1 CGE modelling of Free Trade Agreements

1.1 What are CGE models

Computable General Equilibrium (CGE) models have been, since the late 1980s, the standard tool for conducting large-scale impact assessments. These include a broad range of subjects, such as free trade agreements, government or institutional policies, economic scenarios (e.g. new infrastructure investments) and events (e.g. a drought, or an oil spill).

A CGE model is a quantitative method that simulates the core economic interactions. It uses data on the structure of the economy to estimate the impacts that a shock could have (e.g. in terms of GDP growth, employment, inflation, trade flows etc.).

Despite their usefulness in simulating policy implications, CGE models are often viewed with suspicion as a “black box”, whose results cannot be meaningfully traced due to their structural complexity. Accordingly, the aim of this paper is to briefly illustrate the theoretical and algebraic foundations at the core of all CGE models and highlight their applicability as a tool for evaluating trade agreements.

1.2 Typologies of CGE models

CGE models distinguish themselves by their theoretical frameworks and underlying assumptions. Differences across models reflect differences in the theory that underpins the behavioural equations, the extent to which linkages within the economy are explained, and the data used to conduct the analysis. Overall, CGE models are distinguished based on:

- **the geographical scope** (i.e. regional versus national or international) — CGE models can incorporate multiple regions within a country (i.e. multi-regional), or just a single region (i.e. national). A regional CGE model is based on regional economic theory, as the interactions between regions differ from the interactions between nations. For instance, the effects of government stimulus on regional quality of life and inter-regional migration are not captured in national models, but can be simulated in a regional model. Regional CGE models also account for a region’s influence on national trade patterns. In contrast, national or international models assume that international trade terms and patterns are not influenced by regional activity.

- **the temporal structure** (i.e. static versus dynamic) — a static CGE model is solved for one period, whereas a dynamic CGE model involves multiple periods. Within the dynamic group, there is a further sub-categorisation into inter-temporal dynamic models and recursive dynamic models. In the former, consumers and firms face an inter-temporal utility and profit maximization problem, respectively; in the latter, the model solves a sequence of static equilibria in which behaviour is implicitly based on backward-looking adaptive expectations rather than forward-looking rational expectations.

- **the underlying market structures** (i.e. perfect versus imperfect competition) — CGE models can incorporate alternative market structures. Imperfect competition can be captured by introducing price mark-ups. An important feature of the imperfect competition assumption is that price mark-ups are reduced by intensified competition attributed to the policy shock, thus generating additional welfare gains.

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1 See e.g. International Institute for Sustainable Development (2015) “Quantifying the Mega-regional Trade Agreements; A Review of the Models”.

2 Generally, such treatment is reserved for manufacturing sectors, which feature differentiated products, while perfect competition assumptions are usually used for the primary sectors.
In turn, an important feature of the perfect competition assumption for tariff simulations is that tariff cuts are fully passed through to consumers.

- **the incorporation of FDI** — An increasingly important feature of CGE model has been the incorporation of foreign direct investment (FDI). This is essential for modelling the effects of investment chapters in modern trade agreements and for capturing the effects of services sector liberalization; and

- **the incorporation of heterogeneous firm characteristics** — Where the standard CGE models have a representative firm for a given sector, heterogeneous firms theory suggests that industries are populated by firms that vary widely in size, productivity and other characteristics. Moreover, the theory recognises that firms face fixed costs of entry into export markets. Several CGE models have been developed recently introducing elements of firm heterogeneity. However, such attempts are still at an early stage of development.

### 1.3 An indicative example of the effects of a shift in consumer preferences

Assume consumers’ preferences to shift in favour of a particular domestic good (e.g. because a tariff is imposed on a similar imported good). Naturally, final demand for the domestic good increases. As a result:

- the price of the domestic final good will increase;
- profit-maximising firms will want to produce more of the good and demand more inputs (i.e. intermediary goods, capital and labour); and
- prices in other markets, such as capital and labour, may also increase.

Thus, linkages between sectors result in the original price increase of the final good being transmitted to other markets, thus generating consequences for other sectors. This is due to the effects that input price increases can have on prices of other final goods depending on the production process, or the proportion of inputs used. These are the secondary effects of the shift in preferences.

The functioning of CGE models is underpinned by these effects. The corresponding changes in demand and supply of final and intermediate goods, labour and capital are continuously measured until a new equilibrium is reached. This is the situation where prices balance demand and supply in all markets (i.e. market clear). In the long-run, this implies that all markets that have interacted with each other reach equilibrium.

### 1.4 How do CGE models work

CGE models begin from a pre-policy baseline (i.e. the economic situation before the shift in consumer preferences in the example above), on which simulations are run to determine the post-policy effects. The baseline is generated by using base year (i.e. pre-policy) data in order to set the exogenous variables in the model (fitting the model equations and the behavioural parameters to the data). This means that the model is set to simulate the effects of the shock on the current structure of the economy, which is assumed to be in a stable or equilibrium position.

CGE models reflect the behaviour of economic agents:

- Consumers demand the different consumption goods and services, and provide labour and capital to the firms. Their consumption bundle is determined such that it brings maximum utility to the consumer, given a budget constraint.
  - It is normally assumed that the supply of labour is known, while several types of labour are often distinguished (i.e. from high—skilled to low—skilled). It is assumed that labour markets are in

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3 See e.g. PWC (2014) “A multi-regional computable general equilibrium model of the UK economy”

4 In economics, a variable is exogenous to a model if it is not determined by other parameters and variables in the model, but is set externally and any changes to it come from external forces.
equilibrium at the national level (i.e. no unemployment would remain, although some models relax this assumption) and that the prices of all types of labour are flexible.\textsuperscript{5} For each labour type, supply and demand will become equal to the equilibrium wage.

- Consumers also supply the capital that firms demand. In some CGE models the capital markets are national, whereas other CGE models include international linkages between capital markets. The price of capital is then determined based on global demand and supply.\textsuperscript{6}

- International markets for goods and services are linked as well. The demand for a good is also expressed in international markets, as opposed to solely the domestic market. CGE models assume that in each region a different variety of a good or service is produced and that, in principle, consumers demand all varieties. The demand for each variety then depends on:
  - its relative price and substitution possibilities;
  - transportation or other margin costs;
  - trade barriers; and
  - preferences.

- There are CGE models that explicitly include the government, whereas incorporate government expenditures as part of private consumption. Overall, it is very rare for a CGE model to include the behaviour of government. CGE models do include, nevertheless, the government budget, such that the taxes on imports, consumption and production are equal to subsidies and government consumption. All tax and tariff rates are assumed to be exogenous.

Lastly, it is important to note that most CGE models assume that the sum total of revenue from the production of goods must be allocated to:

- households in return for the labour and capital provided (i.e. primary factor rentals);
- other industries as payments for intermediate inputs; or
- the government as taxes.\textsuperscript{7}

The value of a unit of each commodity in the economy must then equal the sum of the values of all the inputs used to produce it. This reflects constancy of returns to scale in production and implies that in equilibrium producers make zero profit.

### 1.5 CGE modelling data requirements

A Social Accounting Matrix (SAMs) forms the backbone of CGE models. SAMs capture the flows of all economic transactions that occur within a year. Its primary data sources are the Input-Output (IO) tables and the National Accounts (NAs), complemented by a range of other data on taxes, income and expenditure. Using these metrics ensures that the model closely reflects the real economy.

In order to replicate the base year equilibrium in the absence of any shocks, the calibration process uses the above data to estimate most of the coefficients and exogenous variables used in the model (i.e. fitting the data). Existing empirical studies are also often advised to determine parameters which govern demand and supply responsiveness to price changes (i.e. elasticities).

The underlying data is linked together through a set of equations that govern how the economy evolves over time in response to a policy change. These equations are based on economic theory and determine the

\textsuperscript{5} See e.g. CEPS (2014) “The impact of TTIP. The underlying economic model and comparisons”.

\textsuperscript{6} For instance, the GTAP model assumes linkages between international capital markets. If capital is abundant in one country (and relatively inexpensive), it is invested in a country where it is scarce (and relatively expensive). See CEPR (2013a), “Reducing Transatlantic Barriers to Trade and Investment, An Economic Assessment”.

\textsuperscript{7} This assumption is often referred to as the conservation of value principle. See e.g. Wing, S. (2004) “Computable General Equilibrium Models and Their Use in Economy-Wide Policy Analysis: Everything You Ever Wanted to Know (But Were Afraid to Ask)” MIT Joint Program on Science and Policy of Global Change, Technical Note no. 6
relationship between supply and demand for goods, services and factors of production in the economy. Prices of goods and factor inputs are flexible, such that demand and supply equalise at an equilibrium price.

1.6 CGE models and free trade agreements

The most comprehensive approach to modelling mega-regional free trade agreements (FTAs) is to employ a CGE trade analysis. In general, FTAs cover goods, services and investment, and establish obligations and disciplines in a wide range of subject areas.

For instance, welfare can be impacted differently by an FTA, so the net effect may be positive (e.g. due to trade creation), or negative (e.g. due to trade diversion). CGE models thus provide an empirical foundation for policy analysis that can quantify the effects suggested by theory, and indicate the likely net welfare effect. At the core of this process, the imported and domestically produced varieties of a given good are typically modelled as imperfect substitutes. Therefore, the choice between the domestic and the foreign variety depends on a parameter known as the Armington elasticity. Armington elasticities are of key importance in determining the impacts of FTAs in CGE models.\(^8\)

To simulate an FTA, the CGE model must first be calibrated so that the produced outcomes in the baseline situation match those observed in the real economy (e.g. prices or trade volumes). Once this is achieved, simulating an FTA is simply a matter of adjusting or eliminating trade barriers between FTA partners. Particular focus is placed on non-tariff barriers (NTBs) due to the inherent quantification challenges. More specifically:

- **NTBs on goods** — Customs cooperation and trade facilitation are likely to reduce transportation costs between countries. These costs are often higher for trading firms than tariffs.\(^9\) However, quantifying the cost reduction that can be attributed to a given FTA is challenging. Along these lines, FTAs also tend to harmonise the standards under which firms active in international trade operate.\(^10\) However, methods enabling capturing the effect of standards harmonisation, and the effects of the corresponding increase in the extent of tradability of goods, or of raising standards, and the effects of the corresponding increase in the fixed costs of accessing international markets, is at an early stage of development.

- **NTBs on FDI** — In order to assess the effects of FTAs on direct investment, the analysis must include those FDI flows that feed into productive capital. In this respect, the challenge lies mainly in quantifying the policy shock.\(^11\) In order to address such concerns, several indexes available in literature are used, such as the FDI Restrictiveness Index by the OECD.\(^12\)

- **NTBs on services** — Significant NTBs may exist due to non-alignment of standards in the services sectors. However, trade agreement usually do not address such non-alignment issues.\(^13\) Moreover, the multiple modes in which services can be delivered raise concerns. Trade agreements generally do not address Mode 2 services.\(^14\) The focus is mainly on Mode 1, Mode 3 and to a lesser extent Mode 4 services.\(^15\)

\(^8\) Armington elasticities capture the extent of substitutability between goods from different countries.


\(^10\) E.g. in terms of labour, or the environment.


\(^12\) See e.g. [http://www.oecd.org/investment/fdiindex.htm](http://www.oecd.org/investment/fdiindex.htm)

\(^13\) For instance, in the air transport sector, the alignment of regulations is primarily accomplished through Open Skies Agreements, rather than through trade agreements.


\(^15\) The General Agreement on Trade in Services (GATS) is a treaty of the World Trade Organization (WTO) that entered into force in January 1995. The GATS agreement covers four modes of services in cross-border trade. Mode
• **NTBs on intellectual property rights (IPRs)** — On the one hand, IPR protection provides incentives to innovate, which should increase economic activity; on the other hand, IPR protection slows the diffusion of innovation, which should give rise to incentives to imitate and decrease economic activity.\(^{16}\) Moreover, there exists a range of regulatory barriers in IPR, including differences in:
  - the definition of IPR;
  - patent systems and filing procedures;
  - recognition of performance and broadcasting rights;
  - software patentability; and
  - exhaustion rules (i.e., loss of patent rights with first sale).\(^{17}\)

Overall, the model simulation represents what the economy would look like if the FTA had occurred. In most cases, the modelling process will include different scenarios related to the potentially divergent effects of adjusting NTBs such as the ones discussed above, or to account for provisions pertaining to specific sectors (e.g. trade liberalisation in non-agriculture sectors). By comparing post-FTA outcomes with the baseline situation, the model can quantify:

• changes in consumer/producer surplus or other welfare indicators;
• changes in production by sector;
• changes in the returns to the factors of production (i.e., labour by skill, capital, land); and
• changes in imports and exports by sector and by partner in the FTA.

The following tables, presents an overview of the application of CGE models in estimating the effects of the transatlantic trade and investment partnership (TTIP) and transpacific trade partnership (TTP):

**Table 1.1: CGE modelling and the TTIP**

<table>
<thead>
<tr>
<th>Study</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECORYS(^{18})</td>
<td>Assessment of costs of regulatory divergence and of spill-over effects from regulatory convergence. The model captures both rent-creating and cost-creating NTBs.</td>
</tr>
<tr>
<td>CEPR(^{19})</td>
<td>The model engages in a detailed assessment of potential gains from NTBs. The model captures both rent-creating NTBs in the form of higher mark-ups and cost-creating NTBs in the form of higher transportation costs to market.</td>
</tr>
<tr>
<td>CEPII(^{20})</td>
<td>Recursive dynamic model incorporating vertical product differentiation and imperfect competition. The study features higher estimates of services NTBs and incorporates spill-over effects evaluated at 5% of NTBs.</td>
</tr>
<tr>
<td>Institute of Developing Economies(^{21})</td>
<td>Static model that incorporates substitution across sources of intermediate inputs to capture the effect on value chains. Spill-overs effects are captured by assuming trade cost reductions.</td>
</tr>
</tbody>
</table>

\(^{1}\) (cross-border supply) covers services delivered within one country, from the territory of another country. Mode 2 (consumption abroad) covers services delivered in the territory of another country, to a service consumer of the home country. Mode 3 (commercial presence) covers services delivered within the territory of the country, through the commercial presence of the supplier. Mode 4 (presence of a natural person) covers services delivered within one country, with supplier present as a natural person.


\(^{17}\) Some of these issues are directly addressed in FTA texts. For instance, Berden et al. (2009) identify large potential welfare gains from TTIP IPR regulatory convergence: US$5.9 billion per year for the EU and US combined.


The CGE model is complemented by partial equilibrium analysis. The overall analysis includes procurement markets and FDI.

Recursive dynamic model that features a foreign-invested firm alongside the domestic firm in each sector and explicitly models FDI and Mode 3 services. The study uses the FDI Restrictiveness Index. It generates low estimates of TTIP, based on previous US and EU commitments in services and FDI, and a modest evaluation of the effect of the TTIP on regulatory convergence.


### Table 1.2: CGE modelling and the TTP

<table>
<thead>
<tr>
<th>Study</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>East-West Center</strong>²⁴</td>
<td>This study uses a heterogeneous firm CGE model with stylized parameters to describe the distribution of firm productivity. It codes 24 TPP chapters for their effects on NTBs in goods, services, and FDI. The model is solved on a projected data set for future years out to 2030, but is not a dynamic model.</td>
</tr>
<tr>
<td>**Lee and Itakura (2014)**²⁵</td>
<td>This study features a recursive dynamic model, which takes into account international capital mobility. Tariffs and estimates of NTBs in services sourced from the literature are reduced by 20 per cent, and time costs of trade are reduced by 20 per cent to capture NTBs in goods trade.²⁶</td>
</tr>
<tr>
<td><strong>Asian Development Bank</strong>²⁷</td>
<td>This study features the recursive dynamic GDyn model, which takes into account international capital mobility. This study focuses on tariff concessions.</td>
</tr>
<tr>
<td><strong>RIETI</strong>²⁸</td>
<td>This study introduces productivity gains induced by greater imports. It focuses on goods trade and takes into account tariffs and NTBs.</td>
</tr>
<tr>
<td><strong>Centre for WTO Studies</strong>²⁹</td>
<td>This study focuses on tariff effects to identify issues for a non-member of the TPP (India).</td>
</tr>
</tbody>
</table>


### 1.7 Conclusion

CGE modelling offers a straightforward methodological solution to conducting large-scale impact assessments, such as those covering mega-regional free trade agreements. Naturally, as with any other estimation method, CGE analysis has its caveats. More specifically:

- the data requirements for FTAs are extensive;
- frequently, certain data items are arbitrarily determined; and
- the model’s results may be sensitive to the assumptions and data used.

To address these concerns, almost all CGE exercises include a sensitivity analysis to obtain a range of results based on different assumptions or data. Overall, despite the inherent challenges, CGE analysis remains the most comprehensive method for conducting ex-ante policy analysis. Especially for FTAs, analyses of this sort

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are conventionally conducted using CGE models as these have sufficient structural features to capture the main focus areas.