Journal of Global Economic Analysis, Volume 5 (2020), No. 1, pp. 273-345.

Modelling Trade and Other Economic Interactions between Countries in Baseline Projections

BY EDDY BEKKERS[a], ALESSANDRO ANTIMIANI[b], CAITLYN CARRICO[c], DOROTHEE FLAIG[d] , LIONEL FONTAGNE[e], JEAN FOURE[f], JOSEPH FRANCOIS[g], KEN ITAKURA[h], ZORNITSA KUTLINA-DIMITROVA[i], WILLIAM POWERS[j], BERT SAVEYN[k], ROBERT TEH[l], FRANK VAN TONGEREN[m] AND MARINOS TSIGAS[n]

This paper examines the way trade and other economic interactions between countries are modelled in the construction of baseline projections with recursive dynamic computable general equilibrium (CGE) models. Simulations are conducted on the size of trade elasticities, the way the trade balance is modelled (macroeconomic closure), trade growth, and energy prices. Other topics scrutinized are the modelling of zeros, modelling of new technologies and new types of trade policies (trade in data and digitalization), phasing in of future trade policies, and migration and remittances. We

[a] World Trade Organization, Geneva, Switzerland (e-mail: eddy.bekkers@wto.org).
[b] European Commission, Brussels, Belgium (e-mail: alessandro.antimiani@ec.europa.eu).
[c]Wageningen Economic Research Wageningen, Netherlands (e-mail: caitlyn.carrico@wur.nl).
[d]University of Hohenheim, Stuttgart, Germany (e-mail: dorothee.flaig@uni-hohenheim.de).
[e]Centre d'Etudes Prospectives et d'Informations Internationales, Paris, France (e-mail: lionel.fontagne@cepii.fr).
[f]Centre d'Etudes Prospectives et d'Informations Internationales, Paris, France (e-mail: jean.foure@cepii.fr).
[g] World Trade Institute, Bern, Switzerland (e-mail: joseph.francois@wti.org).
[h] Nagoya City University, Nagoya, Japan (e-mail: itakura@econ.nagoya-cu.ac.jp).
[i]European Commission, Brussels, Belgium (e-mail: zornitsa.kutlina-dimitrova@ec.europa.eu).
[j]United States International Trade Commission, Washington, DC, USA (e-mail: william.powers@ustic.gov).
[k] European Commission, Sevilla, Spain (e-mail: bert.saveyn@ec.europa.eu).
[l]Formerly of the World Trade Organization, Geneva, Switzerland (e-mail: robert.teh@bluewin.ch).
[m]Organization for Economic Cooperation and Development, Paris, France (e-mail: frank.vantongeren@oecd.org).
[n]United States International Trade Commission, Washington, DC, USA (e-mail: marinos.tsigas@ustic.gov).

conclude that there is relative consensus about the use of nested Armington preferences, whereas different scholars model the trade balance very differently. The discrepancy between baseline trade growth and historical trade growth is not considered in most models though highly relevant. Research efforts, both in terms of modelling and data collection, should be allocated to a better coverage of other items on the current account (capital income, remittances) and the inclusion of net foreign debt and asset positions, projecting trade growth based on historical patterns, and better tools to model the rapidly growing digital economy.

JEL codes: F17, C68.

Keywords: Trade growth, Macroeconomic closure, Trade structure.

1. Introduction

Recursive dynamic computable general equilibrium (CGE) models are employed extensively by many scholars and international organizations to generate baseline projections on the path of the world economy in the future. The baseline projections are used in turn to help answer a wide range of policy questions related to for example trade rules, climate change, taxes, and agricultural production. How economic behavior and interactions between countries is modelled in (recursive) dynamic CGE-models has an important bearing on the resulting baseline projections. This paper examines the way trade and other economic interactions such as capital flows are modelled in dynamic CGE-models. Current approaches in the field are compared, reviewed, and assessed; in some cases, the effect of different modelling choices is compared through actual model simulations; and recommendations on best practices are then formulated based on the results of the comparison exercises and areas in need of further research and data collection are identified.

Simulations are conducted on four topics: the structure of trade (nested versus non-nested preferences, size of elasticities); the way the trade balance is modelled (macroeconomic closure); modelling of trade growth; and the role of energy prices. Other topics scrutinized are the modelling of zeros, modelling new technologies and new trade rules (rules on trade in data and digitalization), phasing in of future trade policies, and migration and remittances. Although no simulations are conducted on these topics, a discussion of the available and the required work is highly relevant. In the future these topics will play a prominent role in baseline projections focused on trade and other economic interactions.

The simulations are conducted with different recursive dynamic CGE models, based on the same base-data and a uniform set of baseline macroeconomic projections. The base-data consist of an aggregation of the Global Trade Analysis Project (GTAP) Data Base, Version 9.2 to 15 regions, 15 sectors, and 5 factors of production (Aguiar et al., 2016b).[1] The simulations run from 2011 until 2035 or 2040. For the baseline macroeconomic projections, we have employed the middle scenario (medium variant) of the United Nations (UN) projections on population and labor force growth and the Shared Socio-economic Pathways Scenario 2 (SSP2) of the Organization for Economic Co-operation and Development (OECD) for Gross Domestic Product (GDP) per capita growth.[2] No additional features such as differential productivity growth, changing preferences, or skill-specific labor force growth were included.

Since scholars from different research institutes conducted the simulations, different CGE-models were employed. The aim of the simulations was not to compare different models, but rather to illustrate the implications of different choices on, for example, the structure of trade or the trade balance closure on the resulting projections.

The paper is organized thematically, starting with the topics which involve model simulations. Section 2 looks at trade structure and the size of the elasticities. Section 3 addresses the modelling of the trade balance. Section 4 examines trade growth, while Section 5 explores the role of energy prices. Then the remaining topics which do not involve any simulations are discussed. These topics include the extensive margin and zeros in Section 6, the role of new technologies in Section 7, the phasing in of future trade policies in section 8, and the modelling of migration and remittances in Section 9. Section 10 concludes by identifying best practices and recommending an agenda for future research.

2. Trade structure and size of elasticities

2.1 Introduction

We start this paper with a discussion of the way international trade is modelled. The nested Armington model is dominant (Section 2.1) and monopolistic competition models have been used very rarely in dynamic models (Section 2.2). The new quantitative trade literature tends to use a different trade structure similar to the Armington model (Section 2.3). There is a large empirical literature to estimate trade elasticities (Section 2.4 and Section 2.5) leading to different estimates. In Section 2.6 we conclude this Section with an analysis of the impact of variations in the trade elasticity on baseline projections.

[1] Table A1 contains an overview of the aggregation.

[2] We acknowledge the fact that the OECD SSP projections are not fully consistent with UN population projections, as they are rather based on IIASA population projections. The differences between the two different sources are discussed in Fouré et al. (2019).

2.1 Armington model

Theoretical literature exploring the properties of trade in the presence of product differentiation extends back to at least Krugman (1979). As noted by Hertel et al. (1997) multi-region general equilibrium models require an assumption about consumer demand for imported vs. domestic products. Modern trade models, such as those based on Eaton and Kortum (2002) and Melitz (2003), tend to assume that varieties from all sources are similarly substitutable; hence, substitution elasticities do not depend on whether a product is domestic or imported. However, CGE models have long incorporated a nested Armington structure (e.g., Zeitsch et al., 1991). With this assumption, domestic and imported products are imperfect substitutes, exchanged according to a constant elasticity of substitution in the "upper tier" of the nest. A separate elasticity reflects the degree of substitutability between imports from different sources in the "lower tier."

The popularity of the Armington structure is due to at least three appealing properties. First, with Armington preferences intra-industry trade can be modelled. Given that consumers have a love-of-variety between goods from different exporters, they will want to import goods from all exporters so that two countries can be simultaneously exporting and importing the same good (of different varieties). Second, by choosing appropriate values for the Armington taste shifters any pattern of baseline trade can easily be calibrated.[3] Third, the Armington structure is in reduced form equivalent to the Eaton-Kortum comparative advantage model (Arkolakis et al., 2012). In larger-scale models with export taxes and transport margins (not included in the comparison exercise in Arkolakis et al., 2012), the results of policy experiments could be different between the Armington and Eaton-Kortum models although this is not expected.

Differences across trade models are also not absolute. Some recent non-CGE empirical trade models have employed a nested Armington structure. For example, Caliendo et al. (2017) introduce a nested constant elasticity of substitution (CES) structure for demand of intermediate inputs.[4] And there have been numerous examples of CGE models with a single-tier CES demand structure, from Francois and Roland-Holst (1997) to USITC (2019). The choice of model structure has important implications for estimated effects in trade policy simulations. Use of the nested structure can raise the estimated terms-of-trade effects from trade policy shocks, since it increases the sensitivity of domestic

[3] In models written in relative changes (using General Equilibrium Modelling PACKage, GEMPACK) the taste parameters do not have to be set explicitly. In models written in levels the baseline can also be calibrated by setting iceberg trade costs appropriately instead of taste shifters.

[4] They note that the "extra upper-level curvature" in the nested CES structure reduces the potential for corner solutions in multi-sector monopolistic competition models, as first discussed by Kucheryavyy, Lyn, and Rodriguez-Clare (2016).

consumers to import price changes (Brown, 1987). Although models with national product differentiation demonstrate strong terms-of-trade effects, there appears to be little empirical testing of the point at which these estimated effects become "too strong."

Almost all nested models work with the so-called rule of two: the commonly applied assumption that the substitution elasticity among import varieties is twice as high as that between imports and domestic products. An exception is the Modelling International Relationships in Applied General Equilibrium (MIRAGE) model (Fontagné et al., 2013), which works with the square root of two rule. Although the use of the rule of two is widespread, its empirical underpinning is weak. In an early empirical test, Liu et al. (2004) could not reject the rule of two, Feenstra et al. (2018) come to a more nuanced conclusion applying new estimation techniques to highly disaggregated U.S. production and trade data.[5] They find that that there is no significant difference in elasticities over two-thirds of goods, though the rest exhibit significantly higher elasticity of substitution among imports than between imports and domestic products. It is obvious that nested preferences help stabilize the model in response to large shocks, because of the smaller substitution elasticity between imports and domestic goods, though modern solution methods have reduced the importance of this feature. However, Armington models tend to be well-behaved and nested preferences seem more important in trade models featuring monopolistic competition, as discussed below.

Some CGE models, such as Globe and Dynamic Applied Regional Trade (DART), incorporate a constant elasticity of transformation (CET) structure on the sales side.[6] In this approach, domestic sales and exports to different destinations are imperfectly transformable. Including this feature in the model will most likely reduce the impact of shocks on changes in trade flows. For example, a reduction in iceberg trade costs will lead to a smaller shift in the destination of sales. As such the model will be more stable and thus computationally more robust in case of very large shocks. A disadvantage of this approach is that it cannot be reconciled with the micro-founded Eaton and Kortum model of comparative advantage.

2.2 Models of monopolistic competition and firm heterogeneity

Models of monopolistic competition have a long history in the CGE literature. Following the development of the Ethier-Krugman model featuring identical firms, various scholars have incorporated monopolistic competition in CGE

---

[5] Specifically, they apply additional moment conditions to correct for small-sample biases in earlier work by Feenstra (1994) and Broda and Weinstein (2006).

[6] Also, the Environmental Impact and Sustainability Applied General Equilibrium Model (ENVISAGE) and the Standard GTAP Model in GAMS by van der Mensbrugghe (2018) contains the possibility to include a CET-nest between domestic sales and exports.

models (Hertel and Swaminathan, 1996; Francois, 1998). After the development of the Melitz firm heterogeneity model, various researchers included firm heterogeneity in different ways into their CGE-models (Zhai, 2008; Balistreri et al., 2011; Dixon and Rimmer, 2018; Akgul et al., 2016; Jafari and Britz, 2018; Bekkers and Francois, 2018). However, a recurrent theme in the firm heterogeneity literature is the computational problems in solving the model. In many real-world applications the number of countries and sectors or the number of sectors featuring firm heterogeneity is limited. Maybe these computational problems can explain why to the best of our knowledge there is no (published) work on monopolistic competition in dynamic CGE models. However, there are at least three reasons for the incorporation of monopolistic competition and firm heterogeneity into dynamic CGE models. First, scale economies, love-of-variety preferences (or some variant), and firm heterogeneity are real-world features. Second, comparative static experiments have shown that models of firm heterogeneity behave very different in specific cases (e.g., in case of liberalization in a single sector the production effects are much larger as shown by Dixon et al., 2018) compared to perfect competition Armington models. Third, monopolistic competition models tend to generate a strong impact on specialization patterns and are thus useful to study the dynamic effects of events like Brexit or the integration of large countries into the global economy.

There are at least three different options to mitigate computational problems in CGE-models with monopolistic competition, which might be useful in baseline projections with these models.[7] First, the model can be stabilized by including multiple layers of nested preferences. As in most dynamic CGE models a smaller substitution elasticity between domestic and imported goods can be incorporated or a smaller substitution elasticity between imports from different countries in comparison to the substitution elasticity between varieties can be included.[8] Second, labor can be modelled as imperfectly mobile between sectors. Bekkers and Francois (2018) show that imperfect mobility of labor has only a minor impact on the effects of trade cost experiments, although the impact of imperfect labor mobility has not been assessed in a dynamic model. Third, the input-output structure of the data can be averaged such that it is less likely that trade cost experiments would generate infinitely large effects and thus generate computational problems. This approach is discussed in Costinot and Rodriguez-Clare (2013) and a variant of it is implemented in Britz and Jafari (2018) for example. Obviously, if the input-output data are collected accurately, this approach might not be preferable.

[7] See, for example, Bekkers and Francois (2018) for a discussion.
[8] See, for example, Kucheryavyy et al. (2016) for the latter approach.

2.3 Approaches in the new quantitative trade literature

The literature employing so-called new quantitative trade models has expanded rapidly since the beginning of 2000 and the publication of the Eaton and Kortum (2002) model of comparative advantage. New quantitative trade models can be separated into structural gravity models and models employing exact hat algebra. The former type of models builds on the seminal approach of Anderson and Van Wincoop (2003), whereas exact hat algebra was developed by Dekle, Eaton and Kortum (2007). Following Bekkers (2019b) we can identify four differences between the three types of models. First, new quantitative trade models emphasize the importance of structural estimation requiring a unifying framework for theory, estimation, and counterfactual experiments. In concrete terms this means that equations to estimate the parameters of the model are derived from the model and employed to run counterfactual experiments and that the same dataset is used for parameter estimation and for counterfactuals. In practice this means that new quantitative trade models set many nests at Cobb-Douglas, since not all parameters can be estimated from one single dataset. Although this approach is critically discussed in the new quantitative trade literature (Costinot and Rodriguez-Clare, 2013), it is applied frequently in this literature. CGE modelers instead tend to use empirical parameters from the literature whenever they are available.

Second, solution methods differ. Structural gravity modelers tend to solve their models twice, with and without a policy experiment. Modelers employing exact hat algebra instead solve for the ratio of endogenous variables with and without a policy experiment (new and old values). Exact hat algebra takes its name from the fact that the equilibrium equations in ratios hold exactly, whereas conventional hat algebra (employed in models working with GEMPACK) holds approximately although the GEMPACK software takes many steps in arriving at a solution after a policy experiment thus ensuring that the solution is exact. CGE models either solve for the effects of a counterfactual experiment at once (GEMPACK-based models) or in two steps by solving the model first without and then with policy experiment (General Algebraic Modeling System (GAMS)-based models).[9]

Third, the structure of new quantitative trade models differs from CGE models, emphasizing a parsimonious structure omitting many details included in CGE models. In models employing exact hat algebra trade is typically modelled as in Eaton and Kortum (2002). However, as argued above, in reduced form the Eaton and Kortum model does not differ from the Armington structure. The only advantage could be that multi-sector Eaton and Kortum models feature a "structural" parameter for technology in each country and sector. This parameter

[9] In GAMS-based models it is not strictly necessary to solve the model without policy experiments first if the economy is in equilibrium, although this is a good check on the model.

is a measure of absolute advantage in the Ricardian model of trade and shocks to technology can thus be given a "structural" interpretation within the framework of a Ricardian model. As such differences could emerge with productivity in the Armington structure used in the calibration of shocks. Fourth, baseline calibration is different. Whereas CGE models and models employing exact hat algebra calibrate the baseline to actual observed data in a specific year, structural gravity models calibrate the baseline to fitted values of the estimated gravity equation.

Projection work is scarce in the literature employing quantitative trade models, which instead is focused more on comparative static policy exercises (Caliendo and Parro (2015) on the effects of the North American Free Trade Agreement (NAFTA) for example) or comparative static exercises showing the contributions of different channels to explain certain phenomena (Caron et al. (2014) for example on the contribution of non-homothetic preferences to explaining the missing trade puzzle). New quantitative trade models tend to become increasingly complex and recently endogenous capital accumulation and labor market frictions in a dynamic setting have been incorporated in these models (respectively Ravikamur et al., 2019; and Caliendo et al., 2019). Dynamic CGE modelers could for example gain useful insights from recent models incorporating endogenous innovation in their models (Sampson, 2015; Cai et al., 2019).

2.4 Size of trade elasticities

Before moving to simulations on the impact of the size of trade elasticities on baseline projections, the different estimates of trade elasticities in the literature are discussed in this subsection. As noted by Hillberry and Hummels (2013), trade elasticities are of central importance for empirical policy analysis. As discussed below, there is a large literature estimating the size of trade elasticities, but there is no clear consensus on which elasticities to use. There is even less consensus on the proper demand structure for imports, which have also been shown to have substantial implications for welfare and other simulation results.[10] There is no systematic explanation of why the domestic-import elasticity should be lower than the import-import elasticity, though Rauch and Trindade (2003) show that matching frictions between wholesalers and international suppliers can generate Armington elasticities that differ by industry, and Feenstra et al. (2018) note that this effect could be extended to explain different elasticities in a nested Armington structure.

Most models follow the substitution elasticities included in the GTAP Data Base, which were estimated by Hertel et al. (2007). These authors have estimated

[10] Economists have been demonstrating the effects of alternative specifications for over 30 years, from Brown (1987) to McDaniel and Balistreri (2003) to Wunderlich and Kohler (2018). All note that differences in Armington structure and parameterization can generate substantial differences in the estimated effects of trade policy shocks.

sector-by-sector gravity equations using variation in tariffs and transport costs to identify the trade elasticity, including pairwise controls and exporter/importer fixed effects. This study employed customs data from seven countries with high-quality data on transport cost margins (Argentina, Brazil, Chile, New Zealand, Paraguay, USA, and Uruguay) compiled by Hummels (1999). Their estimate of the unweighted average substitution elasticity in the manufacturing sectors is 7. For the services sectors, a substitution elasticity of 3.8 is employed.[11]

There is an extensive literature estimating the trade elasticity, the elasticity of trade values with respect to variable trade costs (equal to the substitution elasticity minus one). Head and Mayer (2014) and Hillberry and Hummels (2013) survey the empirical literature. Head and Mayer recommend a trade elasticity of 5 (implying a substitution elasticity of 6), the median estimate across 32 gravity studies that estimate trade cost elasticities. Similarly, Hillberry and Hummels (2013) note that cross-section and panel estimates focused on foreign-foreign substitution find elasticities equal to 5.0 for the median product.

Head and Mayer (2014) note that gravity equations that employ ratios of bilateral trade to own trade as the dependent variable tend to deliver higher elasticities than those which use levels of bilateral trade with importer and exporter fixed effects. In this literature, normalizing trade flows with trade with self or with other exporters can simplify models and eliminate unobserved terms. Among the ratio-type models, the number of countries used in ratios varies from two to four. Eaton and Kortum (2002) and Head and Ries (2001) use two countries, Caliendo and Parro (2015) use three, and Hallak (2006) and Romalis (2007) use four. Note that several of these papers calculate the dispersion of productivity and not the elasticity of substitution.[12]

When determining which import demand elasticities to use, Hillberry and Hummels (2013) suggest that preferred estimates for estimating welfare and the effects of trade policy in CGE models are those that properly identify the slope of the import demand curve. They note that employing the low elasticities from the macroeconomic real business cycle literature would be "a very bad approximation indeed." Ruhl (2008) explains this "international elasticity puzzle" in which the elasticity in response to changes in exchange rates (typically about unity) is much lower than the elasticity to changes in tariffs. Ruhl's model shows that this finding can be explained if firms do not change export status in response to temporary shocks, while a rise in tariffs (which is viewed as permanent change) induces some exporters to exit the market, generating higher elasticities. Fontagné et al. (2018)

---

[11] Up to Version 5, the GTAP Data Base followed the elasticities from the Sectoral Analysis of Liberalising Trade in the East Asian Region (SALTER) Project based on a literature review and estimates for New Zealand, giving an average of 5.3 across all sectors.

[12] In Eaton and Kortum type models the trade elasticity is equal to the dispersion parameter and the substitution elasticity does not play a role in the equations defining equilibrium.

demonstrate that this puzzle "is worse than you think", since firms absorb about one-third of a tariff hike in their export prices. Similar to Ruhl, Fontagné et al. offer suggestive evidence that trade elasticities rise with the persistence and fall with the volatility of shocks.

Head and Mayer (2014) note that tariff-based estimates are on average higher than those not based on tariffs. While this is certainly well known for the "international elasticity puzzle" just described, substantially lower elasticities are also evidenced in the literature using a structural estimator of import supply and demand elasticities originating with Feenstra (1994). Broda and Weinstein (2006) refined the estimation and used generalized method of moments (GMM) with a constrained grid search to eliminate infeasible estimates (imaginary or less than unity). Soderbery (2015) implements a nonlinear limited information maximum likelihood (LIML) estimator to correct for the upward bias of the GMM estimator in small samples. Feenstra et al. (2018) also note the small sample bias in GMM and instead implement GMM and two stage least squares (TSLS) estimators with additional moment conditions to address the bias. Overall, and as shown in Table 1, we see that these estimates are considerably lower than tariff-based estimates of elasticities, particularly given the high level of disaggregation employed in these studies.

Table 1. Recent estimates of import-import elasticities following Feenstra (1994).

Study	Level of disaggregation (number of products included)	Median estimate	Estimation technique
Broda and Weinstein (2006)	SITC-3 (256 products)	2.2	GMM/Grid search
	10-digit (13,972 products)	3.1	GMM/Grid search
Soderbery (2015)	8-digit (7,633 products)	1.86	LIML/NL
Feenstra et al. (2018)	10-digit (98 products)[13]	3.22	TSLS
		4.05	2-step GMM

Source: Author compilations`s.

2.5 Discussion: Trade elasticity and heterogeneous agents

Head and Mayer (2014) note that structural gravity corresponds to a surprisingly large set of models. A common determinant of trade flows in these models is a bilateral trade accessibility term that combines trade costs and trade elasticities.[14] Many models, such as CES-based Armington-style national product

[13] Feenstra et al. (2018) estimate import elasticities only for a small set of products at the harmonized system (HS) 10 level.

[14] Head and Mayer (2014) note that the gravity equation can be expressed in the form $X_{ij} = GS_iM_jT_{ij}$, where X_{ij} is bilateral trade between importer i and exporter j, G is a constant term (in cross-sectional data), S_i and M_j are importer and exporter specific variables, and T_{ij} is what they term the "bilateral accessibility" term which is a dyadic variable affecting bilateral trade flows.

differentiation, Dixit-Stiglitz-Krugman style monopolistic competition, and Eaton-Kortum models, impose common elasticities across countries. Hence, differences in trade in these models are determined solely by trade costs (as well as the supply and expenditure terms). In contrast, models with heterogeneous agents, either heterogeneous consumers or heterogeneous firms, can exhibit bilateral differences in the trade accessibility terms.

Two recent papers derive theory-consistent methods for quantifying country-pair specific elasticities with heterogeneous suppliers. Bas et al. (2017) develop a model in which elasticities are shaped by exporter participation and thus vary across destinations. Aggregate trade elasticities are a combination of the intensive margin determined by CES demand and the extensive margin driven by the distribution of firm productivity. They find an intensive margin elasticity averaging 4.4 (implying a substitution elasticity of 5.4). Their middle estimate of the aggregate trade elasticity on total flows is 4.79 (which the authors note is close to the median value found by Head and Mayer, 2014), and the difference in coefficients across destination countries is "generally quite large." Spearot (2016) estimates destination-specific effects of trade shocks by allowing Pareto distribution shape parameters to vary by country and industry. Useful to CGE modelers, his effects are estimated at the GTAP sector level. He does not translate his results into elasticities, but shows that the response to trade shocks is determined by industry bilateral trade and tariff matrices in combination with industry-level shape matrices.

We have a better understanding of some puzzles in the elasticity literature, such as why elasticities with respect to exchange rates are substantially below those for tariff rates. Econometric estimates of elasticities have improved substantially in recent years, though some methods impose strong assumptions (most commonly, that elasticities are the same across countries.) Improved estimation techniques have identified many misspecifications and small-sample biases in the original estimators. This has often led to reduced magnitudes – see for example Simonovska and Waugh (2014) and Soderbery (2015). While literature surveys have not examined the change in estimated coefficients over time, it appears likely that magnitudes have fallen over time, with median elasticities of eight, common in the era of Head and Ries (2001) and Eaton and Kortum (2002), seemingly less frequent in recent years. This might have implications for the employed trade elasticities in dynamic CGE models. The average trade elasticity in the GTAP Data Base, based on Hertel et al. (2007), employed by most modelers, is 7 for manufacturing goods. Updating these elasticities based on more recent estimates might lead to a downward revision of the employed elasticities in dynamic CGE models.

2.6 The importance of Armington elasticities in baseline projections

2.6.1 Introduction and setup of simulations

The importance of trade elasticities in general equilibrium modelling is indisputable among modelers and policy analysts (see literature review in previous sub-sections). Although there is a rich literature on the role of trade elasticities in comparative static exercises on for example the welfare gains from trade (Arkolakis et al., 2012 and the literature built on this work) or the welfare effects of trade liberalizations (Costinot and Rodriguez Clare, 2013; Bekkers and Rojas-Romagosa, 2019), there is no research on the role of trade elasticities in dynamic CGE models. To the best of our knowledge, this will be the first attempt to quantify the impact of altering the Armington elasticities on the baseline projection.

For reasons of robustness, we conduct simulations with two different models altering the default GTAP Data Base elasticities by +10% and +20% respectively. The first model is the dynamic GTAP model GDYN[15] and the second model is the World Trade Organization (WTO) Global Trade Model (GTM).[16] The baseline is calibrated to GTAP9.2 data from 2011 aggregated to 15 regions, 15 sectors, and five factors of production. The simulations, running until 2035, are disciplined by macroeconomic projections on GDP per capita growth from the OECD (SSP2) and population and labor force projections from the UN (medium variant). The same projections are employed in the simulations in Sections 3, 4, 5 and 6.

To simulate the impact of changes in Armington elasticities we ran two baseline projection scenarios in addition to the standard baseline with default GTAP Armington elasticities: (i) a baseline with parameters augmented by +10% (scenario 1), and (ii) a baseline scenario including Armington elasticities altered by +20% (scenario 2). It is important to recall, that we have increased both tiers of Armington parameters. That is, we assumed that commodities become more substitutable in both respects: domestic versus imported composites and among import baskets from different geographical origins. So, we have kept the rule of two discussed above.

Figure 1 provides an overview of the sectoral elasticities between domestic and imported goods, i.e. the default GTAP Data Base elasticities employed in the simulations with the two models. The Armington elasticities are the highest in

[15] By incorporating international capital mobility and ownership, GDYN models investment in a richer way than the standard GTAP model, considering changes in wealth. See Ianchovichina and McDougall (2000) for an exposition of the model.

[16] The GTM is a dynamic version of the static GTAP model developed by the GTAP consortium featuring recursive dynamic capital accumulation with various extensions such as variable savings rates (Aguiar et al., 2019). For reasons of comparability with GDYN all the extensions are omitted in the simulations on trade elasticities.

extraction, electrical machinery and transport equipment in all baseline scenarios. The impact of an increase in the Armington elasticities is of course linear by assumption when comparing the default values with the scenarios elasticities.

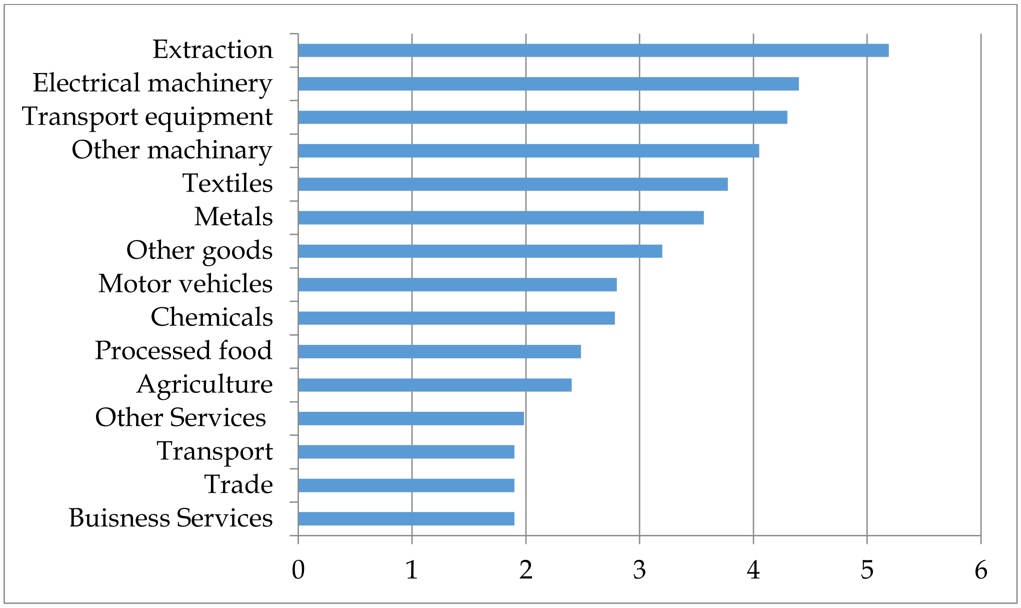


Figure 1. Armington elasticities used in the baseline

Source: GTAP Data Base.

2.6.2 Impact on total trade

Figure 2 displays our simulation results after running the baseline projections and the two scenarios described above with the GDYN model (upper panel) and the GTM (lower panel) for higher values of ESUBD and ESUBM, respectively the substitution elasticity between imports from different exporters and the substitution elasticity between domestic and imported goods. With GDYN total trade is 0.06% lower relative to the baseline in scenario 1 in the first simulation's year (2015) and the difference continues to widen until 2027 when it is 0.46% lower. After 2027 total trade starts recovering until 2035 in which it is -0.13% lower than in the baseline. The results of Scenario 2 are similar to scenario 1, but with a more accentuated gap against the baseline.

The results with the GTM are very different. The value of global trade is projected to be higher relative to the base parameters with the gap widening over time.

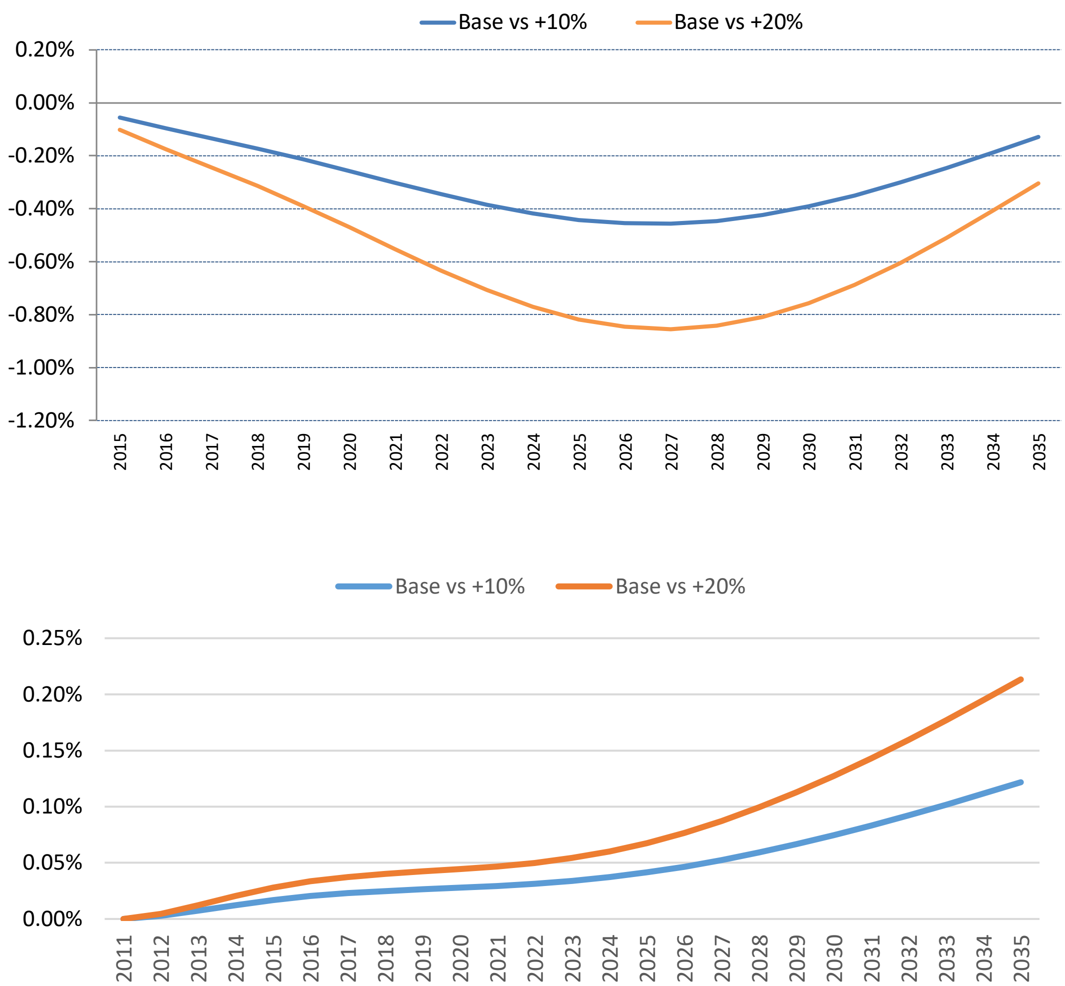
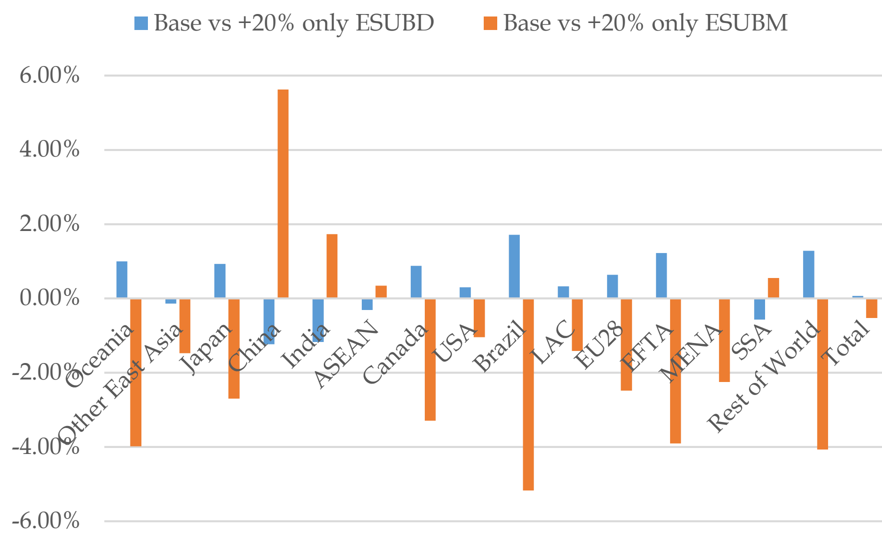


Figure 2. Difference in global export values between base parameters and 10% higher ESUBD and ESUBM and 20% higher ESUBD and ESUBM with GDYN model (upper panel) and GTM (lower panel).

Source: GDYN and GTM modelling results and own calculations.

To understand the large differences between the two models, we focus on the effects by region and furthermore conduct separate simulations with ESUBM and ESUBD. Figure 3 displays the percentage change of exports by region with separately a 20% higher ESUBD and a 20% higher ESUBM, both with the GDYN model (upper panel) and with the GTM. The regional results are remarkably similar. In both models strongly growing countries like China and India raise their exports and thus also their share in global exports with a larger ESUBM, whereas developed countries with lower projected growth such as the European Free Trade

Association (EFTA) and the European Union (EU) reduce their exports. A larger ESUBD instead reduces the export share of strongly growing emerging countries and raises the share of developed economies with lower projected growth. The results show that changing the Armington elasticities in the baseline has non-negligible effects on regional export shares and hence also on regional market shares.



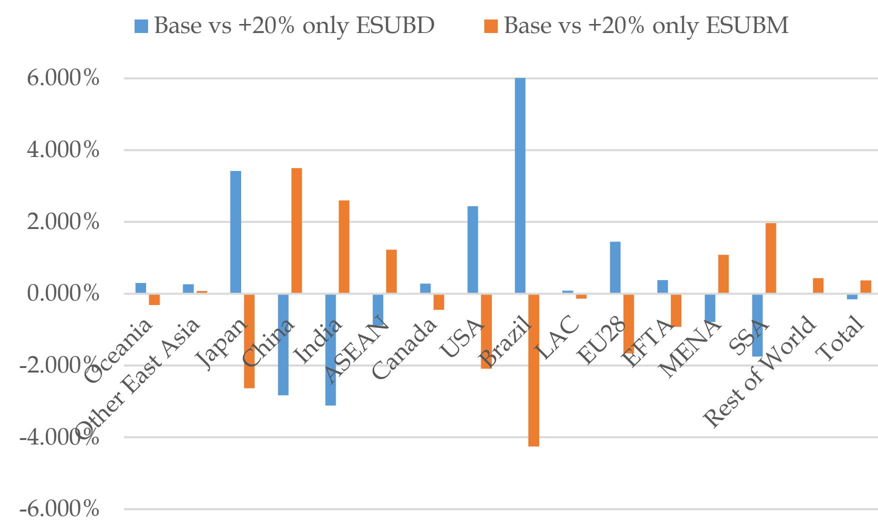


Figure 3. Difference in export values of different regions between base parameters and 20% higher ESUBD and 20% higher ESUBM with GDYN model (upper panel) and GTM (lower panel).

Source: GDYN and GTM modelling results and own calculations.

Intuitively, these results can be explained as follows. With a higher ESUBD, there will be more substitution within strongly growing emerging countries like China towards domestic goods instead of imports. This drives up factor prices in the emerging countries and makes them less competitive as exporters. The result is lower exports. A larger ESUBM instead will lead to more substitution to imports from emerging countries like China displaying strong growth. Therefore, their exports expand.

Next, we return to the aggregate results for the experiments with separate increases in ESUBD and ESUBM with both the GDYN model and the GTM . The shape of the curves in the upper panel of Figure 2 of the simulations with the GDYN model, i.e. the U shape, is largely due to the increase in the second level nest substitution (ESUBM). Further, also the sign of the result at the end of the period would be different. In the case of +20% for ESUBD only, the impact on total trade in 2035 would be positive (+0.07%). In contrast, +20% for ESUBM only, decreases total trade by -0,53%.

The results with the GTM are different. A larger ESUBD reduces the value of global trade, whereas a larger ESUBM raises global trade. Hence, identical patterns at the country level in the two models lead to different results at the global level. The reason is the size of the country results and in particular the share of the different countries in global exports. These shares vary between the two models, which is mainly driven by differences in the way trade balance are modelled. If for example the trade balance of China is projected to improve, then China will export more and hence its increasing trade will get a larger weight in the calculation of global trade changes. These results show the importance of the modelling of the international capital market or the trade balance, a topic addressed in the next section. We find support for earlier findings in the literature, such as McDaniel and Balistreri (2003), who argue that "although the Armington elasticities largely determine the ultimate response, the structure of international capital markets interacts with the Armington elasticities".

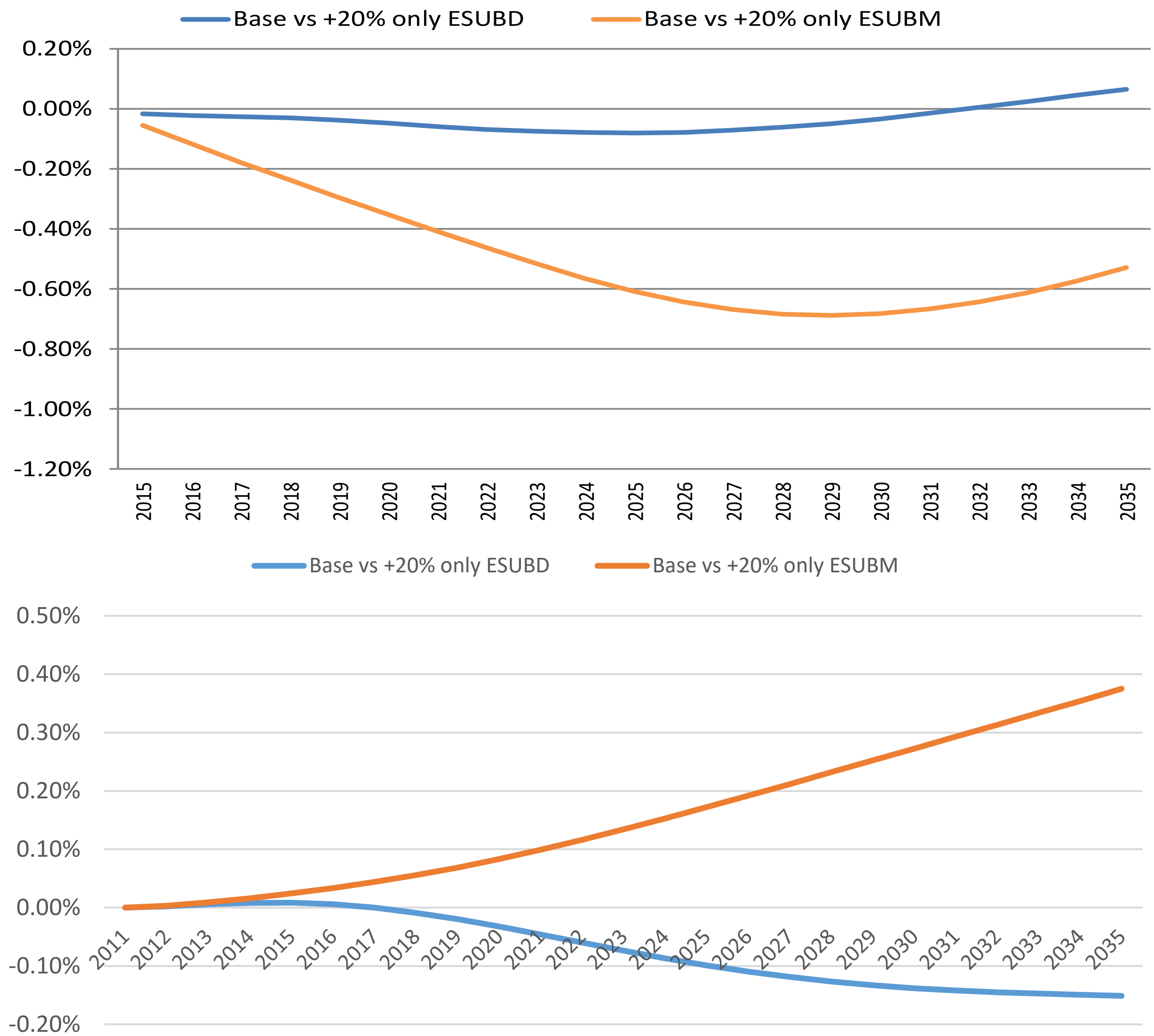


Figure 4. Difference in global export values between base parameters and 20% higher ESUBD and 20% higher ESUBM with GDYN model (upper panel) and GTM (lower panel).

Source: GDYN and GTM modelling results and own calculations.

3. Modelling the trade balance

3.1 Introduction: different ways to model the trade balance

The trade balance is modelled in various ways in dynamic CGE models. The different options can be sketched using the following macro-identity:[17]

$$S - I = X - M \tag{1}$$

In words, the trade balance (exports, X, minus imports, M) must be equal to the difference between savings (S) and investment (I). We abstract in this exposition from possible differences between taxes and government revenues and from other components of the current account such as capital and labor income crossing borders and remittances (discussed below in Section 10). From equation (1), there are three options to model the trade balance. First, both domestic savings and domestic investment are independently determined, so that the trade balance which is on the right-hand side of equation (1) must then follow. An example is one of the default closures in the standard GTAP model (Corong et al., 2017) in which savings are a Cobb-Douglas share of income and global investment is allocated across regions depending on regional rates of return. Another example of this approach is the MIRAGE-Energy (MIRAGE-e) model in which savings rates are determined by demographic factors and income and the change in the investment rate is a function of the change in the savings rate and the difference between savings and investment in the previous period, a Feldstein-Horioka equation, discussed into more detail in Section 3.4 below.

Second, domestic savings and the trade balance can be modelled explicitly, implying that investment follows from equation (1). An example is a closure variant of the standard GTAP model with savings a fixed share of income and the trade balance relative to income fixed. Another example is a nominal trade balance converging to zero over time. Lemelin (2017) points out that a targeted (or fixed) nominal trade balance is not neutral with respect to the choice of numeraire and he suggests fixing the trade balance with respect to a Fisher index of trade prices if the trade balance is fixed in nominal terms (instead of in terms of a ratio).[18]

Third, investment and the trade balance can be modelled explicitly with the savings rate determined by equation (1). An example is ENV-Linkages in which investment, public savings, and foreign savings are modelled explicitly and the marginal propensity to save adjusts in order to satisfy equation (1).

---

[17] This equation follows directly from Y = C + I + G + X - M and Y = C + S + G.

[18] The problem that fixing the trade balance is not neutral with respect to the choice of numeraire can also be addressed by fixing the trade balance ratio instead of the nominal value of the trade balance.

Table A2 provides an overview of the way savings, investment, the current account and the government account are modelled in the 24 models discussed in the workshop "Shaping long-term baselines with CGE models" held at OECD in January 2018 Based on this overview the models are classified into one of the three options for the macroeconomic closure.[19] In seven models, savings and investment are imposed on the model and the current account is a residual variable. In ten models the savings rate and the current/capital account are modelled, and the investment rate is a residual variable. In three models the investment rate and the current account are imposed on the model with the savings rate adjusting accordingly. In five models the macroeconomic closure was not specified.

3.2 Insights from the macroeconomic international finance literature

Useful insights from the international finance literature can be obtained both from (simulation) model-based work and from empirical work. We start with a description of the former. The main difference between dynamic CGE models and models in the international finance literature lies in the treatment of intertemporal decisions. Most dynamic CGE models employ a recursive dynamic structure with agents maximizing utility and profits in each period without taking into account the impact on future periods. Models in international finance instead incorporate intertemporal optimization. This is particularly relevant for the development of the current account which is a function of intertemporal savings and investment decisions.

In the workhorse models in international finance as described, for example, in Obstfeld and Rogoff (1995) the direction of capital flows is determined by differences between the world and the autarky interest rates, which are in turn determined by differences in productivity growth. In particular, a country with an above average growth rate corresponding with a higher than average interest rate is predicted to run a current account deficit. A higher interest rate makes investing attractive for foreigners, thus leading to capital inflows. The intuition in the intertemporal model is that in equilibrium countries will have identical consumption growth. A country with a higher than average growth rate in earlier periods will thus consume more in earlier periods, running a current account deficit. However, empirics do not support the intuition of the standard intertemporal model (Gourinchas and Rey, 2015). Capital flows moved on net from emerging countries to developed countries (in particular the United States) and capital thus moved from high-growth regions to low-growth regions. A wide range of models have been developed in the international finance literature to explain this apparent puzzle, emphasizing various types of financial market

[19] Since we are only interested in the way the trade balance is modelled, the way investment, savings, and the government balance are treated in the different models are not further discussed here.

imperfections depressing the autarky interest rate in emerging countries. As such these models combine a higher than average growth rate in many emerging countries with a lower than average interest rate and current account surpluses in these countries (Gourinchas and Rey, 2015).

For the medium-run to long-run CGE projections the insights drawn from models with financial market imperfections seem less relevant. However, three observations can be made based on the model-based international finance literature. First, intertemporal models come with intertemporal budget constraints, which are usually absent in recursive dynamic CGE models. However, they are important, in particular to prevent countries from embarking on an unsustainable debt path. Second, in intertemporal models anticipation effects can be taken into account, which is not possible in recursive dynamic models. We can think for example of energy taxes, which already affect investment patterns before the taxes are introduced. Given the requirement for a high level of detail in other areas of the model (inclusion of a large number of sectors or a detailed modelling of the energy sector) it seems infeasible to include rational expectations in the model. However, if there is strong policy interest in anticipation effects, it might be worthwhile to employ a model with intertemporal optimization. G-Cubed, the model developed by McKibbin and Wilcoxen (1999) might be a good option in such cases. This model includes intertemporal optimization and intertemporal budget constraints in a medium sized setting.[20] The model is less flexible in some respects than conventional CGE models such as in the choice of Cobb-Douglas consumer preferences across sectors.

Third, in some trade balance closures such as in the standard static GTAP model closure, capital is allocated according to differences in rate of return leading to capital inflows into regions with above average rates of return. This is in line with the direction of capital flows in the intertemporal macro-models. This approach seems to be well-suited for long-run projections from a theoretical perspective, although the empirics of the last 20 years show that capital was flowing predominantly in the opposite direction (from high-growth to low-growth regions).

There is also an empirical macroeconomic literature examining the medium-run determinants of the trade balance. Lane and Milesi-Ferretti (2012) synthesize this work estimating the determinants of the current account in a sample of 65 countries from 1969 until 2008. This empirical framework could be used to discipline the development of the trade balance in projections like the Feldstein-Horioka approach, since many of the determinants of the trade balance in the framework are available in macro-projections in CGE models. In particular, the following determinants could be included. First, a larger GDP growth rate (relative to the average growth rate) is associated with a deteriorating current account in

[20] McKibbin and Wilcoxen (1999) include eight regions and 12 sectors.

emerging countries. Second, the old-age dependency ratio is associated with a worsening current account in emerging countries, because ageing countries tend to dissave.[21] Third, ageing speed defined as the change in the future old-age dependency ratio tends to improve the current account, since ageing in the future requires more current savings. Fourth, the net export position in oil relative to GDP tends to be associated with a more positive current account. And finally, the lagged value of the foreign asset position is associated with a more positive current account through increased capital income. All these variables are available in macro-projections feeding typically into CGE projections, except for the last one, which would be constructed if the model were extended with foreign asset and debt accumulation. Like the empirical approach based on the Feldstein-Horioka relation with changes in the investment rate determined by changes in the savings rate according to an error-correction mechanism, an empirical approach based on the medium-run determinants of the trade balance could be used to discipline the development of the trade balance. In concrete terms, this mean that the trajectory of the trade balance would be imposed on the CGE model based on GDP and demographic projections and the estimated empirical relationships.

3.3 Discussion

The brief discussion of the macro-economic literature gives rise to four useful insights for modelling of the trade balance in recursive dynamic CGE model. First, it is important to account for other items on current account, such as capital income and net transfers. In reality, countries can run consistent trade deficits without problems if this is compensated by for example capital income and we should account for this option in the dynamic CGE models.

Second and related to the first point, it is important to consider the accumulation of net foreign wealth. Britz and Roson (2018) have picked up this issue by including wealth accumulation in their model. However, possibly due to the lack of intertemporal optimization these authors have to include ad hoc adjustments for countries in which income would become unrealistically small.

Third, the requirement that trade balances converge in the long run might be too restrictive, since both other items on the current account and valuation effects play a role. Gourinchas and Rey (2015) summarize the literature on the role of valuation effects, which shows that changes in the value of assets and liabilities can have a significant impact on a country's net foreign asset position. For countries like the United States and the United Kingdom, the net foreign asset position is more favorable than the cumulation of historical current accounts, whereas the opposite holds for countries like China and Russia. Although

[21] China is difficult to explain with this framework, since it is both ageing rapidly and displaying high savings rates. However, the described empirical framework reflects global determinants holding on average.

valuation effects will be hard to model, this literature shows that a sustainable path for the current account does not necessarily require that the present discounted value of future current account balances is equal to zero.

Fourth, insights from the literature on the empirical determinants of the trade balance can be useful in long-run projections of the trade balance of countries. However, for both the Feldstein-Horioka approach and the empirical trade balance approach, researchers should consider that in both cases the empirical model does not generate a perfect fit. In Foure et al. (2013) the sample is split up with the error correction model giving an R^2 of respectively 0.56 and 0.17 for OECD and non-OECD countries. In Lane and Milesi-Ferretti (2012), the fit of the regression model is 0.45 in the main regression with the entire sample. This suggests that the current account also has other determinants and imposing only the estimated empirical model might be too restrictive. An interesting approach could be to combine the empirical model with a rate of return rule for international investment flows or with a converging trade balance. This option will be further explored in the simulations.

3.4 Comparing different approaches: simulations

In this section we compare eight different closures for the trade balance employed in dynamic CGE models. We examine how the different approaches affect the trajectory of the trade balance, the allocation of investment across regions, and the share of different regions in global trade.

The first closure, *Fixed ratio*, fixes the trade balance relative to GDP at its initial level. The motivation for using this closure is that trade imbalances tend to be very persistent historically and the most straightforward way to capture this fact is by fixing the trade balance ratio.

The second and third closures assume that trade imbalances disappear over time. The main motivation for this closure is that in the long run current account imbalances are unsustainable and thus have to be corrected. The second closure, *Converging,* is implemented by assuming that the trade balance ratio falls linearly to zero until the end of the simulation period, 2040.[22] In the third closure, *Fixed value*, the value of the trade balance is fixed, which implies that the trade balance ratio is falling over time because of growing economies.

A fourth more sophisticated closure, *Feldstein-Horioka*, related to the first is to impose that the trade balance follows a Feldstein-Horioka relation in which the investment-GDP ratio is proportional to the savings-GDP ratio. Following the approach in Fouré et al. (2013) we impose that the change in the investment rate in country i in period t, $\Delta \frac{I_{it}}{Y_{it}}$, can be written as a function of the change in the

[22] As a variant a modeler could impose that the trade balance ratio converges to zero at a slower rate, for example only by 2100.

savings rate, $\Delta\frac{S_{it}}{Y_{it}}$, and an error correction term, which is a function of the difference between the lagged level of investment, $\frac{I_{it-1}}{Y_{it-1}}$, and the lagged level of savings, $\frac{S_{it-1}}{Y_{it-1}}$:[23]

$$\Delta\frac{I_{it}}{Y_{it}} = \alpha_i + \beta_i\left(\frac{I_{it-1}}{Y_{it-1}} - \zeta_i - \kappa - \gamma_i\frac{S_{it-1}}{Y_{it-1}}\right) + \delta_i\Delta\frac{S_{it}}{Y_{it}} \tag{2}$$

α_i is a country fixed effect, κ and ζ_i are respectively a constant and a country specific term in the error correction term, and β_i and δ_i are country specific coefficients.

For the four closures outlined so far, we have to take into account that the trade balance cannot be fixed in all n regions, as this would imply that global savings would not be equal to investment. We can call this the n-th region problem. In the first, second, and fourth closure we simply do not impose the closure in one of the regions, Rest-of-World. For the Feldstein-Horioka closure the model crashes if the n-th region is Rest-of-World, because this region is too small to absorb the implied differences between savings and investment in the other regions according to the Feldstein-Horioka rule. Hence, we follow the approach of the MIRAGE-e model in which excess investment in the n-th region, Rest-of-World, is reallocated to the other regions in proportion to the share of each of the regions in global investment. In practice this means that the difference between investment in the n-th region to balance global savings and investment and investment predicted by the Feldstein-Horioka rule in the n-th region is reallocated to all n regions in proportion to the share in initial global investment of all regions.[24] In equation (2) this approach implies endogenous country fixed effects, such that the changes in investment in all regions adjust to guarantee that investment rates comply approximately with the Feldstein-Horioka rule in all regions.

The fifth and sixth options consist of the closures in the standard static GTAP model. In the fifth closure, *Rate of return rule,* the global bank allocates investment across regions such that expected rates of return equalize. This closure implies that capital is flowing on net to countries with an above average rate of return. Henceforth, this rule follows the logic of the macro-economic intertemporal optimization models in which countries with a high rate of return tend to run a current account deficit, thus receiving net investment flows. In the sixth closure (the other static GTAP model closure), *Initial shares rule,* global investment is allocated proportionally across the regions.

[23] We work with the coefficients estimated by Fouré et al (2013), which are different for OECD and non-OECD countries.

[24] In Foure et al. (2013) this approach is coded in the macro-econometric model whose outcomes feed into the dynamic CGE-model MIRAGE-e. In the current simulations this closure is coded directly in the WTO GTM.

Finally, in the seventh and eight closure we combine the Feldstein-Horioka closure with the rate of return closure, inspired by the fact that the Feldstein-Horioka relation empirically explains only a share of the variation in the investment rate. Therefore, the change in the investment rate is modelled both as a function of the change in the savings rate and an error correction term as in equation (2) and as a function of the difference between the global rate of return and the national rate of return as in the fifth closure. The share of each of the components can be varied in the simulations. In the work presented below, the share of the Feldstein-Horioka component is set equal to the R^2 of the Feldstein-Horioka relation estimated in the empirics. In the seventh closure, Combined *FH ROR*, the coefficients of the Feldstein-Horioka relation are as in the original Feldstein-Horioka closure. Hence, the equation for the change in the investment rate is a linear combination of the expressions for the change in the investment rate in the two underlying closures.

In the eighth closure, *Combined FH (adj) ROR*, the coefficients of the Feldstein-Horioka component are adjusted to account for the fact that the change in the investment rate is only determined in part by the Feldstein-Horioka relation. Instead, the coefficients have been set such that the Feldstein-Horioka relation estimated with the simulated data aligns with the empirically estimated coefficients. In both the seventh and eighth closure the nth region is Rest-of-World and in both cases the same approach is followed for the n-th region as for the pure Feldstein-Horioka closure. Hence, excess investment in the n-th region (the difference in investment to balance global investment and global savings and investment to satisfy the described closure) is reallocated to all regions.

The eight closures are implemented in the WTO GTM, a dynamic version of the static GTAP model developed by the GTAP consortium and extended with various features such as endogenous savings rates, differential productivity growth, and adjusting preferences. Like in the other simulations the baseline is calibrated to GTAP9.2 data from 2011 and the baseline projections also used for other simulations as described in Sections 2, 3, 4, 5 and 6. We include adjusting savings rates as a function of demographic factors and income following the specification in Fouré et al. (2013), since the impact of changing savings rates on trade outcomes is likely to differ considerably between the different closures.

3.5 Results of the simulations

We start by showing the impact of the different closures on the development of the trade balances of the different regions. Figures 5A and 5B display the trade balance over time for the eight closures described in the previous subsection (in the same order as presented) for all the fifteen regions, leading to a set of valuable insights.[25] First, the figure shows that the trade balance is very erratic for some closures, in particular for the Feldstein-Horioka rule, the rate of return rule, the initial shares rule, and the combinations of Feldstein-Horioka and rate of return rules. For the rate of return rule this erratic behavior can be explained from the fact that the initial distribution of international investment flows and thus the implied trade balances do not match with the distribution of investment according to differences in rate of return. For the Feldstein-Horioka closure the erratic behavior in the first years seems to be driven by the fact that initial imbalances are big and the error correction term in equation (2) works in the opposite direction compared to the change in the savings rate term. The figure also shows that the combination of the rate of return and Feldstein-Horioka rule displays trade balance ratio patterns close to the rate of return rule.

Second, the rate of return rule generates relatively stable trade balance ratios after the first years. Under the rate of return rule international capital flows towards regions with the highest rate of return. A priori, this should lead to a disconnect between domestic savings and domestic investment and thus both potentially large trade imbalances and erratic trade imbalances. However, the figure shows that trade balances are not erratic and tend to stabilize over time.

Third, as pointed out in the previous subsection, for all trade balance closures except for the rate of return rule and the initial shares rule the chosen closure cannot be followed for one of the regions, the n-th region problem. Hence, the disadvantage of all the closure rules requiring an n-th region is that the trade balance of the n-th region could generate peculiar behavior. Figure 5A shows that for the fixed ratio and converging closure the n-th country displays very different behavior compared to the other regions. The results for the fixed ratio closure show that with fixed initial ratios in n-1 regions, the trade balance turns from positive to negative for the n-th region, indicating that global savings exceed global investments in the n-1 regions requiring a deteriorating trade balance in the n-th region. Instead, with a fixed trade balance value closure the trade balance has to improve in the n-th region. If the n-th region is not of much interest for the research questions at hand, the n-th region problem does not pose a compelling argument against the use of the fixed ratio and fixed value closures in our simulations.

---

[25] Annex Table A.1 contains the results in table format for the eight closure rules, displaying the initial trade balance ratio in 2012 and the final trade balance ratio in 2040 for all eight closure rules.

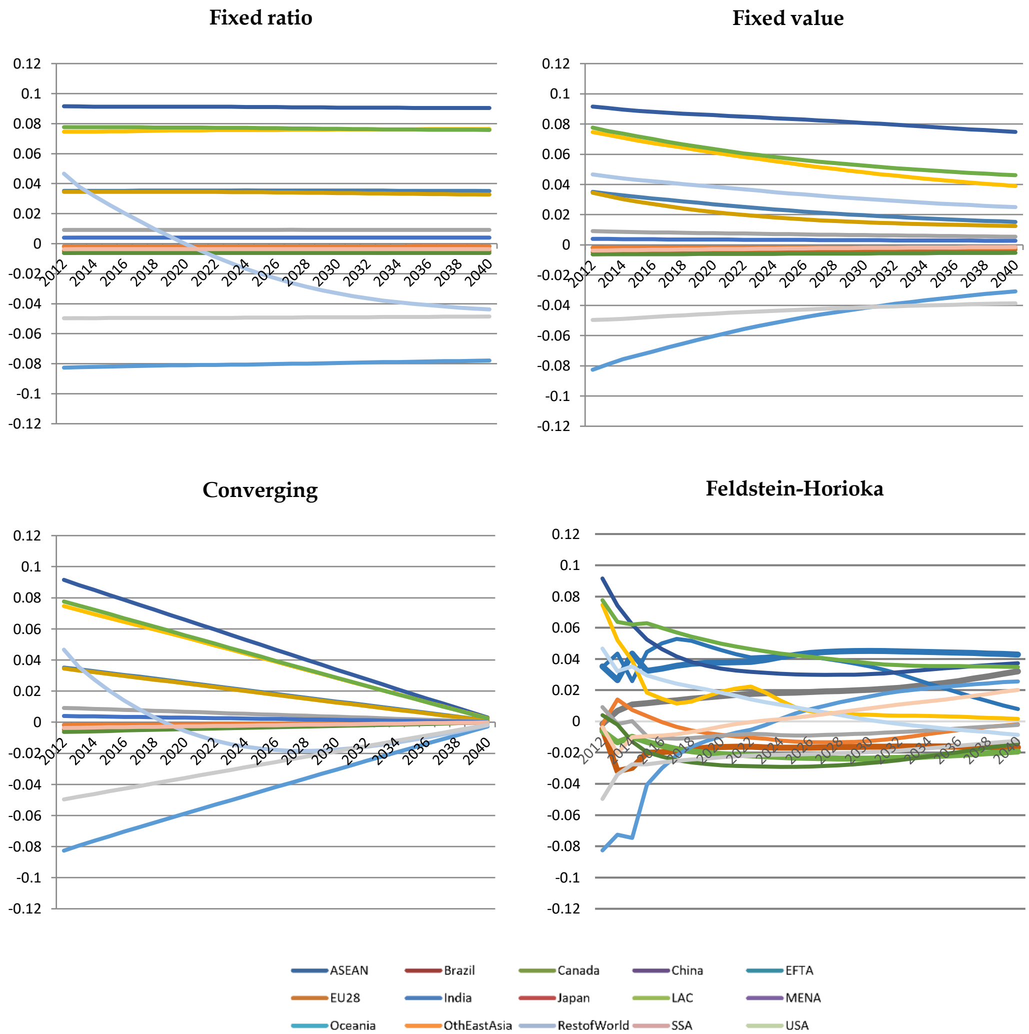


Figure 5A. Trajectory of trade imbalances in different regions for different initial and terminal condition closures**.**

Source: Own simulations with WTO GTM.

Figure 5B shows furthermore that for the Feldstein-Horioka rule the trade balance of n-th region, Rest-of-World, does not deviate drastically from the pattern under for example the rate of return rule. The trade balance in Rest-of-World turns from positive to slightly negative. The same pattern is observed for the combined rules, Combined FH ROR and Combined FH (adj) ROR.

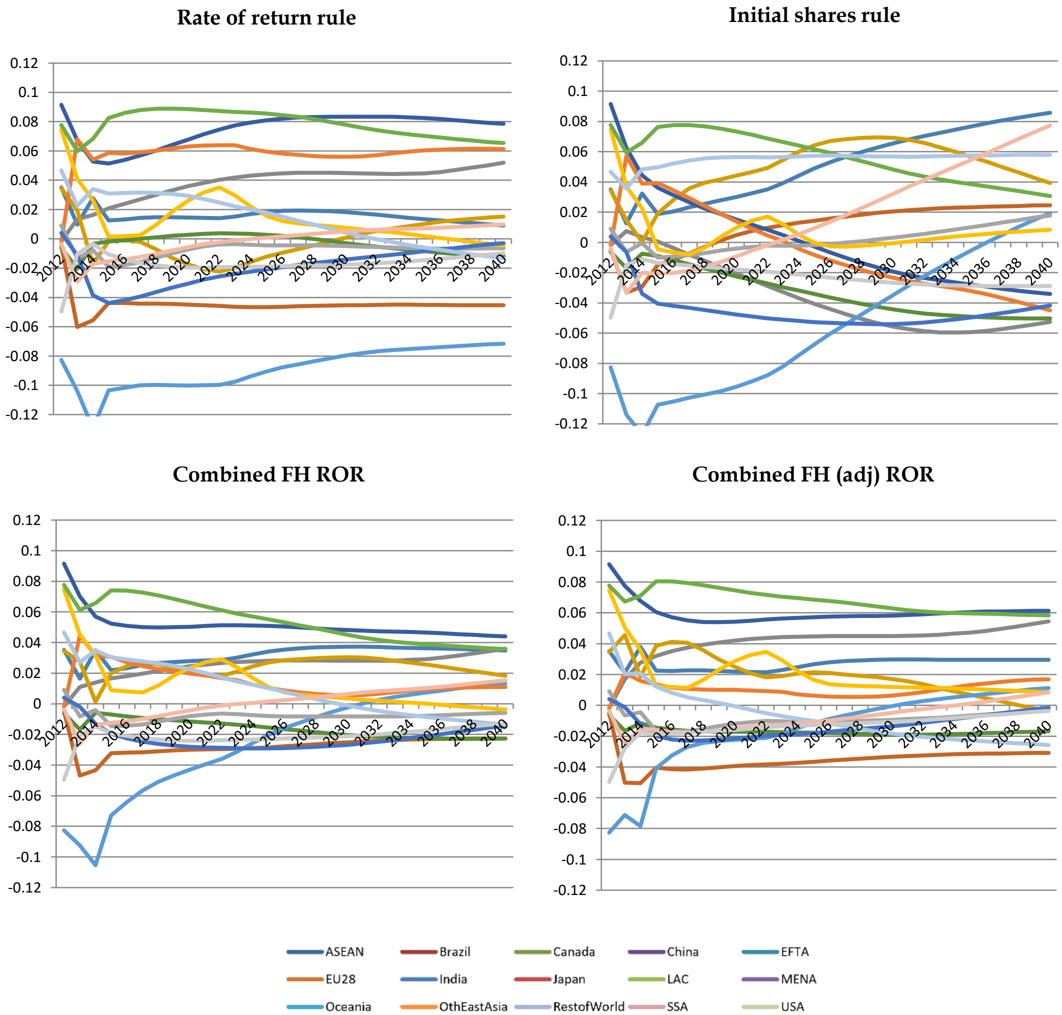


Figure 5B. Trajectory of trade imbalances in different regions for rate of return and Feldstein-Horioka closures.

Source: Own simulations with WTO GTM.

Next, we examine to what extent trade imbalances shrink over time in the different closures. In particular, we display the GDP weighted average of absolute trade balance ratios from 2011 to 2040 in Figure 6. The figure makes clear that there is a clear ranking of closures in terms of convergence of global trade balances. Obviously, the average trade balance converges to zero for the converging trade balance rule. For the fixed value and Feldstein-Horioka rule, the weighted average trade balance also tends to converge. On the other hand, the initial shares rule generates increasing average trade imbalances. The figure makes clear that the rate of return closure also leads to converging average trade balances, although to a much lesser degree than the Feldstein-Horioka rule. As expected, the trade imbalances for the two combinations of closures are in between the separate closures (Feldstein-Horioka and rate-of-return).

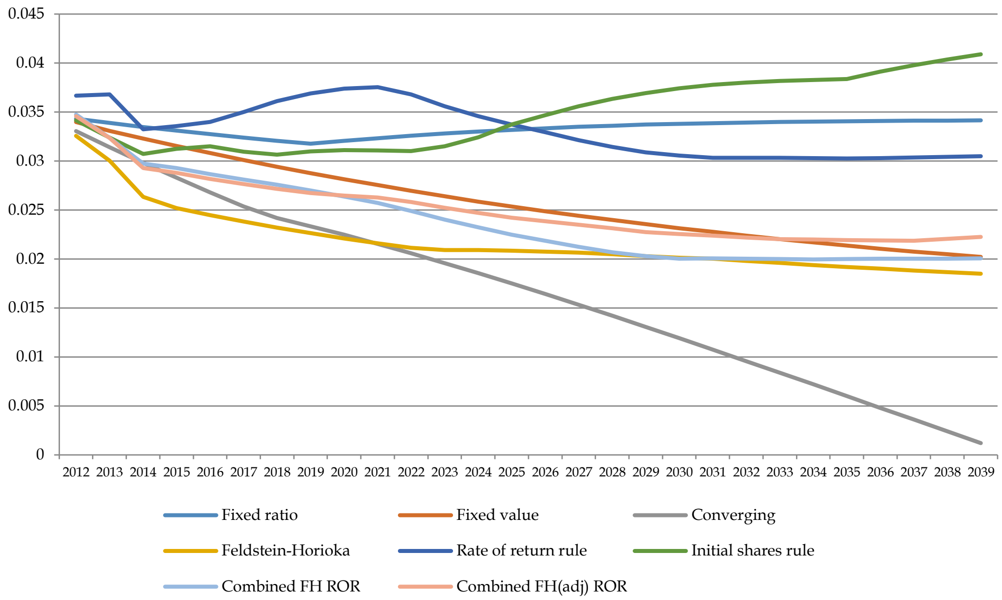


Figure 6. Development of GDP weighted average of absolute trade balances under different closures.

Source: Own simulations with WTO GTM.

Figure 7 shows the change in the trade balance ratio from 2012 to 2040 for some of the largest regions and for the average of the initial deficit and initial surplus countries. The figure makes clear that for most closure rules the trade balance of initial deficit countries improved, and the trade balance of initial surplus countries deteriorates, in line with the picture emerging from Figure 6 that absolute trade imbalances tend to decline. Turning to the individual regions, we see that except for the initial shares rule all closure rules imply little change for the trade balance of the European Union. For China and the United States, most of the closure rules project instead that the trade balance will tend to improve for the United States and deteriorate for China, thus contributing to global convergence of trade imbalances. It seems remarkable that the adjusted combined FH-ROR rule generates both larger increases in the trade surplus for the United States and larger reductions in the trade surplus for China than the separate Feldstein-Horioka closure and the rate of return rule. This is due to the calibration of the Feldstein-

Horioka parameters in the second combined rule, adjusting the Feldstein-Horioka parameters such that the savings and investment ratios generated with the simulations comply with the empirically estimated coefficients, as described in the previous subsection. The coefficient on the error correction mechanism is adjusted upward, such that the Feldstein-Horioka component of the combined rule leads to more convergence between savings and investment. At the same time the forces of the rate of return rule also generate an improvement in the trade balance of the United States and a deterioration of China's trade balance. The reason is that under this rule the United States is projected to channel more net investment funds to emerging economies with higher projected growth rates and thus higher rates of return. In China instead the savings rate is projected to fall stronger than the investment rate, leading to more net capital inflows (and thus a deteriorating trade surplus) under the rate of return rule.

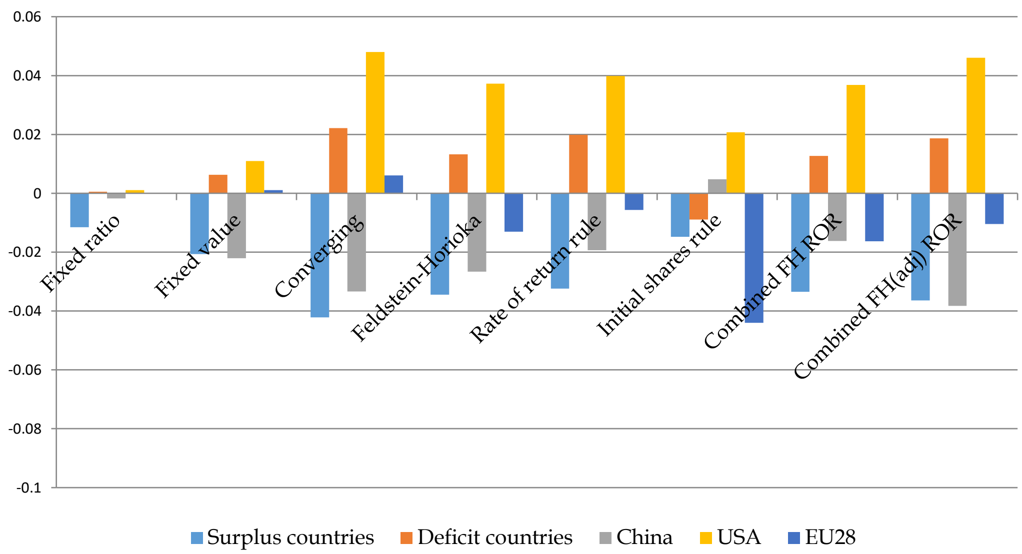


Figure 7. Change in the trade balance in selected regions from 2011 to 2040 in percentage points.

Source: Own simulations with WTO GTM.

Next, we explore how the export share of different regions in global exports is affected by trade balance closures, an often-displayed statistic in dynamic trade simulations. Figure 8 displays the change in the share of exports in global exports in percentage points from 2011 to 2040 for the United States, China, and the initial surplus countries. Reflecting differences in growth rates, the share of China in global trade is projected to rise under all closures and the share of the United States projected to fall. But while the reduction in the share of the United States only ranges between 2 and 4 percentage points for the different closures, the rise in the share of China shows greater variability. Under the Feldstein-Horioka rule the share of China in global trade rises by about 2 percentage points; under the fixed initial trade balance ratio and the rate of return rule, the share rises by about 4 percentage points; and under an initial shares rule by more than 4 percentage points. Furthermore, the countries that start off with trade surpluses tend to see their share of global trade rise with a greater degree of variability across the different rules.

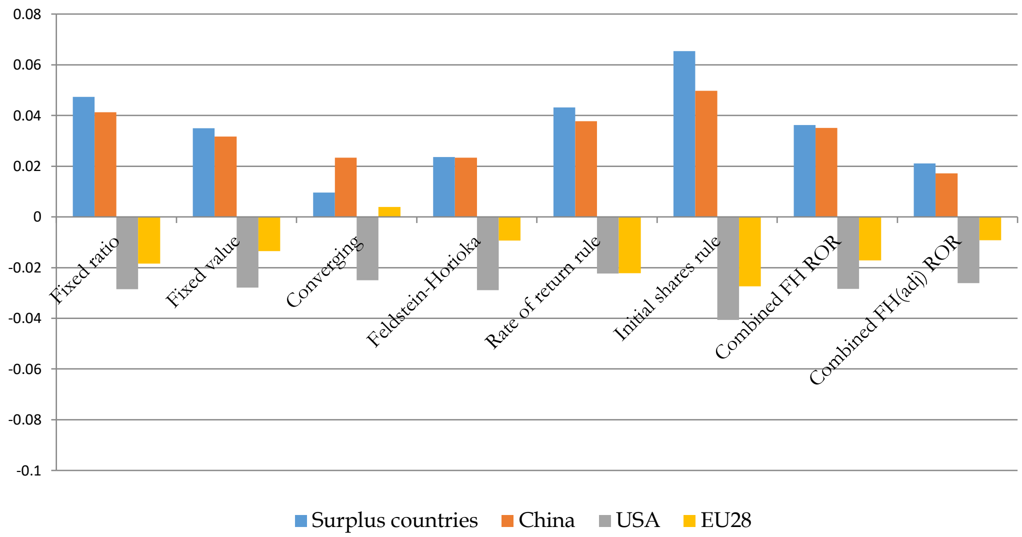


Figure 8. Change in the global export share of selected regions from 2011 to 2040 in percentage points.

Source: Own simulations with WTO GTM.

3.6 Concluding remarks and discussion

The trade balance is modelled in a variety of ways across models: in most models both the savings rate and the trade balance are fixed with domestic investment the residual variable; in some models the savings rate and investment rate are modelled with the trade balance the residual variable; and only in a few models are the investment rate and trade balance imposed with the savings rate as residual variable. Simulations with eight different macroeconomic closure rules show that they lead to widely varying outcomes, not only in terms of the trade balance but also in terms of the share of exports of different regions in global exports. It is not possible to determine which macroeconomic closure is preferable based on the analysis and different research teams make different choices. Three guiding principles play an important role in the choice of a macroeconomic closure. First, intertemporal budget constraints should be satisfied (dynamic consistency). Second, international investment flows should be consistent with empirics. Third, international investment flows should be in line with intertemporal optimization. An ideal macroeconomic closure would satisfy all three principles. However, the guiding principles are sometimes conflicting (models based on intertemporal optimization generate counterfactual predictions such as capital flows moving on net from developed to emerging countries) and may also be difficult to meet, because models would become too complicated (intertemporal optimization) or because data-sources are lacking (keeping track of net debt and asset positions).

Different researchers make different choices based on the weights attached to the different principles. Obviously, the ideal way to deal with dynamic consistency is to keep track of net foreign debt and asset positions and also model the implied capital income. However, this is technically challenging and also requires data on capital income and foreign debt positions which are not readily available in the CGE community. It is imperative to invest more resources in the collection of these data. An imperfect alternative to deal with dynamic consistency is to impose a converging (or nominally fixed) trade balance. This would also mean that countries are precluded from living perpetually beyond their means, since trade deficits converge to zero. Dynamic consistency is an important argument for imposing convergence in trade balances.

The models that include intertemporal optimization obviously value this principle. However, such models are either single country (Intertemporal General Equilibrium Model, IGEM) or feature a limited number of sectors (G-Cubed). Most dynamic CGE models omit this feature. Intertemporal optimization seems mainly important for modeling anticipation effects of policy changes. Furthermore, as discussed in Section 3.2 standard models with intertemporal optimization lead to counterfactual predictions such as capital flows moving to rapidly growing emerging countries. An imperfect alternative to modeling intertemporal optimization is to work with a rate-of-return rule in which international investment flows respond to economic incentives and move from slowly growing regions with low rates of return to strongly growing regions.

Finally, models based on the Feldstein-Horioka rule for investment flows emphasize consistency with empirics. Such approaches could be extended by taking into account other medium-run determinants of trade balances such as economic growth rates, demographics, and oil-dependency. In this paper we have also explored the possibility of combining the empirical approach based on the Feldstein-Horioka rule with an incentives approach based on the rate of return rule. An alternative could be to start with an empirical approach to construct the baseline and then to employ an incentives approach in the policy experiments.

Based on the discussion we conclude with four remarks. First, including intertemporal optimization is technically challenging, might create counterfactual outcomes and seems only necessary if it is important to capture anticipation effects. Second, the choice between converging trade balances, empirically based rules, and incentive-based rules depends on the importance researchers attach to different criteria. However, converging trade balances seem to lack an empirical basis and ideally the problem of dynamic consistency should be resolved in a different way as explained in the next point. Third, more research on modelling intertemporal budget constraints in dynamic CGE models is necessary. This involves modelling net foreign debt and asset positions and implied capital income flows and should be accompanied by better data collection of both foreign asset positions and capital income flows. Fourth, the empirical approach can be extended and there is scope for combining the empirical approach with more incentive-based approaches such as the rate of return rule, which, after further testing, could be a good candidate for best practice. Related to the empirical approach, model coupling could be a fruitful approach. Projections on the trade balance from another model (such as for example G-Cubed) would in such an approach serve as an input into the dynamic CGE model.

4. Modelling of trade growth

4.1 Introduction

The potential impacts of a trade agreement, as well as other policy shocks, are dependent on the baseline level of trade, the latter being determined by the relative size of countries and trade costs. However, trade-related determinants are not very often dealt with explicitly in the baseline. Among the 24 models reviewed in this special issue, only seven include explicit trade-related trajectories in their baseline. These assumptions are either related to trade policies, as in Modular Applied GeNeral Equilibrium Tool (MAGNET) or MIRAGE-e which include mainly EU trade policies in their baseline or are related to transportation costs. The assumptions on transportation cost range from very simple rules of thumb (e.g. ENV-Linkages and the ENVISAGE assume a 1% decrease in transportation costs; MIRAGE-e optionally assume 2% more TFP growth in the transportation sector compared to other services), to the introduction of a specific transportation module focused on international freight, as in the Asia-Pacific Integrated Modeling (AIM) model and ImaclimR.

The purpose of this section is firstly to identify whether the lack of trade-specific assumptions has large consequences for model results using an illustration with the MIRAGE-e model, and secondly to open the discussion on implementable solutions.

4.2 Do CGE models accurately reproduce trade stylized facts?

One of the most common uses of CGE models is to evaluate the impact of a potential trade agreement over time. This raises two issues, as suggested by any gravity setting: i) the change in the size of the exporting and destination country; and ii) the expected changes in the world matrix of trade costs.

Thus, having a proper representation of world trade in the baseline is key to properly assessing the impact of a trade agreement in the medium-run, e.g. 2030 or 2040. The impact of lowering tariffs on a specific bilateral trade flow is likely to be greater if the trade flow in the baseline is large.

A useful test of the credibility of a trade baseline is the implied elasticity of trade to GDP growth. Table 2 summarizes the average apparent trade-to-income elasticity, i.e. the ratio of the growth rate of trade flows over the growth rate of world GDP by decade, both measured in volume terms. This is the unconditional elasticity, as opposed to the elasticity estimated within a gravity framework that would be close to unity and controls for a series of factors impacting trade. This apparent elasticity includes uncontrolled determinants beyond country size, distance or free trade agreements.

Table 2. Estimated world trade-to-income elasticity by decade, goods only, 1950-2017.

1950-63	1964-69	1970-79	1980-89	1990-99	2000-09	2010-17	1950-2017
1.64	1.67	1.53	1.26	2.48	1.45	1.51	1.54

Source: Authors calculation from WTO total trade volume indices and WDI GDP growth.

Two key stylized facts can be drawn from Table 2. First, on average, trade grows much faster than world GDP, around 50% faster since 1950. Second, the trade boom observed in the 1990's is the exception, not the rule.

Can a CGE model reproduce such a long run apparent elasticity "out of the box"? To illustrate this issue, we use the MIRAGE-e model, which has a similar structure to many other models such as the standard GTAP model . We use the standard aggregation, and build a baseline trajectory up to 2040 with MIRAGE-e standard assumptions, which include a carefully designed baseline trajectory built to be consistent with a macroeconomic growth model (Fouré et al., 2013), matching the GDP and population trajectory from EconMap SSP2 (Fouré and Fontagné, 2014) in the model. Any other baseline determinant is kept constant (skill level, savings rate, current account, energy productivity, etc.).

The results of this simple test are clear-cut: a simple baseline fails to reproduce the expected trajectory of world trade and may jeopardize any credible trade policy evaluation. Indeed, the trade-to-income elasticity stemming from such an exercise with the MIRAGE-e model is 1.10 for the period 2011-2040, which is much lower than any observed value in the past 70 years or so. In the rest of this section, we try to identify key determinants of the elasticity that are relatively easy to implement in a CGE model and which are likely to help in designing a trade baseline reproducing the observed or apparent trade to income elasticity.

4.3 The determinants of world trade growth

Usual determinants of trade such as relative prices, exporters' capabilities, expenditure at destination, distance and tariffs are present in CGE models as in any structural gravity model. We now examine other determinants that are not present in the standard structure of CGE models, which impact trade and must be integrated in one way or another in the trade baseline before performing the evaluation of any trade agreement.

4.3.1 Historical determinants

The exceptional trade growth in the 1990's has been documented in the literature (Freund, 2009) identifying two main drivers. First, world value-chains were being "fragmented" and second, large contributors to world GDP growth such as China chose export-oriented growth models. However, these two phenomena are more outcomes of other determinants than drivers of accelerated trade growth: would value-chains have been fragmented if tariffs and transportation costs had remained high?

From a broader perspective, several fundamental determinants may have been at the root of both the trade boom in the 1990's and the high trade-to-income elasticity since 1950. First, transportation costs have decreased over time, and historical data provide us with specific explanations. Energy prices, and in particular real oil prices, have been decreasing on average, reducing the costs of physical transportation. For instance, BP (2018) indicates an average annual decrease by 3.2% between 1980 and 2004. Correcting for the impact of oil price shocks and starting in 1950, oil prices display an annual decrease of 1.96% between 1950 and 2004. In addition, productivity breakthroughs have occurred in the transport sector, in particular the containerization of sea transportation and the development of air transportation. This is more a question of technology than of transportation prices, which did not decrease substantially between 1974 and 2004 (Hummels, 2007). However, quantifying the impact of containerization is not straightforward. Wolff (1999) for instance points out that the growth of total factor productivity in the transportation sector was on average 2 percentage points ("p.p.") higher compared to other services between 1958 and 1987.[26] More recent estimates of the impact of containerization were also provided by Bernhofen et al. (2016). The authors quantify the growth in North-North trade that could be attributed to containerization between 1962 and 1990 at 17.3% per annum.

Second, trade policies have also significantly reduced trade costs. Based on tariff data from Deardorff and Stern (1983), we estimate the decrease in tariff rate to around 4% per annum between 1973 and 2004. In addition, trade costs in a broad sense (time, red-tape, quality of communications) have also been decreasing due to factors such as trade facilitation initiatives (see, for example, Moïsé and Sorescu,

[26] It should be noted that this measure is not supported by more recent data such as the European Union level analysis of capital (K), labour (L), energy (E), materials (M) and services (S) inputs (EU-KLEMS).

2013).[27] The fall in communication costs is in particular identified as an important driver for the expansion of value chains and the trade boom in the 1990s (Baldwin, 2011). These determinants of trade are typically parametrized in CGE models, including MIRAGE-e, and can easily be incorporated in baseline projections.

4.3.2 An illustration with MIRAGE-e

To illustrate how those fundamental drivers of trade impact on the baseline, a series of scenarios is constructed that successively add new elements to the standard specification of the MIRAGE-e model.[28] To draw conclusions about the impact of energy prices on trade, we augment the standard aggregation by adding five energy goods (coal, crude oil, gas, electricity, and petroleum and coal products).

We include alternative assumptions for three of the above discussed determinants:

- Total factor productivity (TFP) in the transportation sector: we consider two alternative assumptions on productivity growth: 4 p.p. or 0 p.p. above TFP growth in other services sectors
- Tariffs: two alternatives are proposed, either with no reduction over time or a reduction by 4% annually.
- Energy prices: we alternatively propose no specific assumption (prices adjust according to the model specifications) or an exogenous trajectory reproducing past stylized facts (3% yearly reduction of prices for oil, constant prices for gas and coal).

Combining these assumptions, we will provide five baseline exercises:

- *Standard*: default transport TFP, tariff and energy price assumptions.
- *TFP*, *Tariffs"*, *Energy prices*: each of the alternative assumption is introduced one at a time.
- Historic: transport TFP, tariff and energy price alternative assumptions are considered jointly.

[27] Another potential determinant of the high historic trade-to-income elasticity could be structural change, i.e. the shift of the economy from agriculture and manufacturing to services as countries grow richer. Since services are on average less tradable and display lower productivity growth, structural change might have contributed to the high trade-to-income elasticity. Manufacturing and agriculture display above average productivity growth and thus grow more than average GDP. These components of GDP are also more tradable, thus leading to higher growth of trade than GDP and thus a trade-to-income elasticity above one. We leave this topic to further research.

[28] We focus exclusively on global trade growth and the global trade-to-income elasticity. Due to space limitations we do not consider trade growth at the regional level.

Table 3 summarizes the results obtained for the apparent trade-to-income elasticity between 2011 and 2040. First of all, when no specific assumptions are made ("Standard" baseline), the figures are far lower than the observed elasticity in past decades, at 1.10 for goods. Among the three determinants tested, the most important one is energy prices, followed by tariffs and finally TFP in the transportation sector. Altogether, these three assumptions based on historical figures for each ("Historic" baseline) lead to a trade-to-income elasticity for goods at 1.33. Compared to the figures in Table 2, this is roughly around the lowest elasticity observed in the past decades, which is better but not sufficiently representative to be considered realistic.

Table 3 also shows that these three determinants are impacting manufacturing more than services (the elasticity is higher for goods than for total trade). This is relevant, as services require less transportation, are thus less dependent on energy prices, and are not directly impacted by tariffs (but rather only by the price of the inputs they import).

Table 3. Estimated world trade-to-income elasticities 2011-2040 under alternative assumptions (MIRAGE-e).

Baseline	Assumptions on			Elasticity of global trade to GDP	
	Energy prices	Transport TFP growth	Tariffs cuts	Goods	Total
Standard	**Endogenous**	**0 p.p.**	**0%**	**1.10**	**1.08**
Energy prices	-3% yearly (oil); Constant (coal, gas)	0 p.p.	0%	1.24	1.20
TFP transport	Endogenous	4 p.p.	0%	1.13	1.12
Tariffs	Endogenous	0 p.p.	4% yearly	1.17	1.14
Historic	**-3% yearly (oil); constant (coal, gas)**	**4 p.p.**	**4% yearly**	**1.33**	**1.29**

Source: Own calculations using MIRAGE-e.

One of the main components of trade costs has not yet been investigated: the trade-restrictiveness of non-tariff measures. Could they represent the missing link that would allow CGE models to replicate historical stylized facts? To illustrate this issue, we start from the "Historic" scenario mentioned above (see bottom row of Table 3), and add a reduction in trade restrictiveness of non-tariff measures, which is calibrated in MIRAGE-e as the sum of ad-valorem equivalents (AVEs) for non-tariff measures (NTMs) on goods as estimated by Kee et al. (2008) and the AVE of time spent in customs as estimated by Minor (2013), using the methodology by Hummels and Schaur (2013). To the best of our knowledge, there is no evaluation of the potential reductions that occurred in the past decades, so we will implement a yearly reduction that is uniform across both regions and sectors within primary and manufacturing sectors,[29] and that ranges from 0% to 20% of the previous year AVE, the latter corresponding to an almost complete fade out in 2040 (independently from the initial trade restrictiveness level). Results in terms of world trade-to-income elasticities are presented in Figure 9.

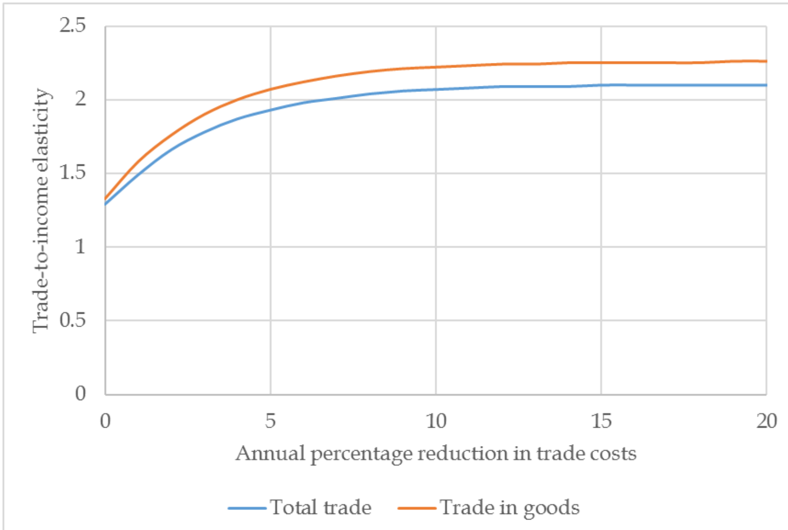


Figure 9. World trade-to-income elasticity 2011-2040 as a function of non-tariff trade costs reduction

Source: own calculations using MIRAGE-e.

Our results are two-fold. On the positive side, a decrease in non-tariff trade costs by less than 1% a year is able to reproduce an average trade-to-income elasticity of 1.54. This suggests a meaningful rule-of-thumb for calibrating trade cost reductions in the baseline. On the negative side however, it is impossible to reproduce a trade elasticity as observed in the 1990's (2.48) keeping reasonable ranges for trade determinants. A complete, and arguably unrealistic, phasing out of non-tariff trade costs would only imply an elasticity of 2.26 for goods trade, which is below the one observed in the 1990s. Once again, trade in services is less impacted by our scenarios because it is only indirectly affected by NTMs on goods through its inputs.

4.4 Key takeaways and recommendations

Our literature review and illustrations have shown that CGE models can be calibrated to obtain baselines exhibiting a credible trade to income elasticity in the long run. Combining a 4 p.p. excess TFP growth in transport technologies, a 3%

[29] We did not consider any reduction in services NTMs because our main interest is to compare our simulation results with past data which are only available for trade in goods.

yearly drop in the real price of oil, the observed annual reduction in tariffs between 1973 and 2004 and a modest reduction in NTMs we reproduced with MIRAGE-e the observed long-term trade to income elasticity, with the notable exception of the 1990s (characterized by a general split of the value chains).

This leaves two difficult questions open. First, the determinants we identified here should still be interpreted with some caution. In particular, there is no empirical evidence of a downward trend in Non-Tariff Measures which could justify imposing a 1% yearly decline in the projections. More empirical work is needed on that front to ensure that this could have been a significant determinant of past trade growth. Second, the trends tested in this paper are not likely to be persistent in future. For instance, the downward trend on energy prices used here is contrary to the projections by IEA (2017) and the trend in tariffs is closer to a tariff war than to further liberalization. As a consequence, assuming a persistent downward trend in tariffs and energy prices would be a heroic assumption for a proper forward-looking baseline.

All this suggests not only working with cautious assumptions, but even more to document precisely what the employed baseline trajectory implies in terms of baseline growth of world trade or the trade-to-income elasticity.

Although it is not yet implemented in any of the models reviewed, it seems to us that a best practice is within our reach by properly calibrating the determinants of trade in the long run. The key determinants used in our illustration (tariffs, energy prices, TFP in the transportation sector, non-tariff measures) are present in the majority of the models and could be properly calibrated in the baseline with only a little more effort on finding credible trajectories for these determinants. While tariffs and energy prices can be calibrated relatively straightforward (no tariff cut beyond what is already signed; energy prices projected by the International Energy Agency), we would need a better quantification for the potential future of TFP in transportation sector and other trade costs reductions. An interesting step in this direction is taken in the World Trade Report 2018 (WTO, 2018), in which a quantification of the potential reductions in trade costs due to new technologies is proposed, taking into account the digitalization of customs procedures, increased efficiency in logistics, a reduction of language barriers and digital innovations in credit and finance.

The issues highlighted in this section, i.e. calibrating a reasonable trade growth path in a baseline exercise, are indeed relevant for trade-oriented models, but are also likely to be important for models focusing on different issues. In the climate change research field, a faster-growing baseline trade will mean that more greenhouse gas will be emitted due to international freight and these emissions are likely to remain outside of any mitigation policy, because of the difficulties to come to an agreement on the freight sector. This also implies that emissions leakage may occur if countries are trading more. In agricultural models, a faster growing trade in the baseline could also lead to higher risks for certain sectors due to more exposure to international fluctuations, or more opportunities in foreign markets, both of which may significantly change the evaluation of agricultural support measures. On the other hand, international trade may also lead to a better ability to adapt to climate change (Gouel and Laborde, 2018).

Beyond those general recommendations in terms of baseline calibration, more work is needed to conduct a proper model comparison on this issue. A step further in this direction could be to implement proper back-casting exercises or historical simulations (understood as a baseline going backwards), in order to document the issue with more detail and to try to identify more rigorously the impact of each determinant. Ideally, this could allow us to identify the missing parts in our models that are responsible for such discrepancy. This is however difficult for the moment, as data is scarce before 1990, and lacks both regional and sectoral details even for the period around year 2000. Nevertheless, we must acknowledge the very important decision by the Center for Global Trade Analysis to provide multiple base years in their recent releases of the GTAP Data Bases, as this will help the community to run the required back-casting exercises.

5. Role of energy prices

5.1 Introduction

As noted in Section 4, energy prices have a direct impact on trade volume through international transportation, which mainly rely on fossil fuels. However, the potential impacts may be wider: trade in energy goods have very specific patterns that are influenced by energy prices, and they may affect the competitiveness of firms especially in energy-intensive sectors. Energy prices could also affect a country's competitiveness through Dutch disease effects. In addition, international trade in energy goods, only covered partially in this section, is also highly impacted by energy prices.

The majority of the models reviewed included a specific mechanism to deal with fossil natural resources. Among the 24 reviewed models, only eight do not document specific assumptions on this topic. In the other models, two approaches are used: (i) fully addressing the issue by including a resource depletion module, an approach followed by a few models (e.g. ENVISAGE, ImaclimR, Emissions Predictions and Policy Analysis (EPPA) model, Regional Model of Investments and Development, REMIND) or (ii) simply calibrating fossil natural resources in their baseline exercise using external projections on energy prices, energy supply or fossil resources which is an approach favored by the majority of models.

5.2 Impact of energy prices on trade: an illustration with MIRAGE-e

In order to illustrate the potential impacts of energy prices on world trade in a simple and accessible framework, we consider in this section a baseline exercise conducted with the MIRAGE-e model. With regards to fossil natural resources, MIRAGE-e adopts the simpler approach described in the previous subsection of imposing long-term energy trends: world energy prices for fossil fuels (coal, oil and gas) are taken as exogenous, and natural resources are endogenously calibrated in the baseline exercise through a world-wide coefficient.

5.2.1 Data

For the purpose of this illustration, we aggregate the GTAP 9.2 Data Base to the standard aggregation, with the only difference that we add detail in energy sectors as in section 4. This adaptation of the aggregation was required because otherwise it was impossible to capture differentiated effects on fossil energies, which are key to the specialization of countries and international transportation.

Different energy prices will be considered in four baseline exercises. The first one (labeled "Endog.") does not impose exogenous energy price trajectories and therefore considers the supply of natural resources as fixed without a response of the supply of natural resources to prices. The three other scenarios are taken from the World Energy Outlook (WEO) (IEA, 2017). The WEO considers prices for natural gas (4 different regional prices), crude oil, steam coal (5 regional prices) and coking coal (5 regional prices), but also for ethanol, biodiesel and biomass. In addition, the WEO also considers three different scenarios up to 2040. The "Current Policies" scenario (CPS) corresponds to projections including the energy-related policies that are firmly enacted as of mid-2016. The "New Policies" scenario (NPS) includes, on top of CPS policies, measures stemming from the implementation of announced policy intensions. Finally, the "450" scenario (PPM450) corresponds to the fulfillment of the objective to limit greenhouse gas emissions to 2°C by 2100, which corresponds to a limitation of greenhouse gas concentration at around 450 particles per million (ppm).

We need to simplify these projections for use in a CGE model like MIRAGE-e because (i) the GTAP Data Base does not differentiate between coking and steam coal; (ii) there is no straightforward mapping between the regional prices given by IEA and the place of extraction (required for endogenous resource depletion); and finally (iii) historical prices between 2011 and 2016 are too volatile to allow a smooth numerical resolution of the model. Figure 10 depicts the outcome of this simplification (taking averages of prices of different energy sources such as different types of coal and smoothing the development of energy prices), which is implemented in the model. The figure displays the trajectory before prices are smoothed.

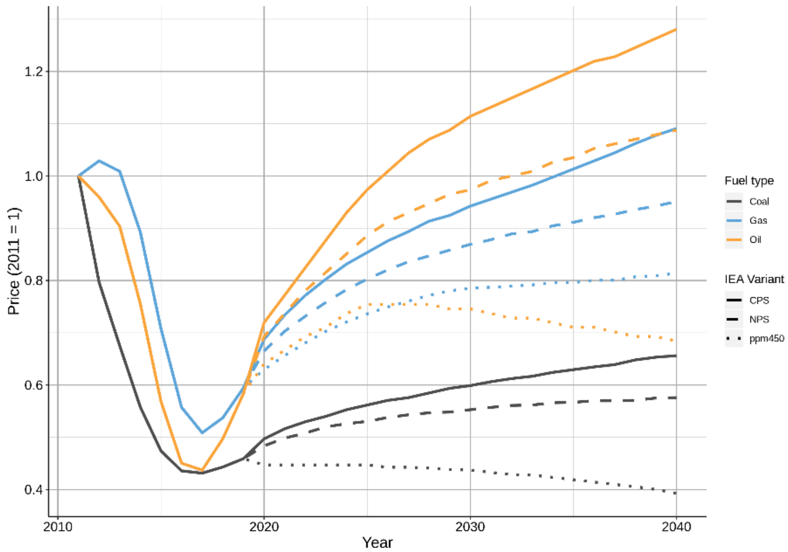


Figure 10. World Energy outlook projections for energy prices.

Note: The figure displays the trajectory of prices of coal, gas and oil under different scenarios before they are smoothed.
Source: IEA (2017) and own computations.

Beyond the actual determinants underlying IEA projections, what interest us in using these different projections is the variability between the CPS, NPS and PPM450 scenarios. Figure 10 show that the different scenarios are sufficiently differentiated, while at the same time remaining within reasonable bounds.

In addition to the GTAP Data Base and the energy price projections, the model also uses its standard macroeconomic projection data from EconMap (Fouré et al., 2013).

5.2.2 Methodology

The three baseline exercises considered will be very simple: they will share the same macroeconomic projections (the SSP2 from EconMap) and will only differ in the energy price projections. In the model, the change in baseline energy prices is represented by an endogenous global-level resource availability factor for each primary energy commodity (coal, gas and oil), which adjusts dynamically in the different baseline exercises such that the average world energy price for each of the primary energy commodities[30] reproduces IEA scenarios (for more details, see Fontagné et al., 2013).

This poses a double question of consistency. First, the macroeconomic model underlying the SSP2 projections uses the medium price scenario (NPS) from IEA

[30] World average energy price is defined here as the geometric average of prices for energy traded worldwide, weighted by trade flows.

(2015). Therefore, using any other price scenario would theoretically require a different set of GDP projections. Second, the price trajectories from IEA (2017) are actually based on several assumptions regarding the policies put in place, which will not be included in the model. As a consequence, such methodology could not be used in a proper evaluation study. This is however sufficient for the exposition purpose in this paper, as it will allow us to isolate the impacts of energy prices on trade, all things being equal. In addition, using the "vanilla" EconMap 2.4 SSP2 scenario also allows for easy replication.

5.2.3 Results

Our results confirm that the price of energy in the baseline have an impact on world trade. Table 4 shows that the annual growth rate of world exports (measured as volume at constant 2011 free on board (FOB) prices) will range between 3.3% and 3.5%. This results in a difference of 5.2% of total trade between the CPS and PPM450 trajectories, which is a moderate difference. Most notably, a very low price as in the PPM450 scenario has greater impact than the other scenarios.

Table 4. Average annual growth rate of world exports volume, 2011-2040 (%).

Price Scenario	Total trade	Primary trade	Secondary trade	Tertiary trade
CPS	3.30	3.51	3.34	2.97
NPS	3.35	3.71	3.36	2.94
PPM450	3.48	4.31	3.43	2.89
Endog.	3.32	3.58	3.35	2.95

Source: Own computations using MIRAGE-e 1.1.

The sectoral composition of trade, which is shown in Table 5, is also sensitive to energy prices, as the range of export growth of manufacturing goods and services range respectively between 3.34 and 3.43% and between 2.89 and 2.97%, which is much narrower than in primary goods (3.51 – 4.31%). This is however not surprising, as this high impact on primary goods is driven by trade in energy goods themselves: oil trade is the more sensitive to lower prices in the PPM450 scenario, while coal and gas are also along the most impacted sectors.

The regional allocation of trade flows is also sensitive to energy prices, though less than we might have expected. For instance, bilateral trade flows between more distant partners are not more significantly affected,[31] while we would have expected higher energy prices to shape the regional allocation of world trade more because of its impact on transportation costs. This is however not a firm

[31] Results not shown here, but available from the authors, show that the slope of the estimated relation between projected trade growth and average distance only varies minimally with no statistical significance, both in levels and in logs. This result persists even if we consider different modes of transport in the aggregation.

conclusion, as we also know that the current GTAP data on transportation costs is based on fitted values of a regression between US modes of transport and US value-to-weight ratio extrapolated to other countries using data on value-to-weight ratios (Nuno-Ledesma and Villoria, 2019). In addition, and perhaps more importantly, the transportation module in MIRAGE-e is rather simple and could be questioned.[32]

Table 5. Differences in trade volumes and world average price by sector in the PPM450 scenario relative to the CPS scenarios in 2040 (%).

Sector	**Trade**	**World price**
Oil	-33.0	86.1
Chemicals	-26.4	64.4
Electricity	-16.9	17.1
Coal	-16.9	68.4
Transport	-8.8	10.9
Other Goods	-5.5	5.8
Gas	-4.4	35.0
Agriculture	-3.3	2.6
Petroleum and Coal products	-1.4	1.4
Extraction	-0.8	-1.3
Processed Food	-0.7	0.9
Textiles and Clothing	-0.3	0.1
Metals	0.1	2.0
Other Machinery	0.8	-0.1
Other Transport Equipment	1.3	-0.7
Motor Vehicles	1.7	-0.2
Electronic Equipment	1.9	-1.3
Trade	4.7	-4.5
Other Services	5.2	-3.6
Business Services Fin Bus	7.8	-6.4

Note: The table should read "There is 33.0% less trade in oil in the PPM450 baseline compared to CPS baseline".
Source: Own computations using MIRAGE-e 1.1.

[32] In MIRAGE-e, the demand for international transportation services is equal, for each trade flow, to the global supply of transportation services (using a constant transport demand to volume share). The global supply is sourced in turn from different transport modes and from different supplying countries according to a Cobb-Douglas function. Because there is no direct link between the supplying country of transport services and the bilateral route for which transport services are demanded, the model has a homogenous energy-content of transportation for each mode and does not allow for regional differences between routes on which goods are transported.

However, Table 6 shows that in some cases, the regional allocation of trade flows is strongly impacted by energy prices. First, trade in primary goods is highly sensitive to energy price scenarios, with the difference in world exports in 2040 between the two most contrasting scenarios (CPS and PPM450) peaking at 50% from Africa and Europe to America. Services and manufacturing goods are less affected (15% difference or less), with peaks for the most remote partners (exports of services from Asia and Oceania to the rest of the world, and from America to Asia and Oceania). These differences arise not because of remoteness, but rather because of sector specialization.

Table 6. Difference in bilateral trade volume by aggregated region and sector in the PPM450 scenario relative to the CPS scenarios in 2040.

	Primary goods			**Secondary goods**			**Services**		
Importer Exporter	Africa and Europe	America	Asia and Oceania	Africa and Europe	America	Asia and Oceania	Africa and Europe	America	Asia and Oceania
Africa and Europe	24.4	52.1	43.3	0.5	6.0	5.4	-0.2	0.7	9.6
America	-5.4	26.2	7.1	-1.3	3.8	2.6	2.3	2.8	15.1
Asia and Oceania	1.8	16.1	12.3	-1.0	2.3	6.7	-12.4	-13.0	-2.6

Source: Own computations using MIRAGE-e 1.1.

For instance, exports of manufacturing goods from Asia and Oceania to Africa, America and Europe are relatively less influenced because they are more focused on sectors that are not much affected by energy prices (Electronic equipment, Other Machinery) compared to, for example, exports from Africa and Europe to America, where Chemicals and Other Goods are exported more. The same interpretation also applies for services exports from Asia and Oceania: they export mainly Business Services and Finance to Africa, Europe and America, but more Trade and Transport to other Asian or Oceanian countries.

5.3 Recommendations

Our results have shown that, for trade oriented CGE analysis in general, taking into consideration energy prices in the baseline might not be mandatory: the overall allocation of trade between sectors and regions is not highly sensitive to the baseline energy price, though the overall level of world trade might be impacted. However, in the case of a study that concerns specific trade partners specialized in fossil exports and energy-intensive goods or services, or to a lesser extent in very energy-efficient sectors, this issue might become key as these trade flows are likely to be reshaped in the baseline, hence altering the potential outcome of any counterfactual analysis.

An issue that should be further explored in future work is the consistency between exogenously imposed energy prices and macroeconomic projections from other models. Most models rely on an exogenous trade balance, which is a relevant long-run assumption for countries with diversified exports. In such countries this balance is determined mainly by savings and investment behavior. However, for short-run simulations, or for energy-exporting countries, and especially very specialized oil-exporting countries, the validity of the assumption of an exogenous trade balance is questionable. For instance, imposing an exogenous trade balance in a high oil price baseline, would lead to the result that oil-exporting countries would maintain their trade balance by compensating increases in the value of oil exports with lower exports in other sectors. In turn, this would significantly affect their terms of trade, leading to large variations in real incomes. Although this issue merits attention, it is outside of the scope of this paper.

6. Extensive margin and zeros

6.1 Introduction

Section 4 of this paper investigated the relationship between aggregate trade growth and GDP growth in long term projections. Another challenge is projecting the future commodity composition of trade and bilateral trade relationships (importer-exporter pairs). This is particularly true for long-term projections that take the model very far away from the initial equilibrium data on which it is calibrated. The composition of bilateral trade in terms of product-market combinations can be expected to change over time. Yet, a typical nested Armington input demand specification is not able to capture big structural changes, even if price movements are relatively big and elasticities of substitution are of the usual order of magnitude in CGE models.

Even a big price change, for example following a significant reduction of trade barriers, will not fully translate into much new trade creation on a given bilateral trade link when initial shares are small, let alone in the extreme case where an initial flow is zero, but potentially positive over time. Such may be the case if the initial trade policy prohibits imports, for example, through a ban or prohibitive tariff, but the barrier is lowered over time, allowing imports to enter. In this section we first explore the changes in the share of zero trade flows in the GTAP Data Base and then discuss some approaches to model changes along the extensive margin over time.

6.2 Relevance of zeros in GTAP Data Base

To analyze whether changes along the extensive margin are important in the data, we consider movements in zero trade flows in the GTAP Data Base, Version 10.2 (Aguiar et al., 2019). We present the results based on two cutoff values for zero trade flows. First, the filtering software employed by GAMS-modelers tends to set the cutoff value at 10 dollars (0.00001 times the unit of one million used in the GTAP Data Base). Second, as discussed below conventional models have a problem projecting large changes in small values of trade. So, we also present the results with a cutoff value of $10,000.

Table 7. Share of trade initially zero and shifting from zero to non-zero for different cutoff levels, different sectors, and different types of countries**.**

	Cutoff at 10,000$			Cutoff at 10$		
	Developed-developed	Developed-developing	Developing-developing	Developed-developed	Developed-developing	Developing-developing
			Initial share of zeros			
Agriculture	72%	81%	89%	26%	33%	40%
Fossil fuels	65%	76%	86%	37%	48%	59%
Manufact'g	32%	54%	74%	4%	9%	16%
Services	7%	18%	44%	0%	0%	1%
			Share of sectors becoming positive			
Agriculture	10%	8%	7%	4%	6%	7%
Fossil fuels	8%	9%	8%	8%	10%	11%
Manufact'g	10%	13%	12%	2%	3%	6%
Services	3%	8%	14%	0%	0%	0%
			Share of trade becoming positive			
Agriculture	2.32%	5.45%	9.54%	0.18%	1.35%	1.40%
Fossil fuels	1.99%	1.96%	3.40%	1.71%	0.95%	1.17%
Manufact'g	0.07%	0.48%	1.06%	0.00%	0.08%	0.17%
Services	0.01%	0.06%	0.29%	0.00%	0.00%	0.00%
			Share of trade becoming zero			
Agriculture	0.63%	2.57%	5.06%	0.16%	0.76%	1.30%
Fossil fuels	0.09%	0.59%	0.69%	0.03%	0.20%	0.19%
Manufact'g	0.02%	0.11%	0.42%	0.00%	0.01%	0.09%
Services	0.00%	0.00%	0.03%	0.00%	0.00%	0.00%

Notes: Trade flows are analyzed at the detailed sector level (57 sectors) and then aggregated to four broad categories. The initial period is 2004 and the final period 2014. "Initial share of zeros" and "Share of sectors becoming positive are measured in terms of the share of sectors in all sectors, whereas "Share of trade becoming positive and "Share of trade becoming zero" are measured in terms of the share in the total value of trade in respectively 2014 and 2004.

Source: Own calculations with the GTAP 10.2 Data Base.

Table 7 displays in turn: (i) the initial share of zeros in the 2004 data, the share of GTAP-sectors switching from zero trade in 2004 to positive trade in 2014, (ii) the value of trade in 2014 with trade being zero in 2004 and trade positive in 2014, and (iii) the value of trade in 2004 with trade being positive in 2004 and trade zero in 2014. There are three main take-aways from these data. First, the share of initial zeros is much larger with a cutoff at 10,000 than with a cutoff at 10. Obviously, the change in the share of trade being zero is a mirror image of this: with a cutoff of 10,000 there is more action along the extensive margin. Second, the share of trade becoming non-zero is highest in agriculture (with the most disaggregated product classification), followed in sequence by fossil fuels, manufacturing, and services. Third, the share of trade becoming positive over 10 years can be substantial. With a cutoff of 10,000, the share of trade which was zero in 2004 and positive in 2014 in agriculture is only 2.32%, 5.45%, and 9.54% for respectively trade between developed countries, trade between developed and developing countries, and trade between developing countries. However, with a smaller cutoff of 10 those shares are much more limited. Most switches from zero to non-zero trade flows have been occurring in agricultural trade and to a lesser degree in services trade between developing countries. This reflects a pattern of more intensified 'South-South' trade, in particular in agricultural and food.

6.3 Modelling changes along the extensive margin

Generally, small trade shares can be the result of four basic factors, three of which are relevant for long-term projections: (i) trade policy; (ii) factors affecting trade costs, such as energy prices and trade technology; (iii) factors determining the production capabilities of countries in specific sectors; and (iv) natural or immutable conditions, such as distance.

A long-term baseline can involve large changes in trade costs, for example when tariff reductions in trade agreements are phased in and or when other factors affecting trade costs change as well, as elaborated in section 4 of this paper. It is also possible that production capabilities expand, because of changes in factor supply or technology.

To deal with the small shares problem, an array of solutions has been proposed in the earlier literature. These range from making ad-hoc changes to model parameters to changing the model structure. Given that the small shares problem arises from limited response because of small or zero initial trade flows, obvious ad hoc solutions include replacing zero trade flows with small positive numbers and/or increasing the substitution elasticity between imported goods, or aggregating regions or products (for example Peterson and Orden (2004)). Obviously, the 'small shares stay small' problem will become less important if the baseline is more aggregated in terms of traded commodities and countries. However, those ad hoc solutions are partial and do not really address the more fundamental problem.

Structural solutions to dealing with the small share problem can be grouped under two headings: homogeneous products or adjusting functional form. The first approach removes the distinction of goods by origin from the model for at least a subset of the commodities. This gets rid of the small share problem by eliminating the need for (CES) aggregation functions, but at the cost of giving up bilateral trade modelling. An example is a study by Gohin et al. (2002).

The second approach replaces the CES function with another functional form that applies to all commodities in the model. Hanslow (2001) replaces the CES with a CRESH function (Constant Ratio Elasticity of Substitution Homothetic). CRESH functions have an additional set of parameters determining the price elasticities of inputs, opening the door to a stronger response to a reduction in trade barriers.

A number of studies (Robinson et al., 1993; Weyerbrock, 1998) opts for an Almost Ideal Demand System (AIDS) function. AIDS functions are flexible functions that can in principle accommodate arbitrary substitution and expenditure elasticities. An AIDS function allows expenditure shares to change when relative import prices changes, in contrast to the fixed expenditure shares in the CES function. However, it requires additional parameters.

While there is no general solution to the small shares problem, there exist ways to impose some structural changes on the trade matrix through 'shifters' in the import demand equations. The question then becomes on what basis those shifts are generated.

Komorowska et al. (2007) proposed a method that uses gravity estimates to generate shift parameters in the standard Armington import demand equations. Their gravity model includes trade barriers as explanatory factors as well as multilateral and bilateral factors, including non-economic factors, to explain bilateral trade flows in agricultural products. Using the Poisson Pseudo Maximum Likelihood (PPML) estimator allows the inclusion of observation with zero values. This last feature enables the utilization of the information embedded in the observations of no trade. The estimated gravity equation is then used by Komorowska et al (2007) to estimate the trade shares that would prevail after a lowering of trade barriers. These estimated shares are subsequently used to calculate an import augmenting shifter for the Armington functions in the CGE model such that the trade shares of the CGE model are consistent with the shares obtained from the gravity model. This shock feeds together with reductions of tariffs and subsidies into simulation experiments. See also Philippidis et al (2014) as well as Burfisher (2011).[33]

More recently, the literature on structural gravity models has explored theoretically consistent ways to estimate trade effects of policy changes in counterfactual scenarios. Anderson et al. (2018) develop a relatively simple procedure that combines PPML estimations with counterfactual trade cost parameters that could be used to back out shift parameters for imports in standard CGE models. The advantage of following this approach is that feedback effects from changes in the multilateral resistance terms are taken into account.

[33]An alternative approach along the same lines could consist of the estimation of a sample selection model for trade flows or solely the estimation of a probit model to explain the existence of zero trade flows. Changes in the predicted zeros could then be employed to discipline changes along the extensive margin in the simulations.

Since the described approaches have not been applied so far in long term projections there are no best practices on this topic. However, the research agenda is clear. Although the gravity estimations in the Anderson et al (2018) setting or in combination with Armington in Komorowska et al (2007) have been used for counterfactual trade policy simulations, its use for long term projections seems promising. While it is still based on observations of the past, it allows for an informed determination of the 'shifters' in import demand functions in the CGE model. To do so, the main variables driving long term projections such as GDP could be included in the gravity equation. In this way counterfactual values for small observed trade values predicted by the gravity model could change significantly, which in turn would lead to significant changes in initially zero values in the trade matrix following the approach in Komorowska et al (2007).[34]

7. Role of new technologies and required trade policies

Issues related to digital trade such as intellectual property, e-commerce, and data flows are increasingly discussed in the context of trade policies, as digital trade is expected to grow at above-average rates, expanding its role in the economy. This creates challenges for existing CGE modeling frameworks. As discussed in Ciuriak (2017), CGE models do not incorporate knowledge capital stocks, R&D investment, flows of royalties, or indices of intellectual property protection. Further, these modelling frameworks lack cross-border data flows as well as information on digitally traded goods. This poses three sets of problems. First, the evaluation of digital trade related provisions, a substantial component of modern deep free trade agreements (FTAs), becomes challenging. Second, developing projections of the evolution of e-commerce, flows of data, and flows of royalties is hard with the available data and modelling tools. Third, the expansion of the digital economy implies that there is an increased need to model imperfect market structures, as the digital economy is characterized by economies of scale and network externalities (Ciuriak, 2018).

While dynamic CGE models may not be the most appropriate tools to address policy issues arising from imperfect market structures, the dynamic CGE modelling framework remains an attractive option to examine the future of digitization and to evaluate deep FTAs, provided modelling tools and data sources are further developed. On the modelling side the inclusion of an innovation module could be useful, which could be a function of IP-protection, the modelling of intangible capital, and a distinction between physically traded goods and

---

[34] Including GDP in the gravity regressions would require either dropping the fixed effects and replacing them with proxies for multilateral resistance terms as in Baier and Bergstrand (2009) or using the structural gravity relations between fixed effects, multilateral resistance terms and GDP as identified by Fally (2015) when calculating the changes in predicted trade as a result of changes in GDP.

services and digitally traded goods and services. On the data side the challenges are even more formidable, requiring information about flows of intellectual property (IP) related income such as royalties and license fees, the value of intangible capital (possibly estimated based on measures of Tobin's Q), the value of digitally traded goods and services, measures of flows in data and of barriers to digital trade. Data flows can be difficult to capture as many data flows may not contain unique information. For example, duplicate information is transferred across borders when creating back-ups on servers located outside the country. The effort to generate data on IP-related income could be related to efforts to generate data on other components of the balance of payments.

There is little existing work on new technologies and trade. The World Trade Report of 2018 (WTO, 2018) models some of the expected trends related to the growth of new, digital technologies. Three trends are simulated until 2030: (1) a fall in trade costs, (2) servicification of the production process, and (3) a reallocation of tasks from labor to capital. These trends are modelled employing standard tools of a dynamic CGE model, such as the 'twist-parameter' and iceberg trade costs.[35] Projections are disciplined by a mix of historical trends and gravity estimation. Given the lack of data, there is no role for e-commerce, intangible capital, and IP-protection in the projections. The OECD has also looked into the impact of new technologies, focusing on the impact of global value chains in a static CGE model (De Backer and Flaig, 2017). They model the impact of new, digital technologies with a productivity growth shock which varies by sector.

8. Phasing in future trade policies

Trade agreements have become progressively "deeper", including areas that go beyond traditional trade policy such as liberalizing behind-the-border trade barriers, protecting investment and harmonizing standards (Hofmann et al, 2017).

The incorporation of tariff commitments in trade agreements in baselines is relatively straightforward although data intensive.[36] If the tariff schedules are publicly available from the text of the trade agreement, the tariff reduction in the baseline could follow the schedules.[37] Alternatively, tariff reductions can be phased in stepwise or linear fashion. To pool their effort on this data-intensive work, a joint International Trade Centre-National Graduate Institute for Policy

[35] Twist-parameters were introduced by Dixon and Rimmer (2002) and can be shocked to change the spending shares in a cost-neutral way, i.e. keeping the aggregate price index constant.

[36] Most models should incorporate a tariff instrument, if not, its implementation is straight forward.

[37] A thorny issue of prime importance for agricultural trade is the conversion of changes in specific tariffs and tariff rate quotas (TRQs) into ad valorem equivalent changes in tariffs, requiring information about future prices and quota utilization rates.

Studies-United States International Trade Commission (ITC-GRIPS-USITC) project is currently compiling a tariff line database for a number or regional trade agreements (RTAs) with a yearly phase in schedule until 2045. The focus of this project is on "RCEP-APEC-EU" countries.[38]

Preferential tariff rates of trade agreements are typically not fully utilized due to restrictive rules of origin, low initial tariffs or relatively high compliance costs. RTA studies typically account for utilization rates by reducing the tariff cuts (examples of this approach include World Bank (2016) and Petri et al. (2011)). In addition, rules of origins required to qualify for preferential rates can be costly to comply with estimates of these costs ranging typically between 6% and 10% of the value of tariff reductions (Anson et al., 2005; Petri et al., 2011). The costs of complying with rules of origin are modelled typically as additional (importer or exporter) input costs.[39]

The modelling of NTMs is challenging when analyzing existing trade restrictions and seems even more so when forecasting their future evolution. While the estimates of the effects of NTMs have improved in recent years[40] it is a challenge to relate a specific FTA concession on NTMs to reductions of these NTM estimates. The main challenge is to identify the part of the NTM that is actionable and relate it to a specific measure. Some NTMs, while increasing prices, yield positive quantity effects for example due to harmonization of standards (Cadot et al., 2018). Further, NTMs are not necessarily discriminatory and yield benefits for third countries, for example, provisions that focus on transparency and procedures. The extent of NTM reductions thus depends on the specific provisions in an FTA and its quantification is typically based on small samples (Copenhagen Economics, 2009; European Commission, 2013; World Bank, 2016). To our knowledge, a project aiming to establish a NTM "concessions" database, similar to

[38] The agreements covered at the end of 2018 are FTAs between the 11 country signatories of the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTTP) agreement, as well as all active FTAs to which 25 Asia-Pacific countries (those who signed the Regional Comprehensive Economic Partnership (RCEP) and the Asia-Pacific Economic Partnership (APEC)) and the European Union are parties. And finally, FTAs that the Rest of the world applies to refer to "RCEP-APEC-EU" countries.

[39] Data on utilization rates and rules of origin (RoO) are typically based on small samples that are applied to a wide set of agreements and sectors. Subsequently, assumptions are relatively rough but significant, for example, World Bank (2016) reduces final tariff cuts up to 31% to address utilization rates and RoO input costs are assumed to increase by 10 % of the tariff reductions for 40% of inputs.

[40] See for example the homepage of the Global EPAs Research Consortium for an overview of databases (http://www3.grips.ac.jp/~GlobalEPAsResearchConsortium/en/data/) or Cadot et al. (2018) for bilateral NTM estimates by group of NTM differentiating price and quantity effects.

tariffs, does not exist. Furthermore, contrary to tariffs, there is no guarantee that non-tariff barriers will not be increased in the future and indeed recent decades saw more restrictive barriers being erected in advanced economies (e.g., Anderson et al., 2016; Kee et al., 2008; WTO-OECD-UNCTAD, 2009-2018).

In addition to the quantification of NTM concessions, there remains the issue of modelling NTMs. Fugazza and Maur (2008) noted serious analytical mistakes from loose specifications of NTMs in CGE modelling. Thus, the choice of modelling approach[41] strongly affects outcomes in terms of size, direction of welfare effects and allocation, even when using the same underlying data (Fugazza and Maur, 2008, Walmsley and Minor, 2016, Flaig and Stone, 2017). For example, the use of ad-valorem tariff equivalents might wrongly create government revenue while efficiency approaches yield positive effects by design (especially when implemented in anon-discriminatory way) and are criticized for strong effects on GDP.[42] Willingness to pay approaches try to address this.[43] They yield more modest GDP effects and greater trade effects compared to efficiency approaches, but cause changes in utility or welfare that do not appear in price and quantity measures and therefore challenge traditional reporting and baseline design.

Finally, services are coming into greater focus in trade agreements. From a modelling point of view services regulations are little researched and data availability is problematic. However, data on barriers on services trade are available from several sources.[44] Other issues, besides quantification of trade barriers in services, include the depiction of services in current trade data and the modelling of services. For example, the largest number of restrictions in the services trade restrictiveness index (STRI) database of the OECD is found in the area of foreign direct investment (FDI), where data on FDI stocks and flows of investment is poor, thus limiting any endeavor to better model this sector.

The ongoing efforts to develop a database for tariff concessions in RTAs will simplify the inclusion of tariff concessions in a baseline. Quantifying concessions made on NTMs on goods and services, which now figure more prominently in RTAs, is challenging. Given all the limitations, a standardized and "precise" way of incorporating NTMs concessions in RTAs does not seem feasible. This is a concern, especially as NTMs are the area where the big economic effects are

---

[41] The development of modelling approaches of NTMs is ongoing and a wide choice of approaches is available, see for example Flaig and Sorescu (2017) for an overview.

[42] In addition, the efficiency approach introduces a gap between import and export quantities as fewer exports are needed to satisfy the same amount of imports. This might cause an issue for reporting and developing the baseline, especially in level-based models.

[43] See for example Walmsley and Minor (2016).

[44] See again for example the homepage of the Global EPAs Research Consortium for an overview of databases.

expected. If the focus of the baseline is trade and bilateral relations, it is not possible to ignore trade cost reductions related to NTM concessions. The use of a simple and transparent "rule" might be a reasonable approach. One possible solution could be to use existing trade relationships as a basis for quantifying the value of NTM trade cost reductions.

9. Migration and remittances

The global population of migrants of working age is estimated at 234 million of which 164 million participate in the workforce. Migrants contribute to local economies, directly through participation in the local workforce as well as indirectly through knowledge spillovers. While globally migrant workers only account for 4.7 per cent of the labor force, regional disparities are large, with migrant workers constituting over 40 and 20 per cent of the workforce in Arab States and North America, respectively, as well as nearly 18 per cent of the workforce in Western Europe (ILO 2018). As such migration has a big impact on factor supply in many countries.

Migrant workers also provide important resources for development to their home countries through remittance flows. In 2017, global remittance flows were estimated at 613 billion USD (World Bank 2018a). The IMF Balance of Payments Manual, 6th Edition (BPM6) decomposes personal remittances into three main components: personal transfers, capital transfers, and the compensation of employees. These definitions rely on whether or not the migrant worker takes up residency in the host country (moving for at least one year) or works in the host country temporarily (moving for less than one year). Personal transfers and capital transfers reflect transfers from households residing in the host country to nonresident households. Compensation of employees comprises remuneration of nonresident workers. Total remittances also capture social benefits transferred abroad (IMF 2009).

Baseline development for dynamic economic models involves the incorporation of exogenous macroeconomic information, including data on the size of the population and the labor force. To capture the economic importance and implications of migration for the global economy, baseline development (data requirements and modelling specifications) would benefit from the consideration of three factors. First, migrants comprise an important part of the population as well as, second, an important part of the labor force. Third, remittances from migrants affect the balance of payments of both sending and receiving countries.

By incorporating these three factors, the baseline framework distinguishes migrants from host country nationals, for the population, the labor force, and the accounting of earnings. This distinction provides an important new source of realism to dynamic modelling frameworks which allows for important policy scenarios to be examined that would not otherwise be possible. This distinction is especially important in countries which send and receive high levels of migrants and remittance flows.

Consider for example, the migration corridor from South and Southeast Asia to the countries of the Gulf Cooperation Council (GCC). Across the GCC region, migrants account for the majority of both the labor force and the population, with the exception of Saudi Arabia where nationals are a greater proportion of the population. Hence, the inclusion of migration in the modelling of GCC states is essential for disentangling how international economic shocks affect the economies of these regions through changes to migrant flows, which comprise a significant proportion of their labor supplies and, accordingly, populations. Aguiar et al. (2016a), for example, examine the effects of an oil price shock on migration from South and Southeast Asian countries to the GCC in a dynamic general equilibrium framework, and they find that low oil prices could dis-incentivize workers to migrate to the GCC as home country economies expand.

For South and Southeast Asian economies who send migrants to the GCC states and elsewhere, remittances can comprise an important part of income. In their research, Aguiar et al. (2016a) focus on Indonesia, the Philippines, Bangladesh, India, Pakistan, and Sri Lanka. On average in 2017, personal remittances in these countries comprise three per cent of income, but for individual countries, the percentage can be much higher with remittance flows to the Philippines accounting for over 10 per cent of income (World Bank 2018c). Thus, the explicit incorporation of remittance flows into a modelling framework is important for analyzing the economic effects of global shocks on the balance of payments for these countries through changes to migrant wages received abroad and transferred home. Aguiar et al. (2016b) find that with less workers migrating abroad under a low oil price scenario, remittances to South and Southeast Asia decline.

The inclusion of migration in the analysis of economies with very high levels of migrant-sending and migrant-receiving economies, such as South and Southeast Asian countries as well as GCC states, is of clear importance. Although the levels of migrant flows and remittances may be relatively less salient in other regions, incorporating migration into dynamic modelling frameworks offers a new dimension for policy analysis, capturing the direct and indirect effects of migration on an economy. As discussed above, Aguiar et al. (2016b) examine indirect effects by assessing how the impact of a global shock affects countries through migration channels. Direct effects comprise how changes in migration itself, such as through policies regulating migrant workers and remittances, affect the economy. Walmsley et al. (2011), for example, develop a static general equilibrium model of migration and use it to analyze how a three per cent increase in the labor force because of migration affects both sending and receiving economies.

The three factors (population, labor force, and remittances) which distinguish migrants from host nationals in a model provide the framework for analyzing these direct and indirect effects of migration. While existing modelling frameworks incorporate these factors, such as in the dynamic general equilibrium model developed by Aguiar and Walmsley (2010), there exist different possibilities for including each factor. Further, for the development of the baseline, attention should be given to the specification of growth in migrants, as a proportion of population and labor force, as well as in remittances.

In the baseline scenario, the stock of migrants may be considered a fixed proportion of the host population. Therefore, with projected population growth incorporated into the baseline, migrant stocks may also increase accordingly. However, depending on the time horizon of the scenario and foreseen policies, this assumption may be reconsidered. For example, a country may set policies to decrease the overall proportion of migrants in its population over time. In this case, growth in migrant stocks should not be considered proportional to population growth.

Similar considerations should be accounted for in terms of the labor force and migrant participation in the labor force. Migrants may be considered a certain proportion of the labor force; however, this proportion also may realistically adjust depending on changes in policies implemented over time. Further, different skills or educational levels of migrant workers likely change over time affecting demographics. The question is whether these anticipated changes should be implemented in the baseline or in the policy scenario, given that the model at hand captures the necessary linkages endogenously.

The incorporation of remittances into the baseline demands additional consideration. Even if the model does not explicitly account for migration endogenously, remittances may still be accounted for in the balance of payments. In this case, the determination of remittance growth should be carefully considered. In some frameworks with endogenous migration, remittances may be considered a proportion of wage earnings, and, hence, changes in remittances would reflect income changes (Walmsley et al. 2011). This, however, does not account for capital transfers, and capturing compensation of employees (remuneration from non-resident work abroad) remains a further complication. Further, remittance growth may also deviate from a fixed proportion of wage earnings if, for example, remittance costs (the costs of sending and receiving relatively small amounts of money from one country to another) decline to 3 percent by 2030 as targeted by the Sustainable Development Goal (SDG) 10.7 (World Bank 2018b). In this case, remittances relative to wages may be expected to increase. On the other hand, remittances could decline over time as the migrant's ties with the home country could become less intensive over time.

In summary, the incorporation of migration into dynamic modelling frameworks allows for enhanced policy analysis, particularly pertaining to population demographics, the labor force, the balance of payments, and the possibility to model "movement of persons", Mode 4 services trade. The inclusion of migration is especially important for countries which have very high outflows and inflows of migrant workers; however, with increasing globalization, migration is only gaining economic importance worldwide. Further research is needed to identify growth paths of migrants and remittances and to distinguish capital transfers and employee compensation in the balance of payments. At present, researchers should clearly state the assumptions made, particularly when including anticipated policy changes in the baseline.

10. Conclusions

In this paper we have critically reviewed and discussed different approaches to model trade interactions between countries in dynamic CGE models. Simulations were conducted on the most important topics, i.e. the way international trade and the trade balance are modelled, the growth of international trade, and the role of energy prices. We conclude in this section by summarizing the main findings and formulating a set of best practices and a future research agenda.

There is broad consensus on the way international trade is to be modelled in the dynamic CGE literature. Most research teams employ nested Armington preferences. A small number of models includes a (nested) CET structure on the export side, which limits the response of international trade to shocks such as differences in growth rates between countries and sectors which change the competitiveness of countries and the pattern of comparative advantage. From the simulations, we see that increasing the size of trade elasticities has limited impact on trade growth and the share of various regions in global growth. Given that research resources are scarce, there does not seem to be a compelling reason to prioritize better estimation of trade elasticities for dynamic work, although this could obviously be different for comparative static policy work.

Projection work employing quantitative trade models is limited in the literature. They typically model trade as in Eaton and Kortum. However, as is well-known since the work by Arkolakis et al. (2012) and Costinot and Rodriguez-Clare (2013), in reduced form this model is identical to a trade model with Armington preferences and hence policy experiments generate identical results. In larger-scale models with export taxes and transport margins, results could be different, but this is not expected. Hence, in dynamic CGE work, the use of trade structures such as Eaton and Kortum is unlikely to yield new insights or findings. This is different for models including monopolistically competitive market structures (Ethier-Krugman or Melitz type models).[45] There is currently no research involving the inclusion of these market structures in dynamic models. However, from the work with static models we know that policy experiments could generate rather different results in monopolistically competitive market

[45] See the work of Dixon et al (2018).

settings. Hence, it will be useful to study the behavior of baseline projections based on a model with monopolistic competition.

The topic of monopolistic competition in an imperfectly competitive market structure brings us to a discussion of the quickly expanding role of digital technologies in the global economy. The current modelling tools at our disposal in dynamic CGE models are insufficient to model markets with economies of scale and network effects and a prominent role for innovation and intangible capital. These complex effects are likely to be present in deep FTAs and so to better understand the dynamic effects of these deep agreements, there will be an increasing need to extend both our modelling tools and data along these lines.

A final topic related to model structure is the lack of a sound micro-founded way to deal with the way changes in trade along the extensive margin are modelled. A nested Armington structure is not able to capture large changes along the extensive margin. Small trade values will remain small even with relatively large shocks to trade costs. Although there is no standard approach in the literature to model significant changes along the extensive margin, we have described a promising approach based on a combination of modelling and econometric estimation which has not been applied so far in dynamic settings.

In contrast to the consensus on the use of the Armington trade structure, the modelling of the trade balance varies widely in dynamic CGE models from empirically based closures (Feldstein-Horioka) to incentive-based closures (rate-of-return rule) to closures addressing dynamic consistency (converging trade balances). In the simulations we have compared seven different closure rules, showing that changes in both trade balances and shares in global trade for surplus and deficit countries vary significantly across the different closure rules. Hence, the way the trade balance is modelled matters for the projections. We have concluded that converging trade balances seem to lack an empirical basis and the problem of dynamic consistency should be addressed in a different way, by extending our models with net foreign debt and asset positions and implied capital income flows. These extensions would require a careful collection of baseline data on both asset positions and capital income flows.

Furthermore, we have argued that intertemporal optimization, which is absent in most dynamic CGE models, could create counterfactual outcomes and only seems necessary if the researcher has to deal with policy questions with an important role for expectations and anticipation effects. Finally, it could be fruitful to combine incentive-based approaches with empirical-based approaches. In simulations we have attempted to do so by combining the rate-of-return closure with the Feldstein-Horioka closure.

A third topic is the way trade growth is modelled. Simulations in the paper show that there is a discrepancy between baseline model outcomes and historical data. The trade-to-income elasticity, measured as the ratio of real trade growth relative to real income growth, is close to one in a baseline dynamic CGE model, whereas historically this elasticity has been larger than 1.5 since the 1950s. Our simulations show that a trade-to-income elasticity close to the historical average can be obtained by including above-average productivity growth in the transport sector, falling oil prices, falling tariffs (in line with historical evidence), and falling non-tariff barriers. However, we also argue that caution is necessary in adding these features, as they should be based on sound empirical work or theoretical mechanisms. For example, falling non-tariff barriers should be motivated based on a scenario featuring new free trade agreements.

The trade-to-income elasticity matters for typical questions of interest addressed with dynamic CGE-models. For example, the degree of trade growth has an impact on greenhouse gas emissions due to international freight. And trade growth exceeding income growth implies for example in agricultural models that countries become more vulnerable to international shocks but could also hedge better against national shocks through participation in international markets. Because trade growth matters for the outcomes of dynamic CGE-models, it is best practice to include the trade-to-income elasticity in baseline results reported.

We have also addressed three further issues related to the interaction between countries in international trade. First, the impact of energy prices on the size and composition of trade is examined with simulations, showing that global trade growth is not affected significantly by changes in energy price projections. However, trade in primary goods of energy-intensive regions is more heavily affected. Second, we have explored how future trade policies can be phased into baseline projections. While a database on tariff schedules of FTAs will become available soon, the outlook for non-tariff measures is not so rosy. There is no widely accepted approach to project changes in non-tariff barriers. Some researchers include reductions in non-tariff measures to target a certain trade-to-income elasticity (Fouré et al., 2013). However, this approach is ad-hoc and lacks an empirical or theoretical underpinning. Third, the importance of migration and remittances in dynamic CGE models is discussed, arguing that the incorporation of migration into dynamic CGE models enables a better assessment of the impact of migration policies on population, labor force, and the balance of payments. This matters especially for countries with large inflows and outflows of migrants.

We have provided an overview of different approaches to model trade interactions between countries in dynamic CGE models, discussing and illustrating the impact of different modelling features, and defining a research agenda of the most pressing issues. We would like to highlight three topics where the need for further research appears most urgent.

First, better coverage is needed of the different components of the balance of payments such as remittances (in relation to migration) and capital income (related to net debt and asset positions and intertemporal budget constraints). They offer a new dimension for policy analysis, capturing the direct and indirect effects of migration on an economy for example, or the possibility for countries to run persistent trade deficits or surpluses.

Second, the discrepancy between real trade growth generated by business-as-usual dynamic CGE models and historical trade growth deserves further attention. We found that to obtain baselines that produce a trade to income elasticity closely resembling what was observed historically, we needed to assume that a number of key policy variables, such as tariffs and non-tariff measures, will follow a future trajectory similar to the past — which to our mind is an assumption that requires careful examination. This could dovetail with research on RTAs which involve commitments about future tariff cuts and disciplines on NTMs as well as research on the effect of technological change on trade costs (see discussion below).

Third, new modelling tools have to be developed and additional data, not currently part of the GTAP Data Base, have to be collected to explore international trade questions related to the rapidly growing digital economy. These additional data could include: (i) estimates of intangible assets, which now makes up a significant portion of capital investment in industrial countries, (ii) estimates of digital trade, and (iii) indicators of the policy environment relevant to the digital economy. Further, new modelling tools will be needed to generate projections on the future evolution of digital trade and how this will interact with the future growth of merchandise and services trade.

Fourth, incorporating monopolistic competition into dynamic CGE models will enable us to consider a wider range of trade outcomes from policy experiments as well as from the process of technological change. We know that scale economies, love-of-variety, and firm heterogeneity are important features of the real-world. Comparative static experiments have shown that models of firm heterogeneity behave very differently in certain cases compared to perfect competition Armington models. Monopolistic competition models are able to generate sharp changes in specialization patterns and are thus useful to study the dynamic effects of singular events like Brexit or market disrupting technological changes. And as we discussed earlier, there are ways to mitigate computational problems in CGE-models with monopolistic competition, which might be employed in baseline projection work with these models.

Acknowledgements and disclaimer

We thank Dominique van der Mensbrugghe, the editors and two anonymous referees for useful comments. Any errors are attributable to the authors. Disclaimer: the opinions expressed in this article should be attributed to its author. They are not meant to represent the positions or opinions of the WTO and its members and are without prejudice to Members' rights and obligations under the WTO.

References

Aguiar, A., A. Ahmed, and C. Carrico. 2016a. "Migration Response to Oil Price Volatility: A Dynamic Simulation of Migration from South and Southeast Asia to the GCC." GTAP Resource No. 5059.
https://www.gtap.agecon.purdue.edu/resources/download/8195.pdf

Aguiar, A., E. Bekkers, E. Corong, R. Koopman, R. Teh and D. van der Mensbrugghe. 2019. "The WTO Global Trade Model: Technical documentation. " WTO Staff Working Paper ERSD 2019-10.

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

Aguiar, A., and T. Walmsley. 2010. "A Dynamic General Equilibrium Model of International Migration." GTAP Resource No. 3387.
https://www.gtap.agecon.purdue.edu/resources/download/5053.pdf

Akgul, Z., Villoria, N. B., & Hertel, T. W. 2016. "GTAP-HET: Introducing firm heterogeneity into the GTAP model. " *Journal of Global Economic Analysis*, 1(1), 111-180. http://dx.doi.org/10.21642/JGEA.010102AF

Anderson, J., & Van Wincoop, E. 2003. "Gravity with gravitas: a solution to the border puzzle. " *American economic review*, 93(1), 170-192.
https://doi.org/10.1257/000282803321455214

Anderson, J., M. Larch, Y. Yotov. 2018. "GEPPML: General equilibrium analysis with PPML." *The World Economy*, 41 (10): 2750-2782.
https://doi.org/10.1111/twec.12664

Anderson, K. and A. Strutt. 2012. "The changing geography of world trade: Projections to 2030. " *Journal of Asian Economics,* 23: 303–323.
https://doi.org/10.1016/j.asieco.2012.02.001

Anderson, K., Jensen, H. G., Nelgen, S. and A. Strutt. 2016. "What is the Appropriate Counterfactual When Estimating Effects of Multilateral Trade Policy Reform?" *Journal of Agricultural Economics,* 67(3): 764–778.
https://doi.org/10.1111/1477-9552.12181

Anson, J., O. Cadot, A. Estevadeordal, J. De Melo, S. Suwa-Eisenmann and B. Tumurchudur. 2005. "Rules of Origin in North–South Preferential Trading Agreements with an Application to NAFTA." *Review of International Economics*, 13(3): 501–17.
https://doi.org/10.1111/j.1467-9396.2005.00520.x

Arkolakis, C., Costinot, A., & Rodriguez-Clare, A. 2012. "New trade models, same old gains? " *American Economic Review*, 102(1), 94-130.
https://doi.org/10.1257/aer.102.1.94

Baier, S. L., & Bergstrand, J. H. 2009. "Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation." *Journal of International Economics*, 77(1), 77-85.

https://doi.org/10.1016/j.jinteco.2008.10.004

Baldwin, R. 2011. "21st Century Regionalism: Filling the Gap between 21st Century Trade and 20th Century Trade Rules." WTO Staff Working Paper ERSD-2011-08. http://dx.doi.org/10.2139/ssrn.1869845

Balistreri, E. J., Hillberry, R. H., & Rutherford, T. F. 2011. "Structural estimation and solution of international trade models with heterogeneous firms. " *Journal of international Economics*, 83(2), 95-108. https://doi.org/10.1016/j.jinteco.2011.01.001

Bas, M., Mayer, T., & Thoenig, M. 2017. "From micro to macro: Demand, supply, and heterogeneity in the trade elasticity. " *Journal of International Economics*, 108, 1-19. https://doi.org/10.1016/j.jinteco.2017.05.001

Bekkers, E., & Francois, J. 2018. "A parsimonious approach to incorporate firm heterogeneity in cge-models. " *Journal of Global Economic Analysis*, 3(2), 1-68. http://dx.doi.org/10.21642/JGEA.030201AF

Bekkers. E. 2019a. "Challenges to the trade system: The potential impact of changes in future trade policy." *Journal of Policy Modeling*, 41: 489–506. https://doi.org/10.1016/j.jpolmod.2019.03.016

Bekkers, E. 2019b. "The welfare effects of trade policy experiments in quantitative trade models: The role of solution methods and baseline calibration." WTO Staff Working Paper ERSD 2019-02. http://hdl.handle.net/10419/195775

Bekkers, E. and H. Rojas-Romagosa. 2019. "The Welfare Effects of Free Trade Agreements in Quantitative Trade Models: A Comparison of Studies about Transatlantic Trade and Investment Partnership." *World Economy,* 42(1): 87-121. https://doi.org/10.1111/twec.12670

Bergstrand, Jeffrey and Scott L. Baier. 2009. "Bonus vetus OLS: A simple method for approximating international trade-cost effects using the gravity equation." *Journal of International Economics*, 77: 77-85. https://doi.org/10.1016/j.jinteco.2008.10.004

Bernhofen, D. M., El-Sahli, Z. & Kneller, R. 2015. "Estimating the effects of the container revolution on world trade." *Journal of International Economics*, 98: 36-50. https://doi.org/10.1016/j.jinteco.2015.09.001

BP (2018). BP Statistical Review of World Energy, 67th edition, June. https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2018-full-report.pdf

Britz, Wolfgang and Roberto Roson. 2018. "G-RDEM: A GTAP-based recursive dynamic CGE model for long-term baseline generation and analysis." Ca'Foscari University of Venice. Department of Economics Working Paper No. 11. http://dx.doi.org/10.2139/ssrn.3167781

Broda, Christian and David Weinstein. 2006. "Globalization and the gains from variety." *Quarterly Journal of Economics*, 121(2): 541–585.

https://doi.org/10.1162/qjec.2006.121.2.541

Brown, Drusilla. 1987. "Tariffs, the terms of trade, and national product differentiation." *Journal of Policy Modeling*, 9(3): 503–526. https://doi.org/10.1016/0161-8938(87)90027-5

Burfisher, M. 2011 *Introduction to Computable General Equilibrium Models*, Cambridge University Press https://doi.org/10.1017/CBO9780511975004.

Cadot, O., J. Gourdon and F. van Tongeren. 2018. "Estimating Ad Valorem Equivalents of Non-Tariff Measures: Combining Price-Based and Quantity-Based Approaches." OECD Trade Policy Papers No. 215, OECD Publishing, Paris. http://dx.doi.org/10.1787/f3cd5bdc-en

Cai, J., Santacreu, A. M., & Li, N. 2017. "Knowledge diffusion, trade and innovation across countries and sectors." FRB St. Louis Working Paper, (2017-29). http://dx.doi.org/10.20955/wp.2017.029

Caliendo, L., & Parro, F. 2015. "Estimates of the Trade and Welfare Effects of NAFTA. " *The Review of Economic Studies*, 82(1), 1-44. https://doi.org/10.1093/restud/rdu035

Caliendo, Lorenzo, Robert C. Feenstra, John Romalis, and Alan M. Taylor. 2017. "Tariff reductions, entry, and welfare: theory and evidence for the last two decades," NBER Working Paper No. 21768. https://doi.org/10.3386/w21768

Caliendo, L., Dvorkin, M., & Parro, F. 2019. "Trade and labor market dynamics: General equilibrium analysis of the china trade shock." *Econometrica*, 87(3), 741-835. https://doi.org/10.3982/ECTA13758

Caron, J., Fally, T., & Markusen, J. R. 2014. "International trade puzzles: A solution linking production and preferences." *The Quarterly Journal of Economics*, 129(3), 1501-1552. https://doi.org/10.1093/qje/qju010

Chateau, Jean, Lionel Fontagné, Jean Fouré, Åsa Johansson, Eduardo Olaberría. 2015. "Trade patterns in the 2060 world economy." *OECD Journal: Economic Studies*, OECD 2015 (1): 67-100. https://doi.org/10.1787/5jxrmdk5f86j-en

Ciuriak, Dan. 2017. "The Knowledge-based and Data-driven Economy. Quantifying the Impacts of Trade Agreements." CIGI Papers No. 156. https://ssrn.com/abstract=3082575

Ciuriak, Dan. 2018. "Rethinking Industrial Policy for the Data-driven Economy." CIGI Papers No. 192. http://dx.doi.org/10.2139/ssrn.3223072

Copenhagen Economics. 2009. "Assessment of Barriers to Trade and Investment Between the EU and Japan." http://trade.ec.europa.eu/doclib/docs/2012/july/tradoc_149809.pdf.

Corong, E., Hertel, T., McDougall, R., Tsigas, M. and van der Mensbrugghe, D. 2017. "The Standard GTAP Model, Version 7." *Journal of Global Economic Analysis*, 2(1), 1-119. http://dx.doi.org/10.21642/JGEA.020101AF

Costinot, A., & Rodríguez-Clare, A. 2014. "Trade theory with numbers: Quantifying the consequences of globalization." In: Elhanan Helpman, Kenneth Rogoff and Gita Gopinath, editor, Handbook of International Economics. Vol 4: 197-261. Elsevier. https://doi.org/10.1016/B978-0-444-54314-1.00004-5

De Backer, K. and D. Flaig. 2017. "The Future of Global Value Chains. Business as Usual or "A New Normal."?" OECD Science, Technology and Innovation Policy Papers No. 41. https://doi.org/10.1787/d8da8760-en

Deardorff, A., & Stern, R. 1983. "Economic Effects of the Tokyo Round." *Southern Economic Journal, 49*(3), 605-624. https://doi.org/10.2307/1058704

Dekle, R., Eaton, J., & Kortum, S. 2007. "Unbalanced trade." *American Economic Review*, 97(2), 351-355. https://doi.org/10.1257/aer.97.2.351

Dixon, P. B. and Rimmer, M. 2002. *Dynamic general equilibrium modelling for forecasting and policy: a practical guide and documentation of MONASH*, 1st ed., vol. 256. Amsterdam: Elsevier. https://doi.org/10.1108/S0573-8555(2002)0000256009

Dixon, P. B., Jerie, M. and Rimmer, M. 2018. *Trade Theory in Computable General Equilibrium Models.* Singapore: Springer Nature. https://link.springer.com/book/10.1007/978-981-10-8325-9

Eaton, Jonathan and Samuel Kortum, 2002. "Technology, Geography, and Trade." *Econometrica,* 70(5): 1741–1779. https://doi.org/10.1111/1468-0262.00352

European Commission. 2013. Reducing Transatlantic Barriers to Trade and Investment: An Economic Assessment. http://trade.ec.europa.eu/doclib/docs/2013/march/tradoc_150737.pdf

Fally, T. 2015. "Structural gravity and fixed effects." *Journal of International Economics*, 97(1), 76-85. https://doi.org/10.1016/j.jinteco.2015.05.005

Feenstra, Robert. 1994. "New product varieties and the measurement of international prices." *American Economic Review*, 84(1): 157–177. https://www.jstor.org/stable/2117976

Feenstra, Robert, Philip Luck, Maurice Obstfeld, and Katheryn N. Russ. 2018. "In Search of the Armington Elasticity." *Review of Economics and Statistics,* 100: 135–150. https://doi.org/10.1162/REST_a_00696

Flaig, D. and S. Stone. 2017. "Local Content Requirements Versus Tariff Equivalents: How We Measure Matters." *The World Economy,* 40(5): 931-948. https://doi.org/10.1111/twec.12426

Flaig, D. and S. Sorescu (2017). "Metro development: Modelling Non-Tariff Measures and Estimation of Trade Facilitation Impacts."
TAD/TC/WP(2016)20/FINAL
http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=TAD/TC/WP%282016%2920/FINAL&docLanguage=En

Fontagné, L., Fouré, J., and Ramos, M. P. 2013. "MIRAGE-e: A general equilibrium long-term path of the world economy." CEPII Working Paper, 2013-39. http://www.cepii.fr/PDF_PUB/wp/2013/wp2013-39.pdf

Fontagné, L., Martin, P., & Orefice, G. 2018. "The international elasticity puzzle is worse than you think. " *Journal of International Economics*, 115, 115-129. https://doi.org/10.1016/j.jinteco.2018.08.011

Fouré, J., A. Bénassy-Quéré, and L. Fontagné. 2013. "Modelling the world economy at the 2050 horizon." *Economics of Transition*, 21(4): 617–654. doi.org/10.1111/ecot.12023. https://doi.org/10.1111/ecot.12023

Fouré, J. and L. Fontagné. 2014. "Long term socio-economic scenarios for Representative Concentration Pathways defining alternative CO2 emission trajectories. " CEPII Research Report 2016-01. http://www.cepii.fr/PDF_PUB/rr/rr2016_01.pdf

Francois, Joseph, and David Roland-Holst. 1997, "Scale Economies and Imperfect Competition." Chapter 11 in J. Francois and K. Reinert (ed.) *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge University Press.

Francois, J. 1998. "Scale economies and imperfect competition in the GTAP model." GTAP technical papers, 16. https://www.jgea.org/resources/download/31.pdf

Freund, C. 2009. "The Trade Response to Global Downturns, Historical evidence." World Bank Policy Research Working Paper 5015. https://doi.org/10.1596/1813-9450-5015

Fugazza, M. and J.-C. Maur. 2008. "Non-tariff barriers in CGE models: How useful for policy?" *Journal of policy Modeling*, 30(3): 475-490. https://doi.org/10.1016/j.jpolmod.2007.10.001

Gouel, Christophe and David Laborde. 2018. "The Crucial Role of International Trade in Adaptation to Climate Change." NBER Working Paper No. 25221. https://doi.org/10.3386/w25221

Gohin, A., H. Guyomard and C. L. Mouël. 2006. "Tariff protection elimination and the Common Agricultural Policy reform: Implications of changes in methods of import demand modelling." *Applied Economics*, 38:13, 1527-1539. https://doi.org/10.1080/00036840500414609

Gourinchas, Pierre-Olivier and Hélène Rey. 2014. "External Adjustment, Global Imbalances, Valuation Effects." In: Elhanan Helpman, Kenneth Rogoff and Gita Gopinath, editor, Handbook of International Economics. Vol 4: 585-645. Elsevier. https://doi.org/10.1016/B978-0-444-54314-1.00010-0

Hallak, J. C. 2006. "Product quality and the direction of trade." *Journal of international Economics*, 68(1), 238-265. https://doi.org/10.1016/j.jinteco.2005.04.001

Hanslow, K. 2001. "The Application of CRESH-Based Functional Forms in CGE Models. " Research Memorandum Cat No.: GA, 506.

Head, K., & Ries, J. 2001. "Increasing returns versus national product differentiation as an explanation for the pattern of US-Canada trade." *American Economic Review*, 91(4), 858-876. https://doi.org/10.1257/aer.91.4.858

Head, K., & Mayer, T. 2014. "Gravity equations: Workhorse, toolkit, and cookbook." In: Elhanan Helpman, Kenneth Rogoff and Gita Gopinath, editor, Handbook of International Economics: 131-195. Elsevier. https://doi.org/10.1016/B978-0-444-54314-1.00003-3

Hertel, T., & Swaminathan, P. 1996. Introducing monopolistic competition into the GTAP model. GTAP Technical Papers 7. https://jgea.org/resources/download/1565.pdf

Hertel, Thomas, Elena Ianchovichina, and Bradley McDonald. 1997. "Multi-region general equilibrium models." Chapter 9 in J. Francois and K. Reinert (ed.) *Applied Methods for Trade Policy Analysis: A Handbook*, Cambridge University Press.

Hertel, T., Hummels, D., Ivanic, M., & Keeney, R. 2007. "How confident can we be of CGE-based assessments of Free Trade Agreements?" *Economic Modelling*, 24(4), 611-635. https://doi.org/10.1016/j.econmod.2006.12.002

Hillberry, Russell and David Hummels. 2013. "Trade elasticity parameters for a computable general equilibrium model." Chapter 18 in P. Dixon and D. Jorgenson (ed.), *Handbook of Computable General Equilibrium Modeling*, North Holland. https://doi.org/10.1016/B978-0-444-59568-3.00018-3

Hummels, David L. 1999. "Toward a Geography of Trade Costs. University of Chicago." http://dx.doi.org/10.2139/ssrn.160533

Hummels, D. 2007. "Transportation Costs and International Trade in the Second Era of Globalization." *Journal of Economic Perspectives* 21(3), 131-154. https://doi.org/10.1257/jep.21.3.131

Hummels, D. L., & Schaur, G. (2013). "Time as a trade barrier." *American Economic Review*, 103(7), 2935-59. https://doi.org/10.1257/aer.103.7.2935

Ianchovichina, E., & McDougall, R. 2000. "Theoretical structure of dynamic GTAP." GTAP Technical Papers 480. Center for Global Trade Analysis, Department of Agricultural Economics, Purdue University. https://ageconsearch.umn.edu/record/28723/files/tp17.pdf

International Energy Agency (IEA). 2015. *World Energy Outlook 2015*. International Energy Agency. Paris, France. https://webstore.iea.org/world-energy-outlook-2015.

International Energy Agency (IEA). 2017. *World Energy Outlook 2017*. International Energy Agency. Paris, France. https://webstore.iea.org/world-energy-outlook-2017.

International Labour Organization. 2018. "ILO Global Estimates on International Migrant Workers: Results and Methodology – Second edition (reference year 2017)." Labour Migration Branch, Conditions of Work and Equality Department, and Department of Statistics.

International Monetary Fund. 2009. "Balance of Payments and International Investment Position Manual: Sixth Edition (BPM6)."

Jafari, Y., & Britz, W. 2018. "Modelling heterogeneous firms and non-tariff measures in free trade agreements using Computable General Equilibrium." *Economic Modelling*, 73, 279-294. https://doi.org/10.1016/j.econmod.2018.04.004

Kee, H. L., A. Nicita, and M. Olarreaga. 2008. "Import Demand Elasticities and Trade Distortions." *The Review of Economics and Statistics* 90 (4): 666-682. https://doi.org/10.1162/rest.90.4.666

Komorovska, Joanna, Marijke Kuiper and Frank van Tongeren. 2007. "Sharing gravity: gravity estimates of trade shares in agri-food." Paper prepared for the 10th annual conference on global economic analysis, Purdue University, West Lafayette, 7-9 June 2007. Organized session "GTAP and gravity". https://www.gtap.agecon.purdue.edu/resources/download/3310.pdf

Krugman, P. R. (1979). "Increasing returns, monopolistic competition, and international trade. " *Journal of international Economics*, 9(4), 469-479. https://doi.org/10.1016/0022-1996(79)90017-5

Kucheryavyy, Konstantin, Gary Lyn, Andrés Rodríguez-Clare. 2016. "Grounded by Gravity: A Well-Behaved Trade Model with Industry-Level Economies of Scale." NBER Working Paper No. 22484. https://doi.org/10.3386/w22484

Lane, Philip R. and Gian Maria Milesi-Ferretti. 2012. "External adjustment and the global crisis." *Journal of International Economics,* 88 (2012) 252–265. https://doi.org/10.1016/j.jinteco.2011.12.013

Lemelin, A. 2017. "Current Account Balances, Exchange Rates, and Fundamental Properties of Walrasian CGE World Models: A Pedagogical Exposition." *Journal of Global Economic Analysis,* 2(1): 1215-324. http://dx.doi.org/10.21642/JGEA.020104AF

Liu, J., Arndt, C., & Hertel, T. W. 2004. "Parameter estimation and measures of fit in a global, general equilibrium model." Journal of Economic Integration, 19(3): 626-649. https://www.jstor.org/stable/23000702

McDaniel C. A and Balestreri E. J. 2002. "A review of Armington trade substitution elasticities." Mimeo USITC.
https://pdfs.semanticscholar.org/f4fb/fa847692345636e4ba12dca45ecd148b1d8c.pdf

McDaniel, Christine A. and Edward J. Balistreri. 2003. "A review of Armington trade substitution elasticities." *Economie internationale,* 2003/2-3: 301–313. https://www.cairn.info/revue-economie-internationale-2003-2-page-301.htm

McKibbin, W.J. and P.J. Wilcoxen. 1999. "The Theoretical and Empirical Structure of the G-Cubed Model." *Economic Modelling,* 16: 123-148. https://doi.org/10.1016/S0264-9993(98)00035-2

Melitz, Marc. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica,* 71(6): 1695–1725. https://doi.org/10.1111/1468-0262.00467

Minor, P. 2013. "Time as a barrier to trade: a GTAP database of ad valorem trade time costs." https://www.gtap.agecon.purdue.edu/resources/download/6124.pdf

Moïsé, E. and S. Sorescu. 2013. "Trade Facilitation Indicators: The Potential Impact of Trade Facilitation on Developing Countries' Trade." OECD Trade Policy Papers, No. 144, OECD Publishing, Paris, https://doi.org/10.1787/5k4bw6kg6ws2-en

Nuno-Ledesma, J., & Villoria, N. (2019). "Estimating International Trade Margins Shares by Mode of Transport for the GTAP Data Base. " *Journal of Global Economic Analysis*, 4(1): 28-49. http://dx.doi.org/10.21642/JGEA.040102AF

Obstfeld, M., Rogoff, K. 1995. "The intertemporal approach to the current account." In: Grossman, G.M., Rogoff, K. (Eds.), Handbook of International Economics. North-Holland, Amsterdam, pp. 1731–1799. https://doi.org/10.3386/w4893

Peterson, E.B. and D. Orden. 2004. "Effects of tariffs and sanitary barriers on high- and low-value poultry trade." Washington DC., IFPRI, MTID discussion paper no. 64. https://www.jstor.org/stable/40987263

Petri, P., M. Plummer, and F. Zhai. 2011. "The Trans-Pacific Partnership and Asia-Pacific Integration: A Quantitative Assessment." East-West Center Working Papers 119, Peterson Institute for International Economics, Washington, DC. https://ssrn.com/abstract=2108399

Philippidis G, H. Resano and A. Sanjuán. 2014. "Shifting Armington trade preferences: A re-examination of the Mercosur–EU negotiations." *Economic Modelling,* 40: 21-32. https://doi.org/10.1016/j.econmod.2014.03.016

Rauch, James and Vitor Trindade. 2003. "Information, International Substitutability, and Globalization." *American Economic Review,* 93(3): 775–791. https://doi.org/10.1257/000282803322157089

Ravikumar, B., Santacreu, A. M., & Sposi, M. 2019. "Capital accumulation and dynamic gains from trade." *Journal of International Economics*, 119, 93-110. https://doi.org/10.1016/j.jinteco.2019.04.009

Robinson, S., M. E. Burfisher, R. Hinojosa-Ojeda and K. E. Thierfelder. 1993. "Agricultural Policies and Migration in a U.S.-Mexico Free Trade Area: A Computable General Equilibrium Analysis." *Journal of Policy Modeling,* 15(5&6): 673-701. https://doi.org/10.1016/0161-8938(93)90009-F

Romalis, J. 2007. "NAFTA's and CUSFTA's Impact on International Trade." *The Review of Economics and Statistics*, 89(3), 416-435. https://doi.org/10.1162/rest.89.3.416

Ruhl, K. J. 2008. "The international elasticity puzzle." Mimeo NYU. https://core.ac.uk/download/pdf/6344759.pdf

Sampson, T. 2015. "Dynamic selection: an idea flows theory of entry, trade, and growth." *The Quarterly Journal of Economics*, 131(1), 315-380. https://doi.org/10.1093/qje/qjv032

Simonovska, Ina and Michael E. Waugh. 2014. "The elasticity of trade: Estimates and evidence." *Journal of International Economics*, 92(1): 34–35. https://doi.org/10.1016/j.jinteco.2013.10.001

Soderbery, Anson. 2015. "Estimating Import Supply and Demand Elasticities: Analysis and Implications." *Journal of International Econom*ics, 96(1): 1–17. https://doi.org/10.1016/j.jinteco.2015.01.003

Soderbery, Anson. 2018. "Trade Elasticities, Heterogeneity and Optimal Tariffs." *Journal of International Economics*, 114: 44–62. https://doi.org/10.1016/j.jinteco.2018.04.008

Spearot, A. (2016). Unpacking the long-run effects of tariff shocks: New structural implications from firm heterogeneity models. *American Economic Journal: Microeconomics*, 8(2), 128-67. https://doi.org/10.1257/mic.20140015

United Nations (2017). "International Migration Report 2017." United Nations, Department of Economic and Social Affairs, Population Division. ST/ESA/SER.A/403. https://www.un.org/en/development/desa/population/migration/publications/migrationreport/docs/MigrationReport2017.pdf

U.S. International Trade Commission (USITC), 2019. *U.S.-Mexico-Canada Trade Agreement: Likely Impact on the U.S. Economy and on Specific Industry Sectors*. Investigation No. TPA 105-003. https://www.usitc.gov/publications/332/pub4889.pdf

Van der Mensbrugghe, Dominique. 2018. "The Standard GTAP Model in GAMS, Version 7." *Journal of Global Economic Analysis*, 3(1): 1-83. http://dx.doi.org/10.21642/JGEA.030101AF

Walmsley, T. and P. Minor. 2016. "Willingness to Pay in CGE Models: Estimating the benefits of improved customs efficiencies within the WTO Trade Facilitation Agreement." ImpactEcon Working Paper Rev2. https://www.gtap.agecon.purdue.edu/resources/download/7858.pdf

Walmsley, T., Winters, A., and A. Ahmed. 2011. "The Impact of the Movement of Labour: Results from a Model of Bilateral Migration Flows." *Global Economy Journal*, 11(4): 1524-5861. https://doi.org/10.2202/1524-5861.1738

Wolff, E. N. 1999. "The productivity paradox: evidence from indirect indicators of service sector productivity growth." *The Canadian Journal of Economics*, 32(2), 281-308. https://doi.org/10.2307/136424

World Bank. 2016. Potential Macroeconomic Implications of the Trans-Pacific Partnership. In: Eds. World Bank (2016). Global Economic Prospects, January 2016: Spillovers amid Weak Growth. https://doi.org/10.1596/978-1-4648-0675-9

World Bank. 2018a. "Migration and Remittances: Recent Developments and Outlook." Migration and Development Brief 29. https://www.knomad.org/sites/default/files/2019-04/Migrationanddevelopmentbrief29.pdf

World Bank. 2018b. "Migration and Remittances: Recent Developments and Outlook." Migration and Development Brief 30. https://www.knomad.org/sites/default/files/2019-04/Migrationanddevelopmentbrief30.pdf

World Bank. 2018c. "Personal remittances received (% of GDP)." World Bank Data Bank. https://data.worldbank.org/indicator/BX.TRF.PWKR.DT.GD.ZS

WTO-OECD-UNCTAD. 2009-20018. "Reports on G20 trade and investment measures." https://unctad.org/en/Pages/DIAE/G-20/UNCTAD-OECD-reports.aspx?UN=1,30

WTO. 2018. *World Trade Report. The Future World Trade: How Digital Technologies are Transforming Global Commerce*.

Wunderlich, A.C. and A. Kohler, A. 2018. "Using empirical Armington and demand elasticities in computable equilibrium models: An illustration with the CAPRI model." *Economic Modelling*, 75: 70–80. https://doi.org/10.1016/j.econmod.2018.06.006

Zeitsch, J., McDougall, R., Jomini, P., Welsh, A., Hambley, J., Brown, S. and Kelly, J. 1991. "SALTER: A General Equilibrium Model of the World Economy," SALTER Working Paper No. 4, Industry Commission, Canberra. http://www.pc.gov.au/ic/research/models/saltermodel/workingpaper04

Zhai, Fan. 2008. "Armington Meets Melitz: Introducing Firm Heterogeneity in a Global CGE Model of Trade." *Journal of Economic Integration*, 23: 575-604. https://www.jstor.org/stable/23001233

Appendix A. Additional tables

Table A1. Regional and sectoral aggregation

GTAP sectors	Country/regions
Agriculture	Oceania
Extraction	East Asia
Processed food	Japan
Textiles	China
Chemicals	India
Other goods	ASEAN
Metals	Canada
Electrical machinery	USA
Motor vehicles	Brazil
Transport equipment	LAC
Other machinery	EU28
Trade	EFTA
Transport	MENA
Business services	SSA
Other services	Rest of the world

Source: Own aggregation of the GTAP model.

Table A2. Modelling the trade balance in different models

Model	**Savings**	**Investment**	**Current Account**	**Government account**	**Classification**
ADAGE	Not documented	Grows at same rate as GDP	Not documented	Gvnmt exp. Grows at same rate as GDP	NA
AIM Model	Fixed private propensity to save	Follows from savings and exogenous CA	Exogenous: fixed capital account	Fixed government deficit	Type 2
DART	Exogenous savings rate	Endogenously determined by savings and price of investment	Endogenous	Gvnmt exp. and budget deficit exogenous	Type 1
EC-MSMR	Exogenous savings rate	Follows from savings and exogenous CA	Exogenous: constant trade balance	Consolidated household	Type 2
ENGAGE	Savings rate converging developed economies' rates	Follows from savings and exogenous CA	Exogenous (not clear from outline)	-	Type 2

ENVISAGE	Fixed private propensity to save	Follows from savings and exogenous CA	Exogenous: fixed capital account	Gvnmt exp. and budget deficit exogenous	Type 2
ENV-LINKAGE	Endogenous marginal propensity to save	Exogenous investment to GDP trajectory	Exogenous net foreign savings trajectory	Gvnmt exp. and budget deficit exogenous	Type 3
EPPA	Fixed private propensity to save	Follows from savings and exogenous CA	Exogenous: BOP is fixed	Fixed government deficit	Type 2
EU-EMS	In progress				
EXIOMOD	-				NA
GDYN	Fixed CD share or endogenous as a function of ratio of wealth to income	Endogenous determined by GDN investment theory or exogenous (adjusting errors in expectations or adjusting risk premium)	Endogenous or exogenous	Consolidated household	Type 1 or type 2
GLOBIOM	-				NA
ICES	Fixed CD share as in GTAP, not adjusting	Rate of return rule GTAP	Endogenous	Consolidated household	Type 1
IGEM	Euler equation, perfect foresight	Follows from savings and exogenous CA	Exogenous with adjusting terms of trade	Deficit and tax rates exogenous, G end.	Type 2
IMACLIM	-				NA
JRC-GEM-E3 Model	Not specified	Not specified	Endogenous or exogenous	tax rates and budget deficit fixed or endogenous	Type 1 or type 2
MAGNET	Fixed CD share as in GTAP, not adjusting	Rate of return rule GTAP	Endogenous	Consolidated household	Type 1
MESSAGE	-				NA
MIRAGE-E	Changing savings rate as a function of	Changing investment rate based on Feldstein-	Determined by trajectory of savings	Consolidated household	Type 1

	demographics and per capita growth	Horioka equation	and investment		
REMIND	Based on intertemporal optimization	Based on intertemporal optimization	Endogenous	-	Type 1
SNOW	Not documented	Determined by savings	Exogenous balance of payments		Type 2
TEA Model	Fixed propensity to save	Follows from savings and exogenous CA	Exogenous decreasing trend in capital account	Consolidated household	Type 2
Thuenen Magnet	Fixed CD share as in GTAP, not adjusting	Rate of return rule GTAP	Endogenous	Consolidated household	Type 1
USDA FARM	Not modelled	Investment is fixed share of expenditure	Either fixed or reduced gradually to zero	Consolidated household	Type 3
Weg_Center	Fixed propensity to save	Follows from savings and exogenous CA	Exogenous: BOP is fixed	Consolidated household	Type 2

Notes: Type 1: Trade balance is endogenous and adjusts to behavior of savings and investment. Type 2: Investment is endogenous and adjusts to behavior of savings and the trade balance. Type 3: Savings is endogenous and adjusts to behavior of investment and the trade balance.

Table A3. Trade balance to GDP ratios (in per cent) under different closures in 2012 and 2040

	Initial (2012)	Fixed ratio	Fixed value	Conver ging	Feldstein -Horioka	Rate-of-return	Initial shares	Combined FH/ROR	Combined FH(adj)/ROR
ASEAN	3.51	3.51	1.52	0.12	4.28	0.91	8.57	3.49	2.95
Brazil	-0.48	-0.50	-0.32	-0.02	-1.66	-4.55	2.45	-2.26	-3.09
Canada	-0.17	-0.16	-0.13	-0.01	3.20	5.20	-5.25	3.60	5.45
China	3.45	3.27	1.25	0.11	0.79	1.52	3.93	1.83	-0.37
EFTA	9.15	9.04	7.48	0.30	3.72	7.85	-3.41	4.40	6.13

EU28	-0.63	-0.62	-0.52	-0.02	-1.93	-1.19	-5.03	-2.26	-1.67
India	-8.26	-7.79	-3.07	-0.28	2.56	-7.16	1.94	1.33	1.12
Japan	-0.19	-0.18	-0.19	-0.01	-0.18	6.13	-4.49	1.10	1.70
LAC	0.91	0.92	0.54	0.03	-0.23	-0.64	1.78	-0.59	-0.28
MENA	7.47	7.64	3.90	0.26	0.16	-0.46	0.83	-0.37	0.84
Oceania	0.40	0.40	0.28	0.01	-1.42	-0.29	-4.17	-1.42	-0.16
Other East Asia	7.76	7.58	4.61	0.25	3.48	6.54	3.07	3.57	5.84
ROW	4.66	-4.38	2.50	-0.21	-0.86	-1.32	5.79	-1.36	-2.58
SSA	-0.37	-0.37	-0.14	-0.01	2.02	0.99	7.74	1.53	0.85
USA	-4.97	-4.86	-3.87	-0.17	-1.25	-0.98	-2.89	-1.28	-0.36

Notes: The table displays the ratio of the trade balance to GDP in per cent in 2012 and in 2040 for the eight different closures.

Source: Own simulations with WTO GTM.