-0.004 (0.00)	-0.004 (0.00)
yield	0.001 (0.00)	0.001 (0.00)*	0.001 (0.00)*
beehive	-0.169 (0.08)**	-0.233 (0.11)**	-0.221 (0.11)*
suppliers	-0.023 (0.00)***	-0.033 (0.00)***	-0.033 (0.00)***
Price (P_{idt})			
price	0.000 (0.00)	-0.000 (0.00)	-0.000 (0.00)
Gravity variables ($Gravity_{idt}$)			
distance	0.030 (0.01)***	0.041 (0.01)***	0.041 (0.01)***
population	0.000 (0.00)	-0.000 (0.00)	-0.000 (0.00)
GDP	-0.002 (0.00)	-0.002 (0.00)	-0.002 (0.00)
Food Security ($Security_{idt}$)			
ESA	-0.005 (0.01)	-0.008 (0.02)	-0.008 (0.02)
PSV	0.148 (0.08)*	0.187 (0.11)*	0.201 (0.11)*
PU	-0.050 (0.03)*	-0.064 (0.04)*	-0.063 (0.04)*
PPI	-0.001 (0.00)*	-0.001 (0.00)	-0.001 (0.00)
Food Safety ($Safety_{idt}$)			
forest	0.070 (0.07)	0.138 (0.11)	0.139 (0.11)
pesticides	-0.001 (0.00)	-0.001 (0.00)	-0.001 (0.00)
weather	0.044 (0.05)	0.049 (0.08)	0.050 (0.08)
Observations	8580	8580	8580
Log-likelihood	-2715	-2728	-2722
Lintest (_hatsq P>|z|)	0.677	0.019	0.041

Note: Robust standard errors (Std. Err.) are in parentheses; *** P < 0.01, ** P < 0.05, and * P < 0.1; *year* and *exporter* dummy are used.

5.5.3. Within sample predictions

Prior sections interpreted and analysed the estimated coefficients of each factor in details. This section provides within-sample predictions of the hazard probability by country and the duration of the sequence. Through identifying the general trend in the hazard probabilities, countries and businesses can acknowledge the performance and competitiveness of themselves and their competitors. This provides significant implications for their future trade strategies.

Figure 5-4 shows the predicted probabilities of failure by exporting country given the condition of whether a relationship has multiple sequences of trade or not (i.e. *multiple* = 1 or 0). Note that these probabilities are estimated using the optimal *probit* estimator of our discrete-time hazard models (i.e. model (4) in Table 5-6). We can find that the hazard rates tend to be L-shaped across all countries. That is, honey exports are most likely to fail in the beginning years of service no matter multiple sequences are present or not. On average, more than 50 per cent of the exports are likely to fail in the first two years of entry. As time passes, the probability of failure decreases gradually ending with stability in the long-run as depicted in Figure 5-4.

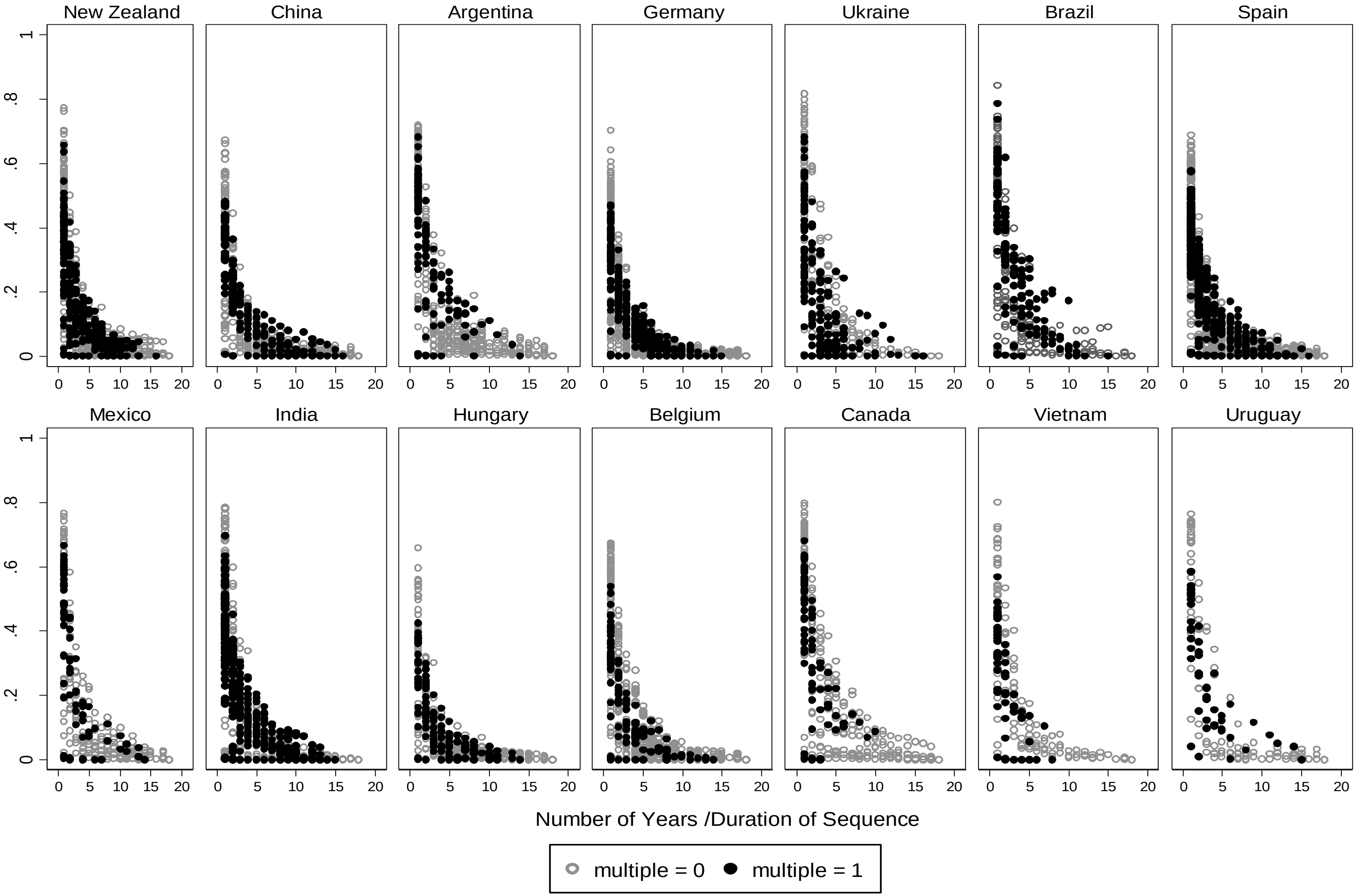
Also, there are indeed some country-specific patterns. For instance, Argentina, Brazil, Mexico, Canada, Vietnam, and Uruguay are likely to experience a higher hazard rate if they attempt multiple entries of trade at their overseas markets. Therefore, we can see that on average, the hazard probabilities of these countries with multiple sequences are distributed at a higher level (shown as black dots). As a result of our estimations, we know that their high likelihood of failure is influenced by various factors such as the number of exporting destination, yield, food security and safety, and fierce foreign competition.

Other than those determinants, there are some other factors that were hard to capture with our models but do tend to influence the honey supply of these particular countries. For instance, Argentina was one of the countries dominating the global honey market as most of its honey production was exported. However, it seems that honey production in Argentina declined significantly in recent decades due to the reduction of pasture and expansion of other plantations such as soybeans, corn, and wheat (Popper, 2008). In Brazil, increased usage of insecticides could be cause for global concern in recent decades as they may leave residuals on crops, bee products, and in the overall environment (dos Santos *et al*., 2018). In addition to those risks, some fundamental issues in the global beekeeping industry are found to be common in major honey exporting countries. These issues are often associated with the ability to diversify the market, low pricing transparency, inadequate skilled-inputs, difficulties with finance, and an inability to conduct quality and standard test (Bradbear, 2009; de Figueiredo Junior *et al*., 2016).

In contrast, multiple sequences are found to be less significant in influencing countries such as New Zealand, China, Spain, India, Hungary and Belgium. The predicted hazard rates of these countries are evenly distributed at different levels. Overall, a few countries are likely to experience a lower hazard rate over time, including China, Germany, Hungary, Belgium, and New Zealand. These countries, therefore, tend to be more competitive in capturing a foreign market, based on our predictions.

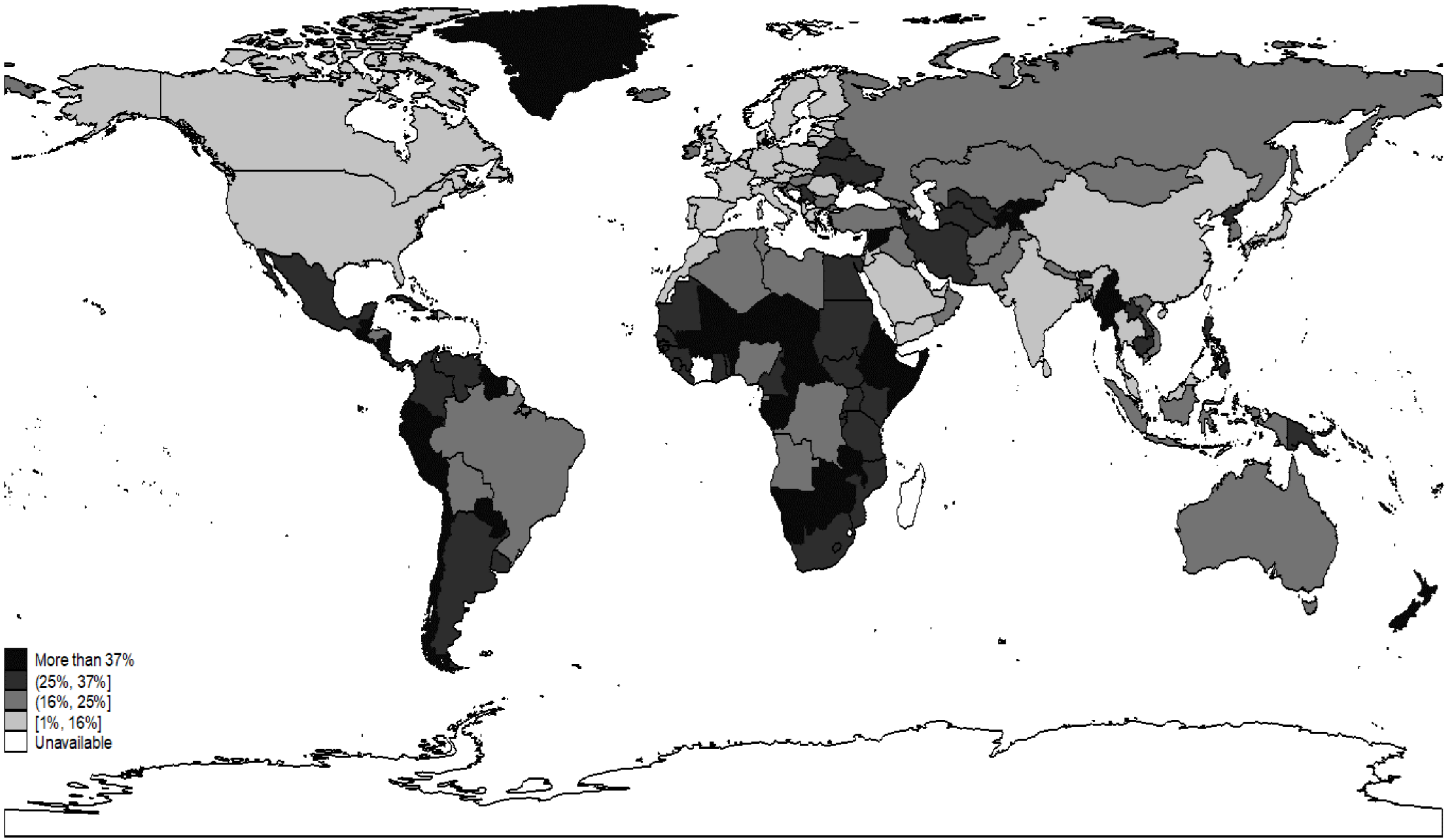
Figure 5-5 depicts the destination-specific average hazard rates predicted based on our optimal discrete-time hazard model (4) in Table 5-6. Given our predictions, the likelihood of the exporting country's failure is also destination-dependent. We can see that honey exports tend to suffer a relatively higher probability of failure in the regions, such as Africa and South America. Also, more than 37 per cent of the honey leading exports are predicted to fail when supplying markets, including New Zealand, Denmark, Peru, Chile, Mali, Niger, Myanmar, and so on. This is possibly related to the self-efficiency of honey production in these countries as well as the tariff and non-tariff measures imposed on honey imports from overseas.

Figure 5-4 Predicted hazard probabilities by exporting country



Source: Author's own estimates.

Figure 5-5 Average predicted probability of failure by destination based on optimal model



Source: Author's own estimates.

However, it is interesting to see that New Zealand is the only country from the top exporting group that is predicted to be a destination with a high hazard rate of trade in honey (see Figure 5-5). As an emerging country exporting high-quality premium honey to the world, New Zealand finds it much easier to enter other markets. Meanwhile, this high standard may also restrict imports of honey from other suppliers. This pattern is closely associated with the size of the domestic demand in New Zealand. In comparison, exporting honey from the 14 countries to North America and East Asia are predicted to be much easier with a relatively lower hazard rate. For instance, China and India both appear to be quite open to honey imports. No more than 16 per cent of the imports are anticipated to fail when trading with these two countries. This can be partly explained by the rapidly increasing per capita income in some developing countries, particularly China and India. Hence, the increased domestic demand for diversified foods needs to be facilitated by stable foreign supplies.

5.5.4. Robustness

To minimise the potential unobserved heterogeneities in the models, we further employ a frailty model with a gamma mixture distribution based on the Prentice-Gloeckler discrete proportional hazards model (Prentice and Gloeckler, 1978). A frailty model, therefore, is a heterogeneity model where the frailties are assumed to be individual- or spell-specific (Gutierrez, 2002). Following Jenkins (2004), we assume that the frailties are destination-specific.

Table 5-7 presents the estimated results of both full and decomposed discrete-time hazard models. It can be noted that unobserved heterogeneity is not significant in Model (2) and (3) as their p-value is higher than 0.05. This means that destination-specific factors can be partly captured by decomposing multiple sequences of trade (i.e. *multiple*). Moreover, we can see that the coefficients for most parameters are much larger in absolute value. This finding is not unexpected as not accounting for unobserved heterogeneity could lead to an under-estimate of the extent to which the hazard rate increases with the positive factors (or an over-estimate of the adverse effects) (Jenkins, 2004). Therefore, our decomposed model (i.e. (4) in Table 5-6 and (3) in Table 5-7 is the most appropriate.

In addition to the overall validity of the model, we also find that the signs of the coefficients are consistent with our previous findings. *duration*, *multiple*, *left-censoring*, the *number of destinations*, *yield*, *PPI*, *pesticides* usage, *distance*, and the *number of suppliers* are the most significant factors explaining honey exporting countries' competitive in survival. Except for *yield* and *distance*, all of the above determinants are estimated to decrease exporting countries' hazard rate of survival. However, among those factors, *yield*, *PPI*, and *pesticides* appear to marginally influence the hazard rate.

Table 5-7 Discrete-time hazard models with gamma frailty

Dependent Variable: *Failed*	(1) Frailty Coef. Std. Err.	(2) Frailty Coef. Std. Err.	(3) Frailty Coef. Std. Err.
Duration and Multiple (D_{idt})			
duration	-0.731 (0.14)***	-0.821 (0.21)***	-0.931 (0.20)***
multiple	-0.326 (0.09)***	-0.323 (0.09)***	-0.243 (0.10)**
*duration*multiple*	------- -----------	0.011 (0.03)	-0.114 (0.07)*
*duration*seq2*	------- -----------	------- -----------	0.467 (0.21)**
*duration*seq3*	------- -----------	------- -----------	0.427 (0.22)*
*duration*seq4*	------- -----------	------- -----------	0.396 (0.28)
*duration*seq5*	------- -----------	------- -----------	-2.336 (1.36)*
Censoring (C_{idt})			
left-censored	-1.399 (0.20)***	-1.384 (0.20)***	-1.348 (0.19)***
*duration*censored*		0.020 (0.03)	0.036 (0.03)
Supply-sided factors (S_{idt})			
destinations	-0.013 (0.00)***	-0.013 (0.00)***	-0.012 (0.00)***
yield	0.001 (0.00)**	0.001 (0.00)**	0.001 (0.00)**
beehive	-0.009 (0.02)	-0.012 (0.02)	-0.011 (0.02)
suppliers	-0.037 (0.00)***	-0.036 (0.00)***	-0.034 (0.00)***
Price (P_{idt})			
price	0.000 (0.00)***	0.000 (0.00)	0.000 (0.00)
Gravity variables ($Gravity_{idt}$)			
distance	0.037 (0.01)***	0.036 (0.01)***	0.035 (0.01)***
population	0.000 (0.00)	0.000 (0.00)	-0.000 (0.00)
GDP	-0.002 (0.00)	-0.001 (0.00)	-0.001 (0.00)
Food Security ($Security_{idt}$)			
ESA	0.004 (0.01)	0.003 (0.01)	0.003 (0.01)
PSV	-0.116 (0.06)*	-0.114 (0.06)**	-0.108 (0.06)*
PU	0.001 (0.01)	0.002 (0.01)	0.002 (0.01)
PPI	-0.002 (0.00)***	-0.002 (0.00)***	-0.002 (0.00)***
Food Safety ($Safety_{idt}$)			
forest	-0.077 (0.05)	-0.074 (0.05)	-0.072 (0.05)
pesticides	0.000 (0.00)**	0.000 (0.00)**	-0.000 (0.00)**
weather	-0.078 (0.07)	-0.078 (0.06)	-0.074 (0.06)
Observations	8580	8580	8580
Log-likelihood	-2850.0	-2849.9	-2842.1
Gamma var.	0.380	0.278	0.191
Prob. >= chibar2	0.019	0.116	0.200

Note: Robust standard errors (Std. Err.) are in parentheses; *** P < 0.01, ** P < 0.05, and * P < 0.1.

LR test of Gamma Var. = 0

5.6. Summary

This chapter examined honey export competitiveness of world-leading countries based on a discrete-time hazard model of trade duration and survival for the top 14 honey exporters in the world. It is the first empirical study involving the world's major honey exporting countries where a selected range of measures are adopted to examine the effects of food safety and security on exports survival.

Based on our empirical estimations, longer duration, multiple entries, left-censoring, distance, and the number of suppliers are the most statistically significant factors reducing countries' hazard rate of survival across all estimators. Notably, the extra one year of staying in a particular market decreases the hazard rate by up to 67 per cent. It can be explained by the cumulated experience of trade activities which tends to lower uncertainties and risks from exporting activities.

In terms of food safety and security, only the political stability, the absence of violence (*PSV*) and prevalence of undernourishment (*PU*), and pesticides usage (*pesticides*) are found to be statistically significant in explaining the variations in the hazard rate. In particular, one extra unit increase in *PSV* index decreases the hazard rate by 13 per cent. This reveals the empirical evidence that food safety and security can influence export competitiveness to a great extent and help countries survive in the overseas markets.

We also predicted the supplier-specific and destination-specific hazard rates. We find that the hazard rates are L-shaped over time. Countries such as Hungary, Belgium, Germany, China, and New Zealand are relatively competitive since they have a lower hazard rate on average. Also, the results indicated that countries including New Zealand, Denmark, Peru, Chile, Mali, Niger, and Myanmar could be the markets with the most difficulties so that exporting countries can hardly maintain a stable and continuous relationship with them.

Our results are consistent with the theoretical predictions of the discrete-time model, confirming that honey trade relationships are indeed short-lived. The finding of this chapter is also compatible with similar studies, as shown in the past literature. Our core finding is that on average, more than 50 per cent of honey exports attempted to enter the foreign markets for more than two times during the period between 2000 and 2017. Also, more than 62 per cent of exports survived less than three years. These two findings highlight the fragile nature of trade relationships and reveal the rigorous competition in the global honey market.

Given the observations on each of the 14 countries in our study, we find that Germany, Belgium, Hungary, China, and New Zealand are relatively competitive in terms of establishing a stable trade relationship with fewer fluctuations and a more extended period of staying. In comparison, Brazil, Uruguay, Argentina, and Canada are relatively less competitive and tend to experience many fluctuations during the trade.

The results of this chapter are relevant in terms of instituting some practical policy measures for improving honey exports. First, the short-lived nature of trade relationships requires the global beekeeping industries to create a positive and scientific agenda on how to differentiate their honey and improve the honey properties to capture a foreign market with a lower hazard rate successfully. Second, the evidence of a significant influence of food security and safety on export survival requires more efforts to encourage fit for purpose regulations and standards for honey production. Finally, as a non-essential good, new uses of honey in foods and other uses to improve human wellness need to be further promoted. This requires a joint and collaborative effort of beekeepers, traders, scientists, and legal authorities.

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Appendices

Appendix A Selection of top honey exporting countries

									Ranking by weight (kg)									
Ranking	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	CHN	CHN	ARG	CHN	CHN	ARG	ARG	ARG	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN
2	ARG	ARG	CHN	ARG	ARG	CHN	CHN	CHN	ARG	ARG	ARG	ARG	ARG	ARG	ARG	ARG	ARG	ARG
3	MEX	DEU	MEX	MEX	MEX	DEU	DEU	MEX	CAN	MEX	MEX	IND	MEX	MEX	MEX	MEX	UKR	UKR
4	DEU	MEX	DEU	DEU	DEU	MEX	MEX	DEU	MEX	BRA	ESP	MEX	IND	IND	UKR	IND	IND	IND
5	CAN	CAN	CAN	BRA	BRA	HUN	HUN	HUN	DEU	DEU	DEU	BRA	DEU	VNM	VNM	UKR	MEX	MEX
6	HUN	HUN	TUR	HUN	HUN	BRA	IND	CAN	HUN	ESP	IND	VNM	ESP	DEU	IND	ESP	ESP	BRA
7	AUS	URY	ESP	CAN	CAN	CAN	BRA	ESP	IND	HUN	BRA	DEU	CAN	BEL	ESP	DEU	DEU	DEU
8	ESP	AUS	HUN	TUR	URY	IND	CAN	URY	VNM	BEL	BEL	ESP	BEL	UKR	BRA	VNM	BRA	ESP
9	ROU	ESP	BRA	ESP	ESP	ESP	URY	VNM	BRA	CAN	VNM	BEL	BRA	ESP	DEU	BEL	BEL	HUN
10	CBU	ROU	URY	ROU	IND	URY	ESP	BRA	ESP	ROU	CAN	URY	HUN	HUN	BEL	BRA	HUN	BEL
									…									
NZL	20	17	24	18	20	16	17	13	15	13	21	16	16	19	17	16	15	16
									Ranking by value (US$)									
Ranking	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	ARG	CHN	ARG	ARG	ARG	ARG	ARG	ARG	ARG	ARG	CHN	ARG	ARG	CHN	CHN	CHN	CHN	CHN
2	CHN	ARG	CHN	CHN	CHN	CHN	CHN	CHN	CHN	CHN	ARG	CHN	CHN	ARG	ARG	NZL	NZL	NZL
3	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	DEU	NZL	ARG	ARG	ARG
4	MEX	MEX	MEX	MEX	MEX	HUN	MEX	HUN	HUN	MEX	MEX	MEX	NZL	NZL	DEU	MEX	DEU	DEU
5	CAN	CAN	CAN	HUN	HUN	MEX	HUN	MEX	MEX	BRA	ESP	NZL	MEX	MEX	MEX	DEU	SLE	UKR
6	HUN	HUN	HUN	CAN	BRA	ESP	ESP	ESP	CAN	ESP	NZL	ESP	ESP	ESP	VNM	IND	ESP	BRA
7	ESP	ESP	ESP	BRA	CAN	NZL	CAN	NZL	ESP	HUN	HUN	IND	CAN	HUN	ESP	VNM	UKR	ESP
8	AUS	AUS	TUR	ESP	ESP	CAN	NZL	CAN	NZL	NZL	IND	BRA	HUN	VNM	BRA	ESP	MEX	MEX
9	BEL	BEL	BRA	TUR	URY	AUS	IND	FRA	BRA	CAN	CAN	VNM	IND	IND	UKR	UKR	BRA	IND
10	USA	URY	VNM	CHL	AUS	BRA	BRA	VNM	IND	ROU	BRA	HUN	VNM	BEL	HUN	BRA	HUN	HUN
									…									
NZL	17	12	18	15	12													

Note: ARG- Argentina, BEL- Belgium, BRA- Brazil, CAN- Canada, DEU- Germany, HUN- Hungary, IND- India, MEX- Mexico, NZL- New Zealand, ESP- Spain, UKR- Ukraine, URY- Uruguay, VNM- Viet Nam, AUS- Australia (unselected), CBU- Cuba (unselected), CHL- Chile (unselected), FRA- France (unselected), SLE- Sierra Leone (unselected), TUR- Turkey (unselected), ROU- Romania (unselected).

Chapter 6 Global Dairy Trade Networks: A Prediction of Trade Relationships

6.1. Introduction

With the rapid development of Global Value Chains (GVCs), global trade relationships tend to be complex with a large number of participants involved. However, global trade, such as agricultural trade remains changeable and vulnerable. For instance, trade relationships in fresh fruit and vegetables are found to be short-lived with multiple sequences of trade. Most of them survived no more than three years (Peterson *et al.*, 2017). This evidence reveals the importance of anticipating the future of trade relationships.

Given the short-lived nature of trade relationships, the commonly known benefits from trade, such as increased income, the standard of living, economies of scale, and technology spillover, are difficult to achieve since they all require a certain period to fulfil once a trade relationship is established. Therefore, the question of what the alternatives for businesses are if they experience a sudden relationship breakdown is of importance to answer if trade relationships indeed have a short duration. Further, fluctuations in agricultural trade relationships further raise concerns about food security. This requires countries to better monitor the trade activities in the global market in order to secure a stable food supply.

Beyond the trade area, network analysis has become an emerging tool observing the complexities in various systems and relations. Since the 2000s, the investigation and prediction on networks have been popular especially in computer science (e.g. social networks- Barabâsi *et al*. 2002; Wu *et al*. 2011), biology (e.g. Protein networks- Maslow and Sneppen, 2002) and engineering (e.g. power grid- Albert *et al*., 2004;

Crucitti *et al*., 2004). In the trade area, countries are closely linking to each other in various ways. These relationships can also be described as a complex network. Unfortunately, there are no mature and systematically established theories linking network and international trade by now. If the rationale of a network-based methodology is in line with trade theories, predicting the new and potential trade relationships within a complex network is possible. This will give empirical trade studies a new and significant area to explore and develop.

Among the recently created approaches, an emerging prediction model is called link prediction. It aims at estimating the likelihood of the existence of a link between two nodes, given the observed topological structure of the network (Lü and Zhou, 2010). Using this network-based approach, trade relationships can be examined on a more complex and dynamic perspective as each participant in global trade ever independently exists in a network. Every one of them has been influencing or been influenced by the trade activities of others.

Using the conventional trade models, it is easy to estimate the influence of one country's activities on another country's trade activities and how bilateral trade is influenced by various factors. For instance, gravity models are the dominant econometric approach used in international trade studies (Baier *et al*., 2014). It performs well to predict the trade flows of existent trade relationships by capturing the influence of countries/region-specific characteristics (e.g. GDP, language, distance, population and so on). However, they are less appropriate to evaluate whether non-existent relationships are likely to be fulfilled in the future. In addition, with the gravity model of trade, it is hard to incorporate every country in the trade network into the empirical model since data for country-specific characteristics may not be available for every country considered.

Furthermore, the gravity model is often utilized with various econometric techniques. This often associated with common issues such as model misspecification caused by potential endogeneities, and unobserved heterogeneities (Baier and Bergstrand, 2002; Kabir *et al*., 2017). In contrast, network-based approach is barely associated with these issues. Complex network theory believes that rich information is embodied in the topological structure of the network (Lü and Zhou, 2013). The decision of connection is an outcome influenced by all the factors, no matter they are measurable or not measurable. Therefore, the results produced by the network-based approach are believed to be efficient if they can successfully pass the validity tests. This feature is the biggest advantage of using the network approach and is also what the standard gravity model unable to fulfill. However, in the meanwhile, this means that with the network approach, it is challenging to estimate the impact of external factors on the formation of a network. This is also the major limitation of this approach given the current development in this area.

Similarly, CGE modelling is widely recognized as a robust method for economic impact analysis and is better to provide a comprehensive representation of how changes in one part of an economy flow through or spill over to other parts (Partridge and Rickman, 2010). As both models barely consider the trade relationship itself, monitoring the dynamics of the entire trade network can be hardly achieved.

Given the context above, this chapter aims to find new and potential relationships within the global dairy trade networks using the link prediction approach and to anticipate their possible patterns of trade in the future. As this particular method is only based on the topological properties of a network, this chapter will attempt to incorporate trade analysis into the network predictions. It is expected that global dairy trade networks have their specific characteristics and link prediction is significant to predict dairy trade relationships in the future.

6.2. Literature Review

There are two types of trade studies. First, numerous studies focus on examining trade patterns and identifying the key determinants of past trade flows or volume at national and micro-level (e.g. Wang *et al*, 2010; Corcos *et al*., 2013). However, those studies do not reveal the future of those currently inexistent trade relationships. Second, only a few emerging studies directly examined trade relations as a 'network'. Some initial papers regard the world trade network as a 'web' such as in Serrano and Boguñá (2003), Serrano *et al*. (2007), and Fagiolo *et al*. (2010).

Another stream of recent studies refers to the structural properties in global trade relationships to a term 'chain' such as in the theory of Global Value Chains (GVCs). The new patterns of international trade then are described as a detailed and fragmented production process, in which each activity can be carried out at the country's competitive cost (Grossman and Hansberg, 2006; Globerman, 2011). Comparing with the concept of network, the GVCs focus on the connected trade activities among economies. It believes that economies have diverse roles in establishing a particular product chain of trade. Some are located at the upstream of the chains and tend to initiate the new ideas of production and innovation of technologies. Those who are located at the mid- and downstream of the chains responsible for the practical production activities and focus on after-sales services. (World Bank, 2017). In contrast, the term 'trade network' tends to emphasize the topological structure and status of participants and relations.

Emerging studies apply network analysis to examine topological properties (e.g. density, degree, distribution) of international trade relationships. Early contributions include Serrano and Boguñá (2003), Kali and Reyes (2007), Bhattacharya, Mukherjee, and Manna (2007), Fagiolo *et al*. (2010), and so on. Followed by recent studies such as De Benedictis and Tajoli (2011), De Benedictis *et al*. (2014), Maeng *et al*. (2012), Kandogan (2018), and Long *et al*. (2019). These studies have empirically enlarged the existing trade analysis by incorporating network-based techniques into their trade models.

However, there are a few concerns about their framework and approach. First, most studies on trade networks do not focus on a single category of product. They attempt to provide a general picture of how countries participated in global trade integration over a certain period. However, different trade products might have formed networks with heterogeneous properties. It means that to avoid biases, each network may need to be treated separately even in various years. Second, those studies are unable to directly predict potential or new trade relationships in the future. This makes the existing trade network studies stagnated in the early stage of network overview and model developing.

With the recent booming algorithms and predictions in computer science, few studies start to employ prediction models onto trade networks. However, to the best of the authors' knowledge, only two papers apply link prediction to anticipate trade relationships. Both focus on energy trade particularly (i.e. crude oil- Guan *et al*. 2016; liquefied natural gas- Feng *et al*. 2018). As with energy products, international trade in primary products such as wine, dairy, fresh fruit and vegetables is less fragmented compared to that in manufacturing products. This means that a greater share of the products traded tend to be directly consumed by final consumers without sophisticated processing. This also makes the construction and structure of trade networks simpler.

6.3. Overview of 2017 Global Dairy Trade (GDT) Network

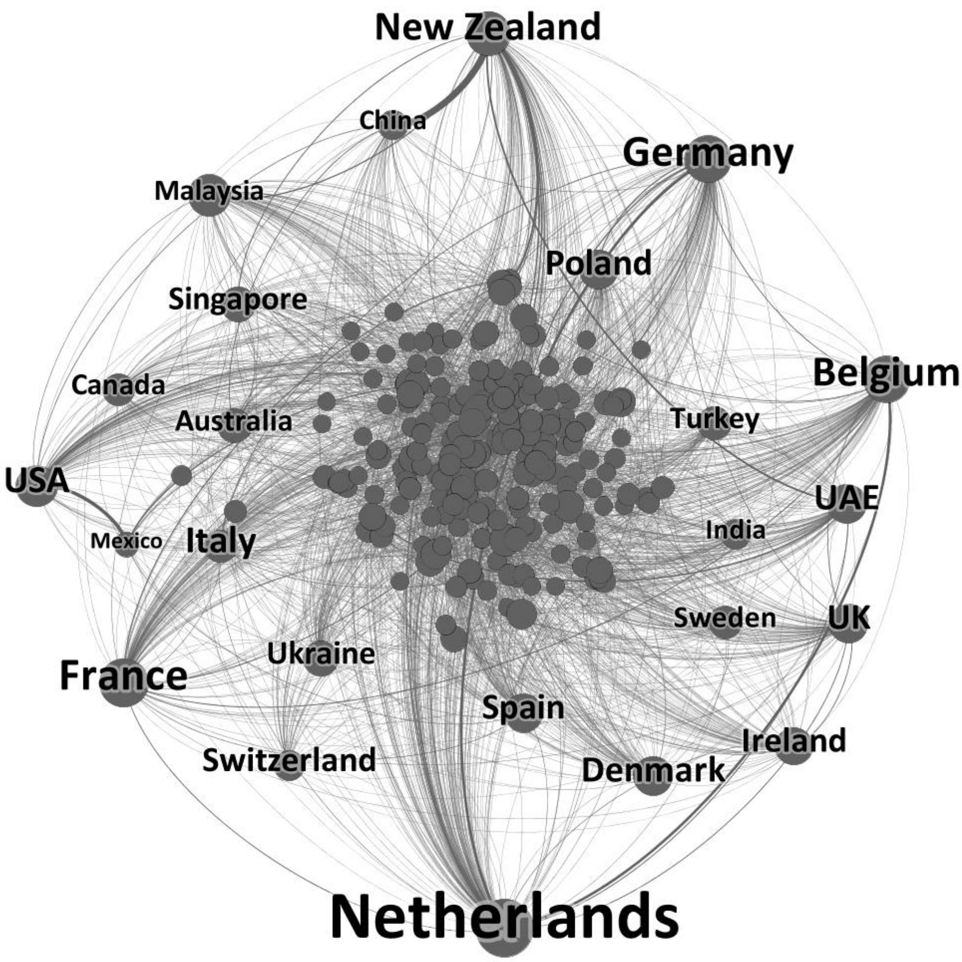
In practice, a network is usually used to describe complex relationships. The construction of a network requires two basic components, which are nodes and edges or links. Same as the social, electrical, transportation, biology and telecommunication networks, trade relationships can also be described as a complex network in which countries as the participants sharing information and resources via an existent edge.

In Figure 6-1, global dairy trade in 2017 is shown as an undirected weighted network. The data used to construct this network is the import and export of milk and cream (HS0402). In this network, every single country is denoted by a weighted node. The weight is measured by the degree of a country/the total number of a country's direct trade partners within the network. Therefore, a larger sized node indicates that the particular country has established a larger number of dairy trade relationships in 2017.

It can be seen from Figure 6-1 that Netherlands was the country with the largest number of trade partners in 2017, followed by other major traders such as Germany, Belgium, France, New Zealand, and the USA. Besides the information given by those weighted nodes, weighted edges also reveal how large the trade volume (in kilograms) between a country pair is. For example, the trade volume between New Zealand and China, USA and Mexico was heavier than the others, indicating that these country pairs had an intensive trade relationship in dairy, compared to their other partners.

Table 6-1 presents the components of the Global Dairy Trade (GDT) networks over time. The 2017 network in Figure 6-1 is made up of 226 countries and 2,934 trade relationships. However, those numbers remain limited compared to a large number of inexistent/or potential trade relationships. It can be seen from Table 6-1 that the total number of countries traded in dairy has been more or less the same over time. Also, the number of existent relationships has been fewer than the number of potential relationships.

Figure 6-1 Global Dairy Trade (GDT) network, 2017



Source: UN Comtrade Database. Authors' own creation.

Table 6-1 Overview of Global Dairy Trade Networks, 2008-2017

Component	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nodes/countries	219	222	220	224	223	225	222	224	223	226
Edges/relationships	2,789	2,764	2,770	2,829	2,864	2,894	3,038	2,994	2,966	2,934
Potentials	21,082	21,767	21,320	22,147	21,889	22,306	21,493	21,982	21,787	22,491

Source: UN Comtrade Database. Authors' summary.

Here it is a puzzle for the initiatives of developing trade relationship prediction models: how can we precisely identify the specific country pairs from the numerous potential relationships? Ideally, there should be more than 25,000 trade relationships in total existed in 2017 if the network was complete. However, we all know this will never happen as trade decisions and activities are usually complex and influenced by multiple factors such as productivity, distance, transportation costs, and population, and so on.

To deal with this puzzle, what this chapter can do is to explore the few relationships that are most likely to emerge based on a precise mechanism. The particular mechanism in this chapter relies on the rationale of the link prediction approach.

6.4. Link Prediction

Link prediction in networks aims at measuring the likelihood of the existence of a link between two nodes, based on the observed structure and the attributes of the nodes. It has been proven to be practically valid in predicting several networks, as noted previously. Early contributions include Liben-Nowell and Kleinberg (2007), Adamic and Adar (2003), Lü and Zhou (2010), and Liu *et al*. (2011). These studies proposed the use of mainstream similarity-based algorithms of link prediction and examined their validity in various networks. Those algorithms are now widely applied to explore the functional implication of relation in network dynamics (Feng *et al*., 2017).

One basic assumption of the similarity-based algorithms is that two nodes will be likely to link if they have a higher level of similarity than others. It is also in line with the traditional trade theories, such as the gravity model of international trade and Linder's country similarity theory. Both of them illustrate that the two countries are likely to trade if they have something in common (Bergstrand, 1990). Those similarities could be sourced from their per capita income, geographical location, language, size of the economy, and so on.

To practically employ the link prediction model, this chapter considers the mainstream similarity indices used in prior literature (Lü and Zhou, 2013; Guan *et al*., 2016; Feng *et al*., 2017). In particular, three types of algorithms based on local information of a network are used. The first type is the similarity indices based on common neighbors (equivalent to 'common trade partners' in this chapter), which include Common Neighbor (CN), Adam/Adar (AA), and Resource Allocation (RA) index. The second type is known as the Preferential Attachment (PA) index. It is based on the 'preferential attachment' principle described by Barabâsi and Albert (1999).

The final type is called the Local Naïve Bayes (LNB) model. It can be applied to CN, AA, and RA indices by assuming that each common neighbor has a various contribution to the likelihood of establishing a linkage between two disconnected nodes (Liu *et al*., 2011). It is believed that this approach is also a feasible way to examine dairy trade networks as well. Suppose there are two disconnected countries, A and B. They have not traded in dairy products for the past few decades. Fortunately, they have two common trade partners C and D. Using traditional common-neighbor-based indices, the contribution of C and D is homogeneous to the likelihood of relationship emergence. However, this would be imprecise if C has frequent trade activities in the global market, while D is relatively isolated by international trade integration. Given this circumstance, the different influence of C and D on linking A and B has to be measured heterogeneously. To the best of the authors' knowledge, this is the first time that LNB models have been utilised in the trade network literature.

Furthermore, indices such as CN, AA, RA, and PA all have both unweighted and weighted algorithms. The unweighted algorithms consider the total number of direct or common trade partners. Specifically, the weighted similarity indices capture the role of different trade partners with different volumes by incorporating the weight of an edge into the unweighted similarity indices. The following sections present both algorithms of link prediction in details. Since each has a different focus and rationale of application, an optimal index will be selected from the set based on calculated accuracy, in order to ensure the validity of predicted results. The algorithms in subsequent sections follow the framework used in Lü and Zhou (2013) and Feng *et al.* (2017).

Algorithm: Common Neighbor (CN) index

The CN index is also known as the structural equivalence. It assumes that a country pair will be more likely to trade in the future if the two countries have more common direct trade partners. In this case, a set of the common direct trade partners connected with country x is defined as Γ(x). Thus, the CN index of a particular relation between country x and country y is defined as follows:

$$s_{xy}^{CN} = |\Gamma(x) \cap \Gamma(y)| \tag{6.1}$$

where $|\Gamma(x) \cap \Gamma(y)|$ denotes the set of the two countries' number of common direct trade partners. However, this algorithm does not take the weight of an edge into consideration. In this case, each existent link or relation has the homogeneous effect on the likelihood of the emergence of new relations. In the weighted form, the volume of trade (kilogram) will be used as the main source of the weight in our link prediction models. Then the weighted CN (WCN) index can be defined as:

$$s_{xy}^{WCN} = \sum_{z \epsilon \Gamma(x) \cap \Gamma(y)} \frac{w_{xz}^{\alpha} + w_{zy}^{\alpha}}{2} \tag{6.2}$$

where α denotes a parameter capturing the contribution of trade volume. z represents a common trade partner of x and y. w_{xz}^{α} refers to the weight of edge linking x and z. In our case, it is measured as the trade volume between x and z. w_{zy}^{α} is also similarly defined as the trade volume between z and y. Note that the value of α may significantly influence the predicted scores of the index. There are three cases that need to be considered particularly:

i. If $\alpha = 0$, w_{xz}^{α} and w_{zy}^{α} equal to 1. The WCN index will be equivalent to the CN index so that trade partners with different trade volume tend to have the same role;

ii. If $\alpha > 0$, trade partners with larger trade volume will play stronger roles in predicted scores;

iii. If $\alpha < 0$, trade partners with smaller trade volume are expected to have a greater contribution.

It is important to note that the calculation of the optimal α for our weighted dairy trade networks can be used to test the validity of both "Weak Ties' and 'Strong Ties' hypotheses. That is, the 'Weak Ties' hypothesis is valid when the optimal α is negative in our case. As explained above, this means that common trade partners with smaller trade volume are expected to have larger influence on linking two disconnected countries compared to those with larger trade volume (Lü and Zhou, 2010). Conversely, the 'Strong Ties' hypothesis is satisfied if the optimal α of our weighted dairy trade network is significantly positive. This may indicate a sign of 'community' or 'group' in the networks. Testing of these two hypotheses also has practical implications for trade policies. For instance, both 'big' and 'small' trade partners are of importance to a trader if the 'Weak Ties' hypothesis is valid. Those 'small' partners sometimes may play an unimaginable role in helping diversify a country's trade integration. As trade relationships are unstable, trading with those 'small' partners are even more fragile. This further requires traders being able to find potential trade partners to ensure their benefits from trade.

Algorithm: Adam/Adar (AA) index

The basic assumption AA index underpinned is that a common direct trade partner of two countries contributes less to the relationship if it has more trade partners. The AA index gives each node a particular weight according to the amount of common direct trade partners. It is specifically measured as:

$$S_{xy}^{AA} = \sum_{z \epsilon \Gamma(x) \cap \Gamma(y)} \frac{1}{\log(k_z)} \tag{6.3}$$

where k_z presents the number of direct trade partners of x and y's common trade partner z. Again, by adding the trade volume contribution parameter α into the above algorithm, the weighted AA (WAA) index can be defined as follows:

$$S_{xy}^{WAA} = \sum_{z \epsilon \Gamma(x) \cap \Gamma(y)} \frac{w_{xz}^{\alpha} + w_{zy}^{\alpha}}{\log\,(1 + s(z))} \tag{6.4}$$

where $s(z)$ refers to a set of direct trade partners of z.

Algorithm: Resource Allocation (RA) index

The RA index improves the validity of link prediction algorithms. It is similar to the AA index but more emphasizes the resource allocation process in networks and believes that resources can be transmitted between two inexistent nodes. In the link prediction model, assuming each intermediary has a certain amount of resources that are available to be transmitted to its direct trade partners, then the unweighted RA index can be measured as

$$s_{xy}^{RA} = \sum_{z\epsilon\Gamma(x)\cap\Gamma(y)} \frac{1}{k_z} \quad (6.5)$$

Then the weighted RA index is defined as

$$s_{xy}^{WRA} = \sum_{z\epsilon\Gamma(x)\cap\Gamma(y)} \frac{w_{xz}^{\alpha}+w_{zy}^{\alpha}}{\mathrm{s(z)}} \quad \mathrm{s(z)} = \sum_{j\in\Gamma(z)} w(z,j)^{\alpha} \quad (6.6)$$

Algorithm: Preferential Attachment (PA) index

The PA index assumes that a node tends to have a higher probability of creating a new trade relation if itself has more trade partners. The unweighted and weighted index can be defined as follows:

$$s_{xy}^{PA} = k_x \times k_y \quad (6.7)$$

$$s_{xy}^{WPA} = \sum_{m\epsilon\Gamma(x)} w_{xm}^{\alpha} \times \sum_{n\in\Gamma(y)} w_{yn}^{\alpha} \quad (6.8)$$

In the weighted algorithm, m is a direct trade partner of x and n is a direct trade partner of y.

Algorithm: Local Naive Bayes (LNB) Model

The LNB model assumes that the contribution of each common direct trade partner is independent. Incorporating the CN, AA, and RA index into the LNB model, we have:

$$\tilde{r}_{xy}^{LNB-CN} = |o_{xy}| \log(s) + \sum_{w\epsilon o_{xy}} \log \widetilde{R_w} \quad (6.9)$$

$$\tilde{r}_{xy}^{LNB-AA} = \sum_{w\epsilon o_{xy}} \frac{1}{\log k_w} (\log s + \log \widetilde{R_w}) \quad (6.10)$$

$$\tilde{r}_{xy}^{LNB-RA} = \sum_{w\epsilon o_{xy}} \frac{1}{k_w} (\log s + \log \widetilde{R_w}) \quad (6.11)$$

$$\text{and } R_w = \frac{N_{\Delta w}+1}{N_{\Lambda w}+1} \tag{6.12}$$

where o_{xy} is a set of x and y's common direct trade partners and equals $|\Gamma(x) \cap \Gamma(y)|$. k_w is the degree of node *w*. $N_{\Delta w}$ and $N_{\Lambda w}$ respectively denote the number of connected and disconnected node-pairs whose common neighbors include *w*. Therefore, R_w is the role function of a given node *w*. Note that LNB-CN, LNB-AA and LNB-RA index will be equivalent to the CN, AA and RA index respectively if R_w= 1 (Liu *et al.*, 2011).

Prediction Step 1: Construct the GDT Network

The first step of link prediction is always to construct the network. This chapter considers the undirected but weighted GDT network. Throughout the paper, nodes represent all the countries traded internationally in milk and cream in 2017, denoting a set $V = (v_1, v_2, \dots, v_N)$. Edges then represent the existent relationships between country pairs, referring to a set $E = (e_1, e_2, \dots, e_N)$. Therefore, for a particular trade relationship between country x and country y, there is a node-to-node link $e_n = (v_x, v_y)$. There are four requirements that constructing a GDT network needs to satisfy. First, countries are unable to connect to themselves; Second, there is only one edge exists between a country pair; Third, the edge is undirected; Forth, the edge is weighted by trade volume (kg) and only represents existent relationships. The constructed weighted 2017 GDT network is the same as the one in Figure 6-1 but with homogenous sized nodes.

Prediction Step 2: Choose the Optimal Index

To choose the optimal index from the mainstream algorithms of link prediction, we calculate the average Area Under the Curve (AUC) value. It refers to a probability that the score of a randomly chosen edge has a higher index score than a randomly chosen inexistent one. It can be calculated by the following function

$$\mathrm{AUC} = \frac{n_h + 0.5 n_e}{N} \tag{6.13}$$

where n' is the number of times that the score of testing links is higher than that of the inexistent links. And $n''$is the number of times that the scores are equal to the same. Theoretically, the value of AUC approaches 0.5 if all the scores are randomly selected. The degree to which the value surpasses 0.5 reveals how much better the algorithm performs better than coincidence. It is expected that most existing edges should have a higher index score than those inexistent. If this is true in most comparisons, the AUC value is higher, suggesting that the index is more accurate to predict the potential edges. In this chapter, 100 independent experiments are made to ensure validity.

Prediction Step 3: Define Inexistent Edges Set E^I

In each experiment, all the existent trade links E need to be randomly divided into two parts, a training set E^T and a testing set E^P. Following Lü and Zhou (2009), Guan *et al.* (2016) and Feng *et al.* (2017), 10 per cent of the existent links are selected and made up a testing set E^P and the remaining links as a training set E^T. Then the relationship between the two sets can be defined as

$$|E^P| = 10\%|E| \text{ and } E^P + E^T = E \tag{6.14}$$

After this, a crucial step is to find the potential/inexistent trade links. The set of those unknown links is denoted by U, which can be calculated as

$$\mathrm{U} = \frac{n(n-1)}{2} \tag{6.15}$$

Thus, the set of all inexistent trade links is $E^I = U - E$.

Prediction Step 4: Calculate and Rank the Index Scores for both E^I and E^T

The final step of link prediction is to calculate and rank the score of each edge in both testing set E^P and inexistent set E^I. After ranking the scores in descending order, the top inexistent edges with the highest index scores are most likely to occur/establish in the future. If most edges in E^P have a higher index score than those in E^I, the accuracy index AUC, would be higher and towards one.

Trade Analysis of the Predicted Results

Two strategies are applied to further identify a country's role and possible patterns in bilateral trade relationships. First, we examine the country's role in a particular dairy trade relationship by calculating the Revealed Comparative Advantages (RCA) index. The RCA index is a measure of a certain country's relative advantage in a particular product (Balassa, 1965). We assume that a country with a relatively higher RCA in the past is expected to be a net exporter in this particular relationship, compared to its trade partner. Second, we identify the future patterns of potential trade relationships by observing how they performed previously.

Table 6-2 presents the corresponding criteria. In general, those relationships can be broadly classified into two types, the 'temporary' and 'new' trade relationships, respectively. Given the intervals of zero trade flows, we can identify how vulnerable those relationships could be in the future. Therefore, we further decompose the temporary trade relationships into four sub-categories, including the stable (SR), slightly active (SAR), moderately active (MAR), and extremely active (EAR) relationships. Relationships predicted to be extremely active are likely to involve multiple sequences of trade in the future.

Table 6-2 Classifications of Trade Relationships

Type	Interval of Years with Zero Trade Flow	Notation
Temporary Relationships		
Stable	Only one interval	SR
Slightly active	Two intervals	SAR
Moderately active	Three intervals	MAR
Extremely active	Four to five intervals	EAR
New Relationships	No trade flows in the whole period of 2008-2017	NEWR

6.5. Data

This chapter collects global annual import and export data of milk and cream (HS0402: milk and cream; concentrated or containing added sugar or other sweetening matter) for the period between 2008 and 2017 from the UN Comtrade Database to construct the GDT networks. HS0402 has been the largest commodity of dairy products in the past. In 2017, it was valued at around US$18.8 billion, which was amount to 7.3 megatonnes (according to 2017 UN Comtrade statistics). There are three strategies to coordinate the dataset. First, we only consider the total trade between the two countries. That is, the intra-industry trade between a country pair are also considered. Second, trade data of regions/areas are eliminated from the original dataset. Third, only trade volume (in kilograms) are considered in order to avoid bias stemming from the usage of trade flows, which is normally involved with the exchange rate.

6.6. Results

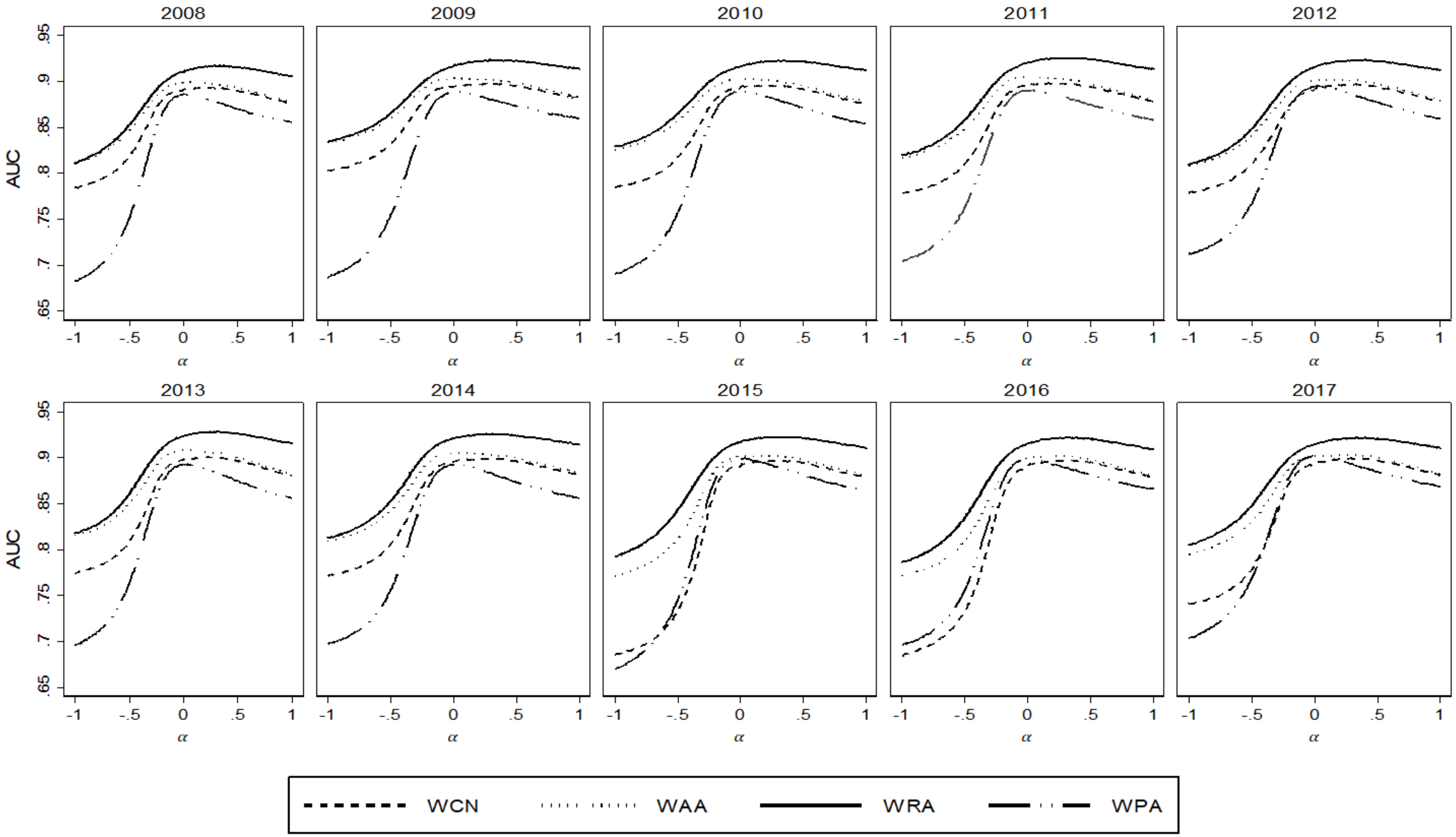
This section presents and interprets the main results from link prediction. First, we select the optimal index of prediction. All the subsequent predictions are based on the calculation of the optimal index. Second, we interpret the predictions based on 2017 GDT network. Trade analysis is adopted during this stage.

6.6.1. Selection of the Optimal Index

Given our results, Weighted Resource Allocation (WRA) is the most appropriate index with the highest accuracy (AUC value), after 100 independent experiments. In each experiment, testing and training set edges are randomly divided in order to minimize biases. Figure 6-2 and Table 6-3 compare the average AUC values of all mainstream algorithms from 2008 to 2017. It can be seen from Figure 6-2 that WRA is represented by a solid line which has been the one with the highest AUC value for each year over the period.

In Table 6-3, WRA is further compared to LNB Common Neighbor (LNBCN), LNB Adam/Adar (LNBAA) and LNB Resource Allocation (LNBRA). It remains the one with the highest evaluation score. This indicates that WRA is best able to explain the topological structure of GDT networks and has the highest accuracy to predict potential trade relationships, compared to other algorithms. However, this result is inconsistent with prior literature on trade networks. For example, Guan *et al*. (2016) find that Common Neighbor (CN) index was one of the structural linking motivations in international crude oil trade. In Feng *et al*. (2017), Preferential Attachment (PA) is the optimal index for finding potential liquefied natural gas trade links.

Figure 6-2 Evaluation of algorithms based on AUC values, 2008-2017



Source: Author's own estimates.

Table 6-3 Comparison of Local Naïve Bayes Indexes with Unweighted and Weighted Resource Allocation Index, 2008-2017

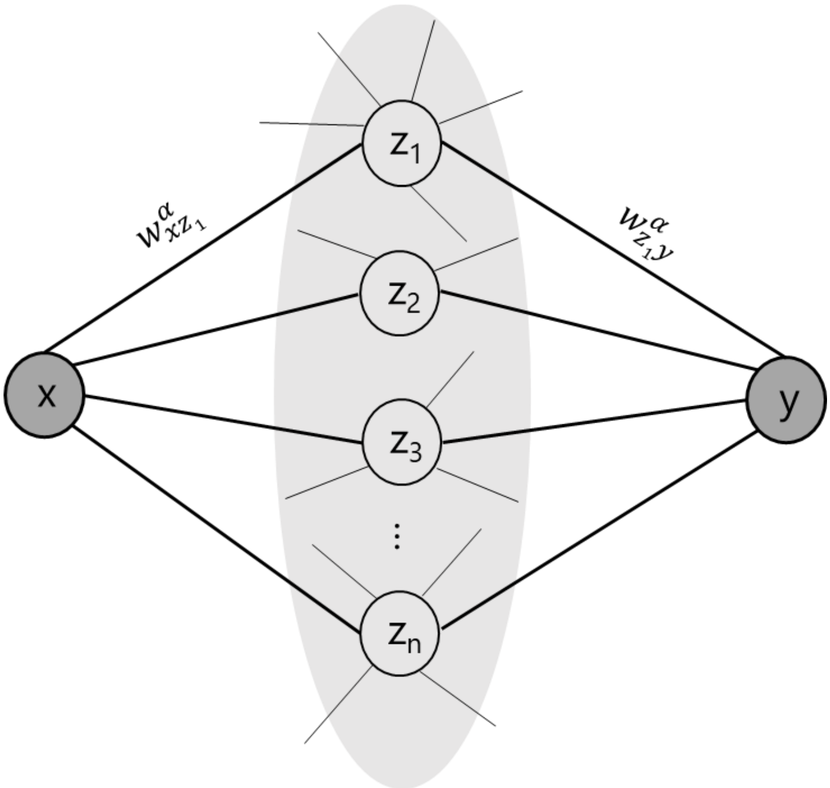
Index	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LNBCN	0.9030	0.9084	0.9080	0.9098	0.9078	0.9139	0.9117	0.9100	0.9074	0.9078
LNBAA	0.9080	0.9138	0.9136	0.9167	0.9129	0.9203	0.9174	0.9148	0.9123	0.9125
LNBRA	0.9133	0.9186	0.9186	0.9219	0.9187	0.9269	0.9238	0.9211	0.9176	0.9168
RA (α = 0)	0.9100	0.9172	0.9171	0.9205	0.9154	0.9241	0.9214	0.9179	0.9157	0.9150
WRA (optimal)	0.9174	0.9235	0.9230	0.9257	0.9236	0.9284	0.9259	0.9232	0.9228	0.9220
α (optimal)	0.33	0.29	0.34	0.31	0.40	0.28	0.31	0.26	0.33	0.40

Source: Author's own estimates.

We further calculate the optimal α, which gives us the highest validity and also captures the role of trade partners with different trade volumes in building a new relationship. However, it can be seen from Table 6-3 that the optimal α ranges from 0.26 to 0.4 in different networks. This result supports the 'Strong Ties' hypothesis, meaning that trade partners with larger trade volume contribute more to linking two disconnected countries. Again, it is inconsistent with the findings in Lü and Zhou (2010) and Feng *et al*. (2017). The former discovers that weak ties play a significant role in link prediction. The latter find that weak ties play the same role as strong ones in international liquefied natural gas trade. This means that the structural cause of different networks might not be the same. This requires future studies to consider a broad range of algorithms in their network analysis of trade.

In addition to the information given by evaluation scores, the rationale of WRA itself has a solid alignment with trade-related assumptions and theories. In the link prediction model, WRA assumes that the resource allocation can be achieved in a network even between two disconnected nodes/countries, such as country x and country y. In Figure 6-3, the rationale of the WRA index is illustrated. The set of common neighbors/trade partners $(z_1, z_2, z_3, \dots, z_n)$ perform as the transmitters that helping the process of resource allocation. However, each transmitter only has a certain amount of resources available to be distributed to its direct trade partners. So the maximum amount of resources that can be transmitted from country x to country y will be a measure of the two countries' similarities, which is also assumed to be positively correlated with the probability of establishing a relationship between them.

Figure 6-3 The rationale of Weighted Resource Allocation (WRA) index



Source: Lü and Zhou (2013). Author's compilation.

6.6.2. Predictions Based on 2017 GDT Network Using WRA Index

Using the optimal index WRA, we calculate the index scores of all testing and inexistent edges and ranked them in descending order. It is assumed that a country pair with a higher WRA score is most likely to trade in milk and cream as they have a higher degree of similarity so that resources (or trade) can be easily transmitted from one to another.

Table 6-4 presents the top 40 potential trade relationships with a high WRA score, given by the topological structure of 2017 GDT network. It can be seen that New Zealand is likely to establish a larger number of trade relationships in dairy, compared to the other countries. Its top potential trade partners in the future include Canada, Ukraine, Turkey, Argentina, and the other six countries. Also, countries such as Peru, Malaysia, and Ukraine, are likely to be involved in a larger number of potential trade relationships in the following years. Given the mechanism of link prediction and the rationale of WRA, this reveals that New Zealand, Peru, Malaysia, and Ukraine will be much easier to access each other's market in the future because they have large similarity with their trade partners so that resources can be distributed freer than the other countries.

It can be noticed that the predictions above are unable to differentiate a country's role from its trade partner in a particular relationship since the undirected network does not specifically describe how the trade flows from one country to another. Therefore, we further calculate the average Revealed Comparative Advantage (RCA) index of all these countries for the period between 2008 and 2017. We assume that a country is more likely to be a net exporter if it has a relatively higher RCA index. As a result, countries shaded in Table 6-4 are anticipated to be a net exporter. For instance, New Zealand and Canada are likely to trade in milk and cream in the following years with a high probability, according to their high WRA score. Also, due to a big difference in their RCAs, New Zealand has more comparative advantage in both production and export compared to Canada and will be a net exporter in this relationship if it is fulfilled.

Table 6-4 Predicted Role of Country in Potential Relationships Based on 2017 GDT Network

Rank	Country A	RCA	Country B	RCA	WRA	Rank	Country A	RCA	Country B	RCA	WRA
1	Canada	0.1	NZ	120.6	6.207	21	Malaysia	0.9	Switzerland	0.2	2.562
2	Malaysia	0.9	Peru	2.2	6.007	22	Australia	3.6	Poland	1.5	2.538
3	NZ	120.6	Ukraine	1.7	5.182	23	Denmark	3.1	Peru	2.2	2.505
4	NZ	120.6	Turkey	0.2	4.213	24	Czech Rep.	0.6	USA	0.9	2.461
5	Peru	2.2	UK	0.6	3.551	25	France	1.6	Uruguay	35.7	2.452
6	Argentina	7.5	NZ	120.6	3.494	26	Italy	0.1	Malaysia	0.9	2.310
7	Mexico	0.2	Peru	2.2	3.375	27	Lithuania	2.7	Ukraine	1.7	2.305
8	Brazil	0.7	Peru	2.2	3.346	28	Belgium	1.8	Uruguay	35.7	2.286
9	Canada	0.1	Ireland	2.3	3.303	29	Ireland	2.3	Turkey	0.2	2.267
10	Australia	3.6	Ireland	2.3	3.289	30	Malaysia	0.9	Uruguay	35.7	2.235
11	Czech Rep.	0.6	NZ	120.6	3.179	31	Portugal	0.8	USA	0.9	2.146
12	Malaysia	0.9	Portugal	0.8	3.105	32	Sweden	1.2	Ukraine	1.7	2.129
13	Belarus	14.5	Germany	0.9	2.943	33	Ireland	2.3	Togo	16.6	2.111
14	NZ	120.6	Portugal	0.8	2.776	34	Canada	0.1	Spain	0.3	2.100
15	Australia	3.6	Canada	0.1	2.669	35	Finland	0.8	NZ	120.6	2.059
16	Belarus	14.5	NZ	120.6	2.663	36	Costa Rica	3.2	NZ	120.6	2.006
17	Poland	1.5	Switzerland	0.2	2.646	37	Australia	3.6	Ukraine	1.7	1.994
18	Jamaica	0.3	Peru	2.2	2.626	38	Belarus	14.5	Poland	1.5	1.992
19	Iran	0.7	Ukraine	1.7	2.614	39	Belgium	1.8	Uganda	4.9	1.836
20	Lithuania	2.7	NZ	120.6	2.576	40	Belgium	1.8	Belarus	14.5	1.821

Note: RCA denotes Revealed Comparative Advantages Index; Countries shaded are predicted to be a net exporter in a particular relationship.

Since trade relationships tend to be fragile with multiple sequences of trade in a period, we realise that potential trade relationships predicted given by 2017 GDT network might have occurred before 2017. Those previously existed discrete sequences of trade are easy to be ignored if our predictions are solely based on the structure of the network in 2017. To reduce potential biases stemming from the ignorance of pre-existence, we identify the patterns of the potential trade relationships according to how they performed between 2008 and 2016.

Table 6-5 and 6-6 display the top 40 potential trade relationships by WRA score and the types of relationships. The detailed classifications are shown in Table 6-2. It can be observed that there are six new trade relationships among the 40 relationships. These relationships had no trade flows in the whole period between 2008 and 2016 so that can be regarded as 'dead' or 'failed' trade relationships based on our assumptions. In the meanwhile, given their high WRA scores within 2017 GDT network, they are predicted to be 'new' relationships and will be occurred in the following years.

Table 6-5 Predicted Patterns of Potential Relationships Based on 2017 GDT Network (Rank 1-20)

			Status over time										
Country A	Country B	WRA	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Type
Canada	NZ	6.207	E	E	N	N	N	E	E	N	N	N	SAR
Malaysia	Peru	6.007	N	N	N	N	N	N	N	N	N	N	NEWR
NZ	Ukraine	5.182	N	E	E	E	N	N	N	N	N	N	SAR
NZ	Turkey	4.213	E	E	N	E	N	E	N	E	N	N	EAR
Peru	UK	3.551	E	N	E	N	E	E	E	E	E	N	MAR
Argentina	NZ	3.494	N	N	N	N	N	N	N	N	N	N	NEWR
Mexico	Peru	3.375	E	N	E	N	N	N	N	E	E	N	MAR
Brazil	Peru	3.346	E	E	E	E	E	E	E	E	E	N	SR
Canada	Ireland	3.303	N	N	N	N	E	N	N	E	N	N	MAR
Australia	Ireland	3.289	E	E	E	N	N	N	N	E	N	N	SAR
Czechia	NZ	3.179	N	N	N	N	N	N	N	N	N	N	NEWR
Malaysia	Portugal	3.105	E	E	E	E	E	E	E	E	N	N	SR
Belarus	Germany	2.943	N	E	N	N	N	E	N	N	N	N	MAR
NZ	Portugal	2.776	E	E	E	E	E	N	N	N	N	N	SR
Australia	Canada	2.669	E	E	E	E	E	E	E	N	N	N	SR
Belarus	NZ	2.663	N	E	N	N	N	N	N	N	N	N	SAR
Poland	Switzerland	2.646	N	N	E	N	E	E	E	E	E	N	MAR
Jamaica	Peru	2.626	N	E	N	E	N	N	E	N	N	N	EAR
Iran	Ukraine	2.614	E	N	E	E	E	N	N	E	N	N	MAR
Lithuania	NZ	2.576	N	N	N	N	N	N	E	N	N	N	SAR

Note: 'E' refers to 'existent relationship'; 'N' represents 'inexistent relationship'. 'SR' refers to 'stable relationship'; 'SAR' denotes 'slightly active relationship'; 'MAR' is 'moderately active relationship'; 'EAR' represents 'extremely active relationship'; 'EAR' refers to 'new trade relationship'; Relationships shaded are predicted to be new trade relationships.

Table 6-6 Predicted Patterns of Potential Relationships Based on 2017 GDT Network (Rank 21-40)

			Status over time										
Country A	Country B	WRA	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Type
Malaysia	Switzerland	2.562	E	N	E	E	E	N	E	N	E	N	EAR
Australia	Poland	2.538	N	N	N	N	N	N	N	E	E	N	SAR
Denmark	Peru	2.505	N	N	N	N	N	N	N	E	N	N	SAR
Czech Rep.	USA	2.461	E	N	E	E	E	N	E	N	E	N	EAR
France	Uruguay	2.452	N	N	N	N	E	N	E	E	N	N	MAR
Italy	Malaysia	2.310	E	N	N	N	E	E	E	E	E	N	SAR
Lithuania	Ukraine	2.305	E	N	E	E	E	E	E	E	N	N	SAR
Belgium	Uruguay	2.286	N	N	N	N	N	N	N	N	N	N	NEWR
Ireland	Turkey	2.267	E	E	E	N	N	N	N	N	N	N	SR
Malaysia	Uruguay	2.235	E	N	E	N	E	E	N	N	N	N	MAR
Portugal	USA	2.146	N	N	N	E	E	E	N	E	E	N	MAR
Sweden	Ukraine	2.129	N	N	N	N	N	N	E	N	N	N	SAR
Ireland	Togo	2.111	N	N	E	N	N	N	N	N	N	N	SAR
Canada	Spain	2.100	N	N	N	N	N	N	N	E	N	N	SAR
Finland	NZ	2.059	N	N	N	N	N	N	N	N	N	N	NEWR
Costa Rica	NZ	2.006	N	E	N	N	N	N	N	N	N	N	SAR
Australia	Ukraine	1.994	N	N	E	N	N	N	N	N	N	N	SAR
Belarus	Poland	1.992	E	E	N	N	N	E	E	E	N	N	SAR
Belgium	Uganda	1.836	N	N	N	N	E	N	N	N	N	N	SAR
Belgium	Belarus	1.821	N	N	N	N	N	N	N	N	N	N	NEWR

Note: 'E' refers to 'existent relationship'; 'N' represents 'inexistent relationship'. 'SR' refers to 'stable relationship'; 'SAR' denotes 'slightly active relationship'; 'MAR' is 'moderately active relationship'; 'EAR' represents 'extremely active relationship'; 'EAR' refers to 'new trade relationship'; Relationships shaded are predicted to be new trade relationships.

It is interesting to see that among the six new trade relationships, three will be established via New Zealand. Besides those new, there are six relationships that are anticipated to be extremely active in the following years, which are marked as 'EAR'. According to the observed patterns, those relationships experienced four to five intervals of zero trade flows between 2008 and 2016. That is to say, their relationships suffered many fluctuations in the past so that their future integration is likely to follow a similar path. Those relationships include the one between New Zealand and Turkey, Jamaica and Peru, Malaysia and Switzerland, and the Czech Republic. For those relationships, more alternatives might be required in order to deal with a sudden breakdown of the relationship.

To further identify the new trade relationships based on the 2017 GDT network, this chapter assumes that trade relationships tend to be relatively 'new' if they have ever appeared during a longer period prior to 2017 (e.g. 2008-2016). As for those particular country pairs, starting to trade might be tougher as they have to cope with various barriers of trade for the very first time or with less experience. Table 6-7 provides a list of those 'new' country pairs that are likely to trade in milk and cream in the following decade. From Table 6-7, we know that particularly Algeria, Uruguay and Viet Nam are most likely to diversify their dairy trade partners in the future. In addition, major traders within the network, including New Zealand, Australia, Malaysia, and Ukraine still have potentials to intensify their trade integration in dairy. This leads to the conclusion that more countries can participate in future dairy trade integration as the current global dairy trade network is not complete.

Table 6-7 Predicted New Trade Relationships Based on 2017 GDT Network

Country A	Country B	2008-16	2017	WRA	Country A	Country B	2008-16	2017	WRA
Czech Rep.	NZ	N	N & P	3.179	Argentina	Ukraine	N	N & P	0.951
Belgium	Uruguay	N	N & P	2.286	Algeria	Mexico	N	N & P	0.949
Poland	Uruguay	N	N & P	1.743	Romania	Ukraine	N	N & P	0.919
Peru	Singapore	N	N & P	1.712	Algeria	Lebanon	N	N & P	0.911
Argentina	Ireland	N	N & P	1.670	Luxembourg	NZ	N	N & P	0.906
Ireland	Uruguay	N	N & P	1.625	Algeria	Cuba	N	N & P	0.892
Australia	Czech Rep.	N	N & P	1.564	Saudi Arabia	Viet Nam	N	N & P	0.890
Peru	Ukraine	N	N & P	1.559	Oman	Togo	N	N & P	0.860
Denmark	Uruguay	N	N & P	1.187	Fiji	Ukraine	N	N & P	0.847
Algeria	Egypt	N	N & P	1.182	Belarus	Sweden	N	N & P	0.846
Jamaica	Malaysia	N	N & P	1.179	Greece	NZ	N	N & P	0.838
Brazil	Russian Fed.	N	N & P	1.158	Algeria	Thailand	N	N & P	0.829
Mozambique	Peru	N	N & P	1.153	Algeria	Oman	N	N & P	0.829
Australia	Uruguay	N	N & P	1.124	Indonesia	Mexico	N	N & P	0.829
Mexico	Egypt	N	N & P	1.081	Algeria	Viet Nam	N	N & P	0.825
Algeria	Bangladesh	N	N & P	1.051	Algeria	Pakistan	N	N & P	0.824
Fiji	Viet Nam	N	N & P	1.049	Algeria	Hong Kong, PRC	N	N & P	0.798
Guatemala	Malaysia	N	N & P	1.042	Algeria	Sudan	N	N & P	0.7904
Italy	Viet Nam	N	N & P	1.002	Czech Rep.	Uruguay	N	N & P	0.767
Belarus	Finland	N	N & P	0.978	Peru	Viet Nam	N	N & P	0.765

Note: ‘E’ refers to ‘existent relationship’; ‘N’ represents ‘inexistent relationship’; ‘P’ denotes ‘potential relationship’ with a high WRA index score

6.7. Robustness

Previous sections provide the predictions of potential trade relationships in milk and cream based on 2017 GDT network. This section aims to provide a robustness checking of how valid our predictions will be by conducting a test prediction based on previous GDT networks. The rationale is that our prediction based on the latest network will be practically valid if most of the predictions based on previous networks have been gradually fulfilled in the subsequent years (e.g. 2009-2017). Specifically, the ‘fulfilment’ is defined as a trade relationship existing at least one sequence after being predicted to be ‘potential’.

Table 6-8 lists the top 10 potential relationships predicted by prior GDT networks in 2008-2016. It includes 37 non-redundant country pairs with the highest WRA scores. According to the definition of a ‘fulfilment’, around 84 per cent of the predictions have been fulfilled successfully over the period concerned. Only 6 out of 37 relationships have not been realised after their first predicted to be potential (marked as ‘*P*’). This illustrates a solid validity of the results from link prediction. Considering the particular countries that will participate in future dairy trade integration, New Zealand and Argentina were the two that predicted to build the largest number of potential trade relationships. Most predictions about these two countries are realised as expected. Meanwhile, a large proportion of the relationships indeed experienced multiple sequences of trade, which is also consistent with the findings of prior literature. This finding further reveals the importance of monitoring the global dairy trade market and searching for potential alternatives as a backup.

Then we have the test predictions based on the 2008 GDT network specifically. In Table 6-9 and 6-10, the top 40 potential trade relationships are displayed. Relationships shaded are those fulfilled relationships. Overall, up to 80 per cent of them has been fulfilled between 2009 and 2017. Their existences are marked as '*E*'.

Table 6-9 and 6-10 presents the top 40 new trade relationships by WRA score. To do so, we further collect milk and cream trade data between 2000 and 2007 from the same data source to define their nature. The 40 relationships shown in Table 6-11 and 6-12 are the 'new' and 'potential' trade relationships, after eliminating the relationships that once existed in the period between 2000 and 2007 from the predictions. As a consequence, 65 per cent of the relationships are found to be fulfilled according to the criteria. This again indicates that our predictions based on prior GDT networks are practically valid to a great extent. Therefore, this chapter is confident that the predictions based on 2017 GDT network will also be valid and fulfilled in the following years.

Table 6-8 Top 10 Potential Relationships Given by Prior GDT Networks, 2008-2016

Country A	Country B	2008	2009	2010	2011	2012	2013	2014	2015	2016
Argentina	Belgium		P	P	P	P	E	E	E	E
Argentina	France		P	P	P	P	E	E	E	E
Argentina	Germany	E	P			P	P	E		E
Argentina	Netherlands	P	P	P	E	E	P	E	E	E
Argentina	NZ	P	P	P	P	P	P	P	P	P
Argentina	UK					P	P			
Argentina	USA		E	P		E	E	E	E	
Australia	Belgium	E	E	E	E	E	E	E	P	P
Australia	Denmark	E	E		E				P	E
Belgium	NZ	P	E	E	E	E	E	E	E	P
Belgium	India	E		E	E		E	P		E
Belgium	Ukraine	P	E	E	E	E	E	E	E	E
Belgium	USA	E	E	E	P	E	E	E	E	E
Brazil	France	P	E		E		E	E	E	E
Brazil	Malaysia	P						E	E	E
Brazil	Netherlands	E	E	P	P	E	E	E	E	E
Canada	NZ	E	E	P	P	P	E	E	P	P
Germany	Peru	E	E	E	E	E	P	E	E	E
Germany	Ukraine	E	P	E	E	E	E	E	E	E
Ireland	NZ	P	E	P	P	P	P	E	E	E
Ireland	USA	E	E	E	E	E	E	P	E	E
Malaysia	Peru					P	P	P	P	P
Malaysia	Spain					E			P	P
Malaysia	Ukraine							P	P	E
Netherlands	Peru	E	E	E	E	E	P	E	E	E
Netherlands	Uganda	E	E	E	E			P	E	E
Netherlands	Ukraine	E	P	E	E	E	E	E	E	E
Netherlands	Uruguay	E	P	P					E	E
NZ	Poland	E			P	P		P	P	P
NZ	India	P	E	E	E	E	E	E	E	E
NZ	Switzerland		E	P	P	E	P	E	P	P
NZ	Turkey	E	E		E		E	P	E	P
NZ	Ukraine	P	E	E	E	P		P	P	P
NZ	UK	P	E	E	E	E	E	E	E	E
NZ	Uruguay		P			E	E	E	E	E
Peru	UK	E	P	E	P	E	E	E	E	E
Poland	USA	E	E	E	E	E	P	P	E	E

Note: 'E' refers to 'existent relationship'; 'N' represents 'inexistent relationship'; 'P' denotes 'potential relationship' with a high WRA index score. Relationships shaded are unfulfilled relationships.

Table 6-9 Prediction of Top Potential Relationships Based on 2008 GDT Network (Rank 1-20)

		WRA	Status over time									
Country A	Country B	Score	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
NZ	India	6.677	N	E	E	E	E	E	E	E	E	E
Belgium	NZ	6.676	N	E	E	E	E	E	E	E	N	E
Argentina	Netherlands	6.188	N	N	N	E	E	N	E	E	E	E
NZ	UK	6.112	N	E	E	E	E	E	E	E	E	E
Ireland	NZ	4.986	N	E	N	N	N	N	E	E	E	E
Argentina	NZ	4.928	N	N	N	N	N	N	N	N	N	N
Belgium	Ukraine	4.819	N	E	E	E	E	E	E	E	E	E
Brazil	France	4.596	N	E	N	E	N	E	E	E	E	E
NZ	Ukraine	4.443	N	E	E	E	N	N	N	N	N	N
Brazil	Malaysia	4.41	N	N	N	N	N	N	E	E	E	E
Argentina	Belgium	4.357	N	N	N	N	N	E	E	E	E	E
Brazil	UK	4.306	N	E	E	N	N	N	N	N	N	N
Australia	Germany	4.097	N	E	E	E	E	E	E	E	E	E
India	Ukraine	4.069	N	N	N	E	E	E	E	N	E	E
Argentina	USA	3.964	N	E	N	N	E	E	E	E	N	E
Argentina	France	3.917	N	N	N	N	N	E	E	E	E	E
NZ	Switzerland	3.832	N	E	N	N	E	N	E	N	N	E
Malaysia	Peru	3.8	N	N	N	N	N	N	N	N	N	N
Malaysia	South Africa	3.704	N	E	N	N	E	E	E	E	E	E
Malaysia	Ukraine	3.642	N	N	N	N	N	N	N	N	E	E

Table 6-10 Prediction of Top Potential Relationships Based on 2008 GDT Network (Rank 21-40)

		WRA	Status over time									
Country A	Country B	Score	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Argentina	UK	3.531	N	N	N	N	N	N	N	N	N	N
Belgium	Peru	3.443	N	E	E	E	E	E	E	E	E	E
China	UK	3.347	N	E	E	E	E	E	E	E	E	E
NZ	Uruguay	3.037	N	N	N	N	E	E	E	E	E	E
France	Peru	2.86	N	E	E	E	E	E	E	E	E	E
Brazil	India	2.821	N	N	N	N	N	N	N	N	N	N
Argentina	Ireland	2.794	N	N	N	N	N	N	N	N	N	N
Argentina	China	2.787	N	E	E	E	E	E	E	E	E	E
Brazil	Ireland	2.74	N	N	N	N	N	N	N	N	N	N
China	Peru	2.723	N	N	N	N	N	N	N	N	N	N
Ireland	Ukraine	2.714	N	N	E	N	N	N	N	N	N	E
Argentina	Switzerland	2.709	N	N	E	E	E	E	E	E	N	N
Argentina	Ukraine	2.611	N	N	N	N	N	N	N	N	N	N
Costa Rica	NZ	2.597	N	E	N	N	N	N	N	N	N	N
China	South Africa	2.593	N	N	E	E	N	N	N	E	E	E
Denmark	Malaysia	2.496	N	E	E	N	E	E	E	E	E	E
Brazil	Singapore	2.49	N	E	N	N	N	N	N	N	N	E
Argentina	India	2.488	N	N	N	N	N	N	N	N	N	E
China	Indonesia	2.483	N	N	N	E	E	E	E	E	E	E
Denmark	Ukraine	2.482	N	E	N	N	N	E	E	N	E	E

Table 6-11 Prediction of Top 40 New Relationships Based on 2008 GDT Network (Rank 1-20)

			Status over time									
Country A	Country B	WRA Score	2000-	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ireland	NZ	4.986	N	P	E	N	N	N	N	E	E	E	E
NZ	Ukraine	4.443	N	P	E	E	E	N	N	N	N	N	N
Argentina	Belgium	4.357	N	P	N	N	N	N	E	E	E	E	E
Malaysia	Peru	3.800	N	P	N	N	N	N	N	N	N	N	N
NZ	Uruguay	3.037	N	P	N	N	N	E	E	E	E	E	E
Brazil	India	2.821	N	P	N	N	N	N	N	N	N	N	N
Argentina	Ireland	2.794	N	P	N	N	N	N	N	N	N	N	N
Argentina	Ukraine	2.611	N	P	N	N	N	N	N	N	N	N	N
Brazil	Singapore	2.490	N	P	E	N	N	N	N	N	N	N	E
Brazil	Ukraine	2.353	N	P	E	E	E	N	N	N	N	N	N
Denmark	Peru	2.195	N	P	N	N	N	N	N	N	E	N	N
Malaysia	Egypt	2.175	N	P	E	N	N	E	E	E	E	E	E
Peru	Singapore	2.147	N	P	N	N	N	N	N	N	N	N	N
NZ	Sweden	1.980	N	P	N	N	N	N	E	E	E	N	E
Indonesia	Peru	1.972	N	P	N	N	N	N	N	N	N	N	N
Belgium	Uruguay	1.948	N	P	N	N	N	N	N	N	N	N	N
Argentina	Poland	1.927	N	P	N	N	N	N	N	N	E	E	E
Argentina	Australia	1.757	N	P	N	N	N	N	N	N	N	N	N
France	Uruguay	1.690	N	P	N	N	N	E	N	E	E	N	N
Brazil	Lithuania	1.643	N	P	N	N	N	N	N	N	N	N	N

Table 6-12 Prediction of Top 40 New Relationships Based on 2008 GDT Network (Rank 21-40)

				Status over time									
Country A	Country B	WRA Score	2000-07	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Czech Rep.	NZ	1.606	N	P	N	N	N	N	N	N	N	N	N
Belgium	Belarus	1.563	N	P	N	N	N	N	N	N	N	N	N
Australia	Sweden	1.556	N	P	N	N	N	N	E	E	E	E	E
Ireland	Sweden	1.525	N	P	N	E	N	N	E	E	E	N	E
Belarus	NZ	1.432	N	P	E	N	N	N	N	N	N	N	N
Argentina	Portugal	1.344	N	P	N	N	N	N	N	N	N	N	N
Belarus	India	1.337	N	P	E	N	N	N	N	N	N	N	N
Switzerland	Uruguay	1.291	N	P	N	N	N	E	N	E	E	N	E
Peru	Thailand	1.279	N	P	N	N	E	N	N	N	N	N	N
Fiji	Philippines	1.225	N	P	N	N	E	E	E	N	E	E	N
UK	Uruguay	1.190	N	P	E	E	E	E	E	N	E	N	N
Peru	South Africa	1.190	N	P	N	N	N	N	N	N	N	N	N
Ireland	Namibia	1.163	N	P	N	N	N	N	N	N	N	N	E
Brazil	Thailand	1.136	N	P	N	N	N	N	N	N	E	N	N
Qatar	USA	1.121	N	P	E	N	E	N	E	E	E	E	E
Russian Fed.	Singapore	1.120	N	P	N	N	N	N	N	N	N	N	N
Malaysia	Turkey	1.109	N	P	N	E	E	N	N	E	E	E	E
Philippines	Egypt	1.0828	N	P	N	E	N	N	N	E	N	N	N
Algeria	Saudi Arabia	1.080	N	P	N	E	N	E	N	N	N	N	N
Côte d'Ivoire	Nigeria	1.074	N	P	N	E	E	E	E	E	N	E	E

Note: ‘E’ refers to ‘existent relationship’; ‘N’ represents ‘inexistent relationship’; ‘P’ denotes ‘potential relationship’ with a high WRA index score. Relationships shaded are fulfilled relationships.

6.8. Conclusion

The recent development of agricultural production and logistics technology has secured an intensive global integration of dairy trade. Unfortunately, trade relationships in dairy are found to be fragile with large fluctuations. Also, uncovering uncertainties in future trade relationships remain difficult as a large number of countries are trading within the network simultaneously. In this chapter we utilised an emerging methodology link prediction, to fill a literature gap concerning the prediction of dairy trade relationships. In doing so, this chapter predicts new and potential trade relationships in dairy and identifies their future trade patterns through a trade network analysis.

Given the results in previous sections, link prediction provides a significant mechanism to predict potential dairy trade relationships. In particular, the Weighted Resource Allocation (WRA) index shows the best performance in prediction, compared to the other indices considered. It well captures the external role of common trade partners in linking two disconnected countries and helping distribute resources and information along the edge. It also emphasises the significance of monitoring the entire trade network and detailed trade relationships and provided an appropriate direction for future trade models. However, this chapter does not find evidence for the existence of 'Weak Ties' in the global dairy trade (GDT) networks as in prior literature. This means that trade partners with a larger trade volume have greater influence than those with a smaller volume.

With regards to the predicted outcomes, this chapter observes that the current GDT network is complicated. However, the number of countries has actually participated in and trade relationships established tend to be limited. Also, the predictions provide a list of country pairs with a high index score that is likely to fulfil in the following decade. Further robustness testing reveals that our predictions would be practically valid.

There are four main contributions of our work. First, it is the first time that the link prediction being applied to agricultural and food trade. It enriches the literature examining international trade networks and will directly contribute to existing trade models and their development and application. Second, observations of this chapter will be crucial for countries and businesses when they are searching for new trade strategies and trade potentials within specific foreign markets. Third, trade participants will be able to acknowledge the changing roles of themselves and the other economies given the network analysis. Furthermore, this chapter will help to develop a solid international trade network theory and encourage further analyses in this particular area of research.

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Chapter 7 Conclusion

This thesis empirically models New Zealand trade in a complex and dynamic environment and contributes to the fields of international and agricultural economics, especially. It addresses an important issue faced by small-sized economies worldwide. That is, how to better understand emerging patterns in their trade and how to benefit from this understanding with their limited resources, production capacity, and market.

The remainder of this chapter summarises the main outcomes of the thesis and draws final conclusions. Section 7.1. provides answers to the research questions. Section 7.2. presents the contribution of the research. Section 7.3. discusses the policy implications of the findings. Section 7.4. discusses the limitations of the research. Section 7.5. presents possible directions for future research.

7.1. Answers to the research questions

i. Is New Zealand trade 'complex'? How does New Zealand participate in GVCs? What are the primary drivers of its participation?

In Chapter 2, the study on New Zealand's GVCs participation provides answers to this question. It shows that the country's position in the GVCs was not 'complex' and has not performed well compared to the other OECD countries. Even though industries such as the food and beverage industry require a large amount of foreign intermediate products for production, it is less likely that these industries will benefit the most from intermediate imports due to the lower level of technologies required by the industry. In contrast, the manufacturing industry strongly dependent on domestic supply chains with fewer overseas value-added content in production. This further discourages the country's participation in GVCs.

Through identifying the determinants of OECD countries' GVCs, the study finds that household disposable income, exported intermediates ratio, import penetration ratio, R&D, FDI and the number of patents applied are the most influential factors of OECD countries' evolution of GVCs. This result highlights the channels that may help improve the country's participation in GVCs and future trade integration.

ii. *Is New Zealand trade characterised by a fragile nature? How well have New Zealand import and export relationships survive? What are the major causes of trade fragility?*

Chapters 3-5 address this question by looking at how New Zealand imports and exports survived from 1989 to 2017. We adopt the discrete-time hazard models to identify the critical determinants of trade failure. As a result, we find that New Zealand trade relationships are fragile with multiple sequences as with the other countries. More than half of them have survived no more than three years.

After employing the discrete-time hazard models, we find that duration of the sequence, the number of entries, distance, GDP per capita, production, import prices, the number of import origins and export destinations explained most of the variation in import survival with high significance. This observation confirms the findings of prior studies on trade duration and survival, indicating that import survival is mainly driven by experience, domestic demand, the economic size of and competition among exporters.

Other than those demand and supply-side factors, Chapter 2 uniquely examines the impact of New Zealand Sanitary and Phytosanitary (SPS) measures on horticulture imports. It finds that the probability of import failure increases as the commodities are being treated with SPS measures. However, countries with a higher level of development can benefit from their experience of being treated. At the disaggregated level, there is some evidence revealing that the fumigation and cold disinfestation combined treatment increases the probability of import failure significantly.

iii. *What is the role of New Zealand in the global trade network? Are there accurate approaches to predicting future trade relationships in a complex network environment? What trade relationships are 'most-likely-to-emerge' for New Zealand?*

Chapter 6 adopts a novel approach to predict global dairy trade relationships based on the complex network theory. Even though it examines trade in a broad context, there are several meaningful implications for understanding the future of New Zealand dairy trade. For instance, by establishing a Global Dairy Trade (GDT) network, it observes that New Zealand as a leading dairy exporter has a strong connection to the world through supplying dairy products to a large number of destinations.

Meanwhile, using the Link Prediction approach, it indicates that the Weighted Resource Allocation (WRA) index is best able to predict future dairy trade relationships, compared to other indices considered. This is because WRA captures the external role of common trade partners in linking two disconnected countries and helping distribute resources and information along the edge, given the accuracy index calculated.

According to the predictions, new dairy trade relationships that are most likely to emerge include trading with countries such as New Zealand, Ukraine, Peru, and Malaysia. As for New Zealand, the 'most-likely-to-emerge' relationships include those with Argentina, Czech Republic, Luxembourg, Greece, and Finland. However, using our previously adopted simple counting of trade sequences approach, relationships such as between New Zealand and Turkey, Malaysia and Switzerland, and the Czech

Republic and the USA are anticipated to be extremely active with multiple sequences of trade in the future.

7.2. Contribution

In recent years, fluctuations in natural conditions, global economic developments, and adjustments in agricultural and trade policies are believed to cause fluctuations in both global demand and supply (FAO, 2017). The significant costs associated with these uncertainties highlight the importance of understanding the new attributes of trade in a complex and dynamic environment.

Given the country's vision of '*doubling the primary exports by 2025*', trade policies are of increasing importance at this stage to help explore the country's potentials and secure a persistent growth in the international trade market (New Zealand Government, 2012). Helping fulfil this vision and the country's other ambitions in trade, frequent participation in Global Value Chains (GVCs) and sustainable trade opportunities (via expanding potential partners and export products) are the two possible directions for the government to dig deeper into in the future.

Chapter 2 of this thesis focuses on New Zealand's GVCs participation. GVCs have become a dominant feature of world trade, interlinking emerging, developing and developed economies (WTO, 2017). The whole process of production, from raw materials to finished products, is increasingly carried out where a country is competitive in terms of both cost and quality (OECD *et al*., 2013). Findings in this chapter highlight the need for New Zealand and other countries to have an open and transparent trade and investment regime to support their further participation in GVCs. Additionally, observations in this chapter highlight the importance of a complementary policy agenda to leverage engagement in GVCs into more inclusive growth.

Chapters 3-5 provide insights into the survival of New Zealand agricultural imports and exports in terms of sequences and duration. They are the first study in New Zealand to uncover the short-lived nature of trade relationships in the agriculture sector. Other than that, an important factor considered in the analysis of Chapter 3 is the application of Sanitary and Phytosanitary measures (SPS) which are measured as the biosecurity treatments required in New Zealand Import Health Standards (IHS).

Similarly, in Chapter 4, the influence of non-tariff barriers has been identified and its impact on the export survival of New Zealand dairy sector has been investigated. The use of this information is the very first attempt to empirically estimate the consequences of non-tariff measures and SPS on New Zealand trade survival. It helps policymakers reduce the unnecessary trade restrictions as non-tariff barriers and other restrictive measures impact not only on foreign suppliers but also on domestic producers.

In Chapter 5, New Zealand's exports survival was compared to other leading exporting countries. It is the first study where honey trade competitiveness is measured based on a duration and survival analysis. Other than the commonly considered supply and demand sided factors, this chapter importantly captures the impacts of food security and safety on honey exports survival. This helps honey exporters better understand how to improve their offshore market survival through a better regulation on standards and safety.

Chapter 6 is the very first study that constructs a Global Dairy Trade (GDT) network and uses the Link Prediction approach to predict agricultural trade relationships. At present, prediction on the mechanism and linking choice of international trade based on Link Prediction are at the leading edge of researches on the complex trade network theory (Xing and Han, 2020). This chapter highlights the need for combining international trade theories with the complex network theory and establishing a novel concept or theory to provide a complete network model of international trade.

7.3. Policy implications

Findings in this thesis are important from a policy perspective, at both the national and international level.

i. Encouraging participation in GVCs using complementary policies

Chapter 2 highlights the low participation of New Zealand in GVCs. However, direct strategies to encourage participation are scarce, and trade policy is not adequate to help achieve this goal. Therefore, complementary policies are needed to obtain the benefits of GVCs for inclusive employment and income growth. Since not all industries are equally and fully prepared for increasing participation in GVCs and businesses may find it hard to adapt to these changes, an effective integration strategy needs to take adjustment conditions and industry specificities into account.

ii. Facilitating trade relationship diversification

Chapters 3-5 have identified a range of factors contributing to New Zealand import and export survival. Key forces helping businesses stay in the market and reducing the economy's vulnerability to global market shocks are associated with diversification both at the product and destination dimensions (OECD, 2013). However, it is often costly and time-consuming for businesses. Therefore, public policies are required to facilitate the process. It may include providing more accessible finance to entrepreneurs and developing a strong and competitive financial market to ensure businesses can issue debt at reasonable rates (Fosu and Abass, 2019). Diversification at the destination or product levels also require the efficient operation of the national innovation system in the economy that facilitates the cooperation of research institutions, industries, and the government.

iii. Reducing the costs of trade protection

The results in Chapters 3-5 provide insights into the significant influence of non-tariff barriers on trade survival. Today, the rising number of quality and safety standards is partly driven by worldwide concerns about the information, coordination, and traceability of commodities (Charlebois *et al*., 2014). However, complexity and heterogeneity of complying with different standards at different markets can sometimes lead to a substantial increase in trade costs. This will likely be a burden, especially to those small and medium-sized businesses. Therefore, increasing global cooperation could help the convergence of different standards and certification requirements and alleviate the costs of such compliance and enhance the competitiveness of traders.

iv. Increasing investments

Strengthening the capacity of the investment promotion activities to address informational failures that may be preventing firms from keeping their export flows active is of foremost importance. In particular, the information about foreign consumers' preferences, help with the identification of potential buyers, or assistance in tackling the regulatory complexities associated with serving international markets is crucial (OECD, 2013). These approaches will likely positively impact the survival and competitiveness of businesses in offshore markets as well as their diversification performance.

v. Promoting and enhancing multilateral and regional trade and investment agreements

Gains from international liberalisation are more significant when more countries participate, and markets are opened on a multilateral basis. The phenomenon of GVCs today strengthens the economic case for advancing negotiations at the multilateral level (OECD, 2013). This is because trade barriers influence not only direct trade partners but also those who sell or purchase intermediates to or from these direct trade partners. Therefore, an agreement that covers a maximum number of products and countries involved in the global production chain is favourable. This also highlights the demand for applying the Most Favoured Nation (MFN) principle in multilateral agreements as it can help remove the potential trade distortions in the market.

7.4. Limitations

It should be noted that this thesis also has limitations. First, all studies commonly used either sectoral or the product-level data and variables for estimation. The estimated models in these studies need to assume that markets are competitive, and there are only homogenous products across firms in a sector. Therefore, they are unable to capture firm heterogeneities and have less targeted policy implications for firms.

Second, data unavailability prevented this thesis from including a wide range of covariates during the model design and estimation stage. Coordinated datasets used in these studies were unbalanced and had a limited number of covariates. Although an imputation strategy was applied to make it balanced, missing true data to some extent reduced statistical power of the model and could cause bias in the estimation of parameters.

Third, in Chapter 6, due to the lack of mature theories linking network and trade theories, only the indices of Revealed Comparative Advantage (RCA) have been calculated to incorporate trade theories into the analysis of prediction results. It makes this chapter less meaningful from the trade than from the network perspective. Also, the forming of international trade relationships is often determined by many factors. Given the framework of the Link Prediction approach, however, only trade volume was considered during the prediction. In the future, further analyses will be conducted with the consideration of geography, economic and political factors for a more specific evaluation of potential trade relationships.

Finally, prediction in this chapter was based on the establishment of an undirected and weighted Global Dairy Trade (GDT) network. Indeed, the real-world network is often more complex with clear directions. Therefore, future research that can develop a directional trade network and help predict the direction of trade flows is critical. However, to date, the complex trade network theories are remaining underdeveloped.

7.5. Future research

Investigations of international trade are likely to remain critical in the following years. This thesis has assessed the complex and fragile nature of trade relationships in multiple sectors. Findings from this thesis suggest some of the future research directions. First, subsequent research on international trade could explore the direction of integrating the complex and fragile nature of trade relationships observed in this thesis with the use of big data to inform trade strategies at various levels. Second, factors such as the increases in per capita consumption are likely to replace the importance of global population growth in global demand in the next decade (Martin, 2018). It is believed that this trend increases the difficulty of forecasting the responses of demand in the dynamically changed world prices (Fukase and Martin, 2017). Therefore, future research topics could focus more on national reforms and regional agreements adapting to the evolving patterns and driving forces of international trade markets. Third, trade costs (both international and internal) are an important factor of both the existence and persistency of bilateral trade (Staboulis *et al*., 2019). Key challenges such as how to deal with high and volatile trade costs caused by distortions, therefore, will remain important at both national and regional levels. This often requires a range of collective works and actions to help devise feasible approaches to the reduction and removal of distortions. Finally, future research could also benefit from adopting new analytical techniques which built on the interdisciplinary models and big data for innovative applications and expand the range of trade questions to which scholars in this field can effectively respond.

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Appendix: Co-authorship Forms

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Co-Authorship Form

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Chapter 2:
New Zealand's Participation in Global Value Chains (GVCs)

About to be submitted

Nature of contribution by PhD candidate	Conceptualisation, data collection, estimation, analysis, writing and reviewing
Extent of contribution by PhD candidate (%)	80

CO-AUTHORS

Name	Nature of Contribution
Prof Frank Scrimgeour	Participation in conceptualisation, positioning and reviewing
Dr Sayeeda Bano	Participation in conceptualisation, positioning and reviewing

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
Prof Frank Scrimgeour	Frank Scrimgeour	6 May 2020
Dr Sayeeda Bano	Sayeeda Bano	6 May 2020

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Chapter 3:
Survival Analysis of New Zealand Fresh Fruit and Vegetable Import Relationships
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Nature of contribution by PhD candidate	Conceptualisation, data collection, estimation, analysis, writing and reviewing
Extent of contribution by PhD candidate (%)	80

CO-AUTHORS

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Dr Sayeeda Bano	Participation in conceptualisation, positioning and reviewing

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Chapter 4: Modelling New Zealand dairy products: evidence on export survival and duration
Published Australian Journal of Agricultural and Resources Economics. Early View. https://doi.org/10.1111/1467-8489.12372

Nature of contribution by PhD candidate	Conceptualisation, data collection, estimation, analysis, writing and reviewing
Extent of contribution by PhD candidate (%)	80

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Name	Nature of Contribution
Dr Sayeeda Bano	Participation in conceptualisation, positioning and reviewing

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Chapter 5:
Competitiveness of Selected Honey Exporting Countries: An Analysis of Their Duration and Survival
About to be submitted

Nature of contribution by PhD candidate	Conceptualisation, data collection, estimation, analysis, writing and reviewing
Extent of contribution by PhD candidate (%)	80

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Prof Frank Scrimgeour	Participation in conceptualisation, positioning and reviewing
Dr Azmat Gani	Participation in conceptualisation, positioning and reviewing

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Chapter 6:
Exploring New and Potential Trade Relationships within Global Dairy Trade Networks: An Application of Link Prediction
Under review *American Journal of Agricultural Economics.*

Nature of contribution by PhD candidate	Data collection, estimation, analysis, writing and reviewing
Extent of contribution by PhD candidate (%)	80

CO-AUTHORS

Name	Nature of Contribution
Prof Frank Scrimgeour	Participation in conceptualisation, positioning and reviewing
Dr Sayeeda Bano	Participation in conceptualisation, positioning and reviewing

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