Københavns Universitet
Økonomisk Institut

An introduction to CGE-modelling and an illustrative application to Eastern European Integration with the EU

Toke Ward Petersen*

September 1997

Abstract:
This paper gives an introduction to Computable General Equilibrium (CGE) modelling, and presents an application of the technique to the analysis of the Europe Agreements between the EU and Hungary, Poland and the former Czechoslovakia. The main purpose of the paper is to illustrate the method, rather than present a state-of-the-art analysis. The CGE-approach makes it possible to pursue the analysis further than possible with analytic methods, and it can yield qualitative as well as quantitative results. A model is presented, and it is used to analyse the consequences of the Europe Agreements as well as the sensitivity of the results to important assumptions. The analysis shows only modest long run gains for the Eastern European countries (around 1-2% of GDP per year), and very small gains for the EU countries. The sensitivity analysis shows that the results are relatively robust to the way the model is calibrated.

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* This paper is a shortened and edited version of my Master's Thesis "Modelling Regional Integration using CGE-models" from the Institute of Economics at the University of Copenhagen (Petersen, 1996). I would like to thank my supervisor Hans Keiding for guidance with the thesis, as well as useful comments on this paper. Furthermore I would like to thank Peter Trier for helpful comments on an earlier version of this paper. However, the usual disclaimer applies. E-mail: twp@dst.dk.

1. Introduction

This paper presents an analysis of the Europe Agreements (EA) between the EU and the Hungary, Poland and the former Czechoslovakia (the so-called Visegrad countries). The main purpose of the paper is to demonstrate *how* this topic can be analysed using a Computable General Equilibrium (CGE) model, and which issues can be addressed. The discipline of CGE-modelling is relatively new; one can consider it an extension of the Input-Output analysis that Wasilly Leontief made popular in the 1960s. The method applies the structure formalised in the Arrow-Debreu model to analyse actual real-life policy issues. But unlike traditional General Equilibrium models, these models are solved numerically and not analytically – their use is policy driven. This approach has its pros and cons. It means that one can solve very large models and need not worry about finding an analytic solution. The price paid for this is a loss of generality, since the results obtained will be specific to the model and the parameters used - *quid pro quo*.

This paper is organised as follows. The first section reviews how far one can get with a theoretical approach when modelling regional integration issues. The second section contains short introduction to CGE-modelling. It is not a crash course in CGE-modelling, but a sound knowledge of the methodology makes it easier to appreciate the illustrative model of the Europe Agreements. The third section briefly introduced the Europe Agreements (EAs), and discusses how to model them. Fourth is a presentation of the model that will be used to analyse the issue. The model is relatively simple, but does still have all the features needed to demonstrate how one could go about modelling the issue. The next section contains a brief presentation of the results that the model generates, as well as a discussion of the sensitivity of the results. The final section summarises the findings of the paper, and discusses exactly how CGE-modelling was a useful tool in investigating the Europe Agreements.

2. Theoretical perspectives on regional integration[1]

Before attempting to model an issue, it is always worth considering, which parts of reality the model should depict, and which features should be left out. When it comes to modelling the Europe Agreements, or regional integration in general, this amounts to considering the arguments that are usually put forward as to why countries engage in such agreements[2]. Here we will limit ourselves to economic reasons, and in particular only look at *trade creation*.

The earliest customs union theory was in the oral tradition, and can be summarised quite briefly: Free trade maximises world welfare; a customs union reduces tariffs, and is thus a move towards free trade; therefore a customs union will increase world welfare (even though it does not lead to a

[1] A word about notation: Following Anderson and Blackhurst (1993), the term Regional Integration Arrangement (RIA), will in this paper cover all of the following types of arrangements (in order of sophistication): Preferential Trading Agreements, Free Trade Areas (FTAs), Customs Unions (CUs), Common Markets and Economic Unions - all characterized by the reciprocal nature of the preferential treatment.

[2] The reasons can be divided in economic and non-economic reasons. Of the economic reasons, the one analysed here (Trade creation) is the most prominent. The other economic reasons all have a strategic nature. See Anderson and Blackhurst (1993) or Petersen (1996).

world welfare maximum). The seminal contribution was made by Jacob Viner (1950), who distinguished between the benefits for a nation of *trade creation* and the potential losses from *trade diversion* from joining a customs union[3]. Unfortunately Viner's conclusion is too simple – in a simple partial-equilibrium diagram it is easily shown the welfare effects of trade creation and trade diversion are ambiguous (Lipsey, 1960). Indeed, customs union theory is a classic example of what Lipsey and Lancaster (1956) have called 'The General Theory of the Second Best': if it is impossible to satisfy all the optimum conditions (here: equal relative prices to the rates of transformation in production), then a change which causes some of the optimum conditions to be satisfied, may make things better or worse (see Lipsey, 1960). Using classical analytical models, it is therefore in general impossible to determine the welfare consequences of customs unions. Pomfret (1986) may be somewhat extreme in labelling customs union theory, as 'one of the most disappointing branches of post-war economics', but as argued by Kowalczyk (1990), 'too much effort has gone into establishing what remains a quite small number of results'.

Unfortunately Viner's terminology is not of much use – it is not operational for quantitative assessments. This problem was noted already by Lipsey in 1960, but until recently it was hard to solve satisfactorily. This is where CGE-modelling comes in handy, since it makes it possible to obtain qualitative as well as *quantitative* results when evaluating a specific Regional Integration Arrangement (RIA). The discipline of CGE-modelling offers a flexible, mutual consistent and powerful numerical alternative to the analytic models. This *deus ex machina* does not come without a price - broadly speaking the price paid is a loss of generality and a need for additional assumptions. In some circumstances, for instance when examining a particular customs union, this price is rather unproblematic.

2.1 Dynamic gains

The theory outlined above is concerned only with static effects. But clearly the creation of a Customs Union or a Free Trade Area can give rise to a large number of dynamic effects, i.e. effects that influence the growth rate of the participating economies. The creation of a Customs Union, is likely to increase the influence of technology spill-overs, increase competition e.g. by adopting uniform standards, increase economies of scale, and the finer division of labour permits a greater degree of specialisation and efficiency. The existing literature identifies and describes a number of these dynamic effects (Baldwin, 1989). But in fact, little is known about the nature of these effects, and even less empirical work has been done in examining the validity of these effects. According to Baldwin these effects are often ignored "for the simple reason that they are poorly understood and supposedly impossible to measure" (1989, p. 248). Thus the model presented in this paper will be purely static, with no regards to dynamic gains.

[3] *Trade creation* is the substitution in consumption of higher cost, domestically produced goods in favour of lower-cost goods produced by the country's new partner. *Trade diversion* is the shift in imports by a country from a low-cost producer outside the customs union to a relatively higher cost producer within the customs union, as a result of the elimination of tariffs from the partner.

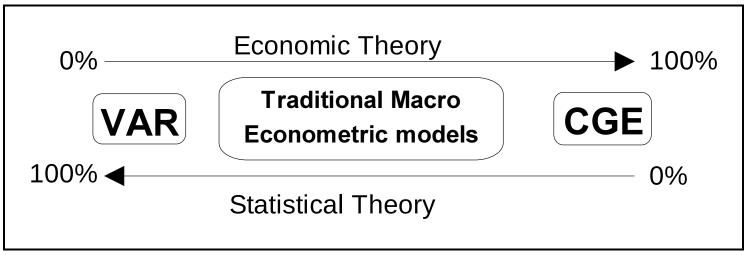
3. The CGE-approach

The purpose of this chapter is to explain the basics of CGE-modelling. All of the concepts introduced will be used in the model presented in the next chapter. For a thorough introduction to CGE-modelling see Shoven and Whalley (1984, 1992) or Ginsburgh and Keyer (1997).

3.1 Introduction

Before introducing CGE-models, it is worthwhile to consider the *family tree* of economic models. Traditional macroeconometric models, can for this purpose be considered as a crossbreed between Vector Autoregressive (VAR)-models and CGE-models. With inspiration from Whitley (1994), this generalisation is illustrated in figure 1 below.

Figure 1: The family tree of economic models



The VAR-models[4] have a very high content of statistics, but almost no economic content - basically one tries to find a “pattern” in the data, that is subsequently explained by an economic phenomena. At this point VAR-aficionados would object, and admittedly the exposition here *is* simplified. But the basic modelling-strategy with VAR-models goes from data to theory. With CGE-modelling it is the other way around - one starts with a theoretical model, and then finds data that fits the construct. CGE-models have an economical theoretical depth, but they take a very liberal view on statistical methodology. The traditional econometric models are located somewhere in between, drawing both on classical statistical methods, as well as some economic theory.

It is important to understand that economists face a trade-off. It is not possible to avoid compromise and build a model that fully adheres to economic theory, and at the same time is empirically and statistically well founded. Both approaches have their pros and cons, and there is no clear answer to which approach is the more suitable – it depends on the situation. When building CGE-models one avoids the Lucas’ critique, because there are no problems with expectations in the estimated parameters used. However, there is a prize to be paid for this; the model becomes less empirically founded.

[4] In VAR-models one tries to explain a vector of variables as a function of their own lagged values (as the name suggests, it is a multidimensional AR-process). The method is described in Hendry (1995) or Johansen (1995).

3.2 The modelling process

The typical construction and application of CGE-models, is shown in the adjacent flowchart. First a dataset is required, that has to be microconsistent, since it is assumed that the economy under consideration is in equilibrium. This is the *benchmark dataset*. Secondly, the parameters of the model are chosen by a *calibration procedure* that yields a set of parameter values that support the benchmark equilibrium. Once correctly specified the model will reproduce the initial benchmark as an equilibrium solution using these calibrated parameter values - this is the *replication check* shown in the figure. At this point the interesting part of the analysis begins: For any policy experiment, or *counterfactual experiment*, these calibrated parameter values can be used to solve for the associated alternative equilibria. Now it is possible to evaluate the effects of the policy experiment comparing the benchmark and the counterfactual equilibrium. This can be thought of as the empirical analogue of the *comparative-static analysis* that is common in theoretical work.

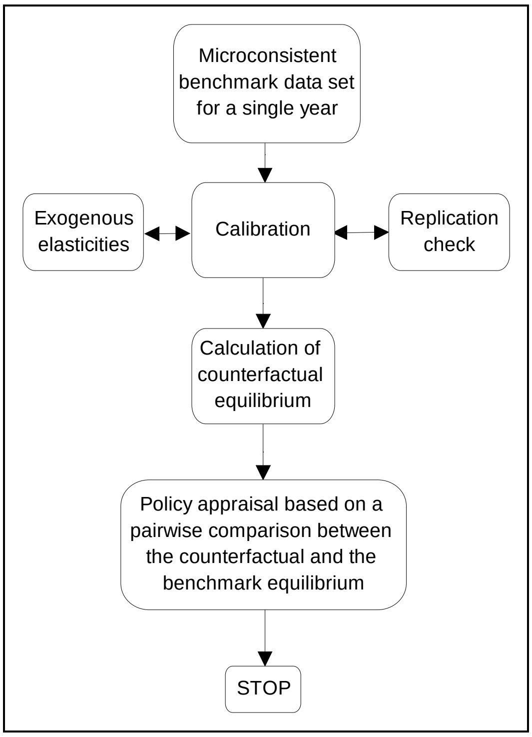


Figure 2: Flowchart of CGE-modelling

Source: Shoven and Whalley (1992)

3.3 Calibration

The calibration procedure mentioned above is straightforward. Suppose that a consumer's demand for the good x_i is observed to be $\tilde{x}_i$, his income is known, $\tilde{M}$, and the prevailing prices are $\tilde{p}_i$. If the consumer has a Cobb-Douglas utility function, then his demand function is given by $\tilde{x}_i = \alpha_i \frac{\tilde{M}}{\tilde{p}_i}$, which is one equation with one unknown[5] - the share parameter α_i. The resulting values of the α_i´s are called *point estimates*. Notice that there are no degrees of freedom left in the estimation procedure - this is why they are not called estimates, but point estimates. We say that the utility function is calibrated to the benchmark data set.

Serious objections can be raised to the calibration procedure, since it relies on data for a single year, which means that whatever stochastic anomalies were present in that year will strongly influence the model. Secondly it assumes that the benchmark year is a 'representative' equilibrium, which sometimes is not the case. However, it is difficult to find a better alternative[6].

[5] This assumes that the α_i's sum to unity (this, however, is unproblematic; it is merely a transformation of the utility function).

[6] This issue is discussed at some length in Shoven and Whalley (1984).

3.4 Hierarchical functions (nesting)

The Cobb-Douglas utility function clearly possesses some economically implausible features, e.g. unitary income elasticities and zero cross-price elasticities. Therefore other functional forms are typically used. The functional forms from the CES-family are the most common - but there are a lot of other possibilities. When choosing a functional form for the utility- or production function, the general approach is to select the one that best allows key parameter values (e.g. income or price elasticities) to be incorporated, while remaining analytically tractable. It is however possible to build more complex (and algebraically complicated!) models using simple functions (Cobb-Douglas or CES), using a technique known as nesting (or *hierarchical functions*).

The basic idea is simple - instead of letting goods enter the utility or production function directly, one use functions of a subset of the original goods. This is best illustrated with an example: instead of using the production function $F(K, L_1, L_2)$ we rewrite it as $G(K, H(L_1, L_2))$. The interpretation of this is straightforward: we imagine that the producer's problem is separable and can be solved sequentially in two steps. First he decides how the two types of labour should be combined into a single labour input, using the function $H(L_1, L_2)$. The optimal mix depends on the factor prices and on how well the two types of labour substitute each other. The resulting labour-mix is an artificial input, and is called a compound good. Secondly, he decides how this compound should be combined with capital in the outer function $G(K, H)$. The solution to this problem depends on the prices on capital and the compound good, as well as how well they substitute each other. This way of building functions in functions, is called *nesting*, and allows building very complex structures, using e.g. simple CES-functions[7].

3.5 Cross-Hauling and the Armington assumption

Examining trade data, one often encounters simultaneous import and export of the same good, which is known as cross-hauling. However, this observation is inconsistent with traditional (Heckscher-Ohlin) trade theory, since under perfect competition it cannot occur. The problem that this poses for model-builders was first solved by Armington (1969), and is called the *Armington assumption*. The problem is solved using the idea of nested functions as introduced above.

We assume that commodities are not homogenous across countries, but are imperfect substitutes for each other. Suppose one of the commodities in the model is cars. Under the Armington assumption Japanese and German cars are not treated as a single homogenous good ("cars"), but as differentiated goods between which there is a specified elasticity of substitution in demand (the Armington elasticity). The homogenous case, with no difference between Japanese and German cars, corresponds to an infinitely high Armington elasticity. An advantage of the Armington assumption is that *complete specialisation* is impossible, simply because the preferences do not permit an extreme degree of specialisation to occur in an equilibrium. This was a problem

[7] A more sophisticated method of nesting is presented by Perroni and Rutherford (1995). This method allows for an arbitrary combination of elasticities of substitution between the goods in the nesting structure, which means that the inputs in a production function need not be separable.

encountered in some of the early numerical models of trade, where countries ended up specialising in one product (Whalley, 1985).

3.6 Counterfactuals and welfare measurement

Assuming that the functional form we calibrated above is 'true', then the inferred parameters contain all information about the consumers' utility function, and thus his preference relation. Now it is possible to perform counterfactual analysis. The type of questions that can be asked, start with "What would happen if ..?", and scenarios thus considered, are called *counterfactuals*. One could for instance consider the impacts of the formation of a customs union, reductions in multilateral tariffs or the effects of an increase in the VAT.

Having calculated a counterfactual equilibrium, comparative statics is used to compare the new counterfactual state with the initial equilibrium. Of particular interest in CGE-models is the concept of welfare-measurement, using compensation criteria[8], trying to determine whether a *potential Pareto improvement* is feasible. This is typically done using the expenditure function (taken from the dual formulation of the consumer's problem), by calculating Equivalent Variations (EV) that measure the monetary value of the consumption bundles, using benchmark prices[9]. A homothetic utility function simplifies the calculations; then EV equals initial income times the percentage change in utility.

EV can be interpreted as the amount of income that if given to the consumer in the initial state, would have exactly the same effect on his welfare, as the move to the alternative state. If EV is positive, this means that the consumer prefers the counterfactual state to the benchmark state, since his utility is higher in the former. The measure becomes particularly useful when more than one consumer is involved - since the EV is measured in monetary units, it can just be added up across the consumers. This leads to the Hicks compensation test: if the sum of the consumers EVs is positive, then it is hypothetically possible for those who stand to gain (those consumers for which EV>0) to compensate those who stand to loose (those consumers for which EV<0), and thus it is possible to make a *potential Pareto improvement* in social welfare, using some lump-sum redistribution scheme. In other words we can determine whether the size of the "aggregate cake" has increased or not. However, the word *hypothetical* should be noted: Usually only the efficiency issues are addressed in CGE-models and the actual redistribution does not enter the analysis.

[8] A brief description of the by no mean unproblematic compensation criteria, can be found in Shoven and Whalley (1992, p.123) or Keiding (1987, p. 32). The relationship between the compensation measures and Consumer surplus are discussed in Willig (1976).

[9] Another measure, Compensating Variations (CV) is often encountered - the difference is that the 'new' prices are used when calculating CV. When making binary comparisons the choice does not matter. But as pointed out by McKenzie (1983, p. 37), EV is a better measure when comparing several counterfactuals, since the benchmark is used as a common reference point. McKenzie's advocacy of the EV rests on the natural feeling, that the status quo vector in some sense is an obvious candidate for a reference point.

3.7 Sensitivity Analysis

A very important part of any CGE-analysis is to examine the sensitivity of the results. There are a number of reasons for this. The first problem is well known from traditional econometrics, namely that the model can be very sensitive to the specification of the functional forms. In a CGE-model this means examining the consequences of changing some of the equations or assumptions. The second type of problems, are caused by the fact that estimates generated by CGE-models do not come with standard deviations, since the calibration procedure leaves zero degrees of freedom. In any functional form, more advanced than the Cobb-Douglas, some parameters can be determined by calibration (calibrated parameters) and some need to be specified exogenously (exogenous parameters) - otherwise there would be more unknowns than equations! These exogenous parameters are usually crucial to the behaviour of the model, and often a minor change in an exogenous parameter can have a large impact[10]. Finally it might happen that the benchmark year is not a representative equilibrium, which will bias the estimated parameters, and thus the results.

4. Eastern European integration with the EU

The first Europe Agreements between the EU and Czechoslovakia, Hungary and Poland were signed in 1991, and became effective as of March 1992. They were later supplemented by additional agreements with Romania, Bulgaria and Czech and Slovak Republics, that in turn became effective in 1993. The four countries: Hungary, Poland and the Czech and Slovak Republics are here labelled the Visegrad four (V4). Czechoslovakia refers to the Czech and Slovak Republics disregarding that they now are two separate republics. The Europe Agreements are the deepest and widest of EU's association agreements. They define the relations between the EU, and the Central and Eastern European Countries (CEECs), not only for trade but also for commercial practises and law, financial co-operation and political contacts. The principal components of the Europe Agreements are the following (Winters, 1992):

- The Visegrad four (V4) must open their markets within ten years to EU goods. The EU will open its non-sensitive markets immediately. For sensitive industrial markets the abolition of tariffs and quantitative restrictions on imports will take a period from four to six years. On agriculture the EU will offer concessions, but nothing like free trade.
- The V4 must adopt the EU competition policy within three years, its intellectual property policy within five years, and make best endeavours to approximate its other laws to EU standards.
- The rules of origin require a 60 percent local content before their exports to the EU qualify for trade concessions. This precludes the Central and Eastern European Countries from many relatively light processing tasks applied to non-EU materials.

Only the first component, i.e. the free trade aspects, will be modelled later since they relatively easily lend themselves to CGE-modelling.

[10] Good examples of this can be found in Hamilton and Whalley (1983) or Perroni and Whalley (1993).

4.1 Free trade aspects

The Europe Agreements aims to establish, what is called a "hub-and-spoke" arrangement: free trade areas between the EU and each of the Central and Eastern European countries separately, over a period of ten years. For most products, the Europe Agreements will offer access to the EU markets free of tariffs and quantitative restrictions within one year. For certain metal products, tariffs will be reduced over four years. Tariffs will persist for up to five years for the 'sensitive sectors': steel products and furniture, leather goods, footwear, glass, vehicles and some chemicals. In the most sensitive sector of all, agriculture, concessions are restricted to a subset of commodities, and then only within quota limits (Winters and Wang, 1994). The set of products with slow liberalisation is precisely the set of goods which the Central and Eastern European Countries export with most success. For the V4-countries 33-48 percent of their exports falls within the most restricted categories: food, footwear, textiles, clothing, Iron and Steel (Rollo and Smith, 93). This means, that the *effective* liberalisation for the Central and Eastern European countries are much slower than what would appear from the large number of immediately liberalised EU trade headings. This is a problem that seriously can constrain the growth of the Central and Eastern European countries, since the short-term export growth for the countries must depend on the goods in which they have a comparative advantage, and can produce to western standards.

The Europe Agreements are an interesting study in Politics, and illustrates EU's faint heart when it comes to committing itself to liberalising market access. Economic interests in the EU have moderated the good intentions. The agreements are the deepest and widest of EU's association agreements, but even so, the market opening they provide has been delayed and subject to a large number of restrictions. It should be remembered, that trade liberalisation is not the only purpose of regional integration. Thus Sapir (1995) suggests that the main purpose of the Europe Agreements, is to help the Central and Eastern European Countries in their transition process, and that economic gains are less important to the agreement. With a proper quantification of the consequences of the agreement, it would be possible to reject or accept conjectures like this. A quantification of the gains associated with the Europe Agreements, is exactly the purpose of the next chapter; it will present a CGE-model of the agreement.

5. A CGE-model of the Europe Agreements

This chapter describes a CGE-model that will attempt to shed light on a number of policy questions relating to aspects of the Europe Agreements. The chapter describes the model and the calibration procedure, whereas the results and the sensitivity analysis are placed in the next chapter. The main purpose of the analysis is to investigate the welfare effects of the Europe Agreements on the European Union, the V4-countries (Hungary, Poland and the former Czechoslovakia) and the rest of the world. It is also interesting to examine, whether the Europe Agreements are the optimal agreements between the EU and the V4-countries, or if it is possible to come up with another agreement, that is preferable (in a welfare sense). Along these lines it is of interest what would happen if the Europe Agreements, instead of being a hub-and-spoke arrangement[11], was a free trade agreement or a Customs Union between EU and the V4-countries.

The model is a relatively simple perfect competition model with five regions with an Armington nest-structure applied to the three goods. The demand and supply structure in the model is somewhat similar to Whalley (1985). The main difference to Whalley's 4-region model, is that here 3 commodities are used (Whalley used 33 commodities) and one representative consumer in each region (Whalley used more than ten).

5.1 The model

The purpose of this section is to present the model. The style is kept informal, focusing on intuition rather than equations[12]. The model describes the world in the year 1991. At this time, the European Union consisted of only 12 countries, and Czechoslovakia was considered one country; thus the model has 5 regions:

- R1: The European Union (12 members)
- R2: Czechoslovakia
- R3: Hungary
- R4: Poland
- R5: The Rest of the World (ROW)

The region "rest of the world" consists of the 20 countries, which traded the most with the EU in 1991 (apart from the V4-countries). This is not the ideal way to define the rest of the world, but is chosen simply to avoid a number of data problems later in the analysis. This division gives the following characteristics of the five regions in the model:

Table 1: Characteristics of the regions in the model

	Region	GNP, 1991 (mil. US$)	Population, 1991 (mill.)
R1	EU	6.784.931	347,2
R2	Czechoslovakia	38.337	15,6
R3	Hungary	34.254	10,3
R4	Poland	87.315	38,1
R5	ROW	13.592.955	2.280,5

Source: World Bank (1995) and own calculations

[11] The idea behind the hub-and-spoke arrangement is that the EU (the hub) has separate Free Trade Agreements with the V4-countries (the spokes), but the spokes do not have mutually free trade. The V4 countries *have* taken steps to liberalise trade internally, and in 1993 they formed a Free Trade Area called CEFTA (Central European Free Trade Agreement). The agreement is built as the EFTA agreement, and its purpose is to create a Free Trade Area for the 65 million people in the four countries (Udenrigsministeriet, 1995, p. 179). However, since the agreement is not working yet, this extension is not considered here.

[12] The model is described more rigorously in Petersen (1996). However, it is completely standard, and therefore equations are left out here. The consumer maximises utility over the nested goods (explained below), subject to a budget constraint with income arising from the sale of endowments of labour and capital, and the redistributed tariff revenues (see below). The producer maximises profits using a constant returns to scale technology, using labour, capital and intermediate goods as inputs (explained below). Finally the government collects revenue from tariffs and redistributes it back to the representative consumer in a lump-sum manner (this means that there are no government purchases).

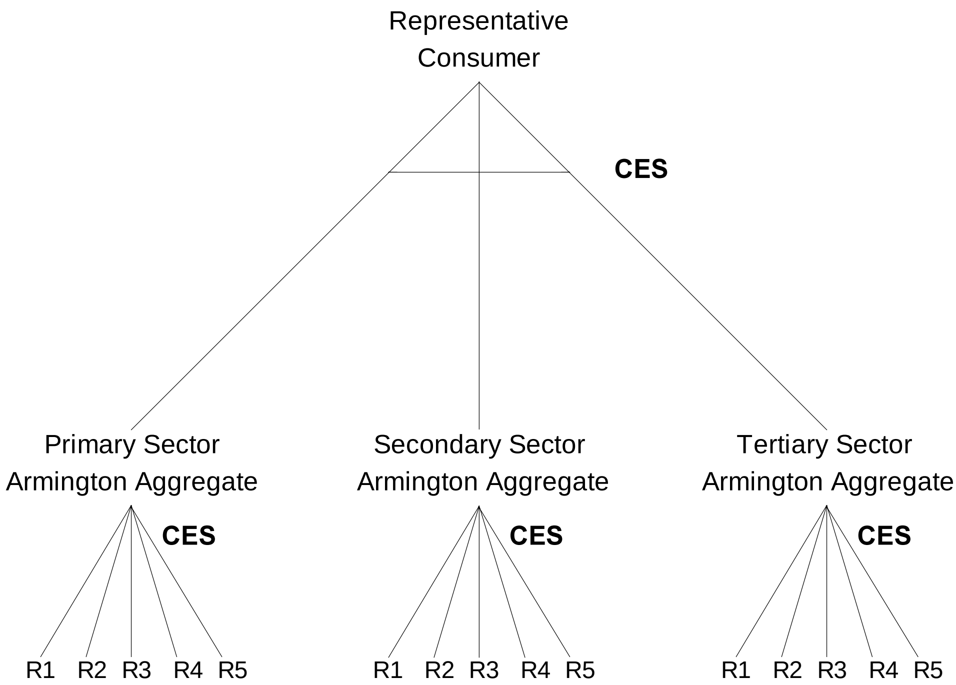
5.1.1 Consumers

Each region in the model has a representative consumer, who derives utility from three goods, - each good representing a sector in the economy:

- Primary sector - primary production
- Secondary sector - manufacturing
- Tertiary sector - services

The Armington assumption is applied to the goods entering the utility function. The final demand functions are derived from two-level nested CES utility functions, and are illustrated in Figure 3 below. At the lower level of nesting, substitution occurs between comparable domestic and imported products (for example domestic produced primary goods and primary goods produced in the other four regions). These Armington aggregates are formed using the Armington elasticities of substitution (ES). At the top level of nesting, substitution occurs between composites of primary, secondary and tertiary goods.

Figure 3: Armington demand structure in the model



The demand structure shown in figure 3 has the following elasticities:

EC: Top-level elasticity of substitution for the representative consumer. Determines the level of substitutability in the utility function between the three sector's goods (upper CES-nest).

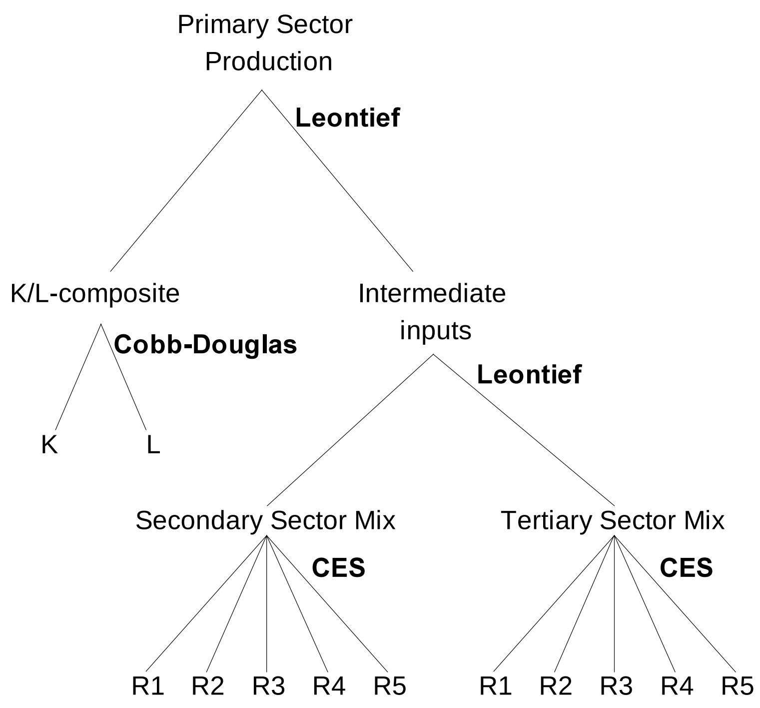
ES: The elasticity of substitution in the Armington composite. Determines how substitutable the same good produced in different countries are to the consumer (lower CES-nest).

5.1.2 Production

Each region has endowments of the two factors: capital (K) and labour (L). These two factors of production are internationally immobile, but mobile between the producing sectors. The consumer owns the endowments, and sells them to the producer. The fact that L does not enter the consumer's utility function implies that the consumers do not value leisure.

The production function is nested and is illustrated in Figure 4 below. At the top level a choice is made between two composite goods: a capital/labour input and an intermediate input composite. The K/L-composite is "produced" using a Cobb-Douglas production function, using capital and labour. The intermediate input composite is produced using a second-level Leontief production function, where the inputs being used are the composites of output from the remaining two sectors in the economy[13]. At this third level, a CES function describes the substitution possibilities for each fixed composite-good input in each industry. The production function for good 1 is illustrated below:

Figure 4: Production function in the primary sector



The elasticity of substitution used to form the intermediate input composite (e.g. secondary sector mix), is the same that consumers apply in their second-level nest; this means that consumers and producers use the same compound goods. This assumption is made for reasons of simplicity rather than realism – it is chosen to reduce further data problems in the calibration.

[13] The meticulous reader might wonder why two Leontief nests are placed on top of each other, instead of placing all the inputs in the top nest. Admittedly this would have the same effect, since placing Leontief structures on top of each other is pointless (this is equivalent to writing the function MIN[a,b,c,d] as MIN[MIN(a,b), MIN(c,d)]). However, the two level nested Leontief structure is made to emphasise the difference between on one side the intermediate inputs between which no substitution occur, and on the other side the factors K and L which can substitute each other.

5.1.3 Trade and tariffs

Revenues from ad-valorem tariffs are distributed back to the representative consumer in a lump-sum fashion; this means that tariffs do not redistribute income, but only influence the relative prices. In the model, the only impediment to trade is tariffs, i.e. no quantitative restrictions or NTBs. These barriers are difficult to model, and an *ad-valorem equivalent* approach is used. This means that all non-tariff barriers are converted to an equivalent tariff: the ad-valorem tariff equivalent is the tariff, that in a tariffs-only world, would give the same impediment to trade, as the initial combination of tariffs and non-tariff barriers (the method is described in Laird and Yeats, 1990).

5.2 Calibration

Having stated the model, the next step is to determine the appropriate values for the parameters of the production and utility functions. This is done through the calibration procedure described in section 3.3; this means solving the model "backwards", from the benchmark equilibrium (in 1992) calculating the parameters in the model.

5.2.1 Data

The data were collected from different sources. All values in the benchmark data set are calculated in value terms (US$) using normal exchange rate conversion. The data used are from 1991 or 1992 (latest available year for all countries), unless otherwise mentioned. The value of production in each country was obtained from the World Bank (1995). For the "aggregated regions" (EU and ROW) the aggregate size of these sectors were calculated using a weighting scheme, with the weights reflecting the size of GNP in the countries. These production numbers play an important part in the Input-Output (IO) tables used in the calibration.

The value of merchandise trade between the five regions was obtained from United Nations (1995) and Eurostat (1995). The trade data were not microconsistent for CGE-modelling purposes[14]. Microconsistency implies that the value of imports must equal the value of exports for each country, since it is not possible to have a deficit or surplus on the balance of payments in the type of static CGE-model presented here. A static model can be thought of as an one-period model, and in an one-period model nobody wants to lend goods, since there is no second period where they could get paid back[15]. The sectoral composition on the trade-matrix above was not available. Only the composition of each country's exports categorised according to their SITC-code was available. Data according to SITC-headings were then aggregated to reflect the sectors in the model. Trade in services is obtained from Eurostat (1995).

The only impediment to trade in the model is as mentioned in section 5.1.3 ad-valorem tariffs. Obtaining these ad-valorem tariff equivalents is not easy. A large effort in calculating the tariff-

[14] The problem with microconsistency was solved manipulating input data to become microconsistent (i.e. so that there is budget balance for all agents and that all markets clear). This was done using the RAS-method known from National Accounts. See Petersen (1996).

[15] Whalley (1985) accommodates this problem by the introduction of ad-hoc capital-account transactions.

equivalents has been done by Laird and Yeats (1990). In a literature study, they find the tariff equivalents for the US, the EU and Japan for selected items; here the point of departure will be these numbers. Unfortunately obtaining the tariff-equivalents for the sectors and countries in the model directly was not possible. The three goods (sectors) are too aggregated across industries, making Laird and Yeats' numbers useless. To make matters worse, there are no numbers for the tertiary sector. The only way to proceed is to construct a tariff structure that seems reasonable, and to apply that to all regions in the model. Therefore the following initial tariff-scheme is used:

- Primary sector: 100%
- Secondary sector: 30%
- Tertiary sector: 10%

The scheme reflects the empirical fact, that the primary sector is the most protected, followed by the other two sectors. Even though most services face no tariffs, usually quite a number of non-tariff barriers are in place, and therefore is the tariff equivalent set at 10 per cent. The tariff equivalents used are admittedly a lot higher than the Most Favoured Nation tariffs one normally encounters - but given that tariffs are the only distortion in the model, they are probably not unrealistic, and serve as a useful point of departure.

Finally the elasticities of substitution (in the CES production and utility functions) need to be specified. Once again this is a difficult task that is done in a rather ad hoc manner; this is one of the main reasons why a careful sensitivity analysis is carried out on these parameters. The values for the parameters are chosen so that they are close to those used by Whalley (1985). The elasticity of substitution between the three composite goods is set to 0,85 in all regions, which allows relatively little substitution between the three composites. The Armington elasticity of substitution (ES) between the same type of goods from the five regions (ES) is set to 1,5 which means that the level of substitutability is relatively higher. For services (good 3) this elasticity is set to 1,2, since services are less likely to be substitutable, than goods from the primary and secondary sector.

5.3 Comments

The purpose of this chapter was to give a brief description of the model, and how it is calibrated. The most extensive shortcut was that the IO-tables for all regions were assumed to be similar to that of Denmark. This is a problem, because IO-data for Denmark, are probably not representative for the countries in the model. This eliminates any Ricardian gains from trade, since it assumes production functions in all countries to be similar. This leaves room for gains from trade of the Hecksher-Ohlin type, as well as a Krugman type of gains due to the Armington-preferences used[16]. A second important assumption, was that trade in services was generalised from EU data. This is problematic because it implies that there is an affine relationship between the size of trade in

[16] The way preferences are constructed (using the Armington assumption) utility will increase when the number of available products increases. Gains of this type of trade can with some right be associated with Krugman (1979), and is often referred to as the love-of-variety effect. Strictly speaking, this model presented here is not Chamberlinian (i.e. monopolistic competition) and the preferences are not of the Dixit/Stiglitz type. However, the intuition as to what drives gains from trade is the same here as in models with Dixit/Stiglitz-preferences, due to the Armington assumption.

services and the size of the tertiary sector - and for instance the public sector is a tertiary sector, but have nothing to export. Finally, it is problematic, that the tariff-equivalent structure was determined on a very ad hoc manner, mainly based on rather old data. In the literature it is not uncommon to make these kinds of assumptions, to overcome certain kinds of data problems. These generalisations make the countries more homogenous, and are thus likely to give a downward bias when evaluating gains from trade liberalisation.

6. Results

At this point the model is ready for the counterfactual analysis. This is where the modelling exercise gets interesting; it is possible to analyse the consequences of the Europe Agreements, and compare it with alternative arrangements. Instead of just analysing the Europe Agreements, they will be compared with another scenario. The central case is a reduction of tariffs on 50 per cent. The alternative scenario illustrates another arrangement, namely a Free Trade Agreement (FTA) contrary to a hub-and-spoke arrangement (this scenario is called FTA50). Relative to the base-case scenario it would additionally allow freer trade between Hungary, Poland and Czechoslovakia. There is no need to examine a Customs Union formation, since all regions' tariffs towards ROW are the same, due to the ad hoc determination of initial tariffs.

6.1 The Europe Agreements

Not all elements of the Europe Agreements can be analysed with the model presented here; the focus is on the trade liberalising aspects. Before proceeding we need to convert the liberalising elements of the Europe Agreements into tariff-equivalents. Once again, these numbers are unavailable, and need to be constructed. It will be assumed that tariffs will be halved on all trade between EU and Czechoslovakia, Poland and Hungary - this is the central case, and is referred to as HASP50.

A single counterfactual experiment generates a very large numbers of variables, and when analysing the results it is necessary to limit the attention to some variables of interest. This is particularly the case when several counterfactuals are being compared. Welfare effects of policy changes are of central importance. This is in line with the majority of theoretical literature on international trade policy, which seeks to identify who gains and who loses, and to what extent. For this purpose the *Equivalent Variations* (EV) measure will be used. This monetary measure allows us to add gains/losses up across consumers. Since EV is an absolute measure (in monetary units), one should take the absolute size of GDP into account, when comparing gains in EV across countries. Therefore the second most important measure is EV/GDP, which equals the relative increase in GDP at the initial relative prices. This number can be thought of as the annual relative increase in GDP caused by the change in policy. The welfare effects are influenced by changes in the *Terms of Trade* (TOT). The measure used here is the net barter terms of trade. It measures the relative price as an index-value, from of a composite of exports in terms of a composite of imports for each region, using fixed quantity weights (benchmark domestic production quantities). The TOT is calculated as a producer price index (i.e. ignoring tariffs). The TOT calculation uses the convention, that a positive change indicates an improvement in a region's TOT. Finally it is of interest to examine the relative changes in the *sectoral output*.

6.1.1 Results from the Central case

The impacts from the central case scenario on the five regions are shown in Table 2 below. Apart from The rest of the world, all countries gain relative to the initial situation. The annual gain measured relative to the size of the GDP (the row labelled EV/GDP in the table) is largest in Hungary and around 1,8 per cent of GDP. In Czechoslovakia the gain is 0,83 %, and in Poland around 1,1 % of GDP. These numbers are admittedly not particularly impressive – annual long run gains around 1 to 2 per cent of GDP are in fact very small. The gains for the EU is surprisingly low - only 0,012 % of GDP.

Table 2: Results from the central case (HASP50)

HASP50	EU	CZ	Hungary	Poland	ROW	Total
EV	614,0	212,5	429,2	613,4	-401,5	1.467,7
EV/GDP	0,012%	0,831%	1,810%	1,055%	-0,004%	0,009%
Change in TOT	0,994%	0,988%	0,926%	0,934%	1,011%	
Primary output	-0,841%	6,763%	16,939%	14,749%	-0,004%	
Secondary output	-0,081%	-0,049%	-2,079%	-1,257%	0,002%	
Tertiary output	-0,002%	-0,385%	-0,615%	-0,437%	0,000%	

However, the magnitude of the numbers is in line with the findings in the literature. It should be remembered that the model presented here ignores dynamic effects, economies of scale etc. It is likely that some of the assumptions made in the calibration procedure biased the gains downwards, since the countries were made more homogenous due to lack of data. Investigations of other regional integration arrangements generally show similar results: CGE-models of the NAFTA (Brown, Deardorff and Stern, 1992) and the internal market in the EU (Gasiorek, Smith and Venables, 1993) predict only minor gains for the participating countries[17] (approx. a couple of per cent of GDP). When dynamics enter the models, usually the gains are somewhat higher.

The EU manages to gain on the Europe Agreements, even though the EU because of changes in relative price experiences a minor drop in the production in all three sectors, the largest being in the primary sector. This paradox can be explained by a positive effect arising from a gain in the region's TOT. The V4 countries experience a gain in their TOT as well as a rather large increase in the production of primary sector goods (17% increase in the size of output in the case of Hungary). On the other hand, they lower their output in the secondary and tertiary sector slightly. The rest of the world is made worse off by the implementation of the Europe Agreements. The loss for the rest of the world is small, and the countries that benefit *could* use lump-sum transfers to compensate the rest of the world, so no region would be made worse off. This is possible since the aggregate benefits (sum of EVs) are positive.

[17] An exception is Cox and Harris (1986) who estimated a 9 percent increase in Canadian welfare as a result from the increase in bilateral trade caused by the CUSTA (Canada-US Free Trade Arrangement). It should be noted, that their model has large economies of scale in production.

It is clear that the gains for the Eastern European countries are small. The long-run annual increase in GDP in Czechoslovakia, Poland and Hungary is in the interval 1 to 2 percent in the central case. These small benefits from the Agreement, show that Sapir (1995) as mentioned may be right, saying that the main purpose of the Agreements is to help the countries in their transition process, rather than to boost trade. Further liberalisation increases the benefits for the Eastern European countries – further calculation reveal that a total removal of tariffs can give gains of up to 5 percent of GDP for the Eastern European countries. However, further liberalisation than 50 per-cent means that the EU looses because of deteriorating terms of trade. When a tariff is lowered, the TOT will typically deteriorate if the tariff is lowered below the level implied by a set of optimal tariffs[18] [Whalley, 1985, p.130]. A large region like the EU, can with significant advantage apply an optimal tariff strategy, and is therefore subject to a potential loss when a tariff is lowered.

6.2 A FTA with the Visegrad four

The Europe Agreements are Hub And Spoke Arrangements (HASP) arrangements. Suppose instead, that it was a Free Trade Agreement (FTA), where all members had mutual free trade. It has been argued, among others by Kowalczyk and Wonnacott (1992), that a HASP arrangement is preferred by the hub (in this case the EU), to a FTA, whereas the spokes (here: Hungary, Czecho-slovakia and Poland) prefer a FTA. It turns out, that CGE analysis is a good framework to evaluate conjectures of this kind. Thus, in this scenario tariffs on all trade between the EU, Czechoslovakia, Hungary and Poland are reduced 50 per cent. The gain (measured by EV) for the EU is 5 per cent lower, than in the HASP50 scenario. The EU experience a decrease in its terms of trade - again this is due to tariffs being lowered below the optimal tariff level. On the other hand, the V4-coun-tries improve their terms of trade, and increase their GDP with between 5 and 24 per cent relative to the HASP50 scenario. The global gain is 4,5% larger than in HASP50, but the relative increase in aggregate GDP is still very modest - only 0,01 % of GDP.

A comparison between the HASP and the FTA verifies that the conjectures by made Kowalczyk and Wonnacott (1992) were right. The computations show that the EU would prefer a Hub and Spoke arrangement, whereas Czechoslovakia, Hungary and Poland prefer a Free Trade Agree-ment. But of cause, there is nothing stopping the V4-countries from liberalising trade mutually in another agreement - in fact they already have done so, with the creation of the Central European Free Trade Agreement (called CEFTA).

6.3 Sensitivity analysis

Sensitivity analysis is, as mentioned in section 3.7, a very important part of a CGE analysis. The results mentioned above all depend on the model, and the results would undoubtedly have been different, had the model been specified differently. The grand question is *how* much the results

[18] This is the optimum-tariff argument first put forward by Bickerdike in 1906: For a large country there exists an optimal tariff different from zero. When the (price) elasticity of import supply is less than infinite, and the elasticity of import demand is greater than zero, then part of the duty is absorbed by the foreign suppliers. The argument is based on the assumption, that foreigners will not retaliate, which does not happen in this example.

would have changed - indeed not an easy question to answer. A good answer could be, that the results obtained should be stable or robust for minor changes in the set-up. Unfortunately this answer is not very operational, as it poses two new questions. First of all the meaning of stable or robust is not clear - there are no easy rules, and there is no equivalent to the 5% significance rule that is commonly used to test hypotheses in econometrics. The second problem relates to what can be defined as “minor changes”. There is no well-defined metric that can be used to measure what constitutes a “minor change”, and it is not easy to measure the distance between two set-ups. These two problems will be dealt with in very different ways. Among CGE-modellers there is consensus as to consider a particular kind of sensitivity analysis. But it comes to evaluating whether results of this sensitivity analysis are stable or robust, a much more ad hoc method is used - namely determining whether or not the results seem plausible or not. This, of cause, is a matter of subjective judgement.

In the model there are two sets of elasticities. The first, *EC*, is the top-level elasticity of substitution for the consumer. The second, *ES*, is the elasticity of substitution in the Armington aggregates defined for each of the 3 goods. In order to obtain an impression of sensitivity of the results, a large number of permutations and combinations of the elasticities are needed, due to the complexity in the nesting structure in the utility and production functions in the model[19]. The elasticities are kept identical across countries, to reduce the number scenarios considered. The alternative sets of elasticities are divided in 2 groups with respect to the likelihood of the alternative set of elasticities specified (11 experiments are carried out in each group). The first group represents values of the elasticities that can be considered likely or plausible, whereas the scenarios in the second group have values of the elasticities that can be considered rather unlikely or extreme. The table showing the elasticities of substitution mentioned, as well as the results of the sensitivity analysis is placed in Appendix I on page 21 (table 3).

6.3.1 Results from the sensitivity analysis

The main variable that will be studied in the sensitivity analysis is the compensating variation measure (EV). This is done to mainly to emphasise that the focal point for CGE-models is welfare analysis. With the *more likely* sets of alternative elasticities the gains/losses for the regions all lie within an interval of [-32%;+30%], with 80 per cent of the regions experiencing an EV that is within an [-15%;+11%] interval (relative to the central case). These numbers are relatively small and not alarming. It is interesting, that even in the best case, the gains from the Europe Agreements are still very modest - for Hungary the annual gains increase from 1,810% of GDP to 1,992%. With the *less likely* set of elasticities (cases 13 to 23), the gains/loses for all regions lie within an interval of [-975%; +1245%], with 80 per cent of the regions experiencing a change in EV on [-42%; +119%] relative to the central case. However, these results *are* rather extreme. Primarily the values of the alternative elasticities are far away from the central case elasticities. Thus the results in the extreme part of the sensitivity analysis, cannot be considered evidence that there is a problem with

[19] A more sophisticated version, not used here, is known as systematic sensitivity analysis. See Harrison and Vinrod (1992).

the way the model functions. With the more likely set of elasticities, the welfare gains from the Europe Agreements *did* change, but not dramatically. Taking into account the general level of uncertainty in these models, it can be considered a satisfactory and rather stable result.

6.4 Comparison with results from other models

The Europe Agreements have been analysed in a number of papers. Unfortunately, most results are difficult to compare with the results presented here, since the analyses are performed using partial equilibrium models[20]. The outputs from partial models are different from the results generated by a General Equilibrium model. Results from partial models concentrate on what happens with a particular sector - for instance Mastropasqua and Rolli (1994) find that the Czechoslovakian foot-wear sector will increase its exports to the EU with 29 percent. Results of this type are rather difficult to compare with the results obtained using the General Equilibrium model that was employed here.

6.5 Limitations to the model

This section describes some possible improvements to the model. First of all, one could improve the results of the model, if it was possible to obtain the proper data from all countries. The generalisations made in the calibration were made out of necessity rather than out of choice. Secondly, one might consider introducing a European Union budget, as well as the Common Agricultural Policy in the model. The effects of the CAP and the structural funds are large and they would undoubtedly affect the welfare consequences for all regions in the model. A third direction to elaborate the model would be to increase the dimensionality, i.e. introduce a larger number of sectors. The present number of sectors (3) does not allow a very detailed description of the goods markets, and does not capture sectoral effects very well. Finally one could improve the welfare considerations by introducing e.g. three socio-economic groups in each region. This would make it possible to judge which groups of consumers end up winning and loosing, instead of just looking at aggregate welfare at country level.

7. Summary

The model of the Europe Agreements showed only small benefits for Czechoslovakia, Hungary and Poland, and even smaller benefit for the EU. Thus it is reasonable to say, that the model supports the critical voices, claiming that the Europe Agreements are mainly of political value and that the economic consequences are small. If the purpose of the agreement was economic gains, then the analysis showed that a Free Trade Agreement would be preferable to the Europe Agreements.

The model probably underestimates the gains that the liberalisation in the Europe Agreements will bring about. First, this can be due to some of the homogenizing assumptions made in the calibra-

[20] An exception is Bach, Frandsen and Stephensen (1997) who build a CGE-model of European Integration. The model is used to evaluate the consequences of integration for the EU common agricultural policy.

tion, where Ricardian gains from trade was ruled out by construction. Secondly, some dynamic gains from the liberalisation should be expected apart from the resource allocation effects mentioned here. These dynamic effects include more innovation, faster productivity gains, greater investment and higher output growth. These effects are ignored here, mainly because they are poorly understood and very difficult to measure. Finally, there are no economies of scale in the model - whereas in reality economies of scale probably play an important role.

7.1 CGE-modelling as a tool

The CGE-approach turned out to be a fruitful approach to the analysis of the Europe Agreements. Compared to the analytic approach, the method could quantify the gains from the agreement – using an analytical approach, it would not even have been possible to get the sign right. Compared to partial back-of-the-envelope calculations the method also has advantages. When examining a complicated issue like the Europe Agreements, it is easy to miss some important feedback effects and general equilibrium effects. In such a situation the CGE-framework comes in handy, since it offers a consistent economically appealing framework for keeping track of the relevant effects.

Some critical comments should also be made. The method used in the analysis is static, and is concerned only with comparing equilibria, ignoring the process of moving from one equilibria to another. Indeed the famous words of Keynes, “In the long run we are all dead”, is relevant when it comes to CGE-models, and often the trajectory path of the system cannot be ignored. The somewhat ad-hoc way the model is calibrated can also be criticised; but unfortunately there is often no good alternatives to the approach. Only a careful sensitivity analysis of the results can, to some extent, relieve these problems.

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9. Appendix I: Sensitivity analysis

Table 3 below shows the EV (colums 6 to 11) for the alternative set of elasticities (columns 2 to 5) used in the sensitivity analysis. The table is in index values (i.e. the increase in EV experienced in the central case is set to 100).

Table 3: Parameter constellation and results from the sensitivity analysis, EV in index values

	EC	ES			Results:					
Case		*prim.*	*sec.*	*tert.*	EU	CZ	Hungary	Poland	ROW	Total
1	0,85	1,5	1,5	1,2	100,0	100,0	100,0	100,0	100,0	100,0
2	0,6	-	-	-	94,5	102,7	103,1	101,8	109,6	97,1
3	-	1,3	-	-	100,7	88,8	82,3	82,5	93,2	88,0
4	-	-	1,3	-	74,0	101,4	107,2	108,6	98,3	95,5
5	-	-	-	1,1	99,5	100,4	100,9	100,7	101,9	99,9
6	-	1,7	-	-	98,7	106,8	111,5	111,3	97,8	109,1
7	-	-	1,7	-	122,3	97,8	91,8	91,8	96,1	104,2
8	-	-	-	1,5	101,3	98,9	97,6	98,0	94,8	100,3
9	-	1,3	1,3	1,1	74,8	92,3	94,2	94,7	105,4	83,0
10	-	1,7	1,7	1,5	123,6	103,5	100,3	100,5	89,7	113,5
11	0,6	1,3	1,3	1,1	68,3	95,3	97,8	96,7	117,5	79,2
12	1,2	1,7	1,7	1,5	129,5	100,7	97,1	98,5	79,3	116,6
13	1,5	-	-	-	113,4	93,7	93,2	95,8	75,7	107,6
14	3	-	-	-	140,5	82,4	86,3	88,5	23,6	126,5
15	-	0,8	-	-	65,9	138,2	1.345,2	286,1	169,8	514,1
16	-	-	0,8	-	-60,4	158,5	203,5	198,0	119,3	107,3
17	-	-	-	0,8	97,8	101,7	103,9	103,3	108,2	99,6
18	-	5	-	-	68,4	106,5	155,2	149,5	59,1	135,7
19	-	-	5	-	257,8	96,5	57,1	59,3	62,2	146,3
20	-	-	-	5	107,1	92,8	84,4	87,5	70,4	100,2
21	-	5	5	5	216,3	106,9	75,2	77,7	19,5	155,1
22	0,6	0,8	0,8	0,8	220,5	380,5	-875,7	494,0	154,7	55,4
23	3	5	5	5	211,4	103,4	71,7	75,3	15,0	151,8