Quantifying the Mega-regional Trade Agreements: A Review of the Models

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Abstract: Major developments in trade policy are currently taking place in the mega-regional trade agreements, in particular in the Trans-Pacific Partnership, the Trans-Atlantic Trade and Investment Partnership, and the Trade in Services Agreement. These agreements are setting new standards and breaking new ground in setting the rules for global commerce. In addition, a large number of other agreements are incorporating state-of-the-art provisions governing at least some aspects of trade and investment. These include the Regional Comprehensive Economic Partnership, the Tripartite Free Trade Agreement, and a large number of bilateral trade and investment agreements. Complementing and internalizing the recent WTO Trade Facilitation Agreement, these agreements are introducing new WTO-plus rules for services and investment, addressing emerging issues, such as electronic commerce and the role of state-owned enterprises, and introducing whole new subject areas to agreements. There is deep interest in understanding the impact of these new developments, both on the part of policy makers in countries that are party to the negotiations and in countries that are excluded, but which will nonetheless be affected by the new standards and rules. Traditional quantitative trade models are being adapted to provide comprehensive answers. This paper reviews these models and considers the extent to which they capture the full effects of the new age agreements. We find that the most comprehensive approach to modelling the mega-regionals is to employ a Computable General Equilibrium model of the type used for multi-sector, multi-region trade analysis. These are the only models with sufficient structural features to capture the main focus areas of the mega-regionals, namely services, investment, and the new "behind the border" issues, while still covering the traditional areas of liberalization, such as tariffs and at least some features of agricultural trade. However, given the wide range of CGE models with different features, inevitably the impact of mega-regionals is probably best captured by meta-analysis of a suite of CGE-based studies, drawing on satellite models for additional structural detail and on sufficient statistics estimates as reality checks.

Keywords: mega-regional trade agreements, services, investment, standards, CGE models

JEL Codes: C68, F14, F17

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Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics
AES	Alternative Expenditure Systems
AGE	Applied General Equilibrium
AGLINK-COSIMO	Agricultural Linkages – Commodity Simulation Model
AGMEMOD	Agricultural Member States Modelling
AIDS	Almost Ideal Demand System
APSIM	Agricultural Production Systems Simulator
ATSC	Advanced Television Systems Committee
Ausregion	Australian Regional model
CAPRI	Common Agricultural Policy Regionalized Impact
CAPSIM	Common Agricultural Policy simulation
CDES	Constant Difference of Elasticities of Substitution
CEPII	Centre d'Études Prospectives et d'Informations Internationales
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CIF	Cost, Insurance, and Freight
DVB-T	Digital Video Broadcasting Terrestrial
ECB	European Central Bank
ECOWAS	Economic Community of West African States
EFTA	European Free Trade Association
EPA	Economic Partnership Agreement
ESIM	European Simulation Model
EU	European Union
FAPRI	Food and Agricultural Policy Research Institute
FDI	Foreign Direct Investment
FOB	Freight on Board
GHG	Greenhouse Gas
GI	Geographical Indication
GLOBE	Global Economic Model (No official acronym available)
GMO	Genetically Modified Organism
GSIM	Global Simulation Model
GTAP	Global Trade Analysis Project
GTEM	Global Trade and Environment Model
HS	Harmonized System
IFPRI	International Food Policy Research Institute
IFRS	International Financial Reporting Standards

iMAP	The integrated Modelling Platform for Agro-economic Commodity and Policy Analysis
IMPACT	International Model for Policy Analysis of Agricultural Commodities and Trade
IO	Input-Output
LES	Linear Expenditure System
MFN	Most-Favoured Nation
MIRAGE	Modeling International Relationships in Applied General Equilibrium
MRIO	Multi-Region Input-Output
NAFTA	North American Free Trade Agreement
NTB	Non-tariff Barrier
OECD	Organisation of Economic Co-operation and Development
PE	Partial Equilibrium
PMR	Product Market Regulation
R&D	Research and Development
RCEP	Regional Comprehensive Economic Partnership
ROO	Rules of Origin
S-Doc	Supplier Declaration of Conformity
SAM	Social Accounting Matrix
SPS	Sanitary and Phytosanitary
STRI	Services Trade Restrictiveness Index
TBT	Technical Barriers to Trade
TFA	Trade Facilitation Agreement
TFTA	Tripartite Free Trade Agreement
TISA	Trade in Services Agreement
TPP	Trans-Pacific Partnership
TRIST	Tariff Reform Impact Simulation Tool
TRQs	Tariff-Rate Quotas
TTIP	Trans-Atlantic Trade and Investment Partnership
UAE	United Arab Emirates
UK	United Kingdom
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
USDA	United States Department of Agriculture
US GAAP	US Generally Accepted Accounting Principles
WEEE	Waste Electric and Electronic Equipment
WITS	World Integrated Trade Solution

1. Introduction

Major developments in trade policy are currently taking place in the mega-regional trade negotiations, in particular in respect of the Trans-Pacific Partnership (TPP), the Trans-Atlantic Trade and Investment Partnership (TTIP), and the 24-party Trade in Services Agreement (TISA). These agreements promise to introduce new standards and break new ground in setting the rules for global commerce. In addition, a large number of other agreements under negotiation are also mandated to incorporate state-of-the-art provisions governing at least some aspects of trade and investment. These include negotiations towards the Regional Comprehensive Economic Partnership (RCEP), which involves 16 Asia and Pacific economies; the Tripartite Free Trade Agreement (TFTA), which involves 23 African economies; and a large number of bilateral trade and investment agreements, including importantly the US-China Investment Agreement. Complementing and internalizing the recent WTO Trade Facilitation Agreement (TFA), which updated trade rules for goods trade. These agreements are introducing new WTO-plus rules for services and investment, addressing emerging issues, such as electronic commerce and the role of state-owned enterprises, and introducing new areas, such as express delivery, environmental, and energy services. There is deep interest in understanding the impact of these new developments, both on the part of policy makers in countries that are party to the negotiations and in countries that are excluded, but which will be nonetheless affected by the new standards and rules adopted by their trading partners and competitors.

This paper reviews the models that are being used for this purpose and considers the extent to which they capture the full effects of the new age agreements, with a view to identifying a framework suitable for analysis of the impact of the mega-regional trade agreements on such developing countries as India, among others.

To preview our main results, the most comprehensive approach to modelling the mega-regionals is to employ a Computable General Equilibrium (CGE) model of the type used for multi-sector, multi-region trade analysis. These are the only models with sufficient structural features to capture the main focus areas of the mega-regionals, namely services, investment, and the new "behind the border" issues, while still covering the traditional areas of liberalization, such as tariffs and at least some features of agricultural trade. However, while many CGE models have been developed with varying features, a truly comprehensive approach remains to be developed:

— While goods trade and cross-border services trade are captured by all major CGE models, few model foreign direct investment (FDI), which is a major area of focus, and fewer still model Mode 3 sales or Mode 4 movement of labour.
— All major CGE models capture the role of intermediate goods, but none effectively captures the effect of tariffs and non-tariff barriers (NTBs) on value chains (or even traditional protectionist measures, such as tariff escalation, which change the composition of trade between raw and processed goods in a discontinuous way).
— Rules of origin (ROOs) effects, including the costs of utilizing preferences, are now routinely incorporated in CGE modelling studies, but the translation of specific formulations of these rules into quantifiable impacts on trade is still largely a matter of "guesstimation". The effect on tradability of inputs due to ROOs regionalization escapes workable treatment.

- To reflect modern trade theory and to capture the effect of competition chapters, a rapidly growing number of models introduce firm-level heterogeneity and introduce ways to capture the pro-competitive effect of firm entry into trade. However, capturing the role of quality in affecting substitutability of imports across alternative sources is at an early stage of development.
- Only a subset of major CGE models is capable of representing both rent-creating and cost-creating NTBs. Equally – if not more – important is to improve estimates of the degree of liberalization in services and investment and of the parameters that translate measures of liberalization in these areas into quantifiable impacts of trade and investment. This is an area of ongoing development and is far from a settled art. The impact of such measures as investor-state dispute settlement and other uncertainty-reducing elements of trade agreements, such as binding dispute settlement, has yet to be made tractable.
- Many chapters appear to be beyond the reach of current modelling capabilities, in some cases, because of a lack of data; this is particularly the case with government procurement commitments, intellectual property chapters (which focus heavily on pharmaceuticals, media content, and geographical indications in agricultural products, which are insufficiently well-represented in the Global Trade Analysis Project, GTAP, database), e-commerce, and labour and environmental chapters.

Mega regionals can be modelled, but only incompletely and with considerable areas left open for qualitative assessment. Much depends on the ability of modellers to quantify the commitments in trade agreements in terms of costs or prices of trade goods and their impact on investment flows; this must be done externally to the models and introduced as policy shocks. Accordingly, a variety of other empirical techniques must be used in conjunction with CGE modelling. In addition, reduced-form CGE models based on essential statistics provide summary estimates of the welfare effects of trade agreements; gravity models provide a check on the impact of agreements on bilateral trade flows; and a range of satellite models can be used to capture environmental impacts, migration, poverty effects, innovation, the complexity of agricultural managed trade systems, and others. Given the wide range of CGE models with different features, inevitably the impact of mega-regionals is probably best captured by meta-analysis of a suite of CGE-based studies, drawing on satellite models for additional structural detail and on sufficient statistics estimates as reality checks.

The paper is organized as follows. The next section reviews the workhorse CGE model and considers the various extensions of the mainstream models that can be used to address new issues. Section 3 considers the scope to use complementary special purpose models in conjunction with CGE models to explore the impacts in such areas as agriculture, where structurally rich agricultural models provide deeper insights than can be derived from the existing CGE models. Section 4 discusses the use of statistical techniques, including gravity models, to inform the choice of model parameters and of partial equilibrium models to help unpack the more aggregate CGE results. Section 5 draws conclusions.

2. CGE Models

In this section, we first briefly review the basic features of CGE models that serve to differentiate the various versions that are presently in use. Then, we outline the challenges in quantifying the mega-regional trade agreements, based on available information as to their likely content. Finally, we consider the roster of available models and identify their comparative merits in terms of being able to address the full range of quantification challenges raised by the mega-regionals.

2.1 Overview

Modern comprehensive trade agreements cover goods, services, and investment and establish obligations and disciplines in a wide range of subject areas. The ex-ante analysis of such agreements is conventionally and necessarily conducted using some form of a multi-sector, multi-region CGE model. This reflects various needs:

- The need to take into account the simultaneous impact of such agreements on a wide range of sectors that interact with each other through domestic and international supply linkages;
- The need to represent economic structures that are affected by policies and to reflect behavioural responses of agents to changes in policies;
- The need to incorporate various reflect resource constraints facing the economy; and
- The need for an accounting framework to generate summary measures of economic welfare and activity.

Multi-sector, multi-region CGE models uniquely combine the basic minimum features to carry out such a task.[1]

At the core of CGE models is a set of **Social Accounting Matrices** (SAMs), one for each country/region represented. A SAM sets out the linkages between a supply and use table and institutional sector accounts (i.e., accounts for firms, households, and governments). This allows the tracing of the circular flow of income within an economy. Production generates incomes, which are allocated to the institutional sectors; incomes are either spent on goods and services or saved; expenditures by institutional sectors constitute demand for domestic production and imports (this demand includes final demand from consumers and demand for intermediate goods from firms); savings, meanwhile, support investment. Trade accounts link the national/regional SAMs.

[1] The history of empirical trade models goes back to Wassily Leontief's pioneering work in the 1950s and earlier with input-output models to determine the factor content of US trade. Various economy-wide mathematical programming models were developed in the 1960s and theoretically-based applied general equilibrium (AGE) models in the 1970s. Large-scale time-series-based econometric models were also used in the 1970s and 1980s for trade policy analysis. However, the interest in structural change drove activity into the CGE field. CGE modelling was well established by the 1990s and is now de rigueur. See Dixon (2006) for a concise history of the evolution.

CGE models build on the SAMs by introducing **behavioural equations** that determine how households respond to changes in relative prices of goods and services and to changes in incomes, how firms respond to changes in product prices and factor costs, and how labour supply and investment respond to changes in wages and rates of return on capital. The models also incorporate various accounting identities that "close" the model by ensuring that, in aggregate, incomes equal expenditures, the balance of payments balance, and so forth. The models represent the world economy in an initial state in which all markets are assumed to clear – i.e., the world is in an initial state of general equilibrium. A policy shock is introduced, which changes the set of prices. With the new prices, there are excess demands in some markets and insufficient demands in others; the model's task is to identify a new set of prices and quantities that clear all markets.

More specifically, CGE models feature the following:

- Trade accounts by sector and region, including trade flows and protection data, covering both goods and services trade;
- Production functions by sector drawing on factor supplies (labour, capital, technology, and land);
- Input-output (IO) tables that map the internal linkages between sectors within an economy and take into account internationally-sourced intermediate goods and services; and
- National accounts (consumption, investment, and government spending) to aggregate the transactions of firms, households, and governments and to summarize trade impacts on standard measures of economic performance.

The massive **data requirements** of CGE models have been met through an international collaborative effort centred on the GTAP at Purdue University (see Hertel, 1997). While there are many CGE models, for all practical purposes, the GTAP data set constitutes the basis for data sets used for analysis of international trade agreements. By the same token, analysis is generally constrained to working within the **GTAP's 57-sector classification** for goods and services. This classification system was developed originally in an agricultural college program and, thus, features considerably more detail on agricultural sectors and less on industrial sectors than is desirable for analysis of the mega-regionals – for example, raw milk is separate from dairy, but pharmaceuticals, which is an interesting sector from an intellectual property and investment perspective, is lumped into one GTAP sector, along with nine other chapters of the harmonized system (HS) covering organic and non-organic chemicals.

The GTAP data set is regularly updated. The currently publicly available version is the 8^{th} edition (see Narayanan, Aguiar, and McDougall, 2012); version 9.0, which will feature several **reference years**, the latest of which is 2011, is available in beta form to developers, with public release scheduled for May, 2015. New versions of the dataset include updates of the base year (e.g., v 9.0 updates from 2007), additions of new countries (e.g., the Africa II database), and updates of the IO tables at the heart of the national SAMs. The regional IO tables are an eclectic mix in terms of the year represented and the level of disaggregation of flows – only 36 of the 134 country/regions in the v 8.0 dataset feature a full 57-sector IO table. There is, accordingly, a non-trivial degree of data development and fitting required to assemble the full dataset.

SAMs are expandable and various **satellite accounts** have been developed for particular purposes: the A version of GTAP (see Mirza, Narayanan and van Leeuwen, 2014) expands labour into five classifications, GTAP-E adds greenhouse gas (GHG) coefficients, GTAP-AEZ adds agro-ecological zones, GMig2 includes bilateral labour migration data and remittances, GTAP-POV adds data to evaluate poverty impacts, and GTAP-FDI includes FDI flows. However, these various datasets typically cannot be easily combined given sectoral and regional coverage limitations.

CGE models distinguish themselves by their **theoretical frameworks**. Differences across models reflect differences in the theory that underpins the behavioural equations, the extent to which linkages within the economy are explained, and the extensions/elaborations of the data set that they introduce. Four basic distinctions involve static versus dynamic, perfect versus imperfect competition, incorporation of FDI, and incorporation of heterogeneous firm characteristics.

Within the **dynamic** group, there is a further sub-division into inter-temporal dynamic models and recursive dynamic models.[2] In the former, consumers and firms solve an inter-temporal maximization problem; in the latter, the model solves a sequence of static equilibria in which the "end of period" capital stock in one year is the "beginning of period" capital stock in the next year. Recursive dynamic CGE models thus do not involve inter-temporal maximization of consumer utility or firm profits; behaviour is implicitly based on backward-looking adaptive expectations rather than forward-looking rational expectations.

CGE models can incorporate alternative **market structures**. Imperfect competition can be captured by introducing price mark-ups that represent monopolistic pure profits in equilibrium. Generally, such treatment is reserved for manufacturing sectors, which feature differentiated products, while perfect competition assumptions are used for the primary sectors. An important feature of the perfect competition assumption for tariff simulations is that tariff cuts are fully passed through to consumers. An important feature of the imperfect competition assumption is that price mark-ups are reduced by intensified competition attributed to the policy shock. The reduction of price mark-ups generates additional welfare gains; the use of this market structure does, however, raise additional issues about calibrating the impact of a policy shock on competition and mark-ups (see Roson, 2006 for a review).

An increasingly important feature of CGE model development has been the **incorporation of FDI**. This is essential for modelling the effects of investment chapters in modern trade agreements and for capturing the effects of services sector liberalization, given the importance of Mode 3 (commercial presence) trade in the services sector.

Finally, CGE modelling is starting to catch up with the theoretical and empirical revolution that has been going on in international trade economics since the establishment of the **heterogeneous firm model** as the industry standard (Melitz, 2003; and Bernard et al., 2003). Where the standard CGE models have a "representative firm" that stands for an industry sector and, thus, features industry average characteristics, heterogeneous firms theory and empirics demonstrate that industries are populated by firms that vary widely in size, productivity and many other characteristics. Moreover, the theory recognizes that firms face fixed costs of entry into export markets. Several recent models have been developed introducing elements of

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[2] Quasi-dynamic effects can also be achieved in a single-period static model by invoking closure rules that allow for labour supply and the capital stock to adjust to wages and rates of return, generating "endowment effects". See Harrison, Tarr, and Rutherford (1995) for an early application of this technique in the context of modelling the Uruguay Round. See Ciuriak and Chen (2008) for an application in an analysis of the Canada-Korea free trade agreement (FTA).

heterogeneous firms theory into CGE models.[3] However, while this is clearly the path of the future, lack of well-developed databases to calibrate the distribution of firm-level characteristics limits the value added of these models for studying the current generation of mega-regional trade agreements.

Other key features of the models are the technical specification of production and consumption functions and the key parameters that govern behaviour. These include the following:

- The Armington assumption of **imperfect substitutability of goods by origin** and the elasticities of substitution that determine the degree of substitutability between imports and domestic products, as well as between imports from different sources for different product groups.
- The production function and the assumptions about **returns to scale** (constant versus increasing); **substitutability of factor inputs** – i.e., constant elasticity of substitution (CES) specification for substitution between labour, capital, and land and the Leontief fixed proportions assumption for substitution between the primary factors and intermediate inputs; and technology.
- The modelling of **consumer demand**: different functional forms have different implications for the response of households to price changes. A basic distinction is between homothetic preferences (which do not change with increasing income) and non-homothetic preferences (which change with increasing income).[4] Aggregation issues raise additional challenges: the consumption good in each sector is constructed as a CES aggregate of domestic and imported varieties, where the imported bundle is determined in a prior step ("nest") as a CES aggregate of imports from different regions. The choice of demand system has very significant implications for the **measurement of consumer welfare** in terms of compensating variation or equivalent variation (de Boer, 2009).[5]
- Trade costs/transportation margins are usually included as "iceberg" costs (i.e., some portion of the product that is shipped "melts" en route and a small amount arrives, as per Samuelson, 1954).[6]

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[3] These include Zhai (2008); Dixon, Jerie, and Rimmer (2013); Balistreri and Rutherford (2013); Oyamada (2013); and Itakura and Oyamada (2013). See Roson and Oyamada (2014) for a review of this emerging field.

[4] Homothetic preferences emerge under various versions of linear expenditure systems (LES) that are sometimes used to model demand. Non-homothetic preferences emerge under alternative expenditure systems (AES), such as the commonly-used constant difference of elasticities of substitution (CDES) specification, introduced by Hanoch (1975), and others, such as the almost ideal demand system (AIDS).

[5] Equivalent variation is the lump sum payment to households that would leave them as well off without the policy change that is being modelled as with the policy change, measured at pre-policy shock prices. Compensating variation is the lump sum payment at post-policy-shock prices. Equivalent variation is the measure of consumer welfare most commonly reported in CGE-based studies.

[6] There are also significant data issues in the transportation margins built into CGE models. The raw data for this margin calculation is the difference between the "freight on board" (FOB) valuation of goods as they exit the exporting country and the "cost, insurance, and freight" (CIF) valuation as the goods land in the importing country. There is a litany of problems in using these data to infer transport costs. Customs clearance costs in the exporting country are included in both FOB and CIF valuations, but customs clearance costs in the importing country are not included in either. The product may leave the exporting country in one time period (month, quarter, or year) and enter the importing country in the next time period. Complicating matters still further is product aggregation: GTAP aggregates combine goods that are traded over long distances and others that are only traded locally, because of high weight-to-value ratios. This muddies the expected relationship that transport costs are higher for more distant destinations – they are, but the nature of the product that goes to more distant destinations is different than that which goes to nearby markets. Goods may travel by air, truck, rail, or ship; unit costs and time differ sharply. Other factors can complicate matters. The documentation

2.2 Quantification Challenges Posed by the Mega-regionals

a) Tariff Reduction/Elimination

The GTAP database provides base year tariff equivalents based on the MacMap database (Guimbard et al., 2012). The level of protection reflects the combination of ad-valorem tariffs, ad valorem equivalent of specific tariffs, and tariff quotas at the bilateral level. Preferential agreements are taken into account. The protection data is built up from the 5,113 products of the HS6 classification, weighted using a reference group of countries, which addresses the endogeneity bias (high tariffs reduce trade flows, which reduces the weight assigned to the tariffs in an aggregation scheme).

However, there remains a significant quantification challenge in developing realistic shocks for agricultural products that feature very high tariffs on key traded products, typically as a result of prohibitively high out-of-quota tariffs, and those that feature policies, such as producer price supports, that compromise the ability of tariff cuts feeding through to prices to affect domestic production and consumption. While these data challenges exist in the framework, there are several ways to address them, as discussed below.

In order to explicitly model tariff-rate quotas (TRQs) with GTAP, extra data are required and extra equations must be added to the model (Elbehri and Pearson, 2005). For practical applications, one would have to collect data on specific sectors' TRQs to employ these models.

Policies such as producer price supports are captured well in the GTAP framework – both model and database, with no need to compromise the ability of tariff cuts feeding through to prices to affect domestic production and consumption.

A sometimes-problematic feature of the GTAP system is that the protection levels for GTAP aggregates reflect base-year trade weights calibrated to the base year (Bouët et al., 2004). Since product composition within GTAP sectors can change significantly over time, the protection data can be badly out of date for particular applications. One good example occurred with the BSE-related ban on Canadian beef exports to Korea; this resulted in the high tariff on chilled and frozen beef exports being given a zero weight in the GTAP v8 database 2007 base year. When Korea eventually withdrew the ban, beef exports resumed. The GTAP base year tariff facing Canada of about 2% was no longer valid as the product group now faced a tariff of 40% on the major traded item. The solution in such cases involves pre-simulating the data set by increasing the tariff and introducing a subsequent shock to the bilateral trade flow to generate representative levels of trade and protection for use in the policy simulation. See Ciuriak and Xiao (2014a) for a discussion.

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accompanying a product may list a country of transshipment as the destination, whereas the importing country will look through to the origin of the goods. Institutional features of trade raise similar issues as transshipment: African tea flows to the world through the Mombasa tea auction, which means that Kenya is listed as the export destination for tea exports in many African states, but Kenya does not actually import tea – it is a supplier; similarly, gold flows to world markets through the London Gold Exchange. These features make comparison of bilateral statistics highly problematic in ascertaining the transportation margin and create a challenge for database construction. See Gehlhar (1995) for a discussion of the issues faced in developing transportation margins used in CGE models. Many of these issues have been addressed in Gehlhar, Wang, and Yao (2008), which employs US bilateral commodity trade data to improve the GTAP data on transportation costs, split into three modes: air, water, and other.

Another potential problem is that the protection data may not capture the effects of tariff escalation or a related problem of tariffs expressed in terms of taxes on gross value rather than value added. For some products, the value added in the processing stage is relatively small; this is the case, for example, in crude vegetable oil produced by crushing canola oilseeds. In such cases, a tariff roughly equal to the value added from processing can result in a mode switch of exports from processed to crude. Japan, for example, applies a zero most-favoured nation (MFN) tariff to canola oilseeds, but applies a specific tariff of 10.90 yen/kg on crude canola oil (HS 151411) and 13.20 yen/kg on refined canola oil (HS 151419).[7] At typical landed values for canola oil, this represents an ad valorem equivalent of about 10-12% for crude and refined canola oil, respectively. On the face of it, this constitutes only a moderate level of protection. However, these specific tariffs are calibrated to be equivalent to the margin obtained in crushing the oil seed to produce vegetable oil and the additional margin to refine it. As a consequence, Canada, which is the world's leading exporter of canola seeds and is also a major exporter of canola oil, shipped about 99% of its canola products to Japan in 2014 in the form of oilseeds (US$1.18 billion worth of canola seed compared to US$8.2 million worth of crude and refined canola oil). In a simulation that fails to take account of the possibility of mode switching, the elimination of an ad valorem equivalent (AVE) of 10-12% would imply, at most, a doubling of canola oil imports by Japan from Canada; however, by removing tariff escalation, the composition of Canada's exports to Japan would change – if the new composition reflected the mix in Canada's worldwide exports of oilseed and oil, Japan's imports of canola oil would rise to the US$380 million level, while canola oilseed imports would fall by a commensurate amount. Without explicitly intervening in the model, the simulation results would show only a very modest increase in GTAP sector 21 "Vegetable oils and fats" and no change in GTAP sector 5 "oilseeds". From a policy perspective, this is a major issue that impacts heavily on the crushing industry in Japan and constitutes a major Canadian negotiating objective in its free trade talks with Japan. To handle this issue in a CGE-based analysis, an external model of the oilseed complex that captures mode switching would be required to generate the structural shift, which would then be imposed on the CGE model.

An emerging issue for CGE modelling is capturing the effect of quality. The simple Armington assumption implies that that electronic goods from China compete directly with US products on the same basis as electronic goods sourced from the European Union (EU). Yet it is well known that EU products have much higher price points than Chinese products in general and compete in different market segments. Some models build a quality dimension into their toolkit (e.g., Decreux and Valin, 2007 in the CEPII MIRAGE model).

b) Goods NTBs

The mega-regionals incorporate various chapters/provisions that address NTBs affecting goods trade. These include the following: customs cooperation, trade facilitation, technical barriers to trade (TBT), sanitary and phytosanitary (SPS) measures, standards, specific product measures (including provisions for mutual recognition of standards), and related areas, such as security measures in the aviation and transportation industries. TTIP is particularly focused on goods NTBs.

The most detailed study of goods NTBs in the context of the mega-regionals was conducted by ECORYS (Berden et al., 2009), which examined the economic potential, competitive effects, and global regulatory

[7] Government of Japan, Ministry of Finance (2012).

implications of a better alignment of regulations in trans-Atlantic trade. This study developed assessments of "do-able" regulatory harmonization for a range of goods (and services) sectors based on literature reviews, business surveys, econometric analyses, consultations with regulators and businesses, and sector expert opinions, cross-checked against existing databases, such as the Organisation of Economic Co-operation and Development (OECD) FDI restrictiveness indicators and Product Market Regulation (PMR) indices. Goods sectors covered include aerospace; automotive; chemicals; cosmetics; electronics; food and beverages; office, information, and communication equipment; iron, steel, and metal products; machinery; medical, measuring, and testing appliances; pharmaceuticals; textiles, clothing, and footwear; and wood, paper, wood products, and paper products.

Importantly, Berden et al. (2009) differentiate between cost-inducing NTBs and rent-creating NTBs. They emphasize regulatory convergence, which has been an ongoing OECD exercise for years. The discussion in this area emphasizes that alignment of US and EU regulations would establish de facto global regulatory standards, which would impact primarily on other countries engaged in the same activities; for example, EU-US alignment on aerospace would impact primarily on countries producing parts and components, including Japan, Brazil, Canada, China, and Russia. In other areas, the impact would fall on different third parties. The range of measures identified is very wide (see Table 1) and many reflect quite fundamental differences in societal preferences. Moreover, many of these are addressed mainly in specialized international organizations.

Table 1: Goods Sector NTBs in EU-US Trade Arising from Regulatory Non-alignment

Goods Sector	Barriers due to divergence in NTBs
Aerospace	Safety and functional standards, public procurement, government support for R&D, and differences in patent systems
Automotive	Safety and environmental standards, public procurement, technological R&D support, and security measures
Cosmetics	Regulation of nanotechnology applications, animal testing of cosmetic products and their ingredients; definition of "cosmetics" in terms of the level of regulation that applies, level of testing to be performed, ingredients permitted, consumer labelling, and performance standards
Chemicals	Regulation, evaluation and authorisation of chemicals, classification and labelling of chemical products, notification procedures of new substances, marketing and application of chemicals, customs regulations, and legislation pertaining to trans-boundary movement of hazardous chemicals and pesticides
Pharmaceuticals	Pricing policies, Health Technology Assessment methods, parallel trading, reference pricing, restrictions on specific chemicals, labelling requirements, re-exporting licences, state-level practices and safety regulations, double-certification needs, and differences in patent legislation
Electronics	Alignment of technical standards not yet included in the EU's suppliers declaration of conformity (S-Docs), safety provisions, recycling and environmental protection, state-level safety and power supply certifications, third party testing requirements, 100% container scanning, differences in intellectual property systems, residence requirements for staff, the EU's Waste Electric and Electronic Equipment (WEEE) directive, different customs and border requirements, and electromagnetic compatibility requirements
Food and Beverages	Farm policies, security-related measures, differences in trademark legislation, SPS measures, state-level regulations, US customs refusal to acknowledge EU origin, and admissibility of genetically modified organisms (GMOs) and related labeling requirements

Source: Berden et al. (2009).

It is an open question to what extent these kinds of issues can be addressed in the text of mega-regional trade agreements. The United Nations Conference on Trade and Development (UNCTAD) has compiled "counts" of NTBS applied by countries (2012) and researchers have developed AVEs of NTBs for use in CGE models. For example, Kee, Nicita, and Olarreaga (2009) combine the following core NTBs to develop their index: price control measures (TRAINS codes 6100, 6200, and 6300), quantity restrictions (TRAINS codes 3100, 3200, and 3300), monopolistic measures (TRAINS code 7000), and technical regulations (TRAINS code 8100). However, working out the effective reduction effected by a trade agreement in actual restrictions, not to mention factoring in the uncertainty effects, is very much an art and in the hands of the modeller, not the CGE model.

Customs cooperation and trade facilitation will typically work to reduce the time and out-of-pocket costs to get goods across borders. These costs are often higher for trading firms than tariffs (see, e.g., Minor and Hummels, 2010; Hummels and Schaur, 2012). They work, therefore, to reduce logistics costs. However, putting a figure on the cost reduction that can be attributed to a given trade agreement is very difficult.

Standards raise a different challenge altogether. An emerging area of work in CGE modelling is to improve the mapping of trade by institutional sectors, which will improve understanding not only of government, but also of supply chain interactions. Mega-regionals will work to increase the standards that firms active in international trade will have to meet in terms of labour and environment, as well as other aspects, including because of the enhanced role of the private sector in establishing standards. How to capture the effect of harmonizing product standards (which should increase tradability of goods) or of raising the standards (which should increase the fixed costs of accessing international markets) is at a very early stage of development.

c) Value Chains

CGE models do take into account intermediate goods and services, but this area has had limited development in a CGE context to date in terms of capturing value chain effects. Models dealing with global supply chain and Multi-Region Input-Output (MRIO) are the frontiers in this area. The detailed data on the use input A from country X in production of output B in country Y is required for this kind of modelling. Studies, such as Mesa-Arango, Narayanan, and Ukkusuri (2015), have propounded and employed ways to develop such a dataset by marrying the IO dataset and bilateral trade data in the GTAP framework – simply assuming that this is merely the product of the imported input A by country X to produce output B and the share of imports of A by X from country Y. An alternative is to develop the data from the HS6 level by assigning trade flows at a disaggregated level to intermediate and final demand (Walmsley, Hertel, and Hummels, 2013).

d) ROOs and Preference Utilization

Utilization of preferences is incomplete (Keck and Lendle, 2012). Moreover, utilization of preferences generates ROOs compliance costs. Estimates of the administrative costs of meeting ROOs range from about 1% to 7% (Ciuriak and Bienen, 2014), though the literature indicates that the costs vary across ROOs regime. CGE models do not directly take into account ROOs or preference utilization; accordingly, the task of factoring in the cost of accessing preferential regimes is left up to the modeller to develop externally to the CGE model and to impose through an ad hoc methodology. One method to take account of ROOs' restrictive effect is to reduce the utilization of preferences based on the empirical data, and to impose an ad valorem cost for utilization of preferences. This is the approach used in such studies as Petri, Plummer, and Zhai (2011) and Ciuriak and Xiao (2014b).

However, taking into account the regionalization of ROOs has so far escaped tractable treatment. This is significant since the North American Free Trade Agreement (NAFTA) ROOs will effectively be regionalized under the TPP. ROOs liberalization *should* make goods more tradable, which should be reflected in a higher elasticity of substitution for goods that benefit from more liberal ROOs. However, such an effect cannot be captured with precision in a GTAP setting, because the elasticity of substitution applies for all trade involving a particular commodity, not simply the portion sourced from regions benefiting from the more liberal ROOs. The calibration of such an effect would be simple guesswork.

The use of ROOs for protectionist/industrial policy purposes is addressed by Mahate and Narayanan (2014) in a study focusing on the re-exports of the United Arab Emirates (UAE) using a newly-developed variant of the GTAP model. To discourage re-exports and enhance local production, countries adopt various policy measures. One such localization measure is the direct imposition of a ROOs requirement for a specific percentage of products to be made or sourced domestically. This effect can be simulated by introducing a shock into the model to reach the new percentage requirement, beginning from the current levels of localization.

e) NTBs on Services

Berden et al. (2009) also document significant NTBs arising from non-alignment of standards in services sectors. Again, as in the case of goods NTBs, there is a large number of non-aligned measures and many of these cases of non-alignment would be difficult to address through a trade agreement. In the air transport sector, the alignment of regulations is primarily accomplished through Open Skies Agreements, rather than through trade agreements.

Table 2: Services Sector NTBs in EU-US Trade Arising from Regulatory Non-alignment

Communication Services	Access to high speed internet connections, the incompatibility of Advanced Television Systems Committee (ATSC) technology with Digital Video Broadcasting Terrestrial (DVB-T) standards in the EU, differences in intellectual property rights (IPR) systems, disadvantageous regulations applying to foreign companies in public procurement, the Buy American Act, the Advanced Technology Programme, delays in opening telecom markets in some EU Member States, monopolies in the postal market, and delays in implementing the EU Utilities Directive
Financial Services	Tax issues for EU firms raised by applying International Financial Reporting Standards (IFRS) instead of US Generally Accepted Accounting Principles (US GAAP), the Patriot Act, the Sarbanes-Oxley Act, differences in implementation of Basle II, duplicative oversight and supervision of the European Central Bank (ECB) and the Federal Reserve, national treatment of non-EU branches of Foreign Credit Institutions, and divergences in IPR
Insurance Services	Differences in capital and collateral requirements, lack of uniform federal US regulation, divergence of regulation between the EU's Solvency II and US regulation, and reciprocal national treatment clauses relating to insurance and investment services

Source: Berden et al. (2009).

For services NTBs, the challenge for CGE modelling is magnified because of the multiple modes of services delivery. Trade agreements generally do not address Mode 2 (movement of the customer) and address Mode 4 (movement of the supplier) in tightly circumscribed ways. The focus is mainly on Mode 1 (cross-border) and Mode 3 (commercial presence). CGE models using the GTAP dataset are set up to deal with cross-border services flows; Ciuriak and Xiao (2014b) develop a model that is capable of modelling Mode 3 trade by introducing a foreign-owned representative firm into each sector. Developing the shock file to estimate the impact of the mega-regionals on cross-border trade is, however, work that must be done externally to the CGE framework, drawing on a growing body of indexes that characterize services regulation.

Calibrating the policy shock raises additional issues. Petri, Plummer, and Zhai (2011) assign policy weights to various measures under discussion in the TPP; an alternative approach is the direct coding approach based on the OECD's Services Trade Restrictiveness Index (STRI) in Ciuriak, Dadkhah, and Xiao (2015). The latter approach is feasible where the text of an agreement is available and captures actual reduction of barriers; it does not, however, capture the reduction of uncertainty when bindings are introduced at – or even above – the level of applied measures.

f) NTBs on FDI

In order to model the impact of mega-regionals on direct investment, the CGE model must incorporate FDI flows that feed into productive capital. Again, the challenge lies mainly in developing the policy shock in quantitative terms. The development of the FDI Restrictiveness Index by the OECD has facilitated matters although not quite as smoothly as in the case of the STRI. A second issue in capturing the impact of the mega-regionals on investment is the role of uncertainty-reducing instruments, such as investor-state dispute mechanisms.

Petri, Plummer, and Zhai (2011, 2013) develop a way to model the impact of trade agreements on FDI: they assign policy weights to various measures under discussion in the TPP. Ciuriak, Dadkhah, and Xiao (2015) extend the direct coding approach based on the OECD's STRI and FDI Restrictiveness Index. The STRI incorporates policies restrictive of investment in services sectors, including on capital and movement of personnel. The FDI Index gauges the restrictiveness of a country's FDI rules by looking at the four main types of restrictions on FDI in a range of goods and services sectors:

— Foreign equity limitations;
— Screening or approval mechanisms;
— Restrictions on the employment of foreigners as key personnel; and
— Operational restrictions, e.g. restrictions on branching and on capital repatriation or on land ownership.

In contrast to the STRI, where the weight assigned to specific policies varies among different services sector based on expert opinion, the FDI Restrictiveness Index applies an equal weights scheme (e.g., the presence of a restriction on foreign personnel has the same weight in mining as in manufacturing). Integrating the information in these two indexes provides the basis for a text-based analysis that quantifies the impacts of mega-regionals on FDI.

g) Intellectual Property and Innovation

IPR protection has many – and typically complex – impacts on economic activity. The complexity of the impacts reflects the "two-edged sword" nature of IPR protection: on the one hand, it provides incentives to innovate, which should lead to more innovation and an increase in measured economic activity; on the other hand, it slows the diffusion of innovation, which should lead to less follow-on and imitative innovation and thus a decrease in measured economic activity. In the long run, the value of the new innovation may or may not dominate: this depends on whether there are path-dependent effects that result in a slower overall economic development path for the global economy (e.g., if slower growth in innovation "followers" dominates faster growth in innovation "leaders").

These various effects of IPR rules on innovation cannot easily be captured in CGE models designed to measure the economic effects of trade agreements, as they do not represent innovation directly and, thus, do not incorporate parameters that capture the effect of IPR changes on trade or investment. Moreover, translating measures in trade agreements into quantifiable impacts is also a challenge.

Petri, Plummer, and Zhai (2011) adopt an FTA text-based method to assess the contribution of the IPR chapters to liberalization attained by the FTA. They assign policy weights that indicate the contribution of each policy area to the overall liberalization impact on their measure of NTBs. Coupled with a subjective evaluation of the extent to which an agreement liberalizes in that area (which can range from zero to one), this yields a liberalization contribution of that area to an overall reduction of NTBs for goods, services, or FDI, respectively. For IPR, their policy weights are as follows: 0.04for goods, 0.04 for services, and 0.14 for FDI. They evaluate US-style FTAs as liberalizing IPR by 80%, meaning that IPR measures reduce NTBs in goods and services trade by 0.032 and for FDI by 0.112.

In terms of identifying regulatory divergence as a barrier, Berden et al. (2009) document a range of regulatory barriers in IPR, including differences in the definition of IPRs, differences in remedies available to have foreign products removed from the market, differences in EU patent filing regulations (e.g., the EU's "first to invent" versus the US's "first to file" principle), differences in patent systems and patent filing procedures at the EU Member State level, differences in recognition of performance and broadcasting rights in the US, geographical indications (GIs), software patentability, and exhaustion rules (i.e., loss of patent rights with first sale). Some of these issues are directly addressed in FTA texts. Berden et al. (2009) identify large potential welfare gains from TTIP IPR regulatory convergence: US$5.9 billion per year for the EU and US combined.

There has been considerable progress in the past decade or so in introducing endogenous innovation into CGE models, primarily in models dealing with energy and environmental impacts, and more so in process rather than product innovation (Baccianti and Löschel, 2014). Simple schemes involve introducing a variable that represents autonomous efficiency gains that are attributed to the policies; here, the challenge is to use external data and modelling to calibrate the shock. Parrado and De Cian (2014) incorporate endogenous factor-based technology changes and technology spillovers through capital imports in a CGE model.

However, a full integration of an innovation model in which changes to IPR protection drive innovation and trade does not yet appear to be have been developed. Accordingly, the expanded protection for sectors, such as pharmaceuticals, content media, and products with geographical indications, and similar issues cannot be directly handled in CGE models, but must be assessed externally and the results imported into the CGE framework to be evaluated alongside other elements of the trade agreements, with the CGE model acting more as an accounting framework rather than an active agent – although the consequences of the externally modelled IPR effects are transmitted by the CGE model throughout the economy.

The empirical basis for calibrating the effects of trade agreements on innovation and technological change/productivity must generally be developed on the basis of external econometric studies. Such an approach is advocated and employed by such studies as Narayanan and Rungta (2014) and Rokotoarisoa, Khorana, and Narayanan (2014).

In terms of trying to quantify IPR in a way that might be actionable in CGE models, several indexes have been developed, the most promising of which is the Intellectual Property Rights Index developed by the Intellectual Property Rights Alliance. This index combines scores for 10 indicators covering 97 countries. By linking this index econometrically to variables captured by CGE models and by assessing the extent to which an FTA modifies these scores, an econometric evaluation of the effect of the IPR chapters in mega-regionals could be obtained.

h) Government Procurement

Evaluating the impact of government procurement chapters is a high priority for policy makers. However, CGE model databases do not map cross-border transactions by institutional sector and, thus, do not show how much each government procures from its trading partners. Such a highly articulated "use matrix" has yet to be developed.

Most trade involving government procurement is, however, conducted through commercial presence. This result emerges from research conducted on the EU single market. The European Commission (1997) found that the overall import share of procurement markets increased from 6% to 10% between 1987 and 1994. Of this, direct imports (purchases from a supplier outside the state of the procurement entity) increased from 1.4% to 3%, while imports on a commercial presence basis increased from 4.5% to 7%. A 2004 report on internal EU procurement found that, in a sample of firms involved in procurement activities, 46% carried out some type of cross-border procurement, but direct cross-border procurement accounted for just 3% of the total number of bids submitted by the sample firms, versus 30% made by foreign firms using local subsidiaries (European Commission, 2004). Accordingly, for a CGE model to capture government procurement, it would have to combine some way of integrating external data on cross-border government procurement and procurement through Mode 3 sales.

The Petri, Plummer, and Zhai (2011) method extends to government procurement. They assign weights to the importance of restrictions to goods (0.15), services (0.12), and FDI (0.09). They also interpret prior US agreements to having reduced NTBs in this area by 96%.

Berden et al. (2009) document that procurement restrictions figure as NTBs in a wide range of goods and services sectors. They estimate that welfare gains from regulatory alignment and reduction of restrictions to government procurement US$13.8 billion for the EU and the US combined under a TTIP.

i) Environment

The use of CGE models to model environmental impacts is very well established. For trade-related environmental impacts, the usual approach is to introduce a satellite model with GHG emission coefficients. Increased output by sector drives emissions, which are added up to generate global GHG impacts of a trade agreement. Other environmental pollution can be modelled in a similar fashion.

A dedicated GTAP model has been developed to model climate change; it includes, in addition to emissions data, substitution amongst sources of energy that have differing environmental footprints. The energy-environment nexus is treated well in the GTAP-E framework, wherein the emissions associated with production, consumption, and factor usage are computed and allowed to change with the rest of the economy as it evolves with the shocks associated with the trade agreements.

The Global Trade and Environment Model (GTEM) is a multi-country, multi-sector, dynamic CGE model, with three inter-connected modules: economic, population, and environment, developed by the Australian Bureau of Agricultural and Resource Economics (ABARE).

However, going the other way – the impact of environmental regulations on trade and investment – is less well developed. Petri, Plummer, and Zhai (2011) assign negative weights to environmental chapters – i.e., if the FTA enforces environmental regulations, it increases NTBs in goods (weight = 0.08; services and FDI weights are zero). They also assign a score to US FTAs of 0.8 for environment, which means that US-style FTAs would increase NTBs in goods by 0.064, while not affecting services or FDI. Since the positive externalities of environmental regulations are ignored, the Petri, Plummer, and Zhai (2011) scores attribute welfare losses to enforcing environmental regulation.

j) Labour Standards

Several labour-based models have been developed over the years, both in CGE and econometric frameworks, to deal with migration and remittances. GMig2, a good example in this regard, involves wage differentials and associated migration between countries, across the sectors. On the issue of labour and environmental standards as well, several approaches are available, but the best way to deal with them is to focus on a specific standard at a time. Narayanan and Walmsley (2012), for example, deal with the issue of banning child labour, by splitting sectors in GTAP framework into two sets of sectors, one that uses child labour and another that does not. With such a framework, one can shock the sectors using child labour and examine its economy-wide implications, as done in this study.

Again, in terms of evaluating the impact of labour regulations on trade and investment, Petri, Plummer, and Zhai (2011) assign negative weights to the labour chapters that are of the same magnitude as for environment – i.e., if the FTA enforces labour regulations, it increases NTBs in goods (weight = 0.08; services and FDI weights are zero). They also assign the same score to US FTAs of 0.8 for labour as for environment, which means that US-style FTAs would increase NTBs in goods by 0.064, while not affecting services or FDI.

k) Validation

Ultimately, model performance depends on a wide range of inputs, drawn from many sources and, in some cases, based on assumptions that may or may not be valid in any given situation. Beckman and Hertel (2010) tested the GTAP-Energy model against history and found that it generated far too price-elastic a response; recalibrating the elasticities in the model resulted in the model tracking behaviour more closely. This type of validation may not be feasible for modelling complex trade agreements, because there are simply too many moving parts – unlike the (by comparison) relatively simple case of modelling energy price shocks. Nonetheless, additional perspective can be obtained on the mega-regionals using gravity models, such as those used by Costinot and Rodriguez-Clare (2013), and reduced-form methods based on sufficient statistics, as in Arkolakis, Costinot, and Rodriguez-Claire (2012); we return to this in the discussion of alternative modelling frameworks below.

Validation based on real world outcomes is another, probably better, approach to validate trade models. Ianchovichina, Hertel, and Walmsley (2014) demonstrate that the GTAP dynamic model captures the slowdown of foreign investment in China, including the timeline. This suggests that modelling investment theory in quite a sophisticated manner, as done in this model, is the key to practical analysis of trade policy models.

2.3 Summary

As the above makes clear, there are significant limitations to the extent to which the various features of the mega-regionals can be captured by simply relying on any individual CGE model. Table 3 provides a summary of the main studies on the TTIP and TPP. The majority of these studies use the GTAP static model, in some cases solved for a projected database. The imperfect competition version of GTAP developed by Francois, van Meijl, and van Tongeren (2005) (GTAP-FMT) has been used heavily for such studies. The GTAP dynamic model, GDyn, is also frequently used to capture both dynamic effects and international capital mobility. The GTAP-FDI model used by Ciuriak and Xiao (2014b) captures FDI liberalization by introducing a foreign-invested representative firm in GTAP sectors. A few alternative models have been deployed for this purpose as well. A representative sample of the literature is shown in Table 3 below. In this rapidly-proliferating literature, numerous special purpose studies focus on one country or another.

Table 3: Models and Modelling Approaches used for the Mega Regionals

Study	Model	Features for Modelling Non-traditional Aspects of Mega-regionals
TTIP		
ECORYS Berden et al. (2009)	GTAP- FMT model Francois, van Meijl, and van Tongeren (2005)	Detailed assessment of costs of regulatory divergence between the EU and US and of spillover effects on third parties from regulatory convergence under TTIP. FMT model captures both rent-creating and cost-creating NTBs.
CEPR Francois et al. (2013)	GTAP- FMT model Francois, van Meijl, and van Tongeren (2005)	FMT model captures both rent-creating NTBs in the form of higher mark-ups and cost-creating NTBs in the form of higher transportation costs to market. Detailed assessment of potential gains from NTBs.
CEPII Fontagné et al. (2013)	MIRAGE Model Decreux and Valin (2007)	Recursive dynamic model that models FDI explicitly, as well as incorporating vertical product differentiation (by distinguishing two quality ranges) and imperfect competition. The model database features its only detailed measure of bilateral trade barriers and of their evolution based on the International Trade Centre's MacMap database. The study features higher estimates of services NTBs and incorporates spillover effects evaluated at 5% of NTBs for third parties, based on expert opinion.
Institute of Developing Economies Cai, Zhang, and Meng (2015)	GTAP-GVC Model	This study features a modified version of the static GTAP model that incorporates an additional "nest" to model substitution across sources of intermediate inputs to capture the effect of TTIP on value chains. It also tries to capture spillover effects – a reduction of NTBs in EU-US trade is assumed to reduce trade costs for third parties exporting to both markets.
World Trade Institute Cottier et al. (2014)	GTAP- FMT model Francois, van Meijl, and van Tongeren (2005)	CGE modelling is complemented by partial equilibrium modelling of specific markets. It performs a statistical analysis of procurement markets, FDI, and services trade and a comparative analysis of the legal texts of existing agreements that might serve as templates for the TTIP.

Open Europe Ciuriak, Dadkhah, and Xiao (2015)	Ciuriak Consulting GTAP-FDI Model developed by Jingliang Xiao	Recursive dynamic version of GTAP that features a foreign-invested firm in each GTAP sector alongside the domestic representative firm and explicitly models FDI and Mode 3 Foreign Affiliate Sales. The study features a text-based approach to coding services and FDI policy shocks, based on the extent to which the TTIP changes the EU's or US's STRI or FDI Restrictiveness Index. It generates low estimates of TTIP, based on previous US and EU commitments in services and FDI, and a modest evaluation of the effect of the TTIP on regulatory convergence.
TPP		
East-West Center Petri et al. (2011, 2012, 2013)	GTAP-based model with heterogeneous firms developed by Zhai (2008)	This study uses a heterogeneous firm CGE model with stylized parameters to describe the distribution of firm productivity. It codes 24 TPP chapters for their effects on NTBs in goods, services, and FDI. The model is solved on a projected data set for future years out to 2030, but is not a dynamic model. It works in FDI impacts.
Lee and Itakura (2014)	GTAP dynamic model GDyn described by Ianchovichina and Walmsley (2012)	This study features the recursive dynamic Gdyn model, which takes into account international capital mobility. GTAP tariffs and estimates of NTBs in services sourced from the literature are reduced by 20%, and time costs of trade, based on Minor and Hummels (2010), are reduced by 20% to capture NTBs in goods trade.
Asian Development Bank Cheong (2013)	GTAP dynamic model GDyn described by Ianchovichina and Walmsley (2012)	This study features the recursive dynamic GDyn model, which takes into account international capital mobility. This study focuses on tariff concessions.
RIETI Kawasaki (2014)	GTAP with capital accumulation	This study introduces productivity gains induced by greater imports. It focuses on goods trade and takes into account tariffs and NTBs.
Centre for WTO Studies Narayanan and Sharma (2014)	GTAP static model	This study focuses on tariff effects to identify issues for a non-member of the TPP, India.
Li and Whalley (2014)	CGE model with monetary structure	Analyses tariff and non-tariff barriers, calculating trade costs between countries empirically with gravity model methodology, and introduces monetary structure to address China's trade imbalance. Focus is on China.
C.D. Howe (Ciuriak et al., forthcoming)	Ciuriak Consulting GTAP-FDI Model developed by Jingliang Xiao	The current working paper version of this study features a recursive dynamic version of GTAP that features a foreign-invested firm in each GTAP sector alongside the domestic representative firm and explicitly models FDI and Mode 3 Foreign Affiliate Sales. Its focus is on identifying the "landing zone" for the TPP negotiations. Its NTB assumptions are based on the Petri, Plummer, and Zhai (2011, 2013) study. It takes into account ROOs effects along with goods, services, and FDI NTB reductions.

Source: compiled by the authors from the literature.

In section 3, we consider complementary models with greater structural detail that can be used to complement CGE-based analysis. This discussion sets the stage for consideration of how these approaches can be combined to obtain the best and most comprehensive estimates of mega-regional trade agreements.

3. Complementary Models

The above discussion shows that the CGE models alone will not be able to fully take into account all the elements addressed in modern mega-regional trade agreements. A variety of complementary models and/or external micro-simulation analyses are required to enable a comprehensive analysis of such agreements in a CGE framework. This section reviews the scope to provide such a comprehensive analysis.

3.1. Gravity Models

The most commonly used models in the trade literature today are gravity models. Based on an analogy to the concept of gravity in physics, gravity equations relate bilateral trade between two countries to the size of trading partners and the distance between them. For empirical work, "distance" in the gravity model is both physical geographical distance, as well as cultural, linguistic, and political distance. Thus, bilateral trade between pairs of countries is modelled as a function of bilateral distance (between capitals or between centres of economic gravity within countries), population and income, common language, common cultural/colonial background, common currency, the presence of an FTA, and various other variables of interest (e.g., diplomatic representation, etc.).

In terms of theoretical foundations, gravity equations can be derived as reduced form equations from all the standard trade theories, including the modern workhorse heterogeneous firms theory. For recent reviews of the theoretical foundations for the gravity equation in trade and investment, see Anderson (2010), Bergstrand and Egger (2011), and Costinot and Rodríguez-Clare (2013). Olivero and Yotov (2012) develop the basis for a dynamic gravity model to support use of the equation using panel data (for an example of dynamic panel methods, see inter alia De Benedectis and Vicarelli, 2005). Egger et al. (2011) develop a structural gravity model to assess the general equilibrium effects of FTAs on trade between all country-pairs in a dataset. Protection/tariff data are included in some gravity models; however, differing levels of protection get picked up as part of "multilateral resistance" (Anderson and van Wincoop, 2003), which captures the effect on bilateral trade of other alternative trading possibilities.[8]

Gravity models have limited applicability to assessing the impacts of the mega-regionals. For the most part, such models are used to estimate ex post whether existing agreements intensify bilateral trade between FTA partners, rather than on an ex ante basis. The usual technique is to include a dummy variable for bilateral relationships that are covered by an FTA. The results tend to show large effects of FTAs on bilateral trade, stronger typically than the results that emerge from CGE modelling. For example, Baier et al. (2008) use a gravity modelling framework to assess whether EU membership causes a country to trade more with other EU members than European Free Trade Association (EFTA) membership. Cardamone (2009) criticizes the use of dummies, rather than, for example, preference margins.

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[8] Multilateral resistance is illustrated by comparing trade between Australia and New Zealand and trade between Austria and Portugal. These two country pairs are about the same distance and have comparable sizes to each other, but Australia and New Zealand trade more intensively with each by an order of magnitude than do Austria and Portugal, because between the former lies the Tasman Strait and between the latter lie many trade opportunities in Spain, France, and Germany.

Notwithstanding the limited extent to which they can take into account structure, gravity models have been used occasionally for ex ante analyses of significant trade policy changes. Felbermayr, Heid, and Lehwald (2013), for example, report massive gains from TTIP of 13.4% of income for the US and of 4.95% on average for the EU. This study relies on econometric estimates of the impact of FTAs on bilateral trade in a gravity model framework. These econometric estimates are used to infer implicit levels of trade protection, which can then be used to shock the model to evaluate the impact of a prospective agreement on an ex ante basis. The main problem with this approach is identifying the sources of trade costs that result in the observed pattern of trade. This, in turn, leads to consequential problems in determining whether a given trade agreement will generate comparable trade and welfare gains by actually addressing those problems.

Finally, it is worth mentioning that gravity models can also be used effectively to estimate the elasticity of trade flows to measures, such as the STRI or the FDI Restrictiveness Index, thus helping to provide empirical support for parameters used in CGE modelling studies to analyse the impact of services and investment chapters.

3.2. General Purpose Partial Equilibrium Models

General purpose Partial Equilibrium (PE) trade models have been developed to enable simulation of trade impacts on specific products or sectors. Commonly used models include the World Integrated Trade Solution (WITS) model, part of the UN TRAINS system; the Global Simulation Model (GSIM), developed by Francois and Hall (2003), also as part of the TRAINS system; the World Bank's Tariff Reform Impact Simulation Tool (TRIST); and the COMPAS family of models developed by Francois and Hall (1997) for the US International Trade Commission.

These trade models are typically based on the same underlying Armington specification as the trade modules in CGE models, such as GTAP. A major advantage of these models is that they have limited data requirements – bilateral trade flows for the product/sector in question; protection data; and demand, supply, and substitution elasticities. GSIM requires domestic shipments data, which are less readily available, but can reasonably be guesstimated. The level of analysis can be at the finest level of disaggregation – the COMPAS system, for example, is used for anti-dumping and countervailing duty analysis. The results are transparent and sensitivity analysis is easy to do, because the models solve very quickly on their Excel platforms. Different models have different strengths – the TRIST model, for example, incorporates richer information on revenue impacts, while GSIM focuses on global market-clearing at the product level, rather than on import-market-only effects.

While such models have been used to analyse the impact of comprehensive trade agreements by running simulations on individual products seriatim (e.g., Banga, 2015 uses the WITS-SMART model to analyze the TPP's impact on Malaysia), the results cannot be meaningfully aggregated to generate summary impact assessments, because the sectoral interactions are not taken into account and, more importantly, the income effects from the comprehensive liberalization package, when layered on the first-round trade effects captured by the PE analysis, can lead to opposite conclusions concerning the impact of the trade deal (see Ciuriak, Lysenko, and Xiao, 2014 for a demonstration of this issue in the context of applying a linked GSIM-GTAP approach to develop impacts of the Canada-Korea FTA on Canadian provinces).

3.3. Special Purpose Models

Special purpose PE and econometric models are widely used to model agricultural production and trade at the global and regional level with a high degree of structural detail. The most comprehensive of these for global agricultural analysis is the OECD-FAO AGLINK-COSIMO (Commodity Simulation Model) model (OECD, 2007). The International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT), documented by Rosegrant et al. (2012) is the basis of various global agricultural projections by the International Food Policy Research Institute (IFPRI). Europe-centred models include the European Simulation (ESIM) model (Banse et al., 2010), the Common Agricultural Policy Regionalized Impact (CAPRI) model (Britz and Witzke, 2013), the Common Agricultural Policy Simulation (CAPSIM) model (Witzke and Zintl, 2005), and the AGMEMOD (Agricultural Member States Modelling) system, which provides detailed information on the agricultural sector in each EU Member State and the EU as a whole (see, e.g., Bartova and M'barek, 2008). A US-centred model is the University of Missouri's Food and Agricultural Policy Research Institute (FAPRI) agricultural model system, documented by FAPRI (2004) and Gerlt and Westhoff (2011). Australia has been active in this area, producing several such models, including the Agricultural Production Systems Simulator (APSIM) developed by an Australian consortium and two models developed by ABARE: the Agrifoods Model, which is a recursive dynamic partial equilibrium model focused on Australian agricultural and food industries, and Ausregion, which focuses on Australian regions. Additionally, there are product-specific models, such as the Cotton Economics Research Institute model, which focuses on the cotton sector.

For the most part, these models are used to develop agricultural projections and to address special issues, such as biofuels policies and climate change. While they have various strengths in terms of policy detail, they have not been used extensively to model issues raised by the mega-regionals, because, in these modelling frameworks, countries generally "trade with the world". In other words, there is no bilateral trade information in such models. In addition, domestic and imported goods are assumed to be perfect substitutes. See Beghin, Bureau, and Gohin (2014) on the limitations of AGLINK-COSIMO-type models for modelling TTIP. That being said, the EU and Ukraine modules in the AGLINK-COSIMO model were used to model the effects of the EU-Ukraine FTA on the agricultural sectors of both economies (Nekhay, Gay, and Fellmann, 2011); the FAPRI model has been used to model particular sectoral outcomes of major trade agreements, such as the Korea-US FTA (Fabiosa, Hayes, and Dong, 2007); and the SMART model was used by Lang (2006) to evaluate the Economic Partnership Agreement (EPA) between the EU and the Economic Community of West African States (ECOWAS).

One noteworthy development is the integrated Modelling Platform for Agro-economic Commodity and Policy Analysis (iMAP), developed by the European Commission's Joint Research Centre. This system includes selected partial equilibrium models (AGLINK, CAPRI, and ESIM), as well as general equilibrium models (GLOBE and MAGNET), to allow the most appropriate model to be chosen for a specific policy question, while facilitating comparisons of results between models in order to substantiate the findings (M'Barek et al., 2012). Similarly, Pelikan, Britz, and Hertel (2015) integrate the general equilibrium and global features of the GTAP model with the regional focus of CAPRI.

3.4. Sufficient Statistics Models

Arkolakis, Costinot, and Rodríguez-Clare (2012) show that the changes in welfare associated with trade liberalization, derived from a wide range of commonly used models, can be captured with two basic statistics: (i) the change in the share of expenditure on domestic goods and (ii) the elasticity of bilateral imports with respect to variable trade costs (the "trade elasticity" in their nomenclature). Changes in bilateral trade flows, in general, and the share of domestic expenditure, in particular, can be computed using only information about the trade elasticity and easily accessible macroeconomic data (Costinot and Rodriguez-Clare, 2013). Ottaviano et al. (2014) use this approach to develop estimates of a trade policy change similar to a mega-regional, namely the United Kingdom (UK) leaving the EU. Their results are comparable to those obtained by Ciuriak et al. (forthcoming) in a study for Open Europe using a CGE-FDI model that captured many of the structural effects of a UK exit from the EU (see Open Europe, 2015).

This approach has the great advantage of simplicity with strong theoretical backing. However, this is not yet a settled art. For example, Ossa (2012) estimates that the welfare gains for the US from trade are significantly greater than the 1.4% derived by Arkolakis, Costinot, and Rodriguez-Claire (2012). Ossa generalizes the Arkolakis, Costinot, and Rodriguez-Claire formula to a multi-industry setting and treats the trade elasticity as a weighted average of the individual industry elasticities. If imports are very important for some industries, the inverse of the trade elasticity rises towards infinity. The net result is a welfare impact that is some four times larger than obtained by Arkolakis, Costinot, and Rodriguez-Claire.

A second limitation of this approach is that it cannot inform on many aspects of interest to policy makers. As Ciuriak (2013) argues:

> Traditional quantitative trade models evaluate these gains in terms of consumption adjustments and factor reallocations across sectors. However, heterogeneous firm models also describe the adjustments across firms within sectors which is of considerable importance in a stakeholder-driven policy-making process. Moreover, while the technologies are known ex post, they are not known ex ante—to the extent that it is the lowering of trade barriers that induces the innovation which puts these technologies in place to be observed ex post, this too is of considerable importance for policymakers. In a similar vein, heterogeneous firm models also describe adjustments that are made within firms across products in multi-product firm models, in conjunction with changes in process technologies, which affects the observed productivity at the firm level. This too is vital information in evaluating prospective trade policies.

Accordingly, the sufficient statistics models will likely serve as a reality check on modelling the mega-regionals, but will not supplant the structural models used to understand how the gains are obtained and the source of impacts.

4. Discussion and Conclusions

The most comprehensive approach to modelling the mega-regionals is to employ a CGE model of the type used for multi-sector, multi-region trade analysis. These are the only models with sufficient structural features to capture the main areas of focus of the mega-regionals, namely services, investment, and the new "behind the border" issues, while still covering the traditional areas of liberalization, such as tariffs and at least some features of agricultural trade. However, while many CGE models have been developed with varying features, a truly comprehensive approach remains to be developed:

— While goods trade and cross-border services trade are captured by all major CGE models, few model FDI, which is a major area of focus, and fewer still model Mode 3 sales or Mode 4 movement of labour.
— All major CGE models capture the role of intermediate goods, but none effectively captures the effect of tariffs and NTBs on value chains (or even traditional protectionist measures, such as tariff escalation, which change the composition of trade between raw and processed goods in a discontinuous ways).
— ROOs effects – including the costs of utilizing preferences – are now routinely incorporated in CGE modelling studies, but the translation of specific formulations of these rules into quantifiable impacts on trade is still largely a matter of guesstimation. The effect on tradability of inputs due to ROOs' regionalization escapes workable treatment.
— To reflect modern trade theory and to capture the effect of competition chapters, a rapidly growing number of models introduce firm-level heterogeneity and introduce ways to capture the pro-competitive effect of firm entry into trade. However, capturing the role of quality in affecting substitutability of imports across alternative sources is at an early stage of development.
— Only a subset of major CGE models are capable of representing both rent-creating and cost-creating NTBs. Equally – if not more – important is to improve estimates of the degree of liberalization in services and investment and of the parameters that translate measures of liberalization in these areas into quantifiable impacts of trade and investment. This is an area of ongoing development and is far from a settled art. The impact of measures, such as investor-state dispute settlement, and other uncertainty-reducing elements of trade agreements, such as binding dispute settlement, has yet to be made tractable.
— Many chapters appear to be beyond the reach of current modelling capability, in some cases because of a lack of data; this is particularly the case with government procurement commitments, IPR chapters (which focus heavily on pharmaceuticals, media content, and GI in agricultural products, which are insufficiently represented in the GTAP database), e-commerce, and labour and environmental chapters. However, attempts have been made to translate the text into quantified impacts on NTBs to goods, services, and FDI.

Mega-regionals can be modelled, but only incompletely and with considerable areas left open for qualitative assessment. Much depends on the ability of the modellers to quantify the commitments in trade agreements in terms of costs or prices of trade goods and their impact on investment flows; this must be done externally to the models and introduced as policy shocks. Accordingly, a variety of other empirical techniques must be used in conjunction with CGE modelling. In addition, reduced-form CGE models based on essential statistics provide summary estimates of the welfare effects of trade agreements; gravity models provide a check on the impact of agreements on bilateral trade flows; and a range of satellite models can be used to capture environmental impacts, migration, poverty effects, innovation, the complexity of agricultural managed trade systems, and others.

Technical capability in this area is developing relatively quickly. As discussed above, approaches have already been developed to complement CGE analysis with additional CPE, gravity, or text-based analysis. A natural way ahead for a policy-oriented global trade model is, thus, a blended approach that marries the best of all of these approaches. Ideally, we can envisage a detailed trade policy CGE model that has a state-of-the-art capability to capture goods, services, and FDI and the effects of all types of NTBs, coupled with various satellite models with details on individual sectors modelled in PE and all parameters estimated econometrically.

For the moment, this is out of reach. Typically, there are trade-offs between the number of features that any single CGE model can incorporate. Moreover, there are basic resource constraints facing modellers in terms of how much detail can be developed on any single agreement. Accordingly, for the time being, the impact of mega-regionals is probably best captured by meta-analysis of a suite of studies based on different CGE models, complemented by various satellite models, and drawing on the particular expertise of different modelling groups.

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