

Modelling trade and other economic interactions between countries in baseline projections

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Abstract.

This paper examines the way trade is modelled in the construction of baseline projections with dynamic computable general equilibrium models. Current approaches in the field are compared, reviewed, and assessed; simulations are conducted on some of the most important choices in modelling trade in dynamic projections; and recommendations are formulated on best practices emerging from the comparison exercise and areas in need of further research and spending of resources on data collection. Simulations are conducted on the size of trade elasticities, the way the trade balance is modelled (macroeconomic closure), trade growth, and value chains and multi-regional input-output structure. Other topics scrutinized are the modelling of zeros, the role of energy prices, modelling new technologies and new types of trade policies (trade in data and digitalization), phasing in of future trade policies, and the role of capital income and remittances. We conclude that there is relative consensus about the use of nested Armington preferences, whereas different teams 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.

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JEL codes: F17, C68

Keywords: Trade growth, macroeconomic closure, trade structure

1. Introduction

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 dynamic CGE-models has an important bearing on the resulting baseline projections.¹ 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 five 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, value chains and multi-regional input-output structure; 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 the role of capital income and remittances.

The simulations until 2035 use the same base-data and a uniform set of baseline macroeconomic projections. The base-data consist of an aggregation of GTAP9.2 to 15 regions, 15 sectors, and 5 factors of production.² For the baseline macroeconomic projections, we have employed the middle scenario (medium variant) of the UN projections on population and labor force growth and the SSP2 scenario of the OECD for GDP per capita growth³. 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.

¹ Contributions to the literature on baseline projections focusing on future trade patterns are, among others, Fouré et al. (2013), Chateau et al. (2015), Anderson and Strutt (2012), and Bekkers et al. (2019).

² Table A1 contains an overview of the aggregation.

³ 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).

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 MRIO structure and Section 6 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 7, the role of new technologies in Section 8, the phasing in of future trade policies in section 9, and the modelling of migration and remittances in Section 10. Section 11 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, which are similar to Armington (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 finish this Section with an analysis of the impact of variations in the trade elasticity on baseline projections.

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), unlike single-country models, 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.⁴ 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, the results of policy experiments could be different between the Armington and Eaton-Kortum models although this is not expected.

Differences across trade models is 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 CES structure for demand of intermediate inputs.⁵ 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 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.”

As noted by Hilberry 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.⁶ 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. (2017) note that this effect could be extended to explain different elasticities in a nested Armington structure.

⁴ In models written in relative changes (using 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.

⁵ 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 Kucheryavyi, Lyn, and Rodriguez-Clare (2016).

⁶ 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.

Very few papers have empirically tested the validity of a nested Armington structure, or the differences in elasticities by tier. 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 Mirage model, 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, Arndt, and Hertel (2002) could not reject the rule of 2, Feenstra et al. (2018) come to a more nuanced conclusion applying new estimation techniques to highly disaggregated U.S. production and trade data.⁷ They find 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, incorporate a constant elasticity of transformation (CET) structure on the sales side.⁸ 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. Hence, adding the CET structure might be a remedy in case modelers run into problems solving their model, although this would admittedly be an ad hoc approach. A further 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-models (Swaminathan and Hertel, 1996; Francois, 1998). After the development

⁷ Specifically, they apply additional moment conditions to correct for small-sample biases in earlier work by Feenstra (1994) and Broda and Weinstein (2006).

⁸ The Standard GTAP Model in GAMS by Van der Mensbrugghe (2018) contains the possibility to include a CET-nest between domestic sales and exports.

of the Melitz firm heterogeneity model, various researchers included firm heterogeneity in different ways into their CGE-models (Zhang, 2008; Balistreri et al., 2011; Dixon and Rimmer, 2016; Akgul et al., 2016; Britz and Jafari, 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 into dynamic CGE models. First, scale economies, love-of-variety preferences (or some variant), and firm heterogeneity are real-world feature. Second, comparative static experiments have shown that models of firm heterogeneity behave very different in specific cases 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.⁹ 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.¹⁰ 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. 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 implemented in Britz and Jafari (2018) for example.

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

⁹ See for example Bekkers and Francois (2018) for a discussion.

¹⁰ See for example Kucheryavyi, Lyn, and Rodriguez-Clare (2016) for the latter approach.

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 (2019) 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 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. 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 policy experiment. Modelers employing exact hat algebra instead solve for the ratio of endogenous variables with and without 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 (GAMS-based models).

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. 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 is focused more instead on comparative static policy exercises (Caliendo and Parro (2015) on the effects of 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 Sposi et al. (2018) and Dvorkin et al. (2018)). Scholars in the two fields would benefit from more interaction. Dynamic CGE modelers could for example gain useful insights from recent models incorporating endogenous innovation in their models (Sampson, 2017; 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. Most models follow the substitution elasticities provided by GTAP, which were estimated by Hertel, Hummels, Ivanic, and Keeney (2007). These authors have estimated 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, which is a measure of how much trade changes with respect to a change in variable trade costs. 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 (2012) 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.

¹¹ Up to Version 5, GTAP followed the elasticities from the SALTER project based on a literature review and estimates for New Zealand, giving an average of 5.3.

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. Fontagne et al. (2018) 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, Fontagne 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 GMM with a constrained grid search to eliminate infeasible estimates (imaginary or less than unity). Soderbery (2015) implements a nonlinear 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 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)	3.22	TSLS
		4.05	2-step GMM

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.¹² Many models, such as CES-based Armington-style national product 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, Mayer, and Thoenig (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

¹² Head and Mayer (2014) note that the gravity equation can be expressed in the form $X_{ij} = GS_i M_j T_{ij}$, 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.

elasticities of eight, common in the era of Head and Ries (2001) and Eaton and Kortum (2002), seemingly less frequent in recent years.

2.6 The importance of Armington elasticities in baseline projections

Introduction

The importance of behavioral parameters in general equilibrium modelling is indisputable among modelers and policy analysts (see literature review in previous sections). Despite this, there is a surprising lack of economic research assessing the impact of changes in various behavioral parameters on modelling results.

The economic literature dealing with this topic is focused on estimating these parameters in econometric models (see discussion in section 2.4 and 2.5 above) and to a lesser extent on assessing the impact of changes in these parameters on macroeconomic variables such as GDP, trade etc. This problem is even more acute when it comes to analyzing the effect of changes in behavioral parameters on baseline projections. 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 this purpose, we use the dynamic GTAP model GDyn to explore the impact of altering the default GTAP database elasticities by one and two standard deviations respectively.¹³ We change both Armington parameters – the substitution between domestic versus imported composites and versus imports from different geographical sources. Our results provide the first insights about the importance of these changes for total and regional trade as well as for commodity trade only.

To simulate the impact of changes in Armington elasticities we alter the standard Armington parameters by 1 and 2 standard deviations respectively. We ran 2 baseline projection scenarios in addition to the standard baseline with default GTAP Armington elasticities: (i) a baseline with parameters augmented by 1 standard deviation (scenario 1) and (ii) a baseline scenario including Armington elasticities altered by 2 standard deviations (scenario 2). It is important to recall, that we have increased both tiers of Armington parameters i.e. we assumed that commodities are becoming more substitutable in both respects: domestic versus imported composites and among import baskets from different geographical origins. So, we have kept the default GTAP assumption that the substitutability across products from different foreign markets is approximately twice as high as the substitutability between domestic and imported commodities.

¹³ 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).

Figure 1 provides an overview of the sectoral elasticities in the different scenarios, i.e. the default GTAP elasticities and the augmented parameters used in the modelling simulations. The Armington elasticities are the highest in 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 baseline scenario and the default plus 1 and 2 standard deviations.

In the two alternative scenarios the Armington elasticities were not altered in the services sectors. There are various reasons for this. First, by default the Armington elasticities are the same for all services sectors except for sector ‘other services’ in which the parameter assumes the value of 1.98 compared to 1.9 for the rest of the sectors in our sectoral aggregation. The second reason is that the Armington elasticities estimates for the services sectors follow a different methodology in addition to the fact that services trade data is of poorer quality than merchandise trade data. Finally, services are far less substitutable than goods.

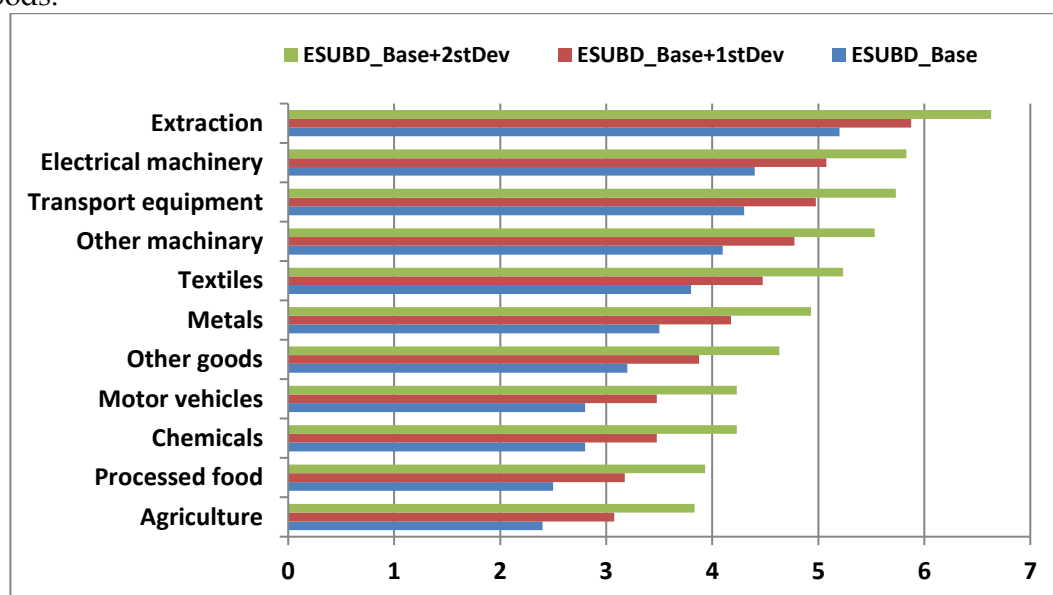


Figure 1. Armington elasticities used in the different baselines scenarios.

Source: GTAP database and own calculations.

Impact on total trade

Figure 2 displays our simulation results after running the baseline projections and the 2 scenarios described above. In scenario 1, which replicates an increase of the Armington elasticities by one standard deviation, total trade is 0.2% lower relative to the baseline in the first year and the difference continues to widen until 2024 when it is 0.6% lower. After 2025 total trade starts recovering until

2035 in which it is 0.1% higher than in the baseline. This is explained by the trend in price indices, which first goes up and then starts to decline.

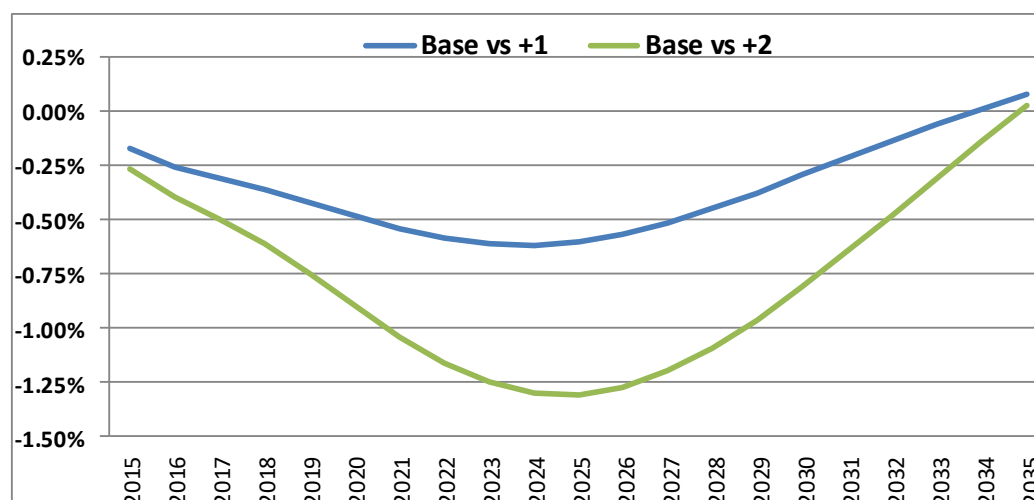


Figure 2. Impact of different baseline scenarios on total trade.

Source: GDyn model and own calculations.

Scenario 2 is similar to scenario 1 and as expected the decline in trade is even larger – starting with a difference of 0.3% in the first year of our simulation and reaching a difference of 1.3% by 2025. Also in this scenario trade recovers at the end of our simulation period, however, by much less so: it is only 0.03% higher in 2035 relative to the baseline.

The results of our simulations show that there is a non-linear impact on trade of altering the Armington elasticities in the dynamic GDyn model. Trade declines in both scenarios. However, the impact on trade in the baseline is the highest after 9 and 10 years for respectively scenario 1 and 2. The slope in both curves displayed in Figure 2 reveals that trade tends to recover quicker after the trough of the U-shaped curve is reached.

Figure 3 provides our simulation results for the three scenarios by the regions included in our regional aggregation. The calculations presented here reflect the regional export shares in total exports. Interestingly, the impact is quite diversified in respect to the different regions included in our simulations. The increase of the Armington elasticities leads to a gradual decline in total trade of the EU by 2.6%, rest of East Asia by 2.2%, EFTA by 1.5%, MENA by 1.5% and Canada by 1.3% in scenario 1. At the same time, total trade is higher for India by 7.5%, China by 3% and rest of the world by 2.1% relative to the baseline with default Armington elasticity values. In scenario 2, the regional impact is more

pronounced. In this case the rest of East Asia experiences the largest decline in the region's share of global exports (lower by 4%), followed by the EU (lower by 3.8%), EFTA (lower by 2.9%), Canada (lower by 2.9%) and Brazil (lower by 2.5%).

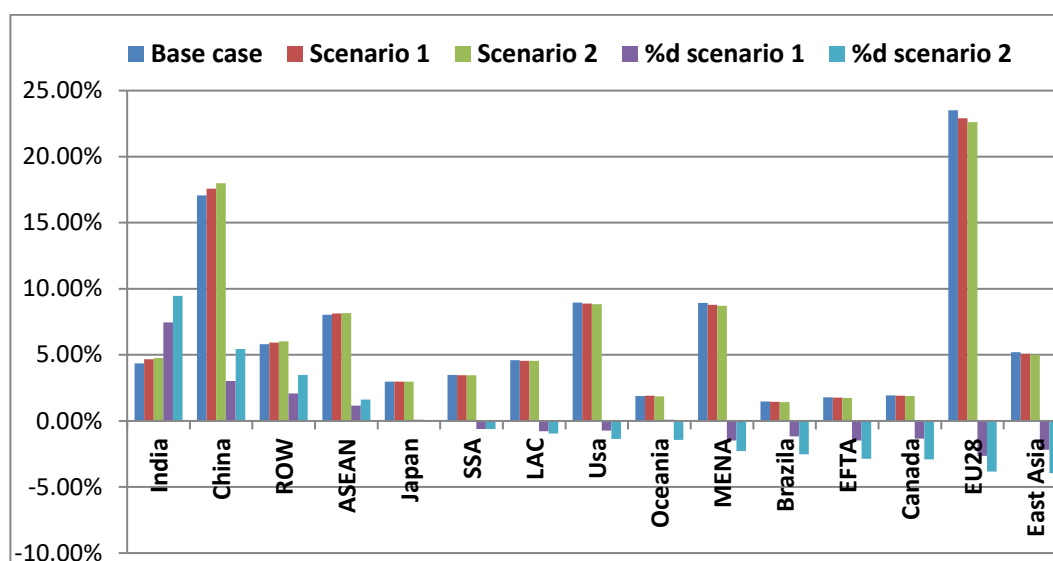


Figure 3. Regional Impact of change in Armington elasticities on different baselines scenarios.

Source: GDyn modelling results and own calculations.

This result shows that changing the Armington elasticities in the baseline has non-negligible effects on regional export shares and hence also on regional market shares. The results suggest that strongly growing countries like China and India raise their share in global exports, whereas developed countries with lower projected growth such as EFTA and the EU reduce their exports. Intuitively, this can be explained as follows. With a larger substitution elasticity, importing countries substitute more towards the strongly growing countries to source their products from. Hence, the share of strongly growing regions in global trade rises.

Employing the changes in the geographical pattern of trade, we can also provide an explanation for the overall reduction in global trade as displayed in Figure 2. Increasing trade elasticities in a distorted world could worsen allocative efficiency. Strongly growing regions like China and India, which have on average high tariffs, would import less and substitute towards domestic goods. With a larger trade elasticity, this effect becomes stronger. For the EU and EFTA, it is the other way around. This provides a possibly counterintuitive result that trade tends to be lower until 2025, the years in which growth is highest for the large emerging countries.

Impact on commodity trade

Larger Armington elasticities lead to a much stronger decline in trade in commodities. We find no recovery of commodity trade at the end of the simulation in 2035. In comparison to the baseline projection, trade is 0.2% lower in 2035 in scenario 1 and 0.1% lower in scenario 2.

There is a pronounced impact on regional shares of total commodity exports in both scenarios. EFTA and the EU for example experience a decline in their shares in total commodity exports by 9.5% and 8% in scenario 1 and by 11.5% and 9.6% in scenario 2 respectively. The shares of India and China in total commodity exports are 36% and 4.7% higher in scenario 1 and 40% and 7.3% higher in scenario 2 respectively.

These stronger effects for the fall in global trade and the changing geographical composition of trade are intuitive, since only the trade elasticities for commodities were changed in the experiments.

3. Modelling of 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:¹⁴

$$S - I = X - M \quad (1)$$

In words, the trade balance must be equal to the difference between savings and investment. 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 the standard GTAP model 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-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.

¹⁴ This equation follows directly from $Y = C + I + G + X - M$ and $Y = C + S + G$.

Second, domestic savings and the trade balance can be modelled explicitly, implying that investment follows from equation (1). An example is the standard GTAP model with savings a Cobb-Douglas share of income and the trade balance relative to income also 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).¹⁵

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).

Table A2 classifies the 24 models discussed in the workshop in Paris in January 2018 based on the three options discussed. In 7 models, savings and investment are imposed on the model and the current account is a residual variable. In 10 models the savings rate and the current/capital account are modelled and the investment rate is a residual variable. And in 3 models the savings and investment rate are imposed on the model with an adjusting current account. In 5 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 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 rate, 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

¹⁵ 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.

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 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 Wilcoxon (1990) might be a good option in such cases. This model includes intertemporal optimization and intertemporal budget constraints in a model with 100 regions.

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. Recent work by Lane and Milesi-Ferretti

(2012) synthesizes 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 emerging countries. Second, the old-age dependency ratio is associated with a worsening current account in emerging countries, because ageing countries tend to dissave. 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.

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 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 seven 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 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.

A second more sophisticated closure 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 Foure

et al. (2012) we impose that the change in the investment rate in country i , $\Delta \frac{I_{it}}{Y_{it}}$

, can be written as a function of the change in the savings rate, $\Delta \frac{S_{it}}{Y_{it}}$, and an

error correction term:

$$\Delta \frac{I_{it}}{Y_{it}} = \alpha_i + \beta \left(\frac{I_{it-1}}{Y_{it-1}} - \zeta_i - \kappa - \frac{S_{it-1}}{Y_{it-1}} \right) + \delta \Delta \frac{S_{it}}{Y_{it}} \quad (2)$$

The third and fourth 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 third closure is implemented by assuming that the trade ratio falls linearly to zero until the end of the simulation period, 2040. In the fourth closure the value of the trade balance is fixed, which implies that the trade balance ratio is falling over time because of growing economies.

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. In the first, third, 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 is reallocated to the other regions. 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 the other $n-1$ regions.¹⁶ 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 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 on net investment flows. In the sixth closure (the other static GTAP model closure) investment is allocated across regions in which global investment is allocated proportionally across the regions.

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 explains only a share of the variation in the investment rate. In particular, 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. The share of each of the components can be varied in the simulations.

¹⁶ 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 was coded directly in the WTO Global Trade Model.

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. The coefficients of the Feldstein-Horioka component are not set equal to the estimated coefficients 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 determined in an iterative procedure. In particular, the coefficients are adjusted such that the Feldstein-Horioka relation estimated with the simulated data aligns with the empirically estimated coefficients. The Online Appendix outlines further details of this approach. This closure is implemented twice, with as n th region for which the described closure is not imposed respectively the USA and Rest-of-World. This is done to examine the impact of setting a different omitted region. 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 the other $n-1$ regions.

The eight closures are implemented in the WTO Global Trade Model, 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 GTAP92 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 Foure 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. Figure 4 displays 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. Although the figure comprises a lot of results it enables us to draw many conclusions. 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 combination of Feldstein-Horioka and rate of return rule. 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, 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, something we will dub the *nth* region problem. The reason is that in equilibrium the value of global savings has to be equal to the value of global investment. For example, under the fixed trade balance ratio the ratio cannot be fixed in all *n* regions since this would lead to an inequality between global savings and global investment. Hence, the disadvantage of all the closure rules requiring an *nth* region is that the trade balance of the *nth* region could generate peculiar behavior. As discussed above, for the Feldstein-Horioka closure and the combined Feldstein-Horioka and rate of return closure, international investment flows in the *nth* region are reallocated across the other *n*-1 regions such that all regions satisfy the imposed rule approximately.

Figure 4 shows that for the fixed ratio and converging closure the *nth* 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 *nth* region, indicating that global savings exceed global investments in the *n*-1 regions requiring a deteriorating trade balance in the *nth* region. Instead, with a fixed trade balance value closure the trade balance has to improve in the *nth* region. If the *nth* region is not of much interest for the research questions at hand, the *nth* region problem does not pose a compelling argument against the use of the fixed ratio and fixed value closures in our simulations.

Figure 4 shows that for the Feldstein-Horioka rule the trade balance of *nth* 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. However, for the combined rule with Rest-of-World as omitted region, the trade balance for Rest-of-World becomes highly negative and furthermore the trade balance for the USA improves substantially. This result seems to be driven by the fact that the difference between residual investments and the trade balance according to Feldstein-Horioka in Rest-of-World is large and thus leads to a considerable reallocation of investment flows.

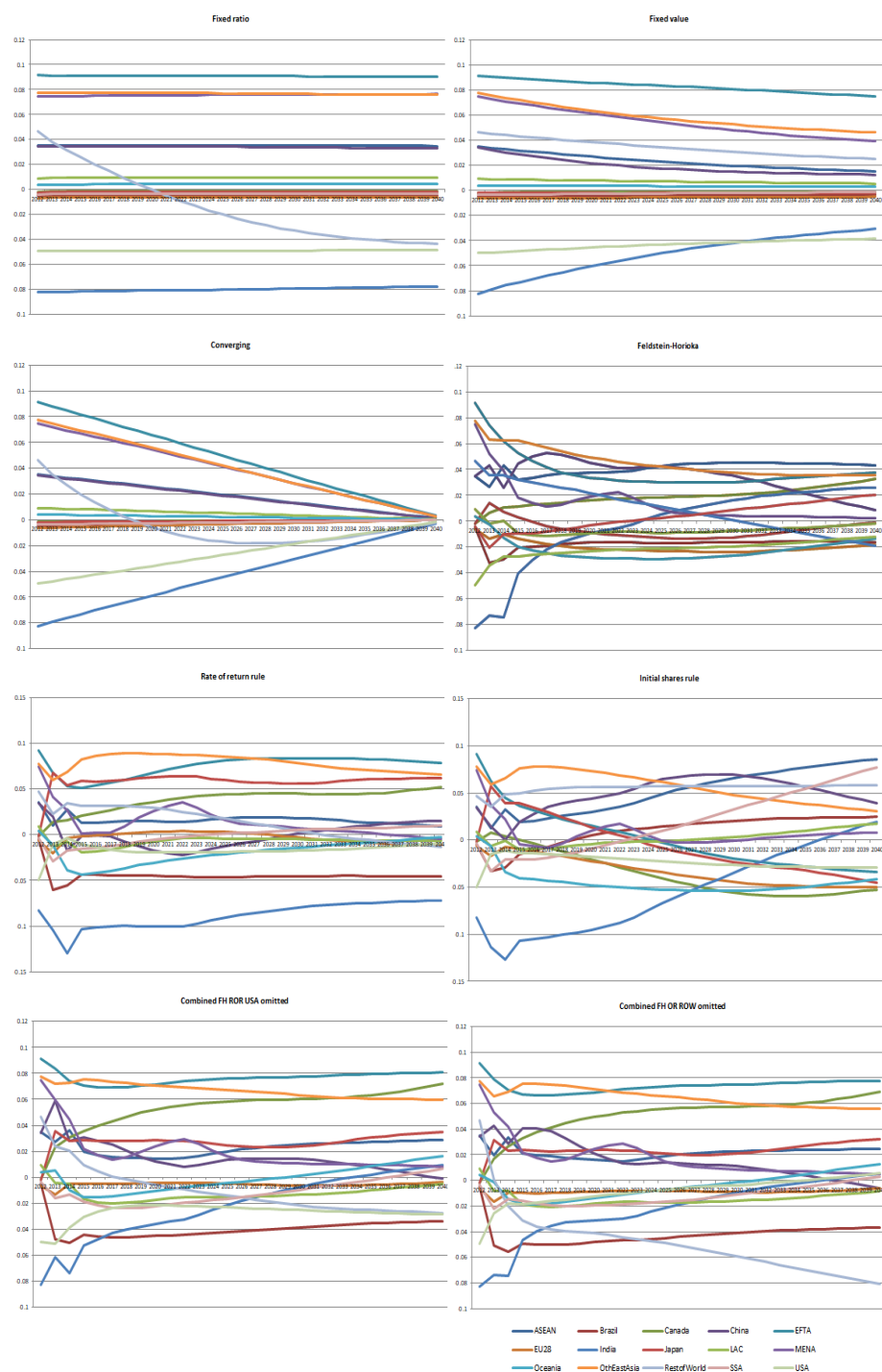


Figure 4. Trajectory of trade imbalances in different regions for different closures

Source: Own simulations with WTO Global Trade Model

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 5. 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.

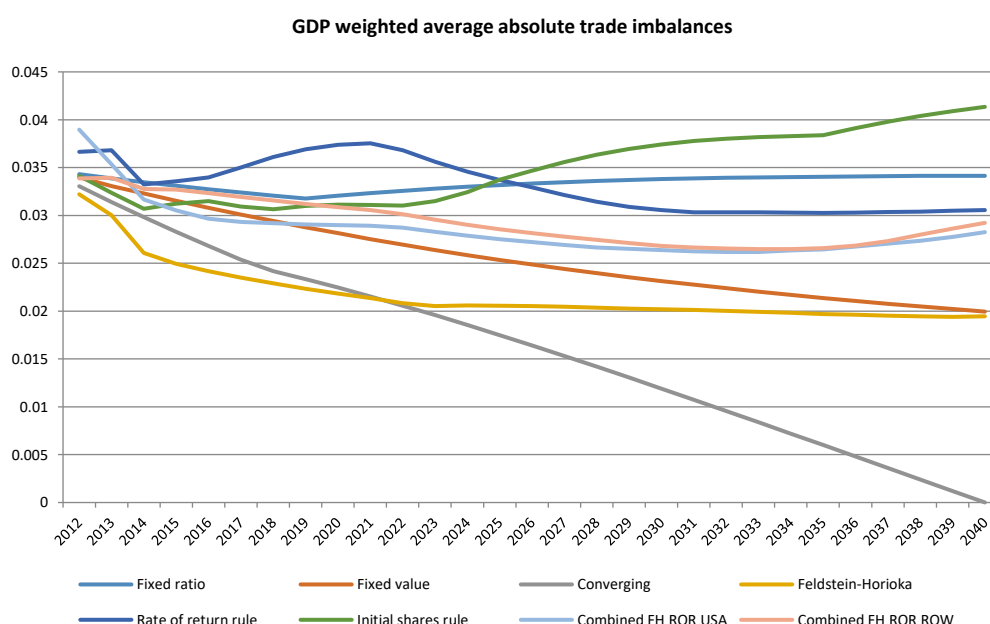


Figure 5. Development of GDP weighted average of absolute trade balances under different closures

Source: Own simulations with WTO Global Trade Model

Figure 6 shows the change in the trade balance ratio from 2011 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 5 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 predict 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. However, the largest improvement in the trade balance of the United States occurs for closures in which the United States is the nth country (the combined FH-ROR rules with Rest-of-World the residual region). Turning to China it is surprising that the combined FH-ROR rules generate larger reductions in the trade balance than the separate Feldstein-Horioka closure and the rate of return rule. This is probably due to the way the combined FH-ROR rule is calibrated, 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.

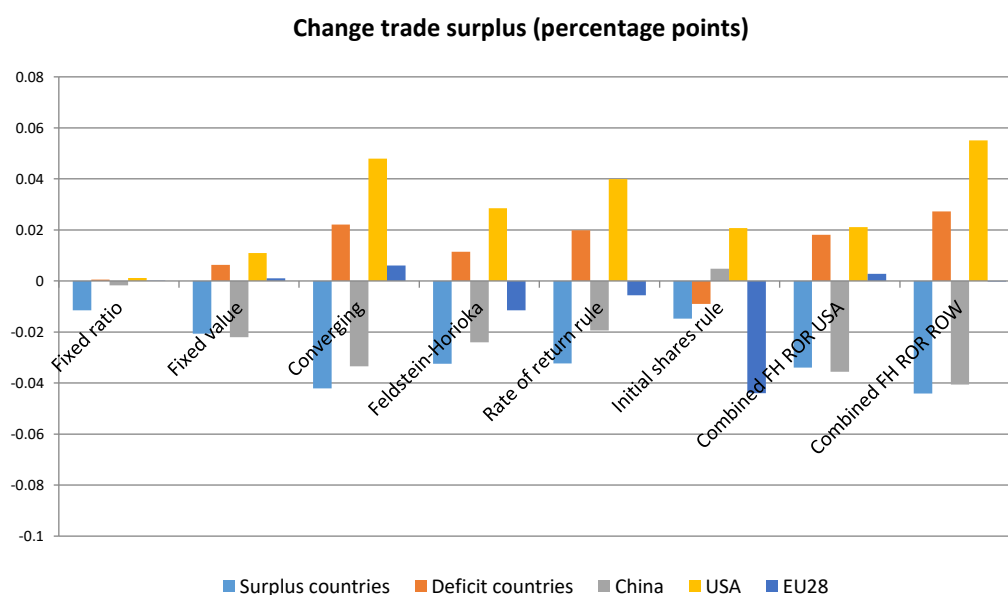


Figure 6. Change in the trade balance in selected regions from 2011 to 2040 in percentage points

Source: Own simulations with WTO Global Trade Model

Next, we explore how the shares of different regions in global trade are affected by trade balance closures, an often-displayed statistic in dynamic trade simulations. Figure 7 displays the change in the share of global trade 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 range 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.

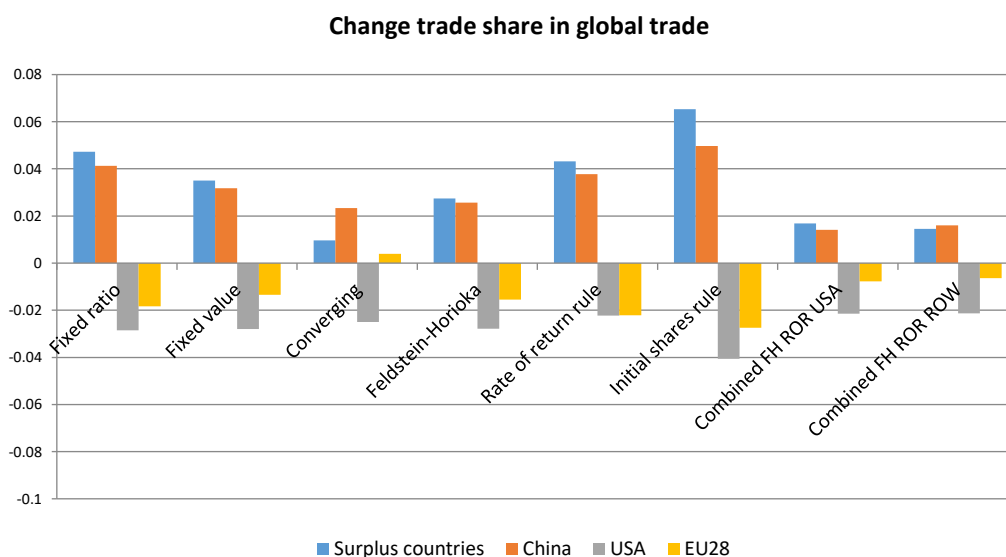


Figure 7. Change in the global trade share of selected regions from 2011 to 2040 in percentage points

Source: Own simulations with WTO Global Trade Model

3.6 Concluding remarks and discussion

There is a wide variety of ways the trade balance is modelled: in most models both the savings rate and the trade balance are fixed with domestic investment the residual variable; in many 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 seven 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 evaluate which macroeconomic closure is preferable 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 importance put on 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 (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. The performance is not great, due to difficulties in dealing with the n th region. 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, if proven fruitful, could be a good candidate for best practice.

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 7 include explicit trade-related trajectories in their baseline, whereas 15 models do have specific assumptions on energy prices (see Fouré et al., 2019). These assumptions are either related to trade policies, as in MAGNET or MIRAGE-e which include mainly EU trade policies in their baseline, or related to transportation costs. The assumptions on transportation cost range from very simple rules of thumb (e.g. ENV-Linkages and 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 AIM and ImaclimR.

The purpose of this section is firstly to identify whether such 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 fairly 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 reference 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 – Apparent 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 (Fontagné et al., 2013), which is very close in terms of structure to other standard models such as GTAP (Corong et al., 2017). 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 paper, 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 the CGE as in any structural gravity model. We now examine other determinants that are not present in the standard structure of the CGE, 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 (resp. a 1.96% decrease 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 1987.¹⁷ 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

¹⁷ It should be noted that this measure is not supported by more recent data such as EU-KLEMS.

broad sense (time, red-tape, quality of communications) have also been decreasing, e.g. with the different trade facilitation initiatives (see e.g. OECD, 2018).

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. In order to be able to draw conclusions on energy prices (more details are provided later in the paper), we augment the standard aggregation by adding 5 energy goods (coal, oil, gas, electricity and petroleum and coal products).

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

- 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”: no specific assumption is retained
- “TFP Transport”, “Tariffs”, “Energy prices”: each of the alternative assumption is introduced one at a time
- “Historic”: All three alternatives are considered jointly.

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. Apparent world trade-to-income elasticity 2011-2040 under alternative assumptions (MIRAGE-e).

Baseline	Assumptions on			Elasticity of global trade to GDP	
	Energy prices	TFP boost in transport	Tariffs cuts	Goods	T otal
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 NTMs on goods as estimated by Kee et al. (2009) 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,¹⁸ 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 8.

¹⁸ 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.

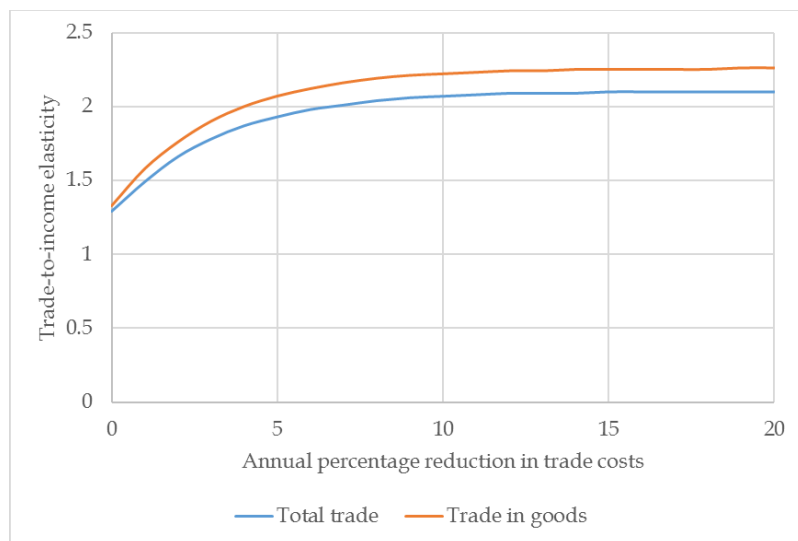


Figure 8. World trade-to-income elasticity 2011-2040 as a function of non-tariff trade costs reduction

Source: own calculations using MIRAGE-e.

Our results are two-fold. On the positive side, a decrease of 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% yearly drop in the real price of oil, the observed annual reduction in tariffs between 1973 and 2004 and a modest reduction in Non-Tariff Measures 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 historical 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 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 will remain outside of any mitigation policy. This also implies that more leakages 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.

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 backcasting 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 GTAP to provide multiple base years in their recent releases, as this will help the community to run the required backcasting exercises.

5. Role of energy prices

5.1 Introduction

As noted in Section 3, 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.

Actually, the majority of the models reviewed included a specific mechanism to deal with fossil natural resources. Among the 24 reviewed models, only 8 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, ImacimR, EPPA, 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. This section will focus on the potential impacts of energy prices on trade, because a general overview of practices regarding fossil resources is already provided in Fouré et al. (2019), while the issue of energy modelling within CGE models is presented in Fæhn et al. (2019) and the coupling with external energy models is dealt with in Delzeit et al. (2019).

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 propose in this section a baseline exercise conducted with the MIRAGE-e model (Fontagné et al., 2013). With regards to fossil natural resources, MIRAGE-e adopts the simpler approach described above of relying in the implementation on 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 database to the standard aggregation, with the only difference that we add detail in energy sectors: we split the “Extraction” sectors into “Coal”, “Oil”, “Gas” (comprising the GTAP gas and gdt sectors) and “Other Extraction”; and we separate “Petroleum and coal products” from the “Chemicals” sector. 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. This first one (labeled “Endog.”) does not impose exogenous energy price trajectories and therefore considers the natural resources as fixed. The three other scenarios are taken from the World Energy Outlook (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 like MIRAGE-e because (i) the GTAP database do 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 9 depicts the outcome of this simplification, which is implemented in the model.

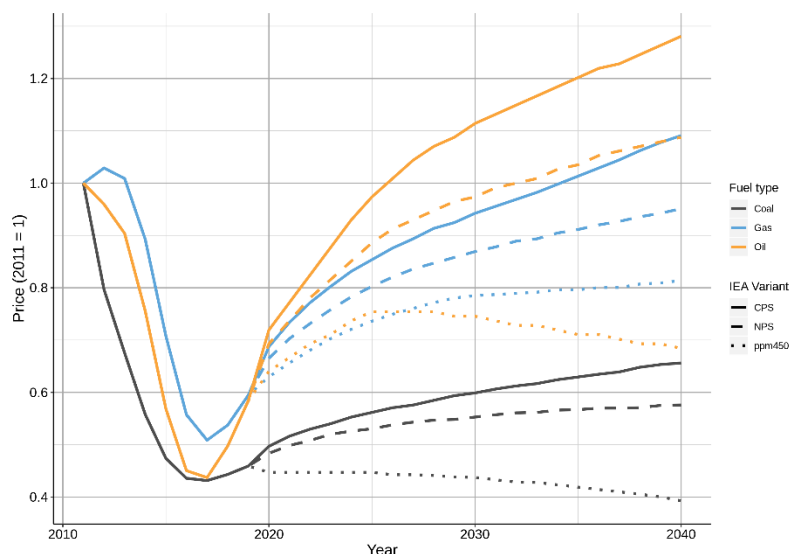


Figure 9. World Energy outlook projections for energy prices.

Note: Thin lines represent price trajectories before smoothing; thick lines correspond to smoothed price trajectories actually implemented in MIRAGE-e.

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 9 show that the different scenarios are sufficiently differentiated, while at the same time remaining within reasonable bounds.

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

5.2.2 Methodology

The three baseline exercises considered will be very simple: the three baselines will share the same macroeconomic projections (the SSP2 from EconMap) and will only differ in the energy price projections. This poses a double question of consistency. First, the macroeconomic model underlying the SSP2 projections uses the medium price scenario (NPS) from IEA (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 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.

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 the price of primary goods is more significantly impacted by the different scenarios, which triggers substitution effects.

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 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,¹⁹ 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 conclusion, as we also know that the current GTAP data on transportation costs is based on U.S. data only and extrapolated, thus heterogeneity in transportation modes and energy-intensity of transportation is understated. In addition, and perhaps more importantly, the transportation module in MIRAGE-e is rather simple²⁰ and could be questioned.

¹⁹ 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 vary minimally with no statistical significance, both in levels or in logs. This result persists even if we consider different modes of transport in the aggregation.

²⁰ ²⁰ In MIRAGE-e, a demand for international transportation is addressed, for each trade flow, to a global supply (using a constant transport demand to volume share). The global supply is then split between modes and supplying countries using simple Cobb-Douglas CET. Hence, the model has a homogenous energy-content of transportation by mode and do not allow for regional differences.

Table 5. Difference in trade volume and world average price by sector in 2040 between PPM450 and CPS scenarios (%)

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.

However, Table 6 shows that in some cases, the regional allocation of trade flows will be strongly impacted. 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, between PPM450 and CPS scenario, 2040 (%)

Exporter	Primary goods			Secondary goods			Services		
	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

Note: The table should read "Exports of primary goods from Africa and Europe to Africa and Europe in 2040 are 24.4% larger in the PPM450 baseline compared to CPS baseline".
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 e.g. 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 towards 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.

6. Value chain trade (MRIO structure)

7. Extensive margin and zeros

7.1 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.

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, e.g. 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 database and then discuss some approaches to model changes along the extensive margin.

7.2 Relevance of zeros in GTAP-Database

We analyze whether changes along the extensive margin are important in the data, we consider movements in zero trade flows in the GTAP-database. An important decision is what cutoff value to set for zero trade flows. 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-database). As discussed below conventional models also 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 displays in turn 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, the value of trade in 2014 with trade being zero in 2004 and trade positive in 2014, and 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), following in sequence by fossil fuels, manufacturing, and services. Third, the share of trade becoming positive over 5 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, with the share of agricultural trade between developing countries becoming positive only being 1.4%. Furthermore, about the same share of trade, 1.3%, was positive in 2004 and has become zero in 2014.

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 database.

7.3 Modelling changes along the extensive margin

Generally, small trade shares can be the result of three basic factors, two of which are relevant for long-term projections: (i) trade policy, (ii) factors affecting trade costs, such as energy prices and trade technology, (iii) 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.

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. Witzke *et al.* (2005) introduce a minimum commitment levels, similar to the LES expenditure system. 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, Burfisher *et al.*, 1993; Weyerbrock, 1998) opts for an AIDS (Almost Ideal Demand System) 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, Kuiper and van Tongeren (2007) proposed a method that uses gravity estimates to generate shift parameters in the standard GTAP 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)).²¹

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.

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).²²

8. Role of new technologies and required trade policies

Deep free trade agreements (FTAs) are increasingly focused on areas related to digital trade such as intellectual property, e-commerce, and data flows. At the same time digital trade is expected to grow at above-average rates, expanding its role in the economy. This creates challenges for existing CGE modeling

²¹ 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.

²² 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.

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 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 this requires the inclusion of an innovation module, which could be a function of IP-protection, the modelling of intangible capital, and a distinction between physically traded goods and services and digitally traded goods and services. On the data side the challenges are even more formidable, requiring information about flows of 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, and measures of flows in data. 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. 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.

9. 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.²³ If the tariff schedules are publicly available from the text of the trade agreement, the tariff reduction in the baseline could follow the schedules. Alternatively, tariff reductions can be phased in stepwise or linear fashion. To pool their effort on this data-intensive work, a joint ITC-GRIPS-USITC project is currently compiling a tariff line database for a number of RTAs with a yearly phase in schedule until 2045. The focus of this project is on “RCEP-APEC-EU” countries.²⁴

Preferential tariff rates of trade agreements are typically not fully utilized due to restrictive rules of origin, low initial tariffs or relatively high compliance cost. 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). Rules of origin are modelled typically as rising (imported) input costs.²⁵

The modelling of non-tariff measures (NTM) 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 years²⁶ it is a challenge to relate a specific FTA concession on NTMs to reductions

²³ Most models should incorporate a tariff instrument, if not, its implementation is straight forward.

²⁴ The agreements covered end of 2018 are FTAs between the 11 country signatories of the 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.

²⁵ Data on utilization rates and 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.

²⁶ 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.

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.²⁷ To our knowledge, a project aiming to establish a NTM "concessions" database, similar to 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 the last decades saw more restrictive barriers being erected in advanced economies (e.g., WTO-OECD-UNCTAD, 2009-2018; Kee et al., 2008, Anderson et al., 2016).

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 approach²⁸ 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 a non-discriminatory way) and are criticized for strong effects on GDP.²⁹ Willingness to pay approaches try to address this.³⁰ 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.³¹ Other issues, besides quantification of trade barriers in services, include the depiction of services in current trade data and the

²⁷ World Bank, 2016, European Commission, 2013 Copenhagen Economics, 2009.

²⁸ 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.

²⁹ 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.

³⁰ See for example Walmsley and Minor (2016).

³¹ See again for example the homepage of the Global EPAs Research Consortium for an overview of databases.

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 expected. If the focus of the baseline is trade and bilateral relations, it is not possible to ignore NTM concessions given its importance. 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 concessions. If a country already has other RTA partners, the rule would involve scaling up the trade share of the country with its new RTA partner to the same level as its trade share with existing RTA partners. Another approach would be to scale up the expected trade share to the same level as countries with similar trade agreements. Where the bilateral trade relationship is not the focus of research, the use of trade elasticities or extrapolation might be a sensible solution.

10. Migration and remittances

The global migrant population is estimated to be 258 million³², which represents an increase of nearly 50 per cent between 2000 and 2017 (UNDP 2017). Migrants contribute to local economies, directly through participation in the local workforce as well as indirectly through knowledge spillover. The population of migrants of working age is estimated at 234 million of which 164 million participate in the workforce. 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).

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

³² excluding refugees, which are estimated to be at 19 million persons (UNHCR, 2018).

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 specification) 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. (2016), 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 disincentivize 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 GDP. In their research, Aguiar et al. (2016) focus on Indonesia, the Philippines, Bangladesh, India, Pakistan, and Sri Lanka. On average in 2017, personal remittances in these countries comprise 3 per cent of GDP, but for individual countries, the percentage can be much higher with remittance flows to the Philippines accounting for over 10 per cent of GDP (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. (2016) 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. (2016) 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 with which they consider how a three per cent increase in migrant workers 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 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.

In summary, the incorporation of migration into dynamic modelling frameworks allows for enhanced policy analysis, particularly pertaining to population demographics, the labor force, and the balance of payments. 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.

11. 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 value chain structure of the models. 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 (2014), 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).³³ 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 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 CGEs 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.

³³ See the work of Dixon et al (2018).

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 for example 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. 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). Second, the discrepancy between real trade growth generated by business-as-usual dynamic CGE models and historical trade growth deserves further attention. Third, new modelling tools have to be developed and additional data collected to explore international trade questions related to the rapidly growing digital economy.

Acknowledgements

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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	Gvnmnt 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	Gvnmnt 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	Follows from savings and	Exogenous: fixed capital	Gvnmnt exp. and budget	Type 2

	save	exogenous CA	account	deficit exogenous	
ENV-LINKAGE	Endogenous marginal propensity to save	Exogenous investment to GDP trajectory	Exogenous net foreign savings trajectory	Gvnmnt 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 demographics and per	Changing investment rate based on Feldstein-Horioka equation	Determined by trajectory of savings and investment	Consolidated household	Type 1

	capita growth				
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.

Supplementary Material