Analysing Trade Facilitation Using Gravity Models

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Senal A. Weerasooriya

Abstract

Trade facilitation is an important aspect of promoting international trade. Hence, international organisations in collaboration with many countries have taken steps to improve trade facilitation. To make this effective, one needs to understand how trade facilitation influences trade. In this context, the knowledge and application of gravity models are substantial. This chapter attempts to provide the reader with what is trade facilitation and its important components. Afterward, the gravity intuition and how trade facilitation can be included in a gravity model is introduced. Finally, the readers are exposed to an actual application of the gravity model using a statistical package.

Keywords

Trade facilitation · Non-tariff measures · Trade policy analysis · Estimating a gravity model

9.1 Introduction

Often bureaucratic delays and 'red tape' pose a burden for moving goods across borders for traders. Hence, in the context of international trade, the concept of trade facilitation has been brought to the forefront as a measure to reduce trade costs. Currently, trade costs account for an equivalent of 219 per cent ad valorem tariff on a product in developing countries (World Trade Organisation 2015). The World Trade Organisation (WTO) members forged the Trade Facilitation Agreement (TFA)

S. A. Weerasooriya (✉)
Faculty of Agriculture, University of Peradeniya, Peradeniya, Sri Lanka
e-mail: senalw@agri.pdn.ac.lk

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which came into force in 2017 to combat this issue. According to the WTO, improving trade facilitation includes simplifying paperwork, modernising procedures, and harmonising customs requirements. In other words, it seeks to improve procedures and controls governing the movement of goods across national borders to reduce trade costs while safeguarding legitimate regulatory objectives. Trade facilitation is often associated with trade policies as policies set the tone for better or worse facilitation. Hence an understanding of trade policy analysis is of great importance to address the issues of trade facilitation.

Before readers try to analyse trade policies, it is imperative that we understand what trade policy is and how it is classified. Trade policy is generally defined as a set of standards, goals, rules, and regulations that pertain to trade relations between countries. Usually, these policies are country-specific and often can be product- or market-specific too. The overarching authority for formulating, implementing, and regulating these policies is bestowed on public officials. In international trade literature, trade policies are broadly categorised into two sections, namely, tariff and non-tariff measures. Tariffs are a tax or duty to be paid on a particular class of imports or exports, whereas non-tariff measures are defined as any trade policy instruments used to regulate international trade other than ordinary tariffs (United Nations Conference on Trade and Development 2015). As readers have been exposed to tariff measures in a previous chapter, this chapter focuses more on Non-Tariff Measures (NTM) and how to analyse their impacts as NTMs are often linked to trade facilitation. For example, many have highlighted the importance of NTMs in changing trade costs and thereby improving (or worsening) trade facilitation (De Melo and Nicita 2018).

Within this milieu, the quantitative analysis of trade policy impacts focused on trade facilitation is one of the major issues researched in applied international trade literature. This is vital due to the integral versatility of trade in shaping trade facilitation and ultimately the development of many nations. In this context, the gravity model has garnered global interest and attraction for analysing trade policies.

The gravity model was first proposed by the Nobel laureate Jan Tinbergen in 1962 to explain international bilateral trade.[1] Named for its analogy with Newton's law of universal gravitation, the gravity model proposes that bilateral trade can be explained by the size of the economies and distance/proximity. Just as planets are attracted to each other in proportion to their sizes and distance, so too are countries. Relative size is determined by current GDP, and economic distance is determined by trade costs, i.e. the more economically 'distant', the larger the trade costs. Tinbergen's explanation initially lacked theoretical foundations and was intuitively driven. However, the gravity model has provided some of the clearest and most robust findings in empirical economics (Leamer and Levinsohn 1995) and remains the workhorse of the applied international trade literature[2] (Shepherd 2012). For

[1]Bilateral trade is the exchange of goods between two nations promoting trade and investment.

[2]See De Benedictis and Taglioni (2011) for a review of the development of the gravity model and its early implementations.

example, Disdier and Head (2008), in their meta-analysis of the effect of distance on trade, cover 1052 separate estimates in 78 papers. Hence, it is important for policy analysts to understand and apply the gravity model appropriately. This chapter provides an elementary understanding of the gravity model and how it can be applied in trade policies that are related to trade facilitation. More specifically, the focus will be on how to analyse the impact of NTMs on trade.[3] The chapter provides an overview of NTMs and the gravity model, data sources, and estimation techniques using real-world data. In addition, the chapter provides STATA[4] codes to run various regression models used under gravity modelling. More specifically, this chapter (i) describes what is meant by trade facilitation, trade facilitation agreement, and its role in reducing trade costs; (ii) describes the role of NTMs within the context of trade facilitation; (iii) defines NTMs, how they are classified, and what type of measures are included under each classification; (iv) explains the logical intuition of the gravity model and its theoretical explanation; (v) identifies and finds the data needed to estimate a gravity model; (vi) lists the main measurement issues associated with gravity models; and (vii) describes the main econometric estimation techniques available to counter various issues in estimating a gravity model.

9.2 The Context

9.2.1 Intentions of the Policy and Global Context

Trade policy today is increasingly integrated with NTMs that are not necessarily designed to restrict or integrate trade but address non-trade regulatory objectives, such as product safety, environmental protection, and national security or intellectual property rights (De Melo and Nicita 2018). Extensive research has shown that from a development viewpoint and regardless of what trade policies a country implements, it is in the national interest of all countries to minimise trade costs (Moise and Le Bris 2013). Reducing trade transaction costs incurred in enforcing NTMs is a major objective and rationale for TFAs. The economic cost of NTMs, in terms of sanitary and phytosanitary and technical barriers to trade measures, is estimated to be around 1.6 per cent of global gross domestic product amounting to USD 1.4 trillion (United Nations Conference on Trade and Development 2019); NTMs have become an important concern for traders as well as for trade policymakers aiming to reduce trade costs.

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[3] Note that gravity model can be used to analyse not only NTMs but tariff measures too.

[4] STATA is a statistical software package.

9.2.2 Trade Facilitation Agreement

Traders from both developing and developed countries have frequently highlighted the vast amount of 'red tape' that exists in moving goods across borders. To address this, WTO members forged the Trade Facilitation Agreement. Negotiations of the TFA were concluded in December 2013 at the Ninth Ministerial Conference of the WTO held in Bali, Indonesia. The protocol of amendment that inserted the TFA into the WTO agreement was officially adopted and opened for ratification by WTO member states in November 2014. The TFA aims to streamline and expedite import and export procedures and customs requirements and enhance co-operation and transparency on cross-border trade rules and regulations (World Trade Organisation 2014, 2015). The TFA contains three sections: Section I on the expected commitments of member states; Section II on 'special and differential treatment' for developing nations and least developed countries; and Sect. III, which calls for the creation of committees on trade facilitation and includes provisions related to definitions and special circumstances.

The TFA entered into force on 22 February 2017, upon ratification by two-thirds of WTO member states, including Sri Lanka (Malith and De Zylva 2017). It includes 12 articles which are:

1. Quickly publishing information in a non-discriminatory and easily accessible manner
2. Allowing interested parties to comment on the application of trade-related regulations
3. Issuing advance rulings on the treatment of imported goods in a reasonable and timely manner
4. Improving procedures to appeal or review decisions made by customs officials
5. Developing a system that efficiently notifies concerned parties of enhanced border controls or inspections, detention of goods, and test procedures for imported goods
6. Regulating and reviewing fees imposed in connection with imports, exports, and penalties
7. Expediting the release and clearance of goods
8. Establishing coordination and cooperation between border control authorities
9. Allowing imported goods to be moved under customs control from the customs office of entry to another office in that state's territory for release or clearance
10. Streamlining formalities connected to the import, export, and transit of goods
11. Facilitating and improving the transit of goods
12. Improving customs cooperation between traders and customs officers and between customs officers of member states (World Trade Organisation 2014; Malith and De Zylva 2017)

The TFA further declared that member states should also establish a National Committee on Trade Facilitation or designate an existing entity to develop national roadmaps and align domestic policy with the TFA. In addition, the TFA allows provision of assistance, in the form of soft and hard infrastructure, for implementing the TFA. The assistance is available through the TFA, WTO, and external organisations (World Trade Organisation 2014).

According to WTO estimates, the TFA is expected to reduce trade costs by an average of 14.5 per cent (World Trade Organisation 2014). Also, the TFA is expected to reduce the average time to import goods by approximately 1.5 days and the average time to export by approximately 2 days. Moreover, the WTO estimates that the TFA could potentially add in the range of USD 345–USD 555 billion to global GDP each year. Developing countries are expected to reap larger gains than developed countries if the TFA is fully implemented: the TFA is anticipated to increase average GDP growth in developing countries by 0.9 per cent, compared to 0.25 per cent in developed countries. Similarly, exports of developing countries are projected to increase by 3.5 per cent per year, compared to a 1.8 per cent increase in developed countries (World Trade Organisation 2014).

9.2.3 Non-tariff Measures

As mentioned above, NTMs are defined as any trade policy instruments, other than ordinary customs tariffs, used to regulate international trade that can potentially have an economic effect on international trade in goods, changing quantities traded or prices or both (United Nations Conference Trade and Development 2015). In general, governments use NTMs for two main purposes: to align trade policy with their economic policies and development objectives and to pursue public policy objectives.

NTMs include a very diverse set of policy measures that can be quite different from each other. As a result, a coherent and proper classification is needed to understand the scope of NTMs. For example, issues related to the implementation of government regulations or enforcement are not defined as NTMs but referred to as procedural obstacles[5] (De Melo and Nicita 2018). The United Nations Conference on Trade and Development (UNCTAD), in collaboration with other international organisations, has developed a detailed classification of policies that can be considered as NTMs. Here, NTMs are broadly classified into technical measures, non-technical measures, and export measures. The non-technical measures are further classified into hard measures, threat measures, and other measures. Within the three broad categories, 16 chapters from A to P are defined by the UNCTAD (2015). These are given in Table 9.1 with the UNCTAD (2015) descriptions of each chapter.

Chapter A which includes Sanitary and Phytosanitary (also known as SPS) measures are applied to protect human or animal life from risks arising from additives, contaminants, toxins or disease-causing organisms; to prevent or limit

[5]For example, lengthy procedures at custom clearance due to inefficiencies at the border are not to be considered NTMs although these may affect trade costs.

Table 9.1 International classification of non-tariff measures

	A	Sanitary and phytosanitary measures (SPS)
	B	Technical barriers to trade (TBT)
Non-technical measures	C	Pre-shipment inspection and other formalities
	D	Contingent trade-protective measures
	E	Non-automatic licensing, quotas, prohibitions, and quantity-control measures other than for SPS or TBT
	F	Price control measures, including additional taxes and charges
	G	Finance measures
	H	Measures affecting competition
	I	Trade-related investment measures
	J	Distribution restrictions
	K	Restrictions on post-sales services
	L	Subsidies (excluding export subsidies under chapter P)
	M	Government procurement restrictions
	N	Intellectual property
	O	Rules of origin
Export measures	P	Export related measures

Source: De Melo and Nicita (2018), United Nations Conference Trade and Development (2015)

other damage to a country from the entry, establishment or spread of pests; and to protect biodiversity. These include measures taken to protect the health of fish and wild fauna, as well as of forests and wild flora. Prohibitions or restrictions for imports under SPS reasons, tolerance limits for residues and restricted use of substances, labelling, marketing and packaging requirements, hygienic requirements, treatment of plant and animal pest and disease-causing organisms, other requirements and conformity assessments related to SPS are some of the measures under chapter A.

Chapter B which includes Barriers to Trade (also known as TBT) refers to technical regulations, and procedures for assessment of conformity with technical regulations and standards, excluding measures covered by the SPS agreement. More specifically, a technical regulation is a document which lays down product characteristics or their related processes and production methods, including administrative provisions, where compliance is compulsory. It can include or deal exclusively with terminology, symbols, packaging, marking or labelling requirements as they apply to a product, process or production method. Prohibitions or restrictions of imports under TBT reasons, tolerance limits for residues and restricted use of substances, labelling, marketing, and packaging requirements, production or post-production requirements, product identity requirement, product-quality or performance requirement and conformity assessment[6] *related to TBT are some of the measures under chapter B.*

[6]A conformity assessment procedure is any procedure used, directly or indirectly, to determine that relevant requirements (under SPS or TBT) are met. It may include, inter alia, procedures for

Chapter C includes pre-shipment inspection and other formalities which refers to requirements and formalities to be performed in the exporting country prior to shipment. Pre-shipment inspection by an independent inspecting agency, direct consignment requirement (goods must be shipped directly from the country of origin without stopping anywhere), the requirement to pass through the specified port of customs, import monitoring and surveillance and other automatic licensing measures are some of the measures under chapter C.

Chapter D includes contingent trade-protective measures that are implemented to counteract certain adverse effects stemming from imports in the market of the importing country, including measures aimed at unfair trade practices, contingent upon the fulfilment of certain procedural and substantive requirements. Antidumping measures (measure applied to imports which are dumped and are causing adverse effects to the importing country), countervailing measures (measure applied to imports to counter any subsidy granted by authorities in an exporting country where subsidised imports of that product are causing injury to the domestic industry producing a similar product), and safeguard measures are some of the measures under chapter D.

Chapter E includes non-automatic licensing, quotas, prohibitions and quantity-control measures other than for SPS or TBT. These are control measures generally aimed at restraining the quantity of goods that can be imported, regardless of whether they come from different sources or one specific supplier. Non-automatic licensing, fixing of a predetermined quota, or through prohibitions other than SPS and TBT reasons, and tariff-rate quotas are some of the measures under chapter E.

Chapter F includes price control measures, including additional taxes and charges. These are measures implemented to control or affect the prices of imported goods in order to, inter alia*, support the domestic price of certain products when the import prices of these goods are lower; establish the domestic price of certain products because of price fluctuation in domestic markets, or price instability in a foreign market; or to increase or preserve tax revenue. They are also known as para-tariffs. Administrative measures affecting customs value, voluntary export-price restraints, variable charges, custom surcharges, seasonal duties, additional taxes, and charges levied in connection to services provided by the government, internal taxes and charges levied on imports, and decreed customs valuations are some of the measures under chapter F.*

Chapter G includes finance measures that are intended to regulate the access to and cost of foreign exchange for imports and define the terms of payment. They may increase import costs in the same manner as tariff measures. Advance payment requirements, multiple exchange rates, regulation on official foreign exchange allocation, and regulations concerning terms of payments for imports are some of the measures under chapter G.

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sampling, testing, and inspection; evaluation, verification, and assurance of conformity; and registration, accreditation, and approval as well as their combinations.

Chapter H includes measures affecting competition which are used to grant exclusive or special preferences or privileges to one or more limited groups of economic operators. State-trading enterprises, for importing and other importing channels, and compulsory use of national services are some of the measures under chapter H.

Chapter K includes restrictions on post-sales services where such measures are used to restrict producers of exported goods to provide post-sales services in the importing country. For example, any after-sales service on exported TV sets should be provided by a local service company in the importing country.

Chapter L includes subsidies excluding export subsidies under chapter P. These include a financial contribution by a government, or via *government entrustment or direction of a private body, or income or price support, which confers a benefit and is specific to an industry, group or a geographical region. For example, the government can provide producers of chemicals a one-time cash grant to replace outdated production equipment.*

Chapter M includes government procurement restrictions. These measures attempt to control the purchase of goods by government agencies, generally by preferring national providers. For example, a government office may have a traditional supplier of its office equipment despite a higher price than similar foreign suppliers.

Chapter N includes intellectual property which is related to intellectual property rights in trade. Intellectual property legislation encompasses patents, trademarks, industrial designs, layout designs of integrated circuits, copyright, geographical indications and trade secrets. For example, there might be a prohibition for importing clothing with unauthorized use of the trademark at a much lower price than the authentic product.

Chapter O includes rules of origin. Rules of origin cover laws, regulations and administrative determinations of general application applied by the government of importing countries to determine the country of origin of goods. Rules of origin are important in implementing trade policy instruments such as antidumping and countervailing duties, origin marking and safeguard measures.

Chapter P includes export-related measures. These are measures that are applied by the government of the exporting country on exporting goods. Export-license, -quota, -prohibition and other quantity restrictions, state-trading enterprises, for exporting and other selected channels, export price-control measures, measures on re-export, export taxes and charges, export technical measures, export subsidies, and export credits are some of the measures under chapter P. (United Nations Conference Trade and Development 2015)

Several interesting patterns or issues may be observed. Firstly, the majority of NTMs are Sanitary and Phytosanitary Measures (SPS) and Technical Barriers to Trade (TBT) measures (see Figs. 9.1 and 9.2). Globally, 41 per cent of the measures are SPS (30 per cent in the Asia Pacific region), and 40 per cent are TBTs (48 per cent in the Asia Pacific), followed by export measures (9 per cent globally and 13 per cent in the Asia Pacific) (United Nations Conference Trade and Development 2019). The case in Sri Lanka is no different (Fig. 9.3).

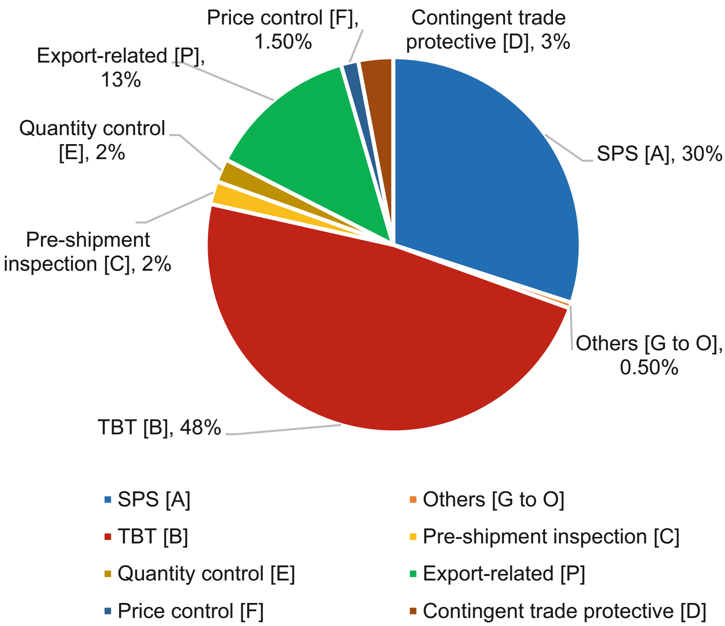

Fig. 9.1 Percentage of NTMs in the Asia-Pacific region, by type. Source: United Nations Conference on Trade and Development (2019)

As heterogeneous SPS and TBT measures account for a major portion of NTMs, the WTO has streamlined these measures in the form of international standards in trying to overcome challenges related to the heterogeneity of regulations. International standards are accepted as the benchmarks against which national measures are evaluated. According to the WTO SPS agreement, unless there is a scientific justification for a more stringent SPS protection, members must base their SPS measures on international standards in order to achieve broad harmonisation (United Nations Conference Trade and Development 2019). Similarly, the WTO TBT agreement places an obligation on member states to use international standards wherever they exist as a basis for their technical regulations and standards, unless the existing international standards or their parts are ineffective or inappropriate to fulfilling the respective legitimate objectives (United Nations Conference Trade and Development 2019).

Secondly, in terms of individual economies, the highest number of NTMs are imposed by developed countries, meaning more developed countries have stronger legislative frameworks (United Nations Conference Trade and Development 2019; Sandaruwan et al. 2020).

Thirdly, over the past two decades, with the rise of multilateral and regional trade agreements and unilateral efforts, tariff measures in the Asia-Pacific region have been halved. However, NTMs have risen dramatically. This is shown in Fig. 9.4.

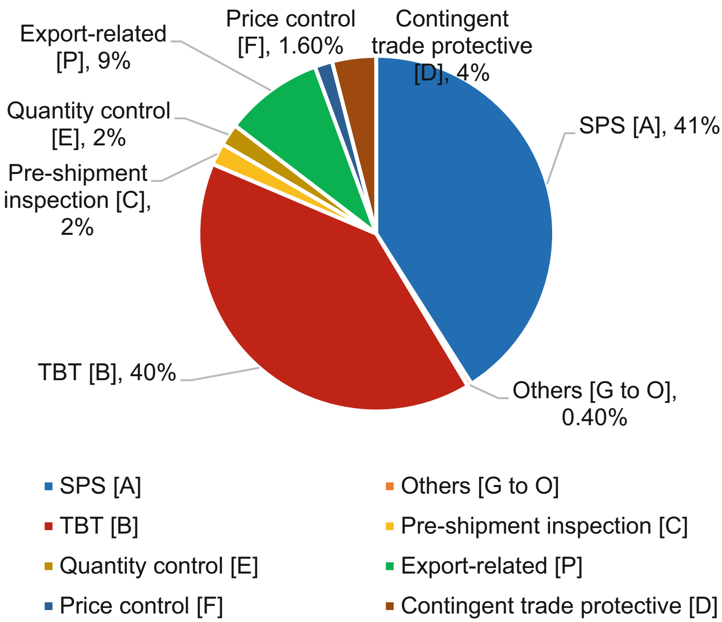

Fig. 9.2 Percentage of NTMs in the world, by type. Source: United Nations Conference on Trade and Development (2019)

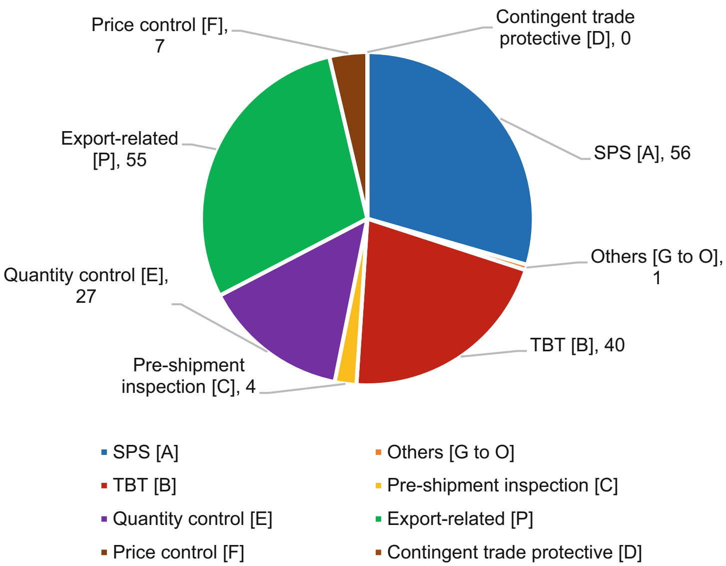

Fig. 9.3 Number of NTMs in Sri Lanka, by type. Source: United Nations Conference on Trade and Development (2020)

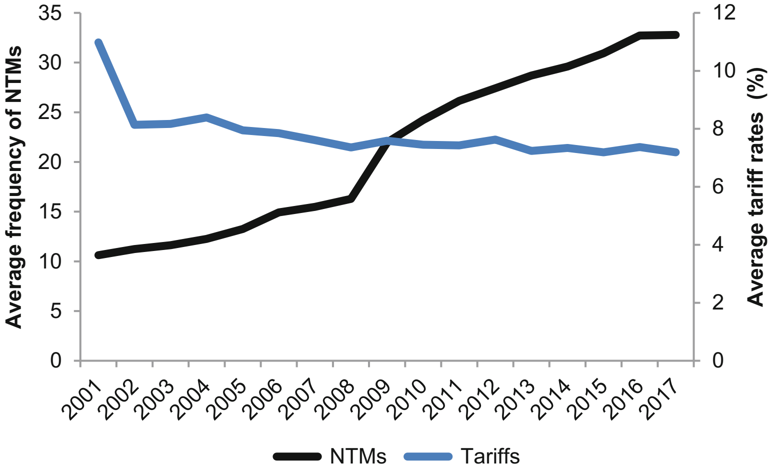

Fig. 9.4 The average frequency of NTMs and average tariff rates from 2001 to 2017. Source: Sandaruwan et al. (2020)

A term that is often associated with trade cost is Non-Tariff Barriers (NTBs). UNCTAD (2019) defines NTBs as policies that induce an adverse impact on trade due to the specific discriminatory and protectionist intent. Unlike for NTMs, there is no widely accepted definition of NTBs. Whether an NTM is an NTB largely depends on the intent of the regulation. In general, NTMs are implemented to serve the public interest and would not necessarily cause a negative impact. In fact, many studies have found a positive impact of NTMs on many related issues (Sandaruwan and Weerasooriya 2019; De Melo and Nicita 2018; Flaaten and Schulz 2010; United Nations Conference Trade and Development 2010). Classifying an NTM as an NTB is contentious as trading partners are most likely to disagree on whether a particular NTM contains a discriminatory or protectionist intent. In de facto terms, technical NTMs are not NTBs unless they have been challenged successfully through the WTO's (lengthy and expensive) dispute settlement process. Nevertheless, some technical NTMs can be viewed as discriminatory rather than necessary, tilting towards NTBs (United Nations Conference Trade and Development 2019). Hence, in some instances, the distinction between NTMs and NTBs can be difficult and contentious.

Another term that is associated with NTMs is procedural obstacles, practical challenges such as long delays in testing or certification, poor or inadequate facilities, lack of information on regulations, or infrastructure challenges. While not NTMs, they are in existence because there are NTMs (United Nations Conference Trade and Development 2019). These procedural obstacles are often an acute issue in the least developed or developing countries where facilities necessary to achieve NTMs are often lacking or inadequate. As a result, these countries have to resort to outsourcing which drives costs up and negatively influences any cost advantage they initially had. Most notably affected are the agricultural and food sectors. This is greatly disadvantageous for countries, with comparative advantage and a large portion of their populations that depend on income generated from the agricultural and food sectors (United Nations Conference Trade and Development 2019).

9.2.4 Policy Milestones of Sri Lanka

Where does Sri Lanka stand in terms of trade facilitation? According to Malith and De Zylva (2017), Sri Lanka takes 5 days to export and 5.4 days to import, respectively; Sri Lanka fares better than emerging economies in South Asia like India and Bangladesh, although it lags far behind Southeast Asian economies like Singapore, Thailand, and Malaysia, especially in terms of time taken to export. Sri Lanka submitted its instrument of ratification in May 2016, becoming the 81st member of the WTO to ratify the agreement. To improve trade facilitation, Sri Lanka pledged towards the TFA in 2017. Sri Lanka was also one of 32 countries to have received support from the World Bank's trade facilitation support programme and one of the first countries to engage with the global alliance for trade facilitation.

Under the TFA, one of the major initiatives taken by Sri Lanka was to establish a National Trade Facilitation Committee, a public-private body headed by the Director-General of Customs and co-chaired by the Director-General of Commerce. Other major initiatives included the creation of a Trade Information Portal and a National Single Window. The Trade Information Portal, hosted by the Department of Commerce in collaboration with the National Trade Facilitation Committee, was launched in July 2018. It provides a one-stop point for information relating to import into and export from Sri Lanka. The National Single Window, involving a collaboration of Sri Lanka Customs and the National Trade Facilitation Committee, was launched in January 2016. It facilitates access to a number of online systems developed for regulatory agencies involved in imports and exports. WTO estimates suggest that Sri Lanka can expect trade cost reductions ranging from 13.9 to 15.8 per cent, following full implementation of the TFA (World Trade Organisation 2015). In addition, the TFA is expected to improve and streamline cross-border procedures, thereby reducing time and cost to export which could allow for greater participation in trade by small- and medium-sized enterprises (SMEs) (Malith and De Zylva 2017).

As of September 2019, Sri Lanka has achieved 52 per cent of the overall implementation of trade facilitation measures in the following aspects: transparency (13 per cent), formalities (14 per cent), institutional arrangements (4 per cent), paperless trade (17 per cent), and cross-border paperless trade account (4 per cent) (United Nations Economic and Social Commission for Asia and the Pacific and Asian Development Bank 2019).

How well has Sri Lanka fared in terms of NTMs? Figure 9.5 shows the number of NTMs by type for selected Asian countries. As shown in Fig. 9.5, Sri Lanka had a total of 191 measures which constituted 56 SPS, 40 TBT, 55 export-related, 27 quantity control, 7 price control, 4 pre-shipment inspections, and 1 other measure

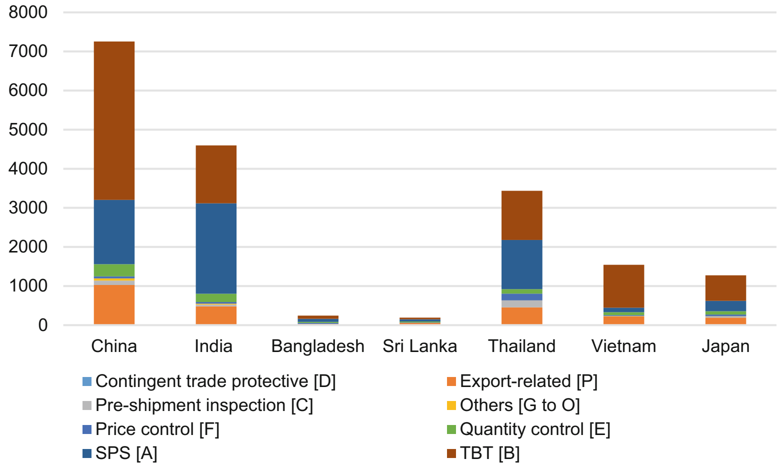

Fig. 9.5 NTMs in selected Asian economies. Source: United Nations Conference on Trade and Development (2020)

(United Nations Conference on Trade and Development 2020). In general, NTMs are already prevalent and are becoming more so as developing countries like Sri Lanka enhance their technical regulatory frameworks (United Nations Conference on Trade and Development 2019).

9.3 An Application

9.3.1 The Gravity Model: Intuitive

As mentioned earlier, Tinbergen's initial idea of using a gravity-like explanation for international trade was intuitive. In other words, it lacked economic theory. The extraordinary stability of the gravity equation and its power to explain bilateral trade flows using the size of the economies and the distance prompted the search for a theoretical explanation for it (Bacchetta et al. 2012). The gravity model specification is similar to Newton's law of universal gravitation and is presented in Eq. (9.1).

$$X_{ij} = \frac{AY_i^{\beta_1} Y_j^{\beta_2}}{T_{ij}^{\theta}} \tag{9.1}$$

where X_{ij} denotes exports (can be imports or net exports) from country i to j, Y denotes the economic size (in terms of GDP), and T denotes trade costs which are approximated by many factors, such as distance, tariffs, and non-tariffs between country i and j. In its most basic form, the gravity model can be written as an empirical equation as given in Eq. (9.2a) which is also known as the intuitive gravity model.

$$lnX_{ij} = \alpha + \beta_1 \, ln \, GDP_i + \beta_2 \, ln \, GDP_j + \theta lnT_{ij} + e_{ij} \tag{9.2a}$$

$$ln \, T_{ij} = \; ln \, (\text{distance})_{ij} + \; \ln \, (1 + \text{Tariff})_{ij} + \; \ln \, (1 + NTM)_{ij} \tag{9.2b}$$

$$\begin{aligned} lnX_{ij} = \alpha & \\ & + \beta_1 \, ln \, GDP_i \\ & + \beta_2 \, ln \, GDP_j \\ & + \beta_3 \, ln \, (\text{distance})_{ij} \\ & + \beta_4 \ln \, (1 + \text{Tariff})_{ij} \\ & + \beta_5 \ln \, (1 + NTM)_{ij} \\ & + e_{ij} \end{aligned} \tag{9.2c}$$

Equation (9.2a) is simply the log-linear form of Eq. (9.1). Here the α term acts as a regression constant, and $\beta's$ and θ are the coefficients to be estimated. A slightly more detailed equation is given in Eq. (9.2c)[7] where trade cost is broken into components.

According to the gravity model, we would expect the $\beta's$ to be positive and θ to be negative. A first sensible place to start would be to use Ordinary Least Squares (OLS) to show the relationship between trade and GDP and trade and distance. OLS typically minimises the sum of squares error and gives the parameters of interests. OLS parameters are intuitively appealing and possess useful statistical properties to conduct hypothesis tests and draw inferences. Under econometric theory, OLS estimates are rendered useful if the following three conditions are met[8]:

- The errors e_{ij} have a mean zero and must be uncorrelated with each of the explanatory variables (exogeneity).
- The errors e_{ij} are independently drawn from a normal distribution with a given constant variance (homoscedasticity).
- None of the explanatory variables is a linear combination of other explanatory variables (no perfect multicollinearity).

If all three assumptions are satisfied, then the OLS estimates are consistent, unbiased, and efficient. Consistency implies that the OLS coefficients converge to the true population values as the sample size increases. Unbiased implies that the

[7]Note that in equation (9.2c), 1 has been added before tariffs and NTMs. Since the equation is estimated in logs, this is to avoid taking the log of zero where tariffs/NTMs are not applied. Zero tariffs/NTMs would send the log to negative infinity while the log of 1 would be equal to zero.

[8]For more details on OLS and other econometric estimation techniques (which will be discussed later), please refer to Wooldridge (2012).

coefficients are not different from the true population values. Efficiency implies that there exists no other estimator that results in a smaller standard error than the standard error produced by the OLS estimators. If these assumptions are violated (which is most common), then OLS would not give accurate results.

9.3.2 Ad Valorem Tariff Equivalent

A common issue in trade policy analysis is that policy interventions take many different forms. A simple question is how can one compare a 10 per cent tariff, a 1000 metric ton quota, a complex licensing procedure, and an LKR ten million-worth subsidy? A frequently used approach in the trade literature is to bring the different types of trade policy instruments into a common metric by estimating ad valorem equivalents (AVEs). Hence, in the context of NTMs and gravity modelling, it is important to understand how this is done. Although there are many approaches,[9] Eq. (9.3) is a common approach proposed by Kalaba and Kirsten (2012) and Sandaruwan et al. (2020)).

$$ln\widehat{X}_{ij} = \beta_A \Psi_{ij} + \beta_4 \ln\left(1 + \text{Tariff}\right)_{ij} + \beta_5 \ln\left(1 + \text{NTM}\right)_{ij} \tag{9.3}$$

where Ψ represents all other explanatory variables except tariff rates and NTMs. Predicted difference between a country pair with a tariff and the same country pair without the tariff would be ($\widehat{X}^{a}$ – export value with tariff, $\widehat{X}^{b}$ - export value without tariff) as shown in Eq. (9.4).

$$ln\widehat{X}_{ij}^{a} - ln\widehat{X}_{ij}^{b} = \widehat{\beta}_4 ln(1 + \text{Tariff})_{ij} - \widehat{\beta}_4\, ln\,(1) \tag{9.4}$$

Predicted difference between a country pair with NTMs and the same country pair without the NTMs would be ($\widehat{X}^{c}$ – export value with NTM, $\widehat{X}^{d}$ –export value without NTM) as shown in Eq. (9.5).

$$ln\widehat{X}_{ij}^{c} - ln\widehat{X}_{ij}^{d} = \widehat{\beta}_5 \ln\left(1 + NTM\right)_{ij} - \widehat{\beta}_5\, ln\,(1) \tag{9.5}$$

A tariff equivalent or AVE of NTMs is the tariff that has the same effect on trade flows. This implies that the left-hand sides of Eqs. (9.4) and (9.5) are equal. Consequently, the right-hand sides of Eqs. (9.4) and (9.5) also should be equal. This is given in Eq. (9.6). By solving for Tariffs, we get Eq. (9.7) which gives the tariff equivalent or AVE of the corresponding NTM for the country pair *i* and *j*.

$$\widehat{\beta}_4 ln(1 + \text{Tariff})_{ij} = \widehat{\beta}_5 \ln\left(1 + \text{NTM}\right)_{ij} \tag{9.6}$$

[9] See Kee et al. (2009).

$$\mathrm{AVE} = (1 + \mathrm{NTM})_{ij}^{\left(\widehat{\beta_5}/\widehat{\beta_4}\right)} - 1 \tag{9.7}$$

Note that the AVE changes according to the way you specify NTMs. If you specify the NTMs as a dummy variable, Eq. 9.7 reduces to $\exp\left(\widehat{\beta}_5/\widehat{\beta}_4\right) - 1$ (for more details on how to do this when NTMs are specified as dummy variables, see Kalaba and Kirsten 2012; and Sandaruwan et al. 2020).

9.3.3 Example

Let's try to run an OLS using the intuitive gravity model and calculate AVE. The dataset is from Sandaruwan et al. (2020) on seafood exports from Sri Lanka to other countries from 2001 to 2017. The database included bilateral data from 107 countries on 144 seafood-related products at the Harmonised System (HS) 6-digit level. Altogether, 26,093 observations were included in the database. Data for this study originated from several sources which are described under Sect. 9.3.4. The following regression Eq. (9.8) will be estimated using OLS.

$$\begin{aligned} lnX_{ijt}^{k} = {} & \beta_0 + \beta_1\, ln\,\mathrm{GDP}_{it} \\ & + \beta_2\, ln\,\mathrm{GDP}_{jt} + \beta_3\, ln\,\mathrm{DIS}_{ij} \\ & + \beta_4\, ln\,\mathrm{POP}_{it} + \beta_5\, ln\,\mathrm{POP}_{jt} \\ & + \beta_6\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) \\ & + \beta_7\, ln\,(1 + \mathrm{SPS})_{ijt}^{k} \\ & + \beta_8\, ln\,(1 + \mathrm{TBT})_{ijt}^{k} \\ & + \beta_9\, \ln\,(1 + \mathrm{OTHNTM})_{ijt}^{k} \\ & + \beta_{10}\mathrm{landlock}_{it} + \varepsilon_{ijt}^{k} \end{aligned} \tag{9.8}$$

where X_{ijt}^{k} is the export value of product k to the i^{th} importing country from Sri Lanka at time t, GDP_{it} is the gross domestic product of i^{th} import country at time t, GDP_{jt} is the gross domestic product of Sri Lanka at time t, DIS_{ij} is the distance between the capital of the i^{th} import country and capital of Sri Lanka, $\mathrm{Tariff}_{ijt}^{k}$ is the tariff rate imposed by country i for exported product k from Sri Lanka, SPS_{ijt}^{k} is the number of SPS measures country i has imposed on the exported product k from Sri Lanka, TBT_{ijt}^{k} is the number of TBT measures country i has imposed on the exported product k from Sri Lanka, $\mathrm{OTHNTM}_{ijt}^{k}$ is the number of other NTMs excluding SPS and TBT country i has imposed on the exported product k from Sri Lanka, $\mathrm{landlock}_{it}$ is a dummy variable where 1 is for landlocked and 0 otherwise, and ε_{ijt}^{k} is the error

Table 9.2 OLS estimates of Eq. (9.8) using STATA

```
. regress lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff lnsps lntbt lnothntm landlock, robust

Linear regression                               Number of obs     =     26,093
                                                F(10, 26082)      =      94.27
                                                Prob > F          =     0.0000
                                                R-squared         =     0.0272
                                                Root MSE          =     4.0836
```

lnexport	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lngdpi	.4520636	.0259471	17.42	0.000	.4012058	.5029215
lngdpj	.1184052	.4344835	0.27	0.785	-.7332063	.9700168
lndist	-.4690078	.0478748	-9.80	0.000	-.562845	-.3751706
lnpopi	-.274703	.0260562	-10.54	0.000	-.3257746	-.2236313
lnpopj	14.22719	3.96477	3.59	0.000	6.456024	21.99836
lntariff	1.123672	.4108558	2.73	0.006	.3183725	1.928972
lnsps	-.1789728	.0431157	-4.15	0.000	-.263482	-.0944636
lntbt	.2026716	.0469719	4.31	0.000	.1106041	.294739
lnothntm	.0364642	.0409085	0.89	0.373	-.0437187	.1166471
landlock	-.1738641	.0963734	-1.80	0.071	-.3627612	.015033
_cons	-22.42951	2.057051	-10.90	0.000	-26.46144	-18.39758

term.[10] The average AVE for SPS, TBT, and other NTMs per country for all seafood products are given by $(1 + \text{Avg\#SPS})^{\left(\widehat{\beta_7}/\widehat{\beta_6}\right)} - 1$, $(1 + \text{Avg\#TBT})^{\left(\widehat{\beta_8}/\widehat{\beta_6}\right)} - 1$, and $(1 + \text{Avg\#OTHNTM})^{\left(\widehat{\beta_9}/\widehat{\beta_6}\right)} - 1$. This can be done for different products or for different countries/regions too.

STATA (version 13 or higher) is used to estimate the above equation. OLS in STATA can be done by using the 'regress' command. It takes the following format:

Regress dependent_variable independent_variable1 independent_variable2 . . . [if . . .], [options]

The 'if' statement can be used to limit the estimation sample to a particular set of observations. If it is not specified, the entire set of observations will be used in the estimation. Although there are many options, one of them is of particular interest in a gravity context (Shepherd 2012). This is the 'robust' option which produces standard errors that are robust to heteroscedasticity in the data.[11] Not accounting for this issue might result in incorrect standard errors. The results of the OLS regression are given in Table 9.2.

[10]Please note that this equation is estimated for demonstration only. Do not assume that this is the best equation to be used at all times.

[11]Another common option is *cluster(variable)* which allows for correlation of the error terms within groups defined by *variable*. For example, errors may be correlated by country pair. To do this, it is necessary to specify a clustering variable that separately identifies each country pair independently of the direction of trade (Shepherd 2012). An example would be distance which is unique to each country pair but is identical for both directions of trade. In this example, we will not use this. Please see Shepherd (2012) for more information.

Table 9.3 A test of the hypothesis that both GDPs are equal to unity

```
. test (lngdpi=lngdpj=1)

 ( 1)  lngdpi - lngdpj = 0
 ( 2)  lngdpi = 1

       F(  2, 26082) =  226.76
            Prob > F =    0.0000
```

Several things can be observed here. First, the R^2 is somewhat low at 0.027. This figure will increase if more independent variables are added to the model and, in particular, once panel data techniques are applied (see Sect. 9.3.5). However, the overall model significance is high with a high F-statistic (with a low p-value) which rejects the null hypothesis that all coefficients are jointly zero at the 0.05 level. To interpret the model closer, we need to look at the estimated coefficients and their corresponding t-statistic and the p-value. Looking at the GDP terms, both influence exports positively. But only the GDP in the importing country is statistically significant (a low p-value). According to the results, a 1 per cent increase in importer GDP tends to increase the export of seafood from Sri Lanka by 0.45 per cent, ceteris paribus. In addition, as distance increases, exports decrease. A 1 per cent increase in distance will result in a 0.47 per cent decrease in seafood exports from Sri Lanka to the importing country, ceteris paribus. Likewise, the population of Sri Lanka and the importing country also are statistically significant with expected signs. A 1 per cent increase in population in Sri Lanka and in the importing country will decrease and increase seafood exports by 0.25 per cent and 14 per cent, respectively, ceteris paribus.

How do we interpret the tariffs and the NTMs? Coefficient estimates obtained for tariffs, SPS, and TBT are statistically significant, whereas the coefficient obtained for other NTMs is not statistically significant. According to the results, a 1 per cent increase in tariffs increases exports by 1.12 per cent, ceteris paribus, which is a surprising result. Similarly, a 1 per cent increase in TBTs increases exports from Sri Lanka by 0.20 per cent, ceteris paribus. Both these results do not conform to the gravity intuition as we would expect these to be negative. Nevertheless, we obtain the expected sign for SPS measures. A 1 per cent increase in SPS measures decreases exports by 0.18 per cent, ceteris paribus. Finally, when the importing country is landlocked, seafood exports decrease, but this is not statistically significant. Please note that we considered $\alpha = 0.05$ for the level of significance.

$$lnX_{ijt}^{k} = \beta_0 + \beta_1\, ln\, \mathrm{GDP}_{it} + \beta_2\, ln\, \mathrm{GDP}_{jt} + \beta_3\, ln\, \mathrm{DIS}_{ij} + \beta_4\, ln\, \mathrm{POP}_{it} + \beta_5\, ln\, \mathrm{POP}_{jt} + \beta_6\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) + \beta_7 \mathrm{bnt}_{ijt}^{k} + \beta_8 \mathrm{landlock}_{it} + \varepsilon_{ijt}^{k} \quad (9.9)$$

By interpreting the coefficient t-statistics for the corresponding coefficients, a number of simple and compound hypotheses may be tested. For example, GDP

Table 9.4 A test of the hypothesis that lntariff is equal to unity

```
. lincom lntariff-1

 ( 1)  lntariff = 1
```

lnexport	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
(1)	.1236724	.4108558	0.30	0.763	-.6816275	.9289722

Table 9.5 OLS estimates of Eq. (9.9) using STATA

```
. regress lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff bntm landlock, robust

Linear regression                                Number of obs     =     26,093
                                                 F(8, 26084)       =     116.28
                                                 Prob > F          =     0.0000
                                                 R-squared         =     0.0268
                                                 Root MSE          =     4.0842
```

lnexport	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
lngdpi	.4635908	.0252922	18.33	0.000	.4140168	.5131649
lngdpj	.0767628	.432572	0.18	0.859	-.7711021	.9246277
lndist	-.4766793	.0461087	-10.34	0.000	-.5670549	-.3863038
lnpopi	-.2708954	.0257122	-10.54	0.000	-.3212928	-.2204981
lnpopj	15.29274	3.953658	3.87	0.000	7.543351	23.04212
lntariff	1.157427	.3986554	2.90	0.004	.3760407	1.938814
bntm	-.274645	.0806744	-3.40	0.001	-.4327712	-.1165189
landlock	-.0897253	.0953355	-0.94	0.347	-.2765881	.0971374
_cons	-23.0951	2.041382	-11.31	0.000	-27.09632	-19.09388

coefficients in the goods trade literature are frequently found to be close to one. We can test whether that is also the case for the seafood data from Sri Lanka. In STATA, we use the command ‘test’. The results are shown in Table 9.3.

Here, we reject the null hypothesis that the coefficients of both GDPs are equal to one, since the p-value is less than 0.05. In addition, we can use the command ‘lincom’ in STATA to test for linear combinations of the coefficients. For example, we can test if the coefficient for lntariff is, in fact, equal to one. The results are shown in Table 9.4. Both ‘test’ and ‘lincom’ are post estimation commands in STATA; they can be done only after running the regression.

According to the results in Table 9.4, we fail to reject the null hypothesis that the coefficient for lntariff is equal to one since the p-value is greater than 0.05.

To look at another way of specifying NTMs, we will use a slightly different specification to Eq. (9.8) as given in Eq. (9.9). Here, instead of the types of NTMs, a dummy variable for the total number of NTMs is defined where $bntm = 1$ if NTMs are present and 0 otherwise. The results are given in Table 9.5.

Similar to the results in Table 9.2, we observe a low R^2. However, the overall model significance is high with a high F-statistic which rejects the null hypothesis that all coefficients are jointly zero at the 0.05 level. Looking at the GDP terms, we can see that only GDP in the importing country is statistically significant with a positive coefficient. A 1 per cent increase in importer GDP tends to increase the export of seafood in Sri Lanka by 0.46 per cent, ceteris paribus. As the distance increases, exports decrease. A 1 per cent increase in distance will result in a 0.47 per cent decrease in seafood exports from Sri Lanka to the importing country, ceteris paribus. We can see that the population of Sri Lanka and the importing country also are statistically significant with expected signs. A 1 per cent increase in population in Sri Lanka and the importing country will decrease and increase seafood exports by 0.27 per cent and 15 per cent, respectively, ceteris paribus. Coefficient estimates obtained for tariffs are again positive and statistically significant. According to the results, a 1 per cent increase in tariffs increases exports by 1.16 per cent, ceteris paribus. We obtain the expected sign for the dummy variable for NTMs which is negative and statistically significant. Compared to no NTMs, when there are NTMs imposed, seafood exports decrease by 24 per cent, ceteris paribus ($e^{-0.27} - 1 = -0.24$). Note that similar hypothesis testing can be carried out as in the earlier example.

9.3.4 Gravity Model: Structural

The gravity model depicted in Eqs. (9.2a, 9.2b, 9.2c) is collectively known as the intuitive gravity model (Shepherd 2012). This is due to the fact that there is no underlying economic theory behind it. This model has certain limitations as described by Shepherd (2012). For example, consider the impact on exports (or imports) between countries i and j due to a change in trade costs between countries i and k. Such change might be a result of a preferential trade agreement that lowers tariffs on their respective goods (think of Sri Lanka as country i, Pakistan as country j, and India as country k). Economic theory implies that such a move may impact the trade of country j although it is not part of the agreement.[12] The intuitive model described above doesn't incorporate this issue as it forces $\frac{\partial logX_{ij}}{\partial logT_{ik}} = 0$. So reducing trade costs on one bilateral trade route does not affect trade on other routes in the intuitive model. This is one of the major weaknesses in the intuitive model as it depicts omitted variable bias (Wooldridge 2012).

As mentioned before, the stability and robustness of the gravity equation and its power to explain bilateral trade flow prompted the search for a theoretical explanation. While many authors have made significant strides, one study by Anderson and Van Wincoop (2003) has received serious attention from a viewpoint of applied trade literature. Eqs. (9.10b, 9.10c, and 9.10d) collectively are the final equation. Please note that you can obtain Eq. 9.10b by taking the logarithm of Eq. 9.10a.

[12] Concepts such as trade creation and trade diversion are classical examples for this.

$$X_{ij}^k = \frac{Y_i^k E_j^k}{Y^k}\left\{\frac{T_{ij}^k}{\pi_i^k P_j^k}\right\}^{1-\sigma_k} \tag{9.10a}$$

$$\begin{aligned} log\,X_{ij}^k = &\ log\,Y_i^k + log\,E_j^k - log\,Y^k + (1-\sigma_k) \\ &\times \left[\log T_{ij}^k - \log \pi_i^k - \log P_j^k\right] \end{aligned} \tag{9.10b}$$

$$\pi_i^k = \sum_{j=1}^{C}\left\{\frac{T_{ij}^k}{P_j^k}\right\}^{1-\sigma_k}\frac{E_j^k}{Y^k} \tag{9.10c}$$

$$P_j^k = \sum_{j=1}^{C}\left\{\frac{T_{ij}^k}{\pi_i^k}\right\}^{1-\sigma_k}\frac{Y_i^k}{Y^k} \tag{9.10d}$$

where X is the exports indexed over countries i and j for sector k; Y is GDP; E is an expenditure; $Y^k = \sum_{i=1}^{C} Y_i^k$, i.e. world GDP; σ_k is the intra-sectoral elasticity of substitution; and T_{ij}^k is the trade costs. The unique feature of this model is the inclusion of two additional variables π_i^k and P_j^k. The first is called the outward multilateral resistance and captures the fact that exports from country i to j depend on trade costs across all possible export markets. The second term known as inward multilateral resistance captures the dependence of imports into country i to j on trade costs across all possible suppliers (Shepherd 2012). Together these two terms overcome the limitation described above in the intuitive model. The final term T_{ij}^k is defined as follows in Eq. (9.10e).[13]

$$\begin{aligned} \log T_{ij}^k = &\ \varphi_1 \ln(\text{distance})_{ij} + \varphi_2\, ln\,\text{Tariff}_{ij} + \varphi_3\, ln\,\text{NTM}_{ij} \\ &+ \varphi_4\text{contig} + \varphi_5\text{comlan} + \varphi_6\text{colony} + \varphi_7\text{comcol} \end{aligned} \tag{9.10e}$$

where distance is the geographical length between countries i and j, contig is a dummy variable that equals one for countries which share a common border, comlan is a dummy variable that equals one for country pairs that share a common official language, colony is a dummy variable that equals one if country i and j were once in a colonial relationship, and comcol is a dummy variable that equals one for country pairs which were colonised by the same country. We will not cover the estimation of this structural gravity model in this chapter. For more details on how to estimate, please refer to the excellent description found in Shepherd (2012).

[13]There are many ways of specifying this which would depend on the research context.

9.3.5 Potential Issues and Other Estimation Techniques

It should be apparent by now that the results in Tables 9.2 and 9.5 are not ideal. In both cases, a very low R^2 is observed and some of the coefficients do not have the expected sign. All in all, it appears that OLS is not the most appropriate regression model. A variety of estimation techniques aimed at overcoming many issues associated with the gravity model have been highlighted in a plethora of studies.

One of the main issues not addressed in the intuitive model is that it omits the multilateral trade resistance term from the model. In addition, these are unobserved because they do not correspond to any price indices collected by national statistical agencies. Therefore, a procedure is needed to account for the multilateral resistance without directly including them in the mode as data points. Fixed-effect (FE) estimation provides a way out if you have a panel dataset. Panel data contains observations of multiple phenomena obtained over multiple time periods for the same individuals. In the gravity context, this individual can be a country pair. Using panel data allows the researcher to use a fixed-effect model to control for the time and/or country fixed-effects. The country fixed-effects proxy the unobserved multilateral resistance terms, while country and year fixed-effects control for correlation between omitted and observed variables (Lopez, Philippidis, and Ezcaray 2013). This is known as endogeneity. However, a drawback of the fixed-effects estimation is that it eliminates variables that are collinear with the fixed-effects. This implies that it is not possible to estimate an FE model that includes data that vary by the exporter (constant across all importers) or by the importer (constant across all exporters). If the policy variable under consideration falls under one of these categories, it would be eliminated during FE estimation.

Another potential issue is zero trade flows. One of the main drawbacks of the OLS is that it cannot take into account the information contained in zero trade flows because these are simply dropped out of the sample while taking the logarithm. To address this, one approach suggested by researchers is the use of a Tobit model which accounts for zero trade flows (Yotov et al. 2016). Most of the time, the bilateral trade matrix is filled with zeros. Dropping these observations as in OLS would immediately give rise to concerns about sample selection bias. One way to see this problem is that the probability of being selected for the estimation sample is an omitted variable in the gravity model. One way of dealing with this problem is to use the sample selection model or the Heckman model (Helpman, Melitz, and Rubinstein 2008).

One of the biggest challenges in obtaining reliable estimates of the effects of trade policy within a gravity model is that, for the most part, trade policy variables are endogenous. In other words, it is possible that trade policy may be correlated with unobservable trade costs. A country’s trade policies are often determined based on the extent of trade it does. This creates a circular causal chain between policies and trade, i.e. a situation of reverse causality. The issue of endogeneity can be addressed by using an instrumental variable and a 2-stage least square (2SLS) technique. However, finding an instrumental variable (or an IV variable) that satisfies the conditions for picking a suitable instrument has proven to be challenging.

Another potential issue is the heteroscedasticity of trade data. If the error in Eq. (9.2a) is highly heteroskedastic, which is highly possible in practice, then the expected value of the error term depends on one or more of the independent variables (Shepherd 2012). This type of heteroscedasticity is different from what is explained in Sect. 9.3.3 and cannot be corrected by simply applying a robust standard error. This warrants the adoption of a completely different methodology. The Poisson Pseudo-Maximum Likelihood (PPML) estimator provides consistent estimators for the gravity equation (Santos Silva and Tenreyro 2006). It also effectively handles the presence of zero trade flows, making it a very attractive choice for empirical gravity analysis (Yotov et al. 2016).

Each of these has its own pros and cons. It is the policy analyst's responsibility to understand the data well enough and conduct a thorough literature review before adopting an estimation technique that s/he can justify. For more details on how to estimate these econometric models in STATA, please refer to Baum (2006), Cameron and Trivedi (2009), and Shepherd (2012).

9.3.6 Data and Data Sources

Here is a comprehensive account of the data needed to conduct all the estimations given above, as well as their sources. Ultimately, the quality of the findings depends on the quality of the data. Hence, it is vital to ensure that the data is up to par. For the analysis of the gravity model (intuitive or theoretical), we need:

- Bilateral trade flows
- Bilateral tariff data
- Bilateral non-tariff data
- Bilateral distances
- GDP and population data
- Other sources

Bilateral trade flows can be obtained from the WTO Integrated Data Base provided by World Integrated Trade Solutions (WITS[14]) which allows data to be extracted from the United Nations Commodity Trade Statistics Database (COMTRADE[15]). In addition, trade-map[16] from the International Trade Centre (ITC) is a useful data source. Bilateral tariff data can be obtained from WITS which allows data to be extracted from the databases of the Inter-America Development Bank (IDB[17]) and Trade Analysis Information System (TRAINS[18]) of

[14]https://wits.worldbank.org/

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

[16]https://www.trademap.org/

[17]https://data.iadb.org/

[18]https://databank.worldbank.org/source/unctad-%5E-trade-analysis-information-system-(trains)

UNCTAD. Similarly, bilateral non-tariff data can be obtained from the TRAINS[19] database. If more details are required about NTMs, they can be found on the WTO Integrated Trade Intelligence Portal (i-TIP[20]). Bilateral distances, along with information on common border, language, common coloniser, and other related variables can be obtained from the Centre for Prospective Studies and International Information (CEPII[21]). GDP and population data can be obtained from the World Bank's World Development Indicators (WDI[22]). After collecting the data, ensure that the data is in the same unit of measure. In addition, log-transformation is required, and along with that, you may want to think of approaches to overcome the zero problems which are prevalent in bilateral trade data.

9.3.7 Policy Experiments

It is important to conceptually understand how the policy works in order to carry out experiments. One of the justifications of using policy experiments is we sometimes do not observe the counterfactual, i.e. there might not be a case where such a policy exists/not exists. In this case, either the policy should be simulated or some experiments must be performed. Before we do this, it is important to understand how NTMs are measured. In the example above, we used the number of NTMs and simply added one to overcome the issue of taking the logarithm of a zero. Another approach was to define it as a binary variable. However, in this, we lose information on the types as well as the number. In addition, there are other ways of quantifying NTMs. Examples include Coverage Ratio, Frequency Index (FI), Prevalence Score (PI), Regulatory Intensity (RI), and Regulatory Distance (RD) (De Melo and Nicita 2018).

9.4 Conclusion

Trade facilitation has been brought into the limelight as a means of combating the negative implications of trade costs. It is widely accepted that NTMs play a pivotal role in influencing trade costs. Hence, analysis of the impacts of NTMs on trade is important for future policy considerations for better trade facilitation. NTMs are increasingly used in global trade; understanding them in a universally accepted classification is important to avoid ambiguity. In addition, it is important to understand the ways by which NTMs can be quantified which have important implications for policy experiments.

[19] https://trains.unctad.org/

[20] https://www.wto.org/english/res_e/statis_e/itip_e.htm

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

[22] https://databank.worldbank.org/source/world-development-indicators

Gravity modelling is quite a useful tool in the context of international trade especially when the user is trying to estimate the factors influencing trade. Various versions of the gravity model have been used widely in applied international trade literature for a long time. Gravity literature has undergone a series of major changes in the last 15 years or so (Shepherd 2012). Therefore, research that does not use the latest models and techniques does not represent a sound basis for drawing policy conclusions. This chapter starts with the simplest of econometric models (OLS) and then goes on to talk about other econometric tools available to counter many issues often associated with trade-related data. The readers should note that this chapter provides an introduction, not provide a comprehensive list of tools used in gravity estimation.

In the context of evidence-based policy-making, it is crucial for researchers to focus on gravity modelling on questions where it has a comparative advantage. In particular, the gravity model describes the behaviour of trade flows, but not economic welfare. For applications that focus on economic welfare, it would be more appropriate to use other methodologies, such as computable general equilibrium modelling (Shepherd 2012). It is the reader's responsibility to look into all aspects and avoid falling into the pitfalls of estimating a gravity model. If such pitfalls are avoided, the gravity model can be a very useful tool for trade policy analysis.

9.5 Assignment[23]

We shall continue with the Sandaruwan et al. (2020) dataset and the OLS estimations given in Tables 9.2 and 9.5. The necessary data and do-files are included for you to proceed with this assignment. Although we discussed the results, we did not calculate the AVE of NTMs from the results in Tables 9.2 and 9.5.

1. First, let's consider Eq. 9.8 which yielded Table 9.2. Average AVE for SPS, TBT, and other NTMs for Sri Lanka for all seafood products are given by $(1 + Avg\#SPS)^{\left(\widehat{\beta_7}/\widehat{\beta_6}\right)} - 1$, $(1 + Avg\#TBT)^{\left(\widehat{\beta_8}/\widehat{\beta_6}\right)} - 1$, and $(1 + Avg\#OTHNTM)^{\left(\widehat{\beta_9}/\widehat{\beta_6}\right)} - 1$. If the average number of SPS and TBT is 13.32 and 6.19, respectively, calculate the average AVE for SPS, and TBT using the above formulas (we will not do this for other NTMs as the coefficient for other NTMs is not statistically significant).
2. Let's consider Eq. 9.9 which yielded Table 9.5. Here a binary variable is specified to indicate whether NTMs are present or not. The AVE is now given by $AVE_{NTM} = \exp\left(\widehat{\beta_7}/\widehat{\beta_6}\right) - 1$. Using this formula, calculate the AVE for NTMs.

[23]This take-home assignment is designed for demonstration purposes only. Do not assume that the methods outlined here are the most appropriate. It would depend on your research question and the nature of your data among many other things.

3. OLS estimation of Eqs. 9.8 and 9.9 doesn't include the multilateral trade resistance term. As explained in Sect. 9.3.5, this may give rise to endogeneity. As a remedy, the FE model can be used where we include year and/or country-specific fixed-effects. In order to do this, first, you have to tell STATA that this is a panel dataset. For that, we use 'xtset' and specify both *year* and *bilateralid* variables (*xtset bilateralid year*). Here we are specifically including country fixed-effects and not year fixed-effects[24]. Now use the 'xtreg' command to estimate FE models for Eqs. 9.8 and 9.9 [25]. Interpret the results in both cases. Are the results different from the OLS results? Also comment on the signs obtained for SPS and TBT. Also, comment on why the variable landlock is omitted from the results.
4. As explained in Sect. 9.3.5, a PPML estimation counters the heteroscedasticity and zero trade value problem. Let's try to estimate a PPML for the following equation[26].

$$X_{ijt}^{k} = \beta_0 + \beta_1\, ln\,\mathrm{GDP}_{it} + \beta_2\, ln\,\mathrm{GDP}_{jt} + \beta_3\, ln\,\mathrm{DIS}_{ij} + \beta_4\, ln\left(1 + \mathrm{Tariff}_{ijt}^{k}\right) + \beta_5\, ln\,(1 + \mathrm{SPS})_{ijt}^{k} + \beta_6\, ln\,(1 + \mathrm{TBT})_{ijt}^{k} + \beta_7 \ln\,(1 + \mathrm{OTHNTM})_{ijt}^{k} + \varepsilon_{ijt}^{k}$$

   (a) First, you will have to install the PPML package in STATA. For that, use 'ssc install ppml'. You may need connectivity to install the PPML package on STATA. Once this is done, use the following line of code.
   (b) 'ppml export lngdpi lngdpj lndist lntariff lnsps lntbt lnothntm'
   (c) Interpret the results. Can you try to calculate the average AVE for SPS, TBT, and other NTMs? (Average number of SPS, TBT, and other NTMs are 13.32, 6.19, and 2.14, respectively. Average AVE for SPS, TBT, and other NTMs for Sri Lanka for all seafood products are given by $(1 + Avg\#SPS)^{\left(\widehat{\beta_5}/\widehat{\beta_4}\right)} - 1$, $(1 + Avg\#TBT)^{\left(\widehat{\beta_6}/\widehat{\beta_4}\right)} - 1$, and $(1 + Avg\#OTHNTM)^{\left(\widehat{\beta_7}/\widehat{\beta_4}\right)} - 1$.)
5. Now try estimating a PPML for the following equation where NTMs are specified as a dummy variable.

[24] For more details on how to set up a panel dataset using *xtset*, refer to STATA documentation available at https://www.stata.com/manuals13/xtxtset.pdf.

[25] You can use the following codes for this purpose.

xtreg lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff lnsps lntbt lnothntm landlock, fe vce (robust)

xtreg lnexport lngdpi lngdpj lndist lnpopi lnpopj lntariff bntm landlock, fe vce(robust)

[26] PPML is applied on the levels of exports, i.e. the dependent variable is exports, not log(exports). However, the explanatory variables can still remain in the log form.

$$X_{ijt}^{k} = \beta_0 + \beta_1 \, ln \, \mathrm{GDP}_{it} + \beta_2 \, ln \, \mathrm{GDP}_{jt} + \beta_3 \, ln \, \mathrm{DIS}_{ij} + \beta_4 \, ln \left(1 + \mathrm{Tariff}_{ijt}^{k}\right) + \beta_5 \mathrm{bnt}_{ijt}^{k} + \varepsilon_{ijt}^{k}$$

(a) You can use the following code 'ppml export lngdpi lngdpj lndist lntariff bntm'. Interpret the results and calculate the AVE for bntm using $exp\left(\widehat{\beta}_5/\widehat{\beta}_4\right) - 1$.

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